UNIVERSITY OF CALIFORNIA

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Phonological Systems of Aphasic Children

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Linguistics

by

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ABSTRACT OF THE DISSERTATION

Phonological Systems of Aphasic Children

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The aim of this research is to compare aspects of the phonological system of children diagnosed as "developmentally aphasic" with the acquisition of phonology by normal children and by children with other deviant language skills.

To date, no one study has focussed on the phonological patterns of more than one "developmentally aphasic" child. The studies on abnormal phonology have been conducted for the most part with deaf children, Down's Syndrome children, and with children whose language system is intact except for phonology. The research reported on in this dissertation analyzed the phonological systems of 16 developmentally aphasic children ranging in age from 4-9 years. The results of the analysis were compared with those reported in the literature on both normal and abnormal populations. It was found that this population used many of the rules that normal children acquiring phonology use as

well as many of the deviant rules other abnormal populations use. A distinctive feature analysis showed that this abnormal population did have the same types of feature errors as children normally acquiring phonological systems but that the Chomsky-Halle feature set may obscure some general trends.

When comparing the results of the analysis with Jakobson's predictions and Stampe's predictions more evidence was found in support of Stampe. Moreover, it was necessary to analyze each child's phonological pattern separately since no specific identifying patterns of disorder could be seen for this group of children as a whole. Each subject performed in an idiosyncratic manner so no conclusions as to the diagnostic category of "aphasia" could be made.

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The dissertation of Alora Johnson Burton is approved.

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CHAPTER 1

INTRODUCTION

The research reported on in this dissertation investigates the speech of sixteen developmentally aphasic children ranging in age from 4 to 9 years and conducted over a six month period. A minimum of two children at each age level were studied. "Developmental aphasia" refers to a relatively isolated defect in the development of expressive and/or receptive aspects of verbal language in children, which defect cannot be attributable to defects of hearing, specific neurological damage, or emotional disturbance (Eisenson, 1972; Tallal and Piercy, 1973, 1974, 1975; Morehead and Ingram, 1973).

No study to date has studied the phonological patterns of more than one "developmentally aphasic" child. Investigations of abnormal phonology (Ingram, 1972; Compton, 1970, 1975, 1976; Bodine, 1974; Oller and Kelly, 1974; West and Weber, 1973) except for the Ingram study have mainly been conducted with deaf children, Down's Syndrome children, and with children whose language system is intact except for the phonological component, i.e., multiple articulation disorders. An investigation of developmentally aphasic children thus seems to fill a research gap. It also was aimed at a comparison of normal and abnormal speech.

In the last number of years much attention has been paid to the acquisition of language by normal children. One of the many goals of such studies has been to provide evidence for general theories of grammars. In many of these studies the principles of generative phonology (Chomsky and Halle, 1968) were used to describe the developmental phonological systems of normal children (Smith, 1973; Ingram, 1974ab; Ferguson, 1975; Edwards, 1973; Moskowitz, 1970, 1971, 1972; Salus and Salus, 1974). Recent studies of abnormal phonology have suggested that there are also regularities in abnormal speech which can be revealed by similar phonological rules (Oller, 1973; Oller and Kelly, 1974; Ingram, 1972; Crocker, 1969; Compton, 1970, 1975, 1976; Farwell, 1972; Menyuk, 1968; McReynolds and Huston, 1971; Bodine, 1974; West and Weber, 1973).

In both types of studies the following general rules (see below for a discussion of "rule") have been proposed to account for the discrepancies between child and adult speech (Ingram, 1976):

Cluster reduction, e.g. stick → tick; st → t (Smith, 1973)

Nasal cluster reduction, e.g. jump → dup; mp → p (Smith, 1973)

Fronting, e.g. cake → tate k → t (Ingram, 1974b)

Back Assimilation, e.g. dog → gog d → g/__ g (Ingram, 1974a, Smith, 1973)

Affricates and Fricatives becoming stops,

e.g. chair → tair; tʃ → t (Smith, 1973; Ingram, 1975)

fish → pit f → p, ʃ → t

Final consonant devoicing, e.g. dog → dok g → k (Smith, 1973, Velton, 1943)

Neutralization of voiced/voiceless contrast in initial and intervocalic positions, e.g. pat → bat p → b (Smith, 1973 happy → habby Ferguson and Farwell, 1975)

Weak syllable deletion, e.g. behind → hind bə → ∅ (Ingram, 1976, Smith, 1973)

Denasalization, e.g. nail → dail n → d (Ingram, 1976)

Assimilation, e.g. truck → fwuck r → w; t → f (Greenlee, 1973)

Delateralization, e.g. lady → wady l → w (Edwards, 1973)

Spirantization, e.g. leaf → zuf l → z (Velton, 1943; Ingram, 1976)

Depalatization, e.g. shoes → soes ʃ → s (Ingram, 1975)

Vocalization, e.g. table → tabow l → oω (Ingram, 1976)

The word "rule" in studies of children's language acquisition has not always been clearly defined. Generally a "rule" seems to be implied if there are regular occurrences of the correct pronunciation, as well as the incorrect. That is, if a child sometimes produces a consonant cluster which occurs in the adult model, but at other times simplifies the cluster by deleting one of the consonants, such a deletion has been referred to as a "cluster simplification rule." Or if a child sometimes substitutes a stop consonant for a fricative, but does not always do so, one might suggest that the child has a stop fricative "rule." All such rules would then be variable rules, or optional rules and never obligatory. Other authors go farther and suggest the existence of rules where the substitutions are <u>always</u> present. But if certain segments and/or features always substitute for others, it is difficult to justify the existence of substitution rules in the child's grammar as opposed to a list of such "cognate" sound correspondences. It is possible that the child's phonological representation of the words or sounds which differ consistently from those found in the adult language is as produced by the child. That is, if a child always substitutes a [d] for the fricative [ð] the child may represent a word like <u>this</u> with an initial /d/ in her internalized dictionary. There are problems with such an analysis, however, if one accepts the notion that at some level the grammar is neutral as to production and perception since studies have shown (Smith, 1973) that children distinguish and react negatively to their own pronunciation when produced by adults. Also, Kornfeld (1971) has shown that although adults may be unable to perceive differences in children's production of, for example [r] and [w] in words like train and twain, acoustic analysis of the two words shows physical differences between the two second segments, which the adult listeners perceive as identical.

If one does posit the existence of substitution rules in the child's grammar, it is clear that such rules are different in kind from those posited in the adult grammar. In generative phonological theory the phonological rules of the grammar relate one level of representation (the systematic phonemic level) to another level (the surface phonetic level) (Chomsky and Halle, 1968). The rules are supposed to reveal "linguistically significant generalizations" about the phonological patterning of the language, i.e., the alternating phonetic forms of morphemes. Such "rules" certainly occur in the child's grammar in addition to rules of deviance, if the latter do occur. That is, by the time a child begins to produce plurals of nouns it is generally the case that the phonetic form of the plural suffix alternates as does the adult's, or at least the [s] - [z] alternation occurs even if the [əz] "allomorph" is acquired later (Berko, 1958).

The study of the acquisition of the phological rules which occur in the model grammar is related to but different, then, from the study of the deviating "rules" which one finds in normal and abnormal child language. We shall, however, use the word "rule" to cover both cases in child language since the literature uses it in these ways. Where this may lead to confusion, we will attempt to distinguish the sense in which the term is being used. For the most part, simple substitution will refer to "rule" in quotes.

It should be mentioned that other studies of child language have focused on the child's speech sound production without reference to adult standards (Ferguson and Farwell, 1975; Olmstead, 1971; Waterson, 1971). These studies have reported on general tendencies or "conspiracies" which act over the entire word, e.g. the persistence of the open syllable, reduplication of syllables, velar dominance, and constraints on the types of consonants that may appear in the same word. It is suggested that these tendencies may parallel morpheme structure constraints in adult phonology. We can also look at these "rules" children use as processes or strategies for simplification of syllable structure as well as simplification that affects entire classes of sounds. For example, the general tendency in child language is to reduce all words to a basic CV or CVC syllable. Different children use different strategies for this--deletion of final consonants, the reduction of clusters to one segment or the deletion of unstressed syllables. For example, in a word with a syllable structure of CVCC, one child may delete the final consonant, while another may delete the next to final consonant--two different strategies which result in the same final syllable structure simplification of CVC. There are also certain sounds which are learned before others, i.e., stops and nasals and glides. When one of these classes of sounds is substituted for the later occurring fricatives and affricates we can say that the child is employing a simplification strategy of substituting stops for fricatives. Vocalization of liquids, e.g. substituting a vowel for either /l/ or /r/ is another type of simplification strategy which may also result in syllable structure simplification, e.g. "bottle → "bado".

The above studies on normal phonological acquisition raises the following questions for the present study on abnormal phonology:

1. What types of distinctive feature errors occur? How does this compare with normal children's error patterns? Is there a hierarchy such that errors occur in certain features more often than in other features? Is there an interdependency of features such that when a particular feature is substituted, in greater than chance occurrence, another specific feature is involved, e.g. does [-nasal] → [+nasal] always involve a simultaneous change from [-voice] to [+voice]? These questions are discussed in Chapter 5.

2. What types of "rules" or regular substitutions, if any, do these children reveal which account for the discrepancy between their production and that of adults? How do these rules compare with those used by normal children as reported in the literature? See Chapter 4 for a discussion.

3. How consistent are the errors? Are the "rules" more variable than those found in a normal child? What types of variability occur and how is it conditioned phonologically? Various authors have reported that developmentally aphasic children display very inconsistent behavior in non-language as well as language tasks.

4. What types of individual differences occur? What strategies do these children use when learning phonology? Do they have prefer-

ences for certain sounds, sound classes or features?

5. What are the implications of the results of the data for:

a. universal order of acquisition of sounds

b. phonological universals, e.g. nasal assimilation, etc.

c. phonological theories of Stampe (1969, 1972) vs. Jakobson (1968).

In summary, then, the research reported on here hopefully provides a much needed account of the phonological systems of aphasic children. It also attempts to compare these findings with those of the studies of other abnormal children and with the normal acquisition of phonology. And finally, it has as its general aim a contribution to our knowledge on theoretical issues such as phonological universals, and theories of language acquisition.

Chapter 2 will present the design of the study including the discussion on the subjects and methodology.

Chapter 3 will present the data analysis.

Chapter 4 will compare the present study with other studies.

Chapter 5 will present the analysis of distinctive features.

Chapter 6 will discuss the subject analysis.

Chapter 7 will discuss the summary of findings and the implications for linguistic theory and language acquisition.

CHAPTER 2

SUBJECTS, DATA COLLECTION AND METHODOLOGY

2.0 Subjects

The subjects consisted of 16 children from the Los Angeles County Severe Language Disorders/Aphasia (SLD/A) Program. There were 14 boys and 2 girls ranging in age from 4-8 years to 9-4 years selected from 5 different school sites. The teachers in the SLD/A program were asked to select children from their classrooms who had obvious articulation difficulties. Since the teachers were certified speech therapists, they were quite familiar with children with articulation disorders. From these referrals, the final population was selected based on the following criteria:

1. formal diagnosis of developmental aphasia (L.A. County standards)
2. normal hearing on standard audiometry (screening at 25dB)
3. absence of peripheral disturbance of verbal articulation such as cleft palate
4. absence of obvious emotional disturbance
5. normal non-verbal intelligence as assessed by either the Leiter (85 and above) or the WISC performance.

The formal diagnosis of developmental aphasia by Los Angeles County standards is as follows:

An individual has a severe disorder of language which may include aphasia, when an eligibility and planning team which includes a credentialed language, speech and hearing specialist, and a credentialed school psychologist, determines that the individual demonstrates a severe disorder of language in at least two areas of language development: phonology, morphology, syntax, semantics and pragmatics. This is evidenced when:

(A) The individual achieves a level of performance, as measured by non-verbal performance instruments (Table 3) which is above the score which represents two standardized deviations below the mean, and

(B) The individual's scores on culturally appropriate standardized tests or subtests of language assessment in the primary language and mode of communication falls lower than two standard deviations below the mean for the individual's mental age.

(C) Or, the individual who cannot be properly assessed by formal language testing, shows a severe disorder of language as determined by an analysis of a representative spontaneous language sample by a qualified language, speech and hearing specialist.

(D) Any exception to A, B, C shall be agreed upon by the eligibility and planning team which includes the parent.

The main assessment instruments used to determine this language deviance are the Illinois Test of Psycholinguistic Abilities (ITPA) and the Northwestern Syntax Screening Test (NSST). A child must score 2 standard deviations from the mean on two auditory subtests; in addition there must be a significant difference between the auditory subtests and the visual subtests.

The children from this study met that requirement as can be seen from Table 1. In addition, most of them scored below the 10th percentile on the _expressive_ NSST.

Table 1. Subjects' Scores on the Illinois Test of Psycholinguistic Abilities (ITPA). Mean Scaled Score = 36, Standard Deviation = 6.

Key: CNT = Could not test

Subj.	Sex	Auditory Subtests						
		Auditory Reception	Auditory Association	Verbal Expression	Grammatic Closure	Auditory Memory	Auditory Closure	Sound Blending
1	M	28	31	24	22	30	24	38
2	M	29	23	26	CNT	27	CNT	34
3	M	34	34	28	27	26	24	40
4	M	26	23	24	21	22	CNT	CNT
5	F	CNT	24	24	20	25	26	29
6	M	29	34	29	39	33	37	24
7	M	31	15	26	18	23	21	37
8	M	39	24	26	33	39	26	28
9	M	21	12	26	18	27	20	18
10	M	31	29	41	23	32	21	32
11	M	30	26	25	CNT	28	CNT	32
12	M	24	10	23	15	21	7	26
13	F	20	24	24	16	20	CNT	CNT
14	M	28	11	30	16	25	12	35
15	M	32	29	33	24	26	35	39
16	M	27	30	43	18	24	27	30

Subj.	Sex	Visual Subtests				
		Visual Reception	Visual Association	Manual Expression	Visual Memory	Visual Closure
1	M	38	37	30	35	Not Tested
2	M	32	39	Not Tested	26	33
3	M	52	42	38	38	29
4	M	38	31	33	26	Not Tested
5	F	38	32	CNT	38	24
6	M	26	27	37	31	Not Tested
7	M	36	34	28	39	30
8	M	37	36	38	34	37
9	M	21	14	27	18	20
10	M	0	33	CNT	CNT	CNT
11	M	39	28	34	38	35
12	M	32	28	30	25	26
13	F	24	33	32	40	32
14	M	26	41	33	30	36
15	M	34	35	45	36	34
16	M	38	44	49	38	38

Table 2 shows the age range by 1 year increments of all the subjects. An effort was made to have equal numbers of children in each group; however, sampling difficulties of the available population made this impossible.

Table 2. Ages of Subjects

Age in years	Subject
4.5-5.5	1, 2
5.6-6.5	3, 4, 5
6.6-7.5	6, 7, 8, 9, 10
7.6-8.5	11, 12, 13
8.6-9.5	14, 15, 16

Table 3 shows the range of I.Q. scores as tested by the Leiter International Performance Scale (L), the Wechsler Intelligence Scale for Children (WISC) or the Wechsler Preschool and Primary Scale of Intelligence (WPPSI).

Table 3. I.Q. Scores of Subjects

Subject	I.Q. Score
1	L - 110
2	L - 126
3	L - 103
4	L - 89
5	L - 94
6	L - 97
7	WPPSI - 107
8	L - 85
9	L - 89
10	WISC - 102
11	L - 89
12	L - 88
13	WISC - 92
14	L - 93
15	L - 107
16	L - 88

Appendix I summarizes test scores from other language and reading tests. The data is not complete for each child. In addition, Appendix I also shows the mean length of utterance for spontaneous speech of the subjects calculated on 100 utterances.

2.1 Data Collection

Two types of speech samples were obtained from each subject -- single words and connected speech. For this study, only the single words were analyzed.

Stimuli: Speech sounds were elicited by the use of specially constructed picture cards depicting familiar objects whose names contained the target sounds. These cards were constructed for this study since previously published articulation tests have been found to be inadequate in that they do not test each phoneme in each context a sufficient number of times. IPA transcription was used to transcribe the children's responses.

One hundred and thirty cards with pictures depicting each phoneme except /ʒ/ tested each phoneme at least twice in initial, intervocalic and final positions. The /ʒ/ sound was not considered an important sound to test in final position since it occurs so rarely, and the words in which it occurs, in some dialects, are words such as "rouge" and "beige" which are unfamiliar to most young children. Although the words used as stimuli have different frequency counts which may have influenced the results, most of the words used are found in young children's vocabularies (See Appendix II for a list of stimuli). All possible English initial and final consonant clusters were tested. These consonant clusters excluded morphological boundaries such as "ts" as in "cats." There are small samples of a few phonemes, since these children, already having difficulty with language learning, did not know the names of some of the pictures although every effort was made to choose words familiar to young children.

2.2 Methodology

Each child was tested individually in a room separate from his/her classroom. The room used was sometimes another classroom or occasionally a bookroom. The materials in the room consisted of a table and two chairs, whatever materials the examiner brought with her and a tape recorder. Each child had previously been tested on the test "Measures of Children's Language Performance", and they were therefore familiar with the procedure for leaving their room to "play picture games."

The child was seated at the table across from the examiner. The cards were shown to the child one by one. To elicit the correct word, the examiner first showed the child the card and asked, "What's this?" In some instances, an elicitation phrase was necessary; for example, for the word "water", "In the sink there is ____." If a child did not know the vocabulary, the word was supplied by the examiner. This picture was then set aside and returned to at the end of the session to see if the child remembered the word. If the child still did not know the word, a "No response" was recorded for that word, and it was eliminated from the analysis.

The child's responses were recorded on a Uher Model M822, reel-to-reel tape recorder. In addition, the examiner transcribed each word at the time of the session. At a later time each word was retranscribed listening to the tape recorder. Two independent transcribers also transcribed one tape on each child. These transcriptions were compared for discrepancies. Where discrepancies occurred, the words were listened to again by both transcribers and one transcription agreed upon by both.

Each child was seen at least 5 times, 3 times for testing and retesting on the 130 words with single word production and twice for connected speech. Each session lasted approximately 40 minutes. The test-retest sessions were scheduled at least one week apart. At the end of each session, the child was given "sticker pictures" as a reward for doing well in the session. Each child looked forward to making their own picture by sticking the stickers on colored paper.

CHAPTER 3

DATA ANALYSIS

3.0 Introduction

Separate analyses were completed for the following categories of sounds: 1) Final consonant clusters, 2) Initial consonant clusters, 3) Liquids and Syllabic Consonants, 4) Affricates, 5) Fricatives, 6) Stops and Nasals, 7) Glides (Approximants), 8) Syllable Structure. The discussion begins with the analysis of the consonant clusters since most of the errors occurred in these categories. The final sections deal with stops, nasals and glides, in which the least number of errors occur.

3.1 Final Consonant Clusters

Five types of final consonant clusters were analyzed:

1) rC, e.g. fork
2) lC, e.g. milk
3) Fricative + Stop, e.g. left
4) Stop + Fricative, e.g. box [ks]
5) Nasal + Consonant, e.g. jump

As stated above, morpheme boundaries did not occur in any of the elicited words. For example, in Consonant Cluster Type #4, there were no plurals as in "ducks". This was done in order to keep the morphological constraints from interfering with the phonological data. These five groups of consonant clusters are discussed separately in detail, and then a summary is presented.

3.11 Word Final /r/ + C Clusters

/r/ + three stop consonants (t, d, k) were elicited using the following stimuli: heart, shirt, card, yard, fork, park. /rp/ as in harp, /rb/ as in curb, /rg/ as in iceberg were not used as stimuli because of their low frequency count and the unfamiliarity to young children of the words in which they occur.

The following rules (c.f. previous discussion of notion of rule) account for the data.

Table 4. Analysis of Final /r/ + C Clusters

Rules	# of responses	% of total
A. Both consonants correct	51	16.14
B. Deletions		
R1: R deletion		
$\begin{bmatrix}+\text{cons}\\ +\text{voc}\\ -\text{lat}\end{bmatrix} \rightarrow \emptyset / \_\_ C\#$	158	50.00
R2: Final C deletion		
$\begin{bmatrix}+\text{cons}\\ -\text{voc}\end{bmatrix} \rightarrow \emptyset / r\_\_\#$	81	25.63
R3: Double consonant deletion		
$CC \rightarrow \emptyset / \_\_\#$	17	5.38
C. Substitutions with two consonants present	9	2.85
TOTALS	316	100.00

As can be seen from the analysis presented in Table 5, the main errors in the children's production of rC-stop clusters involve the deletion of the /r/. Final consonant deletion is the second most frequent error type. Further analysis of the final consonant deletion data, however, shows that over half of the final consonants deleted were /d/'s (58%). The 34 remaining consonant clusters of /rt/ and /rk/ resulting in final consonant deletion can be attributed to 3 subjects (#1, 9, 12) who seemed to use final consonant deletion exclusively as a cluster simplification. Table 6 presents a more detailed account of final consonant deletions.

Table 5. Final Consonant Deletions in Final Clusters

Cluster	# possible	# deleted	% deletions	# deletions/total # deletions
rd	103	47	45.63	47/81 = 58.02%
rt	107	11	10.28	11/81 = 13.58%
rk	106	23	21.70	23/81 = 28.4%
				Total = 100%

Two types of substitutions occurred, accounting for only 2.8% of the total number of errors. They were final consonant devoicing in which final /d/ → /t/, and /r/ vocalization in which /r/ became a type of back rounded vowel. Table 6 presents the substitution errors in more detail.

Table 6. Types of Substitutions in Final Consonant Clusters

Rules	Total Possible	# of resp	% of total possible
R4: Final C devoicing			
$\begin{bmatrix} C \\ +voice \\ +alveolar \end{bmatrix} \rightarrow [-voice] / \begin{bmatrix} C \\ +voc \end{bmatrix} \_\_ \#$	103	6	5.83%
R5: R-vocalization			
$\begin{bmatrix} +cons \\ +voc \\ -lat \end{bmatrix} \rightarrow \begin{bmatrix} -cons \\ +back \\ -high \\ -low \\ \alpha round \end{bmatrix} / \_\_ C\#$	316	3	.95%

Substitutions clearly play a minor role in final consonant cluster errors with deletions occurring 81% of the time, reinforcing the view that children, including aphasic children, tend to simplify or reduce final clusters.

3.12 /l/ + C Clusters

/l/ plus one of three stop consonants (t, d, k) were elicited using the following stimuli: belt, melt, build, cold, milk. /lb/ as in bulb, and /lp/ as in gulp, yelp or help were not used as stimuli because of their low frequency and the possible unfamiliarity of the stimuli words to children. Help may have been familiar to children but it was difficult to elicit from a picture. Table 7 presents an analysis of the responses.

Table 7. Analysis of Final /l/ + C Clusters

Rules	# of responses	% of total
A. Both consonants correct	48	17.91
B. Deletions		
R1a: L deletion		
$\begin{bmatrix}+\text{cons}\\+\text{voc}\\+\text{lat}\end{bmatrix} \rightarrow \emptyset / \_\_C\#$	23	8.58
*R2a: Final C deletion		
$\begin{bmatrix}+\text{cons}\\-\text{voc}\end{bmatrix} \rightarrow \emptyset / l\_\_\#$	75	27.99
*Must be ordered before L-vocalization		
R3: Double consonant deletion		
$CC \rightarrow \emptyset / \_\_\#$	32	11.94
C. Substitutions with two segments present	90	33.58
TOTALS	268	100.00

There were two types of substitution errors--final consonant devoicing and /l/ vocalization as shown in Table 8.

Table 8. Types of Substitutions in Final /l/ Clusters

Rules	Total possible	# of responses	% of total possible	% of substitution errors
R4a: Final C devoicing				
$\begin{bmatrix} C \\ +voice \\ +alveolar \end{bmatrix} \rightarrow [-voice] / \begin{matrix} C \\ +voc \end{matrix} \_\_\#$	107	1	.93	1/116= .86%
R5a: L vocalization				
$\begin{bmatrix} +cons \\ +voc \\ +lat \end{bmatrix} \rightarrow \begin{bmatrix} -cons \\ +back \\ -high \\ -low \\ \alpha round \end{bmatrix} / \_\_C\#$	268	115	42.91	115/116= 99.14%
TOTALS	375	116	43.84	100%

As shown in Tables 7 and 8, the most frequent errors show /l/ vocalization with /l/ becoming either a [ə] or a round back mid vowel resembling an [oo]. In addition to /l/ vocalization, final consonant deletion also was shown to be an important simplification process. Table 9 further analyzes final consonant deletion.

Table 9. Final Consonant Deletions in Final /l/ Clusters

Cluster	# possible	# deleted: /l/ retained	/l/ vocalized	2C → ∅	Total deleted
ld	107	32	7	30	69 = 64.49%
lt	108	11	18	2	31 = 28.7%
lk	53	6	1	0	7 = 13.21%

When comparing these final deletions with final consonant deletion in /r/ clusters, the same trend occurs--namely that a higher percentage of final /d/'s tend to be deleted than final /t/ or /k/. Thus, 64.5% of the possible final /d/'s were deleted after /l/ while only 29% and 13% of the final /t/'s and /k/'s respectively. In addition, when the final consonant was a /d/, the /l/ was either retained, or both consonants were deleted. In very few cases was the /d/ deleted with the /l/ being vocalized. The opposite tendency seems to occur when the final consonant is a /t/; in that case /l/ vocalization occurs more often. The same trend for subjects #1, 9 and 12 to delete final consonants occurred with /l/ clusters as with /r/ clusters. In both the /r/ and /l/ clusters the high frequency of final /d/ deletion may be due to the fact that /d/ is [+voice]. Since no other voiced obstruents occurred in the clusters, we cannot determine this. However, since the /d/ and /t/ behaved differently, the /d/'s higher frequency cannot be attributed to the alveolarity of the segment. See subject analysis in Chapter 6.

Another trend may be noted at this time. As shown in Table 10 there is a tendency to retain the final consonant when /l/ is vocalized and to delete it when the /l/ is present. Both methods reduce the clusters.

Table 10. Comparison Between /l/ Vocalization and Final Consonant Deletion

Rules	# of responses	% of occurence
l-vocalization with final consonant remaining	89/115	77.39%
l-vocalization with final consonant deleted	26/115	22.61%
Final C deletion with /l/ retained	49/75	65.33%
Final C deletion with /l/ vocalized	26/75	34.67%

Thus, in 77% of the cases of /l/ vocalization the final consonant is retained, and in 65% of the cases when the final consonant is deleted, the /l/ is retained.

Combining the rules from /r/ clusters and /l/ clusters, the following rules for the class of liquid + stop clusters can be stated in Table 11. Thus, final /r/ and /l/ clusters were simplified by either deleting the liquid, deleting the final consonant or vocalizing the liquid. Very few of the errors involved deleting both consonants or consonant devoicing.

Table 11. Rules for /r/ and /l/ Clusters in Final Position.

Rules	% of occurrence
A. Correct clusters	16.95%
B. Cluster simplification: CC → (V)C	
R1: Liquid deletion: $\begin{bmatrix}+\text{cons}\\ +\text{voc}\end{bmatrix} \rightarrow \emptyset / \_\_C\#$ 30.99%	
R2: Final consonant deletion $\begin{bmatrix}+\text{cons}\\ -\text{voc}\end{bmatrix} \rightarrow \emptyset / \begin{bmatrix}+\text{voc}\\ +\text{cons}\end{bmatrix}\_\_\#$ 26.71%	
R5: Liquid vocalization $\begin{bmatrix}+\text{cons}\\ +\text{voc}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{cons}\\ +\text{back}\\ -\text{high}\\ -\text{low}\\ \alpha\text{round}\end{bmatrix} / \_\_C\#$ 20.21%	
Total	77.91%
C. Double consonant deletion CC → $\emptyset / \_\_\#$	8.39%
D. Final consonant devoicing C $\begin{bmatrix}+\text{voice}\\ -\text{cont}\\ +\text{alveolar}\end{bmatrix} \rightarrow [-\text{voice}] / \begin{bmatrix}+\text{cons}\\ +\text{voc}\end{bmatrix}\_\_\#$ (7/207)	3.38%
TOTALS	***106.63%

***This totals more than 100% since more than one rule occurred within a word.

3.13 Word Final Fricative + Stop Clusters

The fricative + stop clusters consisted of /s/ + $\left\{\begin{matrix}t\\k\end{matrix}\right\}$ in the following stimuli: biggest, cast, last, ghost, mask; and /ft/ as in left. The word "biggest" was used only when the children could not learn the word "cast" and although the /st/ occurs in an unstressed second syllable, the children seemed to use the same strategy as with the other stimuli; for this reason, the responses were included in the analysis.

Analyzing both the /s/ and /f/ clusters together, the following rules in Table 12 account for the responses.

Table 12. Rules for Final Fricative + Stop Clusters

Rules		# of responses	% of total
A. Correct cluster		5	1.7
B. Cluster simplification: CC → C			
R2a: Final stop deletion			
$\begin{bmatrix}+cons\\-voc\\-cont\end{bmatrix} \rightarrow \emptyset / C\underline{\quad}\#$	207=70.17%		
R6: Fricative deletion			
$\begin{bmatrix}+cons\\-voc\\+cont\end{bmatrix} \rightarrow \emptyset / \underline{\quad}C\#$	15= 5.08%		
	Totals	222	75.25
C. Double consonant deletion			
$CC \rightarrow \emptyset / \underline{\quad}\#$		21	7.12
D. Substitutions with 2 consonants present (i.e. no deletions)		47	15.93
TOTALS		295	100.00

The major process for simplifying fricative + stop clusters was final stop deletion with the fricative being retained (70.2%). In addition, the retained fricative tended to be correct as can be seen from Table 13.

Table 13. Final Consonant Deletion in Final Fricative + Stop Clusters

Error types	# of responses	Percentage
Final consonant deletion with fricative correct	151	72.95
Final consonant deletion with fricative incorrect	56	27.05
Total errors in which final stop is deleted	207	100.00

When two consonants were present, the only error was that with metathesis; it occurred only with the /st/ and /sk/ clusters as shown in Table 14.

Table 14. Metathesis Errors in Final Fricative + Stop Clusters

Error types	# of responses	% of metathesis errors	% of total fric + stop stimuli
Metathesis errors with both consonants correct	28	60	9.49
**Metathesis with substitution errors	19	40	6.44
Total metathesis errors	47	100	15.93

**I am extending the use of the term "metathesis" here to include [st] →[tʃ] since it is likely to occur using two steps: [st] → [ts] and then palatalization of the /s/.

One subject (#8) used both metathesis and palatalization in his final clusters. Thus, the clusters in a word such as "ghost" was metathesized and palatalized: goost → goots → gootʃ. This also occurred in most of this subject's fricatives and will be discussed in Chapter #6.

Substitutions occurred along with the deletions mentioned above. The substitution errors for the fricatives /s/ and /f/ and for the stop consonants /t/ and /k/, occurred as in Table 15.

Table 15. Substitutions Occurring in Final Fricative + Stop Clusters

Phoneme	Substitution	# responses	Total possible	% error
s	h	3		
	f	6		
	ʃ	6		
	θ	52		
		Total 67	240	27.92
f	s	1		
	θ	2		
		Total 3	55	5.45
k	t	5		
	ʔ	8		
		Total 13	53	24.53
t	ʔ	7	242	2.89

Thus, 27.9% of the /s/ phonemes were incorrect, while only 5.45% of the /f/ phonemes were incorrect. The main substitution for the /s/ was [θ] or lisping. The only substitutes for the stop consonants were [t] for /k/, and glottal stop [ʔ] for both /t/ or /k/. It should be noted that in the substitutions given in Table 15 only place of articulation changes while manner and voicing remain constant; these substitutions will be discussed later in the chapter on distinctive feature error types.

3.14 Stop + Fricative Clusters

The only stop + fricative cluster that was elicited was /ks/ as in box and fox. Table 16 presents the responses.

Table 16. Rules for Final Stop + Fricative /ks/ Clusters

Rules	# of responses	% of total
A. Correct cluster	46	43.4
B. Cluster Simplification: CC → C		
R2a: Final consonant deletion		
$\begin{bmatrix}+\text{cons}\\ -\text{voice}\end{bmatrix} \rightarrow \emptyset / [+\text{cons}]\_\_\#$ (25=23.58%)		
R7: Stop deletion		
$\begin{bmatrix}+\text{cons}\\ -\text{cont}\\ +\text{velar}\\ -\text{voice}\end{bmatrix} \rightarrow \emptyset / \_\_ \overset{(s)}{\begin{bmatrix}+\text{cont}\\ +\text{alveolar}\\ -\text{voice}\end{bmatrix}}$ (4=3.77%) Totals	29	27.35
C. Double consonant deletion		
CC → ∅/__#	3	2.83
D. Substitutions with two consonants present		
a. Fricative correct (6=5.66%)		
b. Stop correct (22=20.75%)		
Totals	28	26.42
Totals	106	100.00

There were only two substitutions in this group of clusters. [θ] was substituted for /s/ 22 times or 21% of the time. /k/ was fronted to [t] 6 times or 5.66% of the time. Lisps or [θ] for /s/ will be treated in detail in Chapter 4.

These clusters appear to be easier for the subjects to produce with 43.4% being correct as different from the errors in other clusters types, substitution occurred in 26.4% on a par with final consonant deletion (26.4%). The asymmetry between the fricative + stop and stop + fricative clusters should be noted. 43% of the /ks/ clusters were correct with only 5.7% (3/53) of the /sk/ clusters being correct.

Thus, it might be hypothesized that for some reason, a stop + fricative cluster, at least a stop + fricative clusters of the /ks/ variety, is easier to produce than a fricative + stop cluster. Also, it must be noted that many of the /st/ and /sk/ clusters were metathesized into /ks/ clusters. It may be of interest to note that there are dialects of English which contain a metathesis rule such that the final /sk/ becomes /ks/, e.g. "ask" becomes "aks" but "asking" remains "asking." Such changes as [sk] → [ks] and [ks] → [sk] have occurred but not in final position.

3.15 Final Nasal Clusters

/nd/ clusters were elicited using the following stimuli: hand, sand; /nt/ clusters using elephant, present; /mp/ clusters using jump, lamp; and /ŋk/ clusters using drink, thank. The following rules account for the responses.

Table 17. Rules for Final Nasal Clusters

Rules	# of responses	% of total
A. Correct cluster	227	52.55
includes as correct nasal deletion with nasalization of vowel--optional rule in adult phonology when C = [-voice]; 2 responses = [ŋk]; 10 responses = [mp]		
B. Cluster simplification: CC → C		
R2a: Final consonant deletion		
$\begin{bmatrix}+cons\\-voc\end{bmatrix} \rightarrow \emptyset / C\_\_\#$ 169=39.12%		
R8: Nasal deletion (no vowel nasalization)		
$\begin{bmatrix}+cons\\+nas\end{bmatrix} \rightarrow \emptyset / \_\_\begin{bmatrix}+cons\\-voi\end{bmatrix}$ 4=.93%		
Totals	173	40.05
C. Double consonant deletion		
$CC \rightarrow \emptyset / \_\_\#$ 9		
with vowel nasalization 12		
Total	21	4.86
D. Substitutions with two consonants present	11	2.54
TOTALS	432	100.00

As can be seen from Table 17, these clusters were correct more than half the time (52%). The main strategy for simplifying these clusters was final consonant deletion accounting for 39.12% of the errors. Again, as with other clusters, we find this to be especially true of final /d/'s with 88.07% (96/109) of /d/'s being deleted. All alveolars seem to be deleted more often than labial and velar final consonants as final /t/'s were deleted 48.6% (52/107) of the time as compared with 9.72% (21/216) for labial and velar final consonants. This does not include statistics for double consonant deletion. There were 21 instances of double consonant deletion with 14 of these being alveolar or 66.67%. Thus 6.48% of the possible alveolar final consonants both were deleted and 3.24% of the labial and velar final consonants both were deleted.

Regarding the final /nt/ clusters, it must be noted that they occurred in unstressed final syllables, a fact which may account for the large number of final /t/'s being deleted. However, when compared with the final /nd/ clusters which were not in final unstressed syllables, but rather in single stressed syllables, the subjects seemed to use the same strategy when producing them.

In summary then, the strategy seems to be to delete both consonants or the final consonant if it is an alveolar. 82.41% (178/216) of the labial and velar nasal clusters were correct with the final consonant being deleted only 21/204 (216-12 of the VC) or 10.29% of the time. Whenever the nasal, rather than the final consonant, was deleted the following consonant was voiceless, a fact which seems to agree with previous studies of child language as well as with normal adult pronunciation. One could therefore conclude that these children had acquired this phonological rule, or that this is a natural "process" which may be supressed in some languages (Stampe, 1969).

There were only two types of substitution rules which occurred: 1: devoicing, e.g. /d/ → [t] which occurred only twice and 2: fronting of /ŋ/ → [n] which occurred 9 times. In three of the latter cases, the final consonant was also deleted as in "drink" → [drɪn]. In the other six cases, we could better label the rule as a nasal assimilation or homorganic rule since the result was "drint." Thus the /k/ was fronted to a [t] and the nasal assimilated to the same place of articulation producing an [n] rather than an /ŋ/. This may show that these children use the homorganic nasal rule. One also might conclude that the [n]→[ŋ] occurs as a homorganic rule and the [ŋ] derives from /nk/ or /ng/. Thus, /drɪnk/ → [drɪn] involves no real /ŋ/ → [n] substitution but rather lack of application of the homorganic rule since /k/ → Ø.

Another note of interest is the fact that two subjects made the following errors with the word present.

1. present → [prɛ̃nɪt]
2. present → [prɛsɪs]

There are a number of alternative derivations which could have produced these.

[prɛzɪ̃nt]	[prɛzɪ̃nt]	
↓	↓	
[prɛ̃nɪzt]	[prɛzɪzt]	[prɛsɪ̃nt]
↓	↓	↓
[prɛ̃nɪst]	[prɛzɪst]	[prɛsɪst]
↓	↓	↓
[prɛ̃nɪt]	[prɛsɪs]	[prɛsɪs]
-------------		
or		
[prɛ̃nt]		
↓		
[prɛ̃nɪt]		

We have a number of possibilities for the first case: "present" could become [prɛ̃nɪst] by metathesis and then by deletion of the /s/ [prɛ̃nɪt]. Or "present" could be shortened to [prɛ̃nt] by deletion of [sə] and then vowel insertion used to break up the /nt/ cluster resulting in [prɛ̃nɪt]. In the second case, the fricative /z/ could persist, and then by a voicing agreement change /z/ to [s]./__C with a subsequent final consonant deletion. These children do have trouble in shifting from one task to another, a condition known as perseveration. Thus, this child may perseverate on the /s/ and carry it over into the next syllable.

3.16 Summary of Final Consonant Clusters

As can be seen in Table 18, the final or pre-final consonants of the cluster were deleted in most cases creating a CVC syllable structure rather than the CVCC structure of the stimulus. Two consonants were present in 39.7% of the total number of possible clusters (1417); however, in only 26.6% of these were the consonants the correct ones, i.e. in 13% of the cases incorrect consonants were substituted. For example, [θ] was substituted for /s/ in fricative clusters by those subjects who had frontal lisps. In all cases, manner of articulation was unchanged with place of articulation being in error.

Final consonants were deleted in 39.1% of the clusters, penultimate consonants in 14%, and in only 6.63% were both consonants deleted. Metathesis proved to be of minor importance occurring in only 3.5% of the total number of clusters.

Thus, by far the major strategy for simplifying consonant clusters was final consonant deletion; the next most frequent error was the substitution of one member of the cluster. This summary, however, obscures the different strategies used for the various consonant cluster types. For example, disregarding correctness of the consonants themselves, only 19% of the /r/ cluster words, 17.9% of the /l/ cluster words, and 17.6% of the fricative + stop cluster words were produced with two consonants. However, in stop + fricative and in nasal clusters, two consonants are present in 69.8% and 55.1% of the cases, respectively.

Table 18. Summary of Results of Final Consonant Cluster Analysis. % of Occurrence of Rules.

Type of Cluster	Total	CC correct	Final C deletion	Penultimate Consonant Deletion				CC del	r/l → vowel	Meta-thesis
				Liquid	Fricative	Stop	Nasal			
Nasal + C	432	52.55%	39.12%				.93%	4.86%		.69%
Stop + Fric	106	43.4%	23.58%			3.77%		2.83%		
/l/ + C	268	17.91%	27.99%	8.58%				11.94%	42.9%	
/r/ + C	316	16.14%	25.63%	50%				5.38%	.95%	
Fric + Stop	295	1.7%	70.17%		5.08%			7.12%		15.93%
TOTALS	1417	26.6%	39.1%	14.4%				6.63%	20.2%	3.5%

It thus appears that for this population, the easiest, i.e. most correct final clusters are stop + fricative and nasal clusters, with liquid clusters and fricative + stop clusters being the most difficult, i.e., the most incorrect. Also, although the major rule for simplifying final consonant clusters is final consonant deletion for all the words, this does not seem to hold for liquid clusters. For /r/ clusters, only 25.6% have final consonant deletion with 50% showing /r/ deletion. For /l/ clusters, 27.9% have final consonant deletion with 42.9% utilizing l-vocalization where /l/ becomes some type of back vowel, either a [ə] or a round vowel resembling an [oɷ]. The fact that /r/ and /l/ are liquids, i.e. are [+vocalic] and [+sonorant] and have formant structure similar to vowels may account for the retension of the sonorant segments. This would account for the /l/ vocalization, but does not account for the /r/ deletion if we analyze VrC as a vowel + /r/. However, if we analyze VrC as an "r-colored" vowel, the generalization can be seen.

The above analysis divides the consonant clusters into two different groups:

Group 1: Liquid + C, resulting in deletion or vocalization of the penultimate liquid member of the cluster.

Group 2: Fricative + Stop
Stop + Fricative
Nasal + C resulting in final consonant deletion

The above facts parallel normal phonological development in that the literature (Templin, 1957; Sander, 1961) reports that the liquids are among the last sounds to be mastered by children. They would thus be the sounds normal children would omit or substitute if they only produced one member of a cluster. In the remaining cases, i.e. Group 2, if the subjects had mastered the individual phonemes, but could not produce them in a cluster, it may be hypothesized that they would retain the one of longer duration or greater salience (i.e. the fricative or nasal) especially if they had auditory memory problems--a fact which has been found to be present in this group of children. This would explain the fricative + stop and nasal + C clusters in which the final consonant would be deleted, but not the /ks/ cluster. Hooper (1973) states that the last C position in a syllable is stronger than the penultimate C position. Her one counterexample is /s/ + /p, t, k/ where /s/ is proposed as more stable than the stops. She suggests that this may be due to the phonetic properties of /s/, either its coronality, continuancy or stridency causing its stability.

This does not provide a reason as to why the subjects used final consonant deletion to such a large extent. However, it may explain why the /s/ remains in the final /s/ + stop clusters, but again not why /s/ is deleted in /ks/ clusters.

3.2 Initial Consonant Clusters

Four types of initial consonant clusters were analyzed:

1) Liquid clusters: a. stop + liquid, e.g. plane, present
   b. fricative + liquid, e.g. frog, flower
2) Glide clusters: stop + /w/, e.g., twin, queen
3) /s/ clusters: a. /s/ + stop, e.g. spoon
   b. /s/ + nasal, e.g. smoke
   c. /s/ + liquid, e.g. slide
   d. /s/ + glide, e.g. sweater

4) 3-consonant clusters: /spl/, e.g. splash

/str/, e.g. string

3.21 Liquid Clusters

A. /r/ clusters: Initial /r/ clusters were elicited with the following stimuli:

stop + /r/: breathe, brush, zebra*
present
drink
train, treasure
grass
crib

fricative + /r/: frog, three

Table 19 presents the responses.

Table 19. Analysis of Initial /r/ Clusters

Rules	# of responses	% of total
A. Both consonants correct	79	13.86
B. Deletions		
R9: Liquid deletion $\begin{bmatrix}+\text{cons}\\-\text{voc}\end{bmatrix} \rightarrow \emptyset/\#C\_\_$	157	27.54
R10: Initial consonant deletion $\begin{bmatrix}+\text{cons}\\-\text{voc}\end{bmatrix} \rightarrow \emptyset/\#\_\_\begin{bmatrix}+\text{cons}\\+\text{voc}\end{bmatrix}$	10	1.75
C. Substitutions with two consonants present	324	56.85
TOTALS	570	100.00

*Note: Although the /br/ in zebra is an unstressed syllable, the data are included in the analysis. A separate analysis was done for zebra with the result that the subjects used exactly the same strategy when simplifying this cluster as they did with the word initial clusters. There was one exception. One subject changed /br/ into [bər] or [br̩]. He did not use schwa insertion for any other clusters. He did, however, use the strategy for substituting [r̩] for all final unstressed syllables as in [dɪʃər] for dishes.

The major strategy used by these children was substitution of one member of the cluster accounting for 56.9% of the responses. The next most frequent rule was that of /r/ deletion accounting for 27.5% of the cases. Table 20 gives us a more detailed account of the types of substitutions present.

Table 20. Types of Substitutions in Initial /r/ Clusters

Substitution rules	# of responses	% of total	% of substitutions
R11: Gliding $\begin{bmatrix}+cons\\+voc\end{bmatrix} \rightarrow \begin{bmatrix}-cons\\-voc\\+round\end{bmatrix} /\#C\_$ a. stop + w = 226 b. stop + w, stop → ∅ 8 c. fric + w = 52 286	286	50.18	286/442 = 64.7
R12: /r/ → /l/ $\begin{bmatrix}+cons\\+voc\\-lat\end{bmatrix} \rightarrow [+lat]/\#C\_$	17	2.98	17/442 = 3.85
R13: Schwa insertion $\emptyset \rightarrow [ə] /\#C\_[+cons]$	10	1.75	10/442 = 2.26
Various substitutions for the initial consonant (X = substitution) stop + /r/: X_ 18 Xr 20 Xw 46 Xl 1 fric + /r/: X_ 19 Xr 2 Xw 19 Xl 4 129	129	22.63	129/442 = 29.1
TOTALS	570		100.00

As shown in Table 20, the major strategy for simplifying initial /r/

clusters is the substitution of a labial glide ([w]) for the /r/ which occurred in 50.2% of the responses. The initial consonant either the stop or the fricative was in error 22.6% of the time. Of the 442 substitutions which occurred in initial /r/ clusters, 64.7% of them were the substitution of the [w] for the /r/ while only 29.2% of them occurred in the initial consonant. It is thus evident that the /r/ is the more difficult member of the cluster and is omitted or substituted by an earlier acquired glide.

Stop vs. fricative clusters: 14.75% of the total number of stop clusters were correct, with 10.09% of the fricative clusters being correct. The /f/ itself was correct 87.27% (48/55) times with the errors occurring in the liquid. However, the /θ/ itself was correct in only 14/54 cases or 25.93% of the time. Only 14.8% of the /θ/ clusters were correct with many errors in both the liquid and the fricative, the major substitutions being to substitute [f] for /θ/ and [w] for /r/ resulting in the [fw] cluster. Stops were correct in 79.39% (366/461) of the cases thus having the major errors occurring in the liquid. The following is a list of the stops in order of more percent correct to less: k (100%), p (88.89%), b (86.25%), g (81.82%), t (68.75%), d (56.36%). Thus, the alveolars seem to be the most unstable or most incorrect phonemes, being correct only about 55-70% of the time.

B. /l/ clusters: Initial /l/ clusters were elicited with the following stimuli: stop + /l/: block, plane
clown
glasses, glove

fricative + /l/: flower

Table 21 accounts for the responses.

Table 21. Analysis of Initial /l/ Clusters

Rules	# of responses	% of total
A. Both consonants correct	105	32.21
B. Deletions		
R9: Liquid deletion		
$\begin{bmatrix}+\text{cons}\\+\text{voc}\end{bmatrix} \rightarrow \emptyset / \#C\_\_$	131	40.18
R10: Initial consonant deletion		
$\begin{bmatrix}+\text{cons}\\-\text{voc}\end{bmatrix} \rightarrow \emptyset / \#\_\_\begin{bmatrix}+\text{cons}\\+\text{voc}\end{bmatrix}$	1	.31
C. Substitutions with two consonants present (affricates treated as single segments)	89	27.30
TOTALS	326	100.00

As shown above, liquid deletion is a major strategy for simplifying /l/ clusters, accounting for 40% of the cases with substitution processes coming as a second strategy. Table 22 gives us a more detailed account of types of substitutions present.

Table 22. Types of Substitutions in Initial /l/ Clusters

Substitution rules	# of responses	% of total	% of substitutions
R11: Gliding		(326)	
$\begin{bmatrix}+\text{cons}\\+\text{voc}\\+\text{lat}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{cons}\\-\text{voc}\\+\text{round}\\-\text{lat}\end{bmatrix}$ /#C__	72	22.09	67.93
a. stop + w = 70 b. fric + w = 1 c. ____ + w + 1 72			
R12a.: /l/ → /r/			
$\begin{bmatrix}+\text{cons}\\+\text{voc}\\+\text{lat}\end{bmatrix} \rightarrow$ [-lat]/#C__	6	1.84	5.66
R13: Schwa insertion			
∅ → [ə]/#C__[+cons]	11	3.37	10.38
Various substitutions for initial consonant	17	5.21	16.03
a. X__ 15 b. Xl 1 c. Xw 1 17			
TOTALS	106		100.00

As shown above, gliding occurred 22% of the time as a simplifying strategy, with the initial consonant in error in only 5% of the cases. Of the total of 106 errors, gliding accounted for 68% of them, with initial consonant errors occurring as 16% of the substitutions.

<u>Stop vs. fricative clusters</u>: Only 5.56% (3/54) of the fricative + /l/ clusters were correct while 37.5% (102/272) of the stop + /l/ clusters were correct. The main strategy for simplifying the fricative clusters was liquid deletion, with 88.9% (48/54) of the /l/'s being

deleted. Stop + /l/ clusters, on the other hand utilized two major strategies rather than just one. Gliding accounted for 25.73% (70/272) and liquid deletion accounted for 29.78% (81/272). This did not happen with /r/ clusters.

C. Summary: Initial /r/ and /l/ clusters: It appears that /l/ clusters are correct more often than /r/ clusters--32% vs. 14%. Also, the resulting errors appear to be different. /l/'s are deleted more often than /r/'s while the /r/'s are substituted for by [w] half of the time as shown in Table 23. However, Kornfelds's (1971) observations must be noted here. She found that although the productions of an underlying /w/ and a substitution of [w] for an underlying /r/ sound alike to adults, spectrographic analysis proved them to be different. Thus, the two productions seem to be represented differently by the children since they are perceptually and productively distinct. The data collected for this study was not analyzed accoustically and the perceptions of the transcribers are thus being used, although these might obscure the actual differentiations made by the children.

Table 23 also shows more /l/ clusters are correct than /r/ clusters. In addition, there were fewer different substitutions for stop consonants in /l/ clusters than in /r/ clusters: i.e. /l/ was deleted 40% of the time, became [w] 22% of the time; the remaining errors were small in percentage. However, with /r/ clusters the initial consonant was incorrect 22.6% of the time as opposed to 5.25% for the /l/'s.

Table 23. Comparison of Responses for /r/ and /l/ Clusters

Rules	% of occurrence /r/	% of occurrence /l/
A. Both consonants correct	13.86	32.21
B. Deletions		
Liquid deletion	27.54	40.18
Initial consonant deletion	1.75	.31
C. Substitutions with two consonants present	56.85	27.30
a. Gliding: Liquid → [w]		
/r/ = 48.23% /l/ = 22.09%		
b. Various substitutions for initial consonants		
/r/ clusters: 21.75% /l/ clusters: 5.21%		

3.22 Glide Clusters

Initial stop + glide clusters were elicited with the following two stimuli: twin, queen. Table 24 presents the analysis of the responses.

Table 24. Analysis of Initial Glide Clusters

Rules	# of responses	% of total
A. Both consonants correct	62	66.67
B. Deletions		
R10a: Initial consonant deletion		
$\begin{bmatrix}+\text{cons}\\-\text{voc}\\-\text{cont}\end{bmatrix} \rightarrow \emptyset / \#\_\_\begin{bmatrix}-\text{cons}\\-\text{voc}\end{bmatrix}$	5	5.38
R14: Glide deletion		
$\begin{bmatrix}-\text{cons}\\-\text{voc}\\+\text{round}\end{bmatrix} \rightarrow \emptyset / \#C\_\_$	8	8.6
C. Substitutions with two consonants present	18	19.35
TOTALS	93	100.00

As can be seen from Table 24, two-thirds of these clusters are correct--the major errors occurring in the initial consonants and not in the glide. The initial consonant was in error 17 times, while the glide was in error only once. /kw/ clusters were correct 85% (40/47) of the time while /tw/ clusters were correct only 47.8% (22/46) of the time. This parallels the fact that alveolars have tended to be more incorrect than velars in other clusters.

3.23 /s/ Clusters

The following stimuli were utilized to elicit /s/ clusters:

a) s + stop: spoon, spider
sticky, stove
school, skate

b) s + nasal: smile, smooth
snake, snow

c) s + liquid: sleeping, slide

d) s + glide: sweater, swimming, swing

Table 25 shows the major strategies for /s/ cluster simplification.

Table 25. Summary of /s/ Cluster Responses

	Cluster /s/ +			
	nasal	glide (w)	stop	liquid (l)
Total possible	212	162	321	108
% correct	19.34	16.67	14.33	12.04
% /s/ deletion	66.98	16.05	72.59	00.00
% 2nd consonant deletion	7.08	37.65	8.41	50.00
% substitutions with 2 consonants present	6.6	29.63	4.67	37.96
Totals in %	100.00	100.00	100.00	100.00

The analysis reveals that for /s/ + nasal and /s/ + stop clusters, the same strategies for simplifying clusters were used, i.e. deletion of the /s/. Since nasals are stops this is not surprising. However, in liquid and glide clusters, the /s/ is often retained with second consonant deletion, or sonorant deletion being a major strategy along with various substitution errors. For the /s/ + glide clusters, the main substitutions occur for the /s/; for the liquid the main substitutions occur for the lateral, e.g. [w] is often substituted for /l/. If we look back at other liquid and glide cluters, we see that the same pattern emerges here as elsewhere, i.e. more errors occurring with the liquid or glide than with the initial consonant. The following rules account for the deletions in Table 26. The substitutions will be discussed in the chapter on distinctive features.

Table 26. Deletion Rules for Initial /s/ Clusters

Rules	% occurrence
R15: /s/ deletion	
$/s/ \rightarrow \emptyset / \#\_\_ \left[\left\{ \begin{matrix} -\text{voc} \\ +\text{cons} \\ +\text{nas} \end{matrix} \right\} \right]$ — −voc	16
+cons	72
+nas	67
R16: Liquid and glide deletion	
$\begin{bmatrix} \alpha\text{cons} \\ \alpha\text{voc} \end{bmatrix} \rightarrow \emptyset / \#s\_\_$	
α = +	50
α = −	37

3.24 3-consonant Clusters: str and spl

Stimuli for eliciting spl was splash and for str was string. No 3-consonant cluster was correctly produced by any of the subjects. Only one subject produced a 3-consonant cluster of [stw]. The following table shows the types of errors.

Table 27. Summary of Rules for 3-Consonant Clusters

Cluster	Total possible	1. Liquid deletion	2. /s/ deletion	3. Stop deletion	4. Liquid →/w/
SPL	53	39.62%	83.02%	16.98%	32.08%
STR	51	15.7%	86.27%	31.37%	70.58%

Note: These do not add up to 100% because there are various combinations of rules possible, i.e. liquid deletion as well as /s/ deletion.

Thus, the 3-consonant clusters are similar to the 2 consonant stop + liquid clusters in that /r/ clusters show gliding as a major strategy while /l/ clusters show deletion. Table 28 shows the various percentages of the combinations of rules present.

Table 28. Combinations of Rules for Initial 3-Consonant Clusters

Combination	Cluster	
	SPL	STR
234 = [w]	0%	9.8%
12 = stop	35.85%	9.8%
24 = stop + [w]	26.42%	52.94%
13 = [s]	3.77%	5.88%
34 = [sw]	5.66%	1.96%
2 = stop + liquid	20.75%	13.73%
1 = [s] + liquid	7.55%	0.00%
4 = [s] + stop + [w]	0.00%	5.88%
TOTALS	100.00%	100.00%

We can see that for the [str] clusters, /s/ deletion and substitution of [w] for /r/ are the two major strategies. Table 28 shows that over 52% of the [str] clusters result in a stop + /w/ being present. However, with the [spl] clusters, liquid deletion is as major a strategy as [w] substitution. Thus, there are three major results with the [spl] clusters: 1: only a stop, 2: a stop + /w/ and 3: a stop + a liquid.

3.3 List of Rules for Consonant Clusters

Table 29 shows a list of the rules discussed which are necessary for describing the major deletions and substitutions used in initial and final consonant clusters.

Table 29. Summary of Rules Used in Consonant Clusters

Rules	Rules
R1: Liquid and glide deletion $\begin{bmatrix}\alpha\text{cons}\\ \alpha\text{voc}\end{bmatrix} \rightarrow \emptyset / \left.\begin{matrix}\_\_C\# \\ \#C(C)\_\_\end{matrix}\right\}$	R8: Liquid vocalization $\begin{bmatrix}+\text{cons}\\ +\text{voc}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{cons}\\ +\text{back}\\ -\text{high}\\ -\text{low}\\ \alpha\text{round}\end{bmatrix} / \_\_C\#$
R2: Final C deletion $\begin{bmatrix}+\text{cons}\\ -\text{voc}\end{bmatrix} \rightarrow \emptyset / [+\text{cons}]\_\_\#$	R9: Gliding $\begin{bmatrix}+\text{cons}\\ +\text{voc}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{cons}\\ -\text{voc}\\ +\text{round}\end{bmatrix} / \#C\_\_$
R3: Double consonant deletion $CC \rightarrow \emptyset / \_\_\#$	R10 /r/ → [l] R11: /l/ → [r]
R4: Initial consonant deletion $\begin{bmatrix}+\text{cons}\\ -\text{voc}\end{bmatrix} \rightarrow \emptyset / \left.\begin{matrix}\_\_[+\text{cons}] \\ \begin{bmatrix}-\text{cons}\\ -\text{voc}\end{bmatrix}\end{matrix}\right\}$	R12: Metathesis: sk → ks st → ts R13: Schwa insertion $\emptyset \rightarrow [ə] / \#C\_\_[+\text{cons}]$
R5: Fricative deletion $\begin{bmatrix}+\text{cons}\\ -\text{voc}\\ +\text{cont}\\ +\text{alv}\end{bmatrix} \rightarrow \emptyset / \left.\begin{matrix}\_\_C\# \\ \#\_\_C(C) \\ \#\_\_\begin{bmatrix}-\text{cons}\\ -\text{voc}\end{bmatrix}\end{matrix}\right\}$	R14: Fronting: velar → alveolar R15: Lisping: /s/ → [θ] R16: /s/ → [f]/__w assim. rule R17: /θ/ → [f]/__w assim. rule
R6: Nasal deletion $[+\text{nasal}] \rightarrow \emptyset / \_\_\begin{bmatrix}+\text{cons}\\ -\text{voi}\end{bmatrix}\#$	R18: /θ/ → [s] R19: Stops and /s/ → affricates
R7: Final C devoicing $\begin{bmatrix}C\\ +\text{alv}\end{bmatrix} \rightarrow [-\text{voice}] / C\_\_\#$	R20: Stops → labial fricatives (assimilation rule) R21: Lateral lisp: /s/→[s̬]or [ɬ]

3.4 Liquids

/r/ and /l/ were elicited in initial, intervocalic and final positions by utilizing the following stimuli:

Table 30. Stimuli for Liquids

Phoneme	Initial	Intervocalic	Final
/r/	rabbit, rock raining, rug	eraser, carrot, giraffe measuring, refrigerator	ear there
/l/	lamp, left, last	balloon, elephant, television, violin	smile school

It must be noted that the intervocalic stimuli occur between stressed and unstressed vowels. However, the analysis took this into account in the following manner. Intervocalic /r/ was realized as an initial consonant in some cases because of a process called "weak syllable deletion" in the literature. This happened frequently for "eraser" and "giraffe." In these cases, the /r/ has been noted as an initial consonant, i.e. <u>eraser</u> → [reɪsr̩]. Intervocalic position was very difficult for many children since many could not produce 2 and 3 syllable words. In instances where the children produced [bun] or [blun] for /bəlun/ this was coded as a "No response" since no intervocalic position existed. Only instances of true intervocalic position were considered as such, e.g. /bəlun/ → [bəjun]. Weak syllable deletion in 2 and 3 syllable words will be discussed in Chapter 6. Table 31 shows the percentages for correct production, substitutions and no responses for liquids in initial position. These analyses are based only on adult transcriptions. Therefore, as noted above, it is possible that the substitution of [w] for the liquids, is a physically different [w] from underlying /w/ (c.f. Kornfeld, 1971).

Table 31. /l/ and /r/ in Initial Position

Phoneme	% correct	Total	% substitutions w	j	Other	Total %
/l/ (143)	55.94	44.06	(13.99)	(29.37)	(.7)	100
/r/ (259)	20.46	79.54	(79.54)			100

As Table 31 reveals, /l/'s seem to be easier to produce, i.e. more often correct, than /r/'s with two possible substitutions--[w] and [j]. For /r/, only 20% were correct and the major substitution was a [w]. This parallels the data collected on liquid clusters as well--the /r/ clusters were much more difficult, i.e. less correct, than the /l/ clusters. Informal observation and testing did show that the children could distinguish the difference between words such as "light vs. white vs. write." However, no formal testing was done in audiotry discrimination of these particular phonemes.

Table 32 shows the analysis of liquids in intervocalic position.

Table 32. Intervocalic Liquids

Phoneme	% correct	Total	% substitutions w	j	ʔ	Stops	Other	Total %
/l/ (108)	70.37	29.63	(3.7)	(2.78)	(19.4)	(3.7)		100
/r/ (136)	12.5	87.5	(76.47)		(5.89)		(5.15)	100

/l/'s were either produced correctly, or the environment for intervocalic position was not met. For example, many children omitted the initial syllable of "balloon" and changed "elephant" to something like [ɛʔfənt] or [ɛlfənt], either omitting an entire syllable or making the /l/ a syllable final segment. The same thing happened with /r/'s although [w] was substituted for most of the /r/'s in intervocalic position.

It is possible that the final /l/ test words selected were poor choices. There was a definite difference between the strategies that the children used for "smile" vs. "school." In regular adult production of <u>smile</u>, the words often become bisyllabic, i.e. [smaɩl̩] with a syllabic [l̩]. This seldom happens with "school." The subjects treated "smile" as they did other words with syllabic consonants and "school" as a word with just a final consonant. Final /r/ is often analyzed as retroflexion on the vowel rather than as a separate segment. However, /r/ was vocalized in addition to having the main vowel present. This may lend support to the phonological analysis of <u>Vr</u> represented as a sequence rather than as a retroflex vowel. Table 33 presents the analysis of the final liquids.

Table 33. Final Liquids

Phoneme	% correct	% total subs.	# substitutions			% deletions	Total %
				[ə]	[oɷ]		
/l/ (104)	19.23	46.15	school	(5)	(3)	34.62	100
			smile	(1)	(39)	0.00	
/r/ (108)	23.15	75.92		(58) (53.7%)	(24) (22.22%)	.93	100

It is interesting to note that in final position, /r/ is correct more than /l/. However, we must look at the word "smile" carefully. In some dialects, and in many English accents, it is correct to produce "smile" as [smaɩoɷ] with some type of rounded back vowel substituting for the /l/. It may be that in final position, the velarized [ɫ], is harder to distinguish from vowels than nonvelarized /l/ in initial and intervocalic position.

3.5 Syllabic Consonants

Nasals and liquids may be syllabic postconsonantally. To elicit syllabic consonants the following stimuli were used:

[n̩]: chicken, kitten, television, wagon

[l̩]: candle, puzzle, saddle, table

[r̩]: eraser, feather, flower, hammer, mother, spider, sweater, sugar, teacher, treasure, tiger, zipper

Table 34 shows the pattern of errors for this population for syllabic consonants.

Table 34. Syllabic Consonants

Syllabic consonant	% correct	Total	% substitutions			% deletions	Total %
			[ə]	[oo]	Other		
[n̩] (183)	86.34	12.57	(4.92)		(7.65)	1.09	100
[r̩] (627)	36.2	63.8	(33.49)	(30.3)		0.00	100
[l̩] (197)	17.26	82.75	(3.05)	(79.7)		0.00	100

The analysis reveals that syllabic nasals were produced correctly more often than [r̩] which was produced correctly more than [l̩]. Syllabic [r̩] is correct 36.2% which is more than /r/ in any other position, i.e. #__V = 20.5% correct, V__V = 12.5% correct and V__# = 23% correct. Liquid vocalization is responsible for the greatest number of errors for syllabic liquids and parallel the literature on common substitutions for liquids. There was a variety of substitutions for syllabic [n̩] which will be discussed in the chapter on distinctive features.

3.6 Affricates

The affricates /tʃ/ and /dʒ/ were elicited in initial, intervocalic and final positions using the stimuli in Table 35.

Table 35. Stimuli for Affricates

Phoneme	Initial	Intervocalic	Final
/tʃ/	cheese, chicken	catching, teacher	match, witch
/dʒ/	jump, juice	pajamas, refrigerator	cage, page

Due to weak syllable deletion, /dʒ/ was often realized in initial position, e.g. "pajamas" as [dʒæmiz]. Whenever this happened, "pajamas" was coded as a "no response" for /dʒ/ in intervocalic position and was recoded for initial position. In addition, if the initial syllable of "giraffe" was deleted, this was coded as a "no response" rather than an omission since it involved an entire syllable.

Table 36 shows the pattern of errors for the responses.

Table 36. Affricates in Initial, Intervocalic and Final Positions

Phoneme	Position	% correct	% substitutions Stop	Fricative	Affricate	Other	% deletion or [?]	Total %
/tʃ/ (110)	Initial	51.81	24.55	20	3.64			100
(106)	Intervoc	38.68	17.93	30.19	12.26		.94	100
(106)	Final	24.53	.94	31.13	43.4			100
/dʒ/ (206)	Initial	40.78	35.44	10.19	7.76	5.83		100
(45)	Intervoc	17.78	26.67	24.44	22.22	2.22	6.67	100
(108)	Final	21.29	.93	38.89	31.48		7.41	100

The analysis shows that, not surprisingly, initial affricates are correct more often than medial or final affricates. The data for the voiced affricate /dʒ/ may be a bit skewed since it shows that /dʒ/ in intervocalic position is correct less than in final position. This is possibly due to the fact that one of the words chosen for intervocalic position was "refrigerator." "Refrigerator" is a polysyllabic word which the children had much difficulty with and we can draw no valid conclusions from the responses to that word. Further investigation of the voiced affricate is warranted. Deletions occurred infrequently for all positions, possibly because of the salience of the acoustic signal for these consonants. The most prevalent errors were the substitution of a stop for initial affricates and a fricative or fronted affricate for final affricates. Intervocalic position had an equal percentage of substitutions of stops, fricatives and affricates. The most common stop substituted was an alveolar [t] or [d]; the affricate substitution was an alveolar affricate [ts] or [dz]. Occasionally there were lateralized affricates [t̯ʃ] and [d̯ʒ] substituted (⌢ = lateralized).[1] Since stops were very common substitutions, we might want to look at affricates as a cluster or a sequence of /t/ + /ʃ/ or /d/ + /ʒ/. In this case, we would say that there had been a deletion of the second member of the cluster and this analysis would parallel that for initial clusters of stop + liquid. In final position, in our previous cluster data, final consonant deletion was the most prevalent rule. Thus, if we analyzed affricates as clusters, we would expect that the fricative would be deleted resulting in [mæt] for "match." However, the results found here show that the penultimate or stop is deleted, the fricative being retained. Thus, it may look as if in initial position we could analyze affricates as a sequence but not in final position. Another possibility is that stops may be easier to produce for these children in initial position than in final position and that in final affricates, the fricative has more perceptual salience and is thus retained.

For the word "giraffe" a number of subjects simplified the affricate to a stop, deleted the unstressed [ə] vowel and sometimes changed the /r/ to a [w], resulting in either [bræf] or [bwæf], with the alveolar stop changing by assimilation to the roundness of the /r/ or /w/ (/r/ is sometimes labialized in initial position). Also, the same children who changed [dr] to [gr] in consonant clusters, changed [ʤər] to [gr] which may be described by the following processes* in Table 37.

Table 37. Processes Involved With the Word "Giraffe"

Process	Phonetic result
	ʤəræf
1. Affricate stop	↓
	dəræf
2. Schwa deletion in a weak syllable	↓
	dræf
3. Velar-dental interchange or backing	↓
	græf
and occasionally	
4. Liquid deletion	↓ gæf

3.7 Fricatives

Fricatives were elicited in initial, intervocalic and final positions using the stimuli in Table 38.

*This and the previous examples of such processes is very much a linguist's account of what might have happened.

Table 38. Stimuli for Fricatives

Phoneme	Initial	Intervocalic	Final
f	fish, feather, food, fork, fox	coffee, elephant	giraffe, knife
v	vase, violin	oven, television or t.v.	glove, stove
s	saddle, sand	eraser, glasses	grass, juice, vase
z	zipper, zebra	puzzle, present	cheese, nose
ʃ	sheep, shirt sugar	dishes, splashing, washing	brush, fish
ʒ	none	measure, treasure	none
θ	thank, thumb	none	bath, mouth
ð	this/that; there	feather, mother	smooth, breathe

Table 39 shows the order from most to least correct for fricatives with data from all positions added together and summarized. Table 40 on the following page shows each position--initial, intervocalic and final positions separately.

Table 39. Fricatives in Initial, Intervocalic and Final Positions Summarized across all positions

Phoneme	Total possible	% correct	% substitutions	% deletions	Total %
f	484	86.78	11.98	1.24	100
s	340	59.41	38.53	2.06	100
v	282	56.03	39.36	4.61	100
z	323	39.94	54.18	5.88	100
ʃ	425	33.18	64.0	2.82	100
ʒ	98	23.47	74.49	2.04	100
θ	215	19.07	75.81	5.12	100
ð	314	17.52	74.2	8.28	100

We can see that for all the fricatives, /f/ is the most often correct, followed by /s/ and then /v/. The least correct fricatives were the dental fricatives with less than 20% correct.

Table 40. Analysis of Fricatives by Position

Phoneme	Initial Position				Intervocalic Position				Final Position			
	Total possible	% correct	% substi-tutions	% dele-tions	Total possible	% correct	% substi-tutions	% dele-tions	Total possible	% correct	% substi-tutions	% dele-tions
f	267	93.26	6.74	0	108	83.33	16.67	0	109	74.31	20.18	5.51
s	90	73.33	26.67	0	105	60.95	39.05	0	145	49.66	45.51	4.83
v	70	71.43	28.57	0	106	69.81	30.19	0	106	32.08	55.66	12.26
ʃ	165	43.03	55.15	1.82	151	29.8	69.54	.66	109	22.94	69.72	7.34
z	107	42.99	57.01	0	107	33.65	66.35	0.	109	43.12	39.45	17.43
ʒ					98	23.47	74.49	2.04				
θ	106	33.02	65.09	1.89					109	5.5	86.24	8.26
ð	107	28.04	70.09	1.87	103	19.42	77.67	2.91	104	4.81	75.0	20.19

Looking at Table 40, we can see that fricatives in initial position maintain essentially the same rank ordering as for all the positions summarized. The only difference is that /ʃ/ is correct more often than /z/ in initial position but only by about 1%. It is interesting to note that /s/ in initial position is correct 73.3% of the time, with /z/ being correct only 43% of the time. However, this margin narrows to only 6% difference in final position. Thus, /z/ is fairly stable in its percentage of correctness across positions (Initial = 43%; Intervocalic = 34%; Final = 43%). However, /s/ drops in percentage across positions (Initial = 73%; Intervocalic = 61%; Final = 50%). /f/ shows the same type of pattern as /s/; however, /v/ has a different pattern being correct more often in initial (71%) and intervocalic (70%) positions with final position falling off to only 32% correct. The types of substitutions used for fricatives will be discussed in more detail in Chapter 4.

3.8 Stops and Nasals

Stops and nasals were elicited in initial, intervocalic and final positions using the stimuli in Table 41.

Table 41. Stimuli for Stops and Nasals

Phoneme	Initial	Intervocalic	Final
p	page, park, penny pig, puzzle	sleeping, zipper	cup, sheep
b	bath, belt, biggest, box, boy, build	rabbit, table	crib, tub
m	mask, match, measuring, melt, milk, mother, mouth	hammer, swimming	game, gum, thumb
t	table, teacher, tiger, toe, tongue, tub	sweater, cutting, kitten	carrot, coat, skate, eat, rabbit
d	dishes, dog, duck	spider, saddle	food, slide
n	knife, knock, nose	penny, raining	balloon, clown, gun, plane, queen, spoon, train, violin
k	cage, cake, candle, card, carrot, cast, catching, coat, coffee, cold, cookie, cup, cutting, king, kitten	chicken, cookie, sticky	block, cake, duck, knock, rock, snake
g	game, ghost, gum, gun	biggest, sugar, tiger, wagon	dog, frog, pig, rug
ŋ			king, string, swing, tongue

Table 42. Analysis of Stops and Nasals by Position
Arranged in order of most to least correct for initial position only.

Phoneme	Initial Position				Intervocalic Position				Final Position			
	Total possible	% correct	% substi- tutions	% dele- tions	Total possible	% correct	% substi- tutions	% dele- tions	Total possible	% correct	% substi- tutions	% dele- tions
b	321	100	0	0	108	88.89	11.11	0	95	83.16	12.63	4.21
g	220	98.18	1.82	0	214	88.32	11.68	0	214	79.44	11.68	8.88
k	811	96.67	3.27	0	161	93.17	6.83	0	316	88.29	1.27	10.44
d	165	96.36	3.64	0	85	51.77	48.23	0	109	44.04	3.67	52.29
m	366	94.81	5.19	0	108	85.19	14.81	0	164	91.46	6.71	1.83
t	322	94.41	5.59	0	164	48.17	51.83	0	279	70.96	3.23	25.81
p	268	93.28	6.72	0	107	87.85	12.15	0	109	88.99	3.67	7.34
n	164	90.24	9.76	0	109	83.49	16.51	0	407	80.1	5.16	14.74
ŋ									210	80.48	16.19	3.33

As Table 42 reveals, most of the stops and nasals in initial position are produced correctly (from 90-100% correct) There were no deletions in initial or intervocalic position and most errors occur in final position. The one exception to that is for intervocalic /t/, in adult phonology realized phonetically as a flap or tap [ ], which had 52% error. There is some tendency for intervocalic stops and nasals to be glottalized ([ ]) or for a glide to be substituted instead of the target phoneme. Final consonant deletion is more common for the alveolar consonants; in fact, /d/ is deleted 52% of the time in final position, followed by /t/ with 25.8% and /n/ with 14.7%. This fact supports the previous findings that alveolars tend to be the most unstable and deleted more often in final position.

The following Table 43 accounts for the main error types used by the subjects for stops:

Table 43. Main Rules Accounting for Errors in Stops
These percentages do not add up to 100% since the total possible changed in each case.

Rules	Total possible	% occurrence
A. Consonant correct	4068	87.44
B. Final consonant deletion	1122	17.2
1. With labials	204	5.88
2. With velars	530	9.81
3. With alveolars	388	33.25
C. Substitutions		
Fronting: k → [t, ts, tʃ, s] g → [d, dz, dʒ, z]	1936	1.24
Final consonant devoicing (b, d, g)	418	6.22
Glottalization in intervocalic position ([ʔ])	839	7.99
Gliding in intervocalic position	839	2.62
Deaspiration of initial voiceless stops	1401	4.21
Aspiration of intervocalic /t/, i.e. /t/ not realized as [ɾ]	164	19.51

The rule the deaspiration of initial voiceless stops, accounted for all the errors but 4 in initial voiceless stops. Since for many, if not most English speakers, initial voiced consonants are phonetically unaspirated voiceless stops, the children were therefore producing the phonetic "allophone" of "voiced" stop phonemes. They then have a contrast between aspirated and unaspirated voiceless stops.

If we look at the final consonant deletion rule we find that final consonants are deleted 17.2% of the time. However, in looking only at the alveolar consonants, we find that 33.25% of the /t/'s and /d/'s are deleted while only 6% of the labials and 10% of the velars. This agrees with previous findings in final clusters of alveolars being deleted more often than labials and velars. For intervocalic /t/, or phonetically [ɾ], 19.5% of the time the children did not apply the flap rule, but rather realized the /t/ as [t^h]. However, in 48% of the cases, they did apply the flap rule showing that they are at least beginning to learn this phonetic detail rule.

Table 44 shows the rules which account for the major nasal errors in this study.

Table 44. Main Rules Accounting for Errors in Nasals
These percentages do not add up to 100% since the total possible changed in each case.

Rules	Total possible	% occurrence
A. Consonant correct	1528	86.58
B. Final consonant deletion	781	9.35
with labials	164	1.83
with velars	210	3.33
with alveolars	407	14.74
with vowel nasalization	781	7.3
C. Substitutions		
Fronting: ŋ → n	210	9.05
Intervocalic glottalization [ʔ]	217	8.3
Gliding: m → w; n → j, w	747	1.21
Final stop addition: n→nd; ŋ →ŋg	617	3.24
/m/ → [n]/__#	164	6.1

Again, we see that final consonant deletion occurred more often with the alveolar nasal /n/ than with the /m/ or the /ŋ/. We can see also that when the children did delete a nasal, they often nasalized the vowel, thus retaining the information that a nasal had been present in underlying form. Denasalization occurred only about 3% of the time, showing that nasality is very salient for these subjects. Further discussion of nasals errors will be reported on in the next chapter.

3.9 Glides (Approximants)

The glides /w/, /j/ and /h/ were elicited using the following stimuli: /w/ = wagon, washing, witch; /j/ = yard, you; /h/ = hand, heart, hammer. Table 45 shows the results of the analysis.

Table 45. Analysis of Glides

Phoneme	Total possible	% correct	% substitutions	% Total
w	162	98.15	[v] 1.85	100
h	164	95.73	[ʔ] 4.27	100
j	106	84.91	[ʔ] 5.66	100
			[l] 9.43 15.09	100

As we can see there are very few errors in these sounds. The only substitution for /w/ is a [v] which is acoustically and articulatorily similar. The major substitutions for /j/ are [l] and [ʔ] and for /h/ a [ʔ] is substituted. It may be noted that the [l] was substituted for /j/ only in the word "yard" and thus may be a peculiarity of that word alone or of /j/ + /a/.

3.10 Syllabic Structure

Monosyllabic words. The following canonical forms of one syllable words were elicited:

CV	=	3	e.g.	boy
VC	=	2		eat
CVC	=	32		bath
CCV	=	2		snow
CCVC	=	21		spoon
CVCC	=	22		fork
CCVCC	=	1		drink
CCCVC	=	2		string

Two syllable words. There were 38 two-syllable words of varying canonical forms. Only the two which were CVCV structure were specifically analyzed. The remainder were analyzed to see how many were correct and how many were changed to a CVCV syllable structure since speech defective children have been reported to change syllable structure to open CV syllables (Renfrew, 1966).

Polysyllabic words. There were six 3-4 syllable words which were analyzed for percent correct and for weak syllable deletion.

3.11 Analysis of Monosyllabic Words

Table 46 shows the percent of the monosyllabic words which were correct. We can see that the CV words are the most correct with 99.4% correct responses. CVC words followed with 84.9% correct and CCVCC words with 81.8% correct. These figures may be misleading since the only CCVCC syllable was "drink" which ended in a nasal cluster. As shown in the earlier phoneme analysis of final clusters, nasal clusters were the easiest for the subjects. Initial consonant clusters were easier than final as shown by the fact that CCVC was correct 50.1%, CCV, 47.2% while CVCC was correct only 27.8% of the time. There were only 3 responses which met the criteria for CCCVC structure and accounted for 2.9% of the responses.

Table 46. % Correct of Syllable Structure of Monosyllabic Words

Monosyllabic Words		
Canonical form	Total possible	% structure correct
CV	163	99.4
VC	110	47.3
CVC	1718	84.9
CCV	108	47.2
CCVC	1093	50.1
CVCC	1176	27.8
CCVCC	55	81.8
CCCVC	104	2.9

Turning now to the types of substitutions for the various syllable structure, Table 47 presents a confusion matrix for the canonical forms and their substitutions. It shows that open syllable structures (CV, CCV, V, VV, CVV, CCVV, CVCV) substituted for closed syllable structures in 608/4256 or 14% of the cases; in addition open syllable structure substitutions account for 36.7% (674/1839) of all the errors. CVC substitutions account for 52.6% of the errors, and 22.7% of the possible syllables closed by one or more consonants. It is extremely rare that a target open syllable will have a closed syllable substituting for it, happening only once in this study. This assymetry of substitutions strongly supports the view that open syllables are "unmarked" as to structure.

Table 47. Substitution Matrix for Monosyllabic Words

Target Syllable Structure	Substitutions																	Totals
	CV	VC	CVC	CCV	CCVC	CVCC	CCVCC	CCCVC	V	VV	VVC	CVV	CVVC	CCVV	CCVVC	CVCV	CVCVC	
CV			1															1
VC									16	39	3							58
CVC	198					15						40	1			5		259
CCV	63															3		66
CCVC	111		313	60		4						33		7	2	2	11	543
CVCC	70		621									21	89					801
CCVCC	3		1			6												10
CCCVC	1		31	2	67													101
Totals	446	0	967	62	67	25	0	0	16	39	3	94	90	7	2	10	11	1839

Table 48. % Correct of Monosyllabic Words Using Categories of Consonants
S = stop; F = fricative A = affricate; L = liquid;
G = glide; C = any consonant.

Syllable structure	Total possible	% structure correct
CV		
SV	109	99.1
GV	54	100.0
VC		
VS	55	70.9
VL	55	23.6
CVC		
SVN	273	91.9
SVS	383	86.7
SVF	55	78.2
FVN	54	75.9
NVF	163	73.0
NVS	55	72.7
GVA	54	68.5
NVA	54	66.7
FVF	120	55.8
SVA	108	52.8
AVF	110	44.6
FVL	53	9.4
LVS	107	7.5
CCV		
FLV	54	74.1
FNV	54	22.2
CCVC**		
SGVC	93	86.0
FGVC	54	37.0
SLVC	465	31.0
FLVC	109	21.1
CVCC**		
CVSF	106	69.8
CVNS	270	54.1
CVLS	584	18.2
CVFS	255	1.2
CCVCC = SLVNS	55	81.8
CCCVC		
FSLVS	52	0.0
FSLVN	52	0.0

**The consonant clusters were analyzed specifically for category but not the single consonant in syllable initial or final position

Table 48 further analyzes syllable structures according to the types of consonants present, i.e. fricatives, stops, liquids, glides, and affricates. One can see that syllables with glides, stops, and nasals are the most correct. The following is the rank order for syllables correct at least 70% of the time:

1. GV
2. SV
3. SVN
4. SVS
5. SGVC
6. SLVNC
7. SVF
8. FVN
9. FLV
10. NVF
11. NVS
12. VS

The syllables with liquids are the least correct (FVL = 9.4%; LVS = 7.5%) with the exception of CVFS which is correct only 1.2% of the time.

3.12 Two-syllable Word Analysis

Table 49 shows the percent correct for two-syllable words and the percent changed to a CVCV syllable structure.

Table 49. Two-syllable Words

Syllable structure	Total possible	% correct	% changed to CVCV	% misc. errors
CVCV	109	100		0
CVCVC CVCCVCC CVCCVC CCVCVC CCVCVCC CVCCV	1670	46.2	38.7	15.1

100% of the CVCV syllable structure was correct, with 38.7% of the other possible syllable two-syllable structures changed to this open syllable type. This agrees with the many studies which cite CVCV as early syllable type in phonological acquisition. It also shows that this deviant population like others cited in the literature (Renfrew, 1966, Ingram, 1972, Panagos, 1974) tend to keep an open syllable structure whenever possible.

3.13 Polysyllabic Word Analysis

Three and four syllable words often did not show the same types of errors as the subjects used for other words, especially "refrigerator" and "television." Weak syllable deletion was used in almost every case and the responses were extremely varied. Only 16.8% (48/286) of the responses had the correct syllable structure. Table 50 presents some of the different types of errors for two of the polysyllabic words. These error types are similar to the errors discussed by Waterson (1971), in that the friction and stridency of the affricate in refrigerator seems to be reproduced by various other sounds, notably /f/ and /s/. In television the fricatives are rarely omitted entirely. In the production, [tɛləɛndʒɩn] the subject seems to have found nasals as well as the stridency of the /ʒ/ more salient and thus attempted to reproduce them. Tables 51 and 52 present a more detailed analysis of syllable structure.

Table 50. Sample Errors for Two 3-Syllable Words

Refrigerator	Television
1. fɪsəʔeɪr ; fɪseɪtr̩ ; fɪsr̩	tɛʔəwɪs̰r̩
2. frɪdʒəweɪrr̩ ; fɪðəweɪʔoʊ; fɪdzəweɪs	twɛʒəwɛə
3. zɪreɪrr̩	tɛʔvɪsn̩
4. friʔfl̩ ; fwəfəfoʊ ; frɪdzfoʊ	tɛləvɪn
5. fiweɪr	tɛlwɑʒn̩
6. fɪʒəweɪɾoʊ ; fɪðəweɪɾoʊ	tɛləɛndʒɪn
7. fɪdzweɪs	tɛlvɪd
8. fɪsweɪɾr̩	tɛləvɪʔr̩

Table 51. Syllable Structure Analysis Showing Percentage Correct and Percentage Changed to CVC and CV Syllable Structures

Subject	Syllable Structure (% correct) 1 CV	2 CVC	3 CVCC	4 CCVC	5 CCVCC**	6 VC	7 CVCV	8 CCCVC	% 3, 4, 5, 8 changed to CVC	% 2-6, 8 changed to open syllable
1	100	44	10.6	7.35	0	0	100	0	53.8	43.5
2	100	82.2	18.2	39.3	100	0	100	0	30.2	29.7
3	100	100	53.1	74.3	100	100	100	0	22.4	3.4
4	100	86.5	8.6	27.1	100	33.3	100	0	53.2	20.5
5	100	94.7	36.2	62.3	100	30	100	0	41.3	4.7
6	100	100	28.6	55.9	100	50	100	0	38.6	7.1
7	100	94.4	28.1	46.4	100	33.3	100	0	38	13.9
8	100	98.9	42.4	61.8	100	50	100	0	30.8	13.4
9	100	71.7	19	51.6	100	70	100	0	48.5	20.1
10	100	94.8	27.8	35.4	80	60	100	0	38.5	6.48
11	100	86	45.5	69.6	100	67.7	100	0	30.6	9.88
12	100	41.1	0	4.7	0	50	100	0	44.2	52.3
13	89	95.7	13.6	20.3	0	50	100	0	62.6	5.1
14	100	100	34.9	85.5	100	50	100	50	31.3	2.9
15	100	96	37.5	65.2	100	50	100	0	34.9	3.7
16	100	96.8	34.9	78.5	100	50	100	0	24.3	7.5

Table 52. Percentage of 34 2-syllable Words Being Changed to CVCV Syllable Structure
Based on 3-5 attempts at each word minus the no responses.

Subject	Total possible	# of 2 syllable words changed to CVCV syllable structure	% of total
1	102	29	28.4
2	98	65	66.3
3	102	11	10.8
4	99	38	38.4
5	163	62	38
6	99	51	51.5
7	102	38	37.3
8	102	40	39.2
9	146	18	12.3
10	170	61	35.9
11	102	29	28.4
12	100	30	30
13	100	58	58
14	102	39	38.2
15	136	60	44.1
16	102	21	20.6

FOOTNOTE TO CHAPTER 3

1. Although [ ] is the IPA symbol for a lateral alveolar fricative, I chose to use a diacritic [ ] for all lateralized fricatives and affricates. Thus [s], [z], [ ], [ ], [t], [d] would represent lateralized versions of the phonemes /s, z/, / , / and /t , d /. This was done to emphasize that the abnormality of production is the same for all six phonemes.

CHAPTER 4

COMPARISON WITH OTHER STUDIES

4.0 Final Consonant Clusters

According to Moulton (1976), in normal adult speech when two consonants with the same voicing values (i.e. both voiceless or voiced) occur at the end of words, the second consonant, if it is a stop, is often dropped. This deletion is most common when a following word begins with a consonant. Thus, we would have the following types of optional rules for adult speakers of English.

1) Fricative + stop → fricative

left → [lɛf] ;cast →[kæs]

2) Liquid + stop voiced → liquid

cold →[koʊl] but belt →[bɛlt]

In final nasal clusters, he suggests the two rules may apply. If the cluster is voiced as in /nd/, the final /d/ may be deleted if it does not signal a past tense. However, if the final sound is voiceless as in /nt/, then there is an optional rule of [nasal] → $\emptyset$/ ___ $\begin{bmatrix} C \\ -voi \end{bmatrix}$, after the vowel is nasalized. Thus: <u>can't</u> → [kæ̃t] but <u>canned</u> → [kæ̃nd].
There is thus a tendency for final consonant deletion in normal pronunciation. Because of this optional rule, children could hear the same words with both consonants or with only one. We would then expect children to show variability in their production of final consonant clusters based on the variability in input.

If we look at the final /l/ cluster words, we see that 17.9% were correct with both final consonants present. There were 32 cases where only the final alveolar /d/ was deleted. According to Moulton, this is an optional rule in adult phonology. Therefore, if we count these 32 deletions as correct, the total comes to 80 cases or 29.85% correct. For fricative + stop clusters, the subjects used final consonant deletion as a major strategy 70.17% of the time which also parallels the adult optional rule.

The simplification of final nasal clusters also parallels adult rules with 88% of the final /d/'s deleted. In addition, when the nasal was deleted, the following consonant was voiceless. Thus, we have included this figure in the total percent correct. If we add the 96 cases of final /d/ deletion to the total correct we get 323 or 74.77% correct for final nasal clusters. It would thus appear that these children have acquired some of the rules of the adult grammar. Their responses, however, were of words produced in isolation not in context followed by consonant initial words. It might be that the optional rule has only been partially learned.

Ingram (1976) has reviewed most of the studies of normal and abnormal child phonology up to 1976. There have been no large studies since Templin (1957) of normal children's acquisition of final consonant clusters. Templin (1957) reported ages for the acquisition of consonants based on an articulation test given to 480 children from the ages of 3.0 to 8.0. 90 consonant clusters were tested either by imitation or through spontaneous naming of a picture. Templin considered a sound to be acquired at a certain age when 75% of the children at that age level produced it correctly. Table 53 presents the sequence of consonant cluster acquisition with earliest final consonant clusters listed first.

Table 53. Acquisition of Consonant Clusters by Templin

	Type of cluster		Age acquired (75%)
Acquired by age 4;0	Nasal + stop	ŋk	3
		mp	3;6
	Liquid + nasal	rm	3;6
	Stop + obstruent	pt	3;6
		ks	3;6
	Liquid + stop	lp	4
		lt	4
	Fricative + stop	ft	4
Acquired after age 4;0	Liquid + stop	rp	4;6
		lb	4;6
	Liquid + fricative	lf	4;6
		rf	4;6
	Liquid + stop	lk	6
		rb	6
		rg	6
	Nasal + stop	nt	6
		nd	6
	/s/ + stop	sk	7
		st	7

Ingram (1976, p. 27-28) cautions us about the interpretation of Templin's data since both imitation and spontaneous speech were included and only one word per sound was used. One might question the particular methods of analysis used by Templin but the data of the present study show similar trends; the nasal clusters and the stop + fricative clusters were the most often correct. According to Templin's data these two clusters were acquired early. However, liquid clusters and fricative + stop clusters seem to be more difficult for the subjects investigated in this study than for the normal children studied by Templin.

More recent studies (Moskowitz, 1970; Ingram, 1974ab; Ferguson and Farwell, 1975; Edwards, 1973; Menn, 1971) of child phonology acquisition have been conducted by linguists on small populations of subjects. These studies were more interested in processes children were using in the acquisition of sounds than the age at which they were acquired. One general process which many authors (Smith, 1973; Ingram, 1976; Oller, 1973) report on seems to serve to simplify the syllable structure of words. This process, final consonant deletion, is especially prevalent when reducing clusters. In addition, some authors state that the reduction of the clusters to one member is often predictable in that it is often the "marked" member of the clusters that is deleted (Ingram, 1976). This raises the question of what is meant by "markedness".

Ingram (1976, p. 32) states that "The member that is deleted is often predictable; the most common process is the deletion of the marked member." He than gives some examples from Smith (1973) where the /s/ is deleted in initial and final clusters, the liquid in stop + liquid or liquid + stop and in fricative + liquid clusters, e.g. stop → [tɑp], desk → [dɛk], clock → [kak], milk → [mɩk] and from → [fɔm]. Ingram does not define what he means by "marked". Smith (1973, p. 166) states:

> The second general function of realization rules is to reduce clusters of consonants or vowels. Again, we have a tendency which appears to be universal...; and again we have a range of possible rule-types within the general tendency, and a situation where these possibilities appear to be ranged in some form of hierarchical order. The most clear-cut tendency is where one member of the cluster is a stop and the other is not, in which case the cluster is almost invariably reduced to the stop alone.

He discusses various other realization rules as tendencies only. In fact, Smith quotes from Cairns' article on markedness (1969) and discounts Cairns' hypothesis as to the order of acquisition of clusters. Smith states, "The data for one child are clearly inadequate to support any generalizations, and more studies are needed, but on the present evidence there is clearly but little support for Cairns (p. 169). He further discusses marking conventions and states, "In fact, it seems that with the exception of one or two isolated examples of the type cited, marking conventions are completely irrelevant" (p. 200). Therefore, although we can fairly safely predict certain rules over other rules, this may have little to do with markedness unless these predictions themselves are the basis for deciding on what segments are more or less marked.

Edwards (1974) suggests that "correct phonemic perception of an opposition is acquired before correct production of that opposition, and that unmarked sounds are acquired before marked ones (p. 207). She defines markedness in the following manner: "In an unmarked-marked opposition, the marked sound is distinguished by the presence of an additional phonetic feature. For example, an oral and nasal vowel of the same quality are by this view unmarked and marked respectively, since the nasal vowel has the same features or characteristics of the oral vowel plus the feature of nasality." But this is an arbitrary position. It might hold with the original notion of markedness as put forth by the Prague School Linguists such as Trubetzkoy (cf. Baltaxe, 1969) but it cannot hold with the present notion of distinctive features in which each feature has two (binary) values and one does not speak of the presence or absence of a feature but which value of a feature. Edwards suggests that stops are unmarked with regard to fricatives because of the addition of the [+continuant] value. Since, however, all stops are [-continuant] one could just as easily have named the feature [+stop] and then it is clear to see why Edwards' notion does not hold water.

A number of criteria have been suggested by which sounds may be classed as marked or unmarked. According to Lightner (1965), Shane (1967), Postal (1968), and Chomsky and Halle (1968) among others, the less complex sounds are the least marked and also the "normal" state of a speech sound would represent the unmarked version of such a sound. In addition, the unmarked sounds would be found in more of the world's languages, more frequently in any one language, would be acquired earliest by children and would disappear first in cases of language pathology such as aphasia. Linguistically the unmarked members of speech pairs would be those members appearing in neutralized environments. Fromkin (1970) points out there is a good deal of circularity regarding the notion of markedness. This theory is supposed to predict what sounds a child will acquire first and most easily but what is considered marked or unmarked is supposed to derive from what a child acquires earliest and most easily.

There are other problems with the notion of "markedness" when used in child language acquisition studies. Note for example, that according to Chomsky-Halle marking conventions (1968, SPE) /s/ is the least marked fricative. But /f/ appears to be the first acquired by many children. It is not possible to conclude that each child has her own system of markedness because then markedness has no meaning as a universal theory. There are, however, apparently some general tendencies which may prove to be universal in acquisition. Hopefully, studies such as this one will provide some of the evidence needed for a valid markedness theory. Although we are less than sanguine about the validity of any posited theory to date, because our data are generally too sparse, the discussion which follows does refer to those ideas on a theory of markedness put forth by other researchers, as related to the present study.

Greenlee (1974) discusses general stages of initial consonant cluster acquisition, and Ingram (1976) further discusses this in relation to markedness. He states that Stage I shows the deletion of the entire cluster, Stage 2 deletion of marked or occasionally unmarked members and Stage 3, the substitution of a member; Stage 4 is 90% correct use of a cluster. However, the examples given by Ingram do not adhere strictly to posited markedness conventions. For example, he states that given /s/ + consonant, the /s/ is deleted and presents the following examples:

initial position	final position
stop → [tap]	desk → [dɛk]
small → [mɔ]	
slide → [laɪd]	

Proposed marking conventions suggest that stops and nasals are less marked than fricatives. By this convention the /s/ would be deleted in <u>stop</u>, <u>small</u> and <u>desk</u>. However, the word <u>slide</u> presents a problem as to whether /s/ or /l/ is more marked. /l/ appears to be the rarer of the two sounds in languages in the world and it may be learned later than

/s/ by some children. By these criteria, /l/ would be more marked than /s/. In summary, taking posited marking conventions into account we can only hypothesize the following rules for Stage 2:

Liquid + stop	→ delete the liquid
Fricative + stop	→ delete the fricative
Stop + fricative	→ delete the fricative
Nasal + stop	→ no prediction
/s/ + liquid	→ no prediction

Regarding the latter two clusters, the literature reports two stages of acquisition for the nasal + stop cluster. The nasal tends to be deleted when the final consonant is voiceless, but the stop tends to be deleted if the final consonant is voiced (Smith, 1973; Ingram, 1976). However, as discussed above, this may be related to adult phonological rules. Thus, the children may use the same rule as the adult but fail to apply the nasalization rule before deleting the nasal. That is, the ordering of the children's rules may differ from the adults.

In discussing clusters containing /l/, Smith reports that his son deleted final and preconsonantal /l/ and deleted post-consonantal sonorants--/l, r, w, j/. He further states that "this is an extremely widespread rule with claims to universality: at least as far as the deletion of /l/ and /r/ is concerned (Smith, 1973, p. 18). This would lead to the prediction that in a word such as slide the /l/ would be deleted; however, this does not happen in all cases. Sometimes the /s/ is deleted contrary to proposed marking conventions. Smith (1973, p. 166) found that post consonantal alveolar consonants are deleted and clusters are reduced to a stop. However, if both are stops, the second is deleted. This would lead us to conclude that he found inconclusive evidence regarding marked vs. unmarked deletions.

In Stage 3 of cluster acquisition, clusters begin to occur but there is usually a type of substitution for one of the members. Since most of the data written have been about initial clusters, we can only speculate on final clusters.

Edwards (1971) discusses the labiovelarization of /l/ and the loss of r-ness of one subject, Daniel from the age of 1;6 to 3;1. These processes resulted in the substitution of a vocalic element resembling a /u/ quality or a /ə/ quality vowel. In addition, if the /r/ was stressed, a vowel /o/ with an off glide /ə/ was substituted. This, she states, is typical for a rounded syllabic [r]. Thus she has examples like: [buədi], birdie; [hoəsi], horsie and [meuk], milk. We can refer to these processes as deretroflexion and l-vocalization.

In Compton's (1975) and Oller's (1973) studies of abnormal phonology, they both found the same types of rules as were found in normal children. All five children reported on by Oller showed processes affecting liquids, often changing them to more vowel-like elements such as [o], [ə] and [w] depending on the position in the word. In addition, the children deleted one member of a cluster to simplify it. Occasionally the sound that the children omitted was the unexpected one--or as Ingram would state, the "unmarked" member, e.g. omitting the stop in a /s/ + stop cluster: stop → [sap]. Examples from Smith (1973) and Lorentz (1976), however, are for initial clusters only.

In light of the previous discussion on marking conventions, we can reanalyze the present data using the following:

With clusters of "liquid + stop", liquid is marked, stop is marked since stops and nasals are the most common sounds in languages of the world (Greenberg, 1965). With clusters of "fricative + stop" and "stop + fricative" fricative is marked with respect to the stop for the same reasons as mentioned above. With clusters of "nasal + stop" there is no way to tell which is marked and which is unmarked. Thus, if we reanalyze our data according to the above conventions, we can conclude that marking conventions do not help in all cases. Table 54 presents the percentages of occurrence of particular deletion rules for the present study.

Table 54. Deletion Rules for Final Clusters Using Marking Conventions

Type of cluster	Deletion rules				% of occurrence
Stage I:	Deletion of entire cluster				6.63%
Stage II:	Deletion of one member of cluster				53.5%
	Marked member	%	Unmarked member	%	
a. Liquid + obstruent	Liquid → ∅	30.99	Obstruent → ∅	26.91	
b. Fricative + stop	Fricative → ∅	5.08	Stop → ∅	70.17	
c. Stop + fricative	Fricative → ∅	23.58	Stop → ∅	3.77	

In the first case, i.e. liquid + obstruent, there is almost an equal number of obstruents deleted as liquids, showing that one cannot predict for specific subjects which consonant in a two-consonant cluster will be deleted. For an individual child one may predict the deleted consonant depending upon the particular strategy the child uses for consonant cluster simplification--liquid deletion or final consonant deletion. In the fricative and stop clusters, it is evident that these subjects are using the strategy of final consonant deletion whether the phoneme is marked or unmarked. This supports the hypothesis that the second consonant in a final cluster is marked in relation to the first regardless of category. The data for nasal clusters supports this hypothesis also. See Table 55.

Table 55. Deletion Rules for Final Nasal Clusters

Type of cluster	Deletion rule	% of occurrence
Nasal + C	Nasal → Ø	.93
	C → Ø	39.12

This shows that final consonant deletion was a major strategy for simplifying nasal clusters as well. It appears then, that for this population, final consonant deletion as a simplification process overrides any proposed marked-unmarked processes.

This led us to suggest a new markedness convention, i.e. $C_1C_2\# \rightarrow C_1\#$. In only liquid clusters did markedness prove to be of any importance accounting for 30.99% of deletion for both /r/ and /l/ clusters together and 50% of deletions of /r/ alone. It may be that this population is too old to compare with the studies of children in the first three years.

In summary, it appears that these children used the same types of processes for consonant cluster simplification as those reported in the normal and abnormal literature. However, final consonant deletion was used to a much higher degree than has been reported on in other studies.

4.1 Initial Consonant Clusters

There has been a great deal of research conducted on initial consonant clusters. Templin (1957) as discussed above, found that /s/ + nasal, liquid or stop consonants and stop + liquid clusters tend to be acquired by age four. The individual clusters and age of acquisition are listed below in Table 56.

Table 56. Summary of Templin's Initial Consonant Acquisition Data (1957)

	Type of cluster	Cluster	Age acquired (75%)
Acquired by age 4;0	s + nasal	sm	4
		sn	4
	s + stop	sp	4
		st	4
		sk	4
	stop + liquid	pl	4
		pr	4
		bl	4
		br	4
		tr	4
		dr	4
		kl	4
		kr	4
		gl	4
	stop + glide	tw	4
		kw	4
Acquired after age 4;0	stop + glide	gr	4;6
	f + liquid	fr	4;5
		fl	5
	s + liquid/glide	sl	7
		sw	7
	θ + liquid	θr	7

As discussed briefly above, a child will usually simplify a cluster by deleting one of the members. Greenlee (1974) has proposed four stages of initial consonant cluster acquisition as follows:

Stage 1: Deletion of entire cluster: clown → [aɷn]

Stage 2: Reduction of cluster to one member: clown → [kaɷn]

Stage 3: Substitution of one member of a cluster: clown → [kwaɷn]

Stage 4: Correct use of cluster: clown = [klaɷn]

Very few examples of Stage 1 have ever been found. Those cited occurred in very early months and were reported by Greenlee of 2 children speaking French.

As discussed earlier a number of authors have discussed the reduction of clusters by deletion of one member of the cluster, often referred to as the "marked" member (cf. earlier discussion on marking conventions). (Ingram, 1976; Smith, 1973) Ingram (1976) reports that occasionally children delete the unmarked member of a cluster and gives the following examples from Smith:

1. stop → [sɔp]
2. trolley → [lɔli]
3. three → [li]

Another process that children use in Stage 2 and then on into Stage 3 is a process which Ingram calls "weakening of stops". This is an assimilation process, and he cites examples from his daughter's production of "truck".

[gʌk]	1;9	[fʌk]	2;0
[gʌk]	1;10	[frʌk]	2;0
[kʌk]	1;10		

When the second member of a cluster is a liquid (/r/, /l/), it is often first produced as a labial glide /w/ and the stop assimilates not only the loss of closure but also the labiality of this element as in [fwɩn] for "twin". It may be noted that although adults may judge single stops and stop from underlying C + /r/ clusters to be homophonous, several studies have examined these productions spectrographically (Menyuk, 1971; Kornfeld; 1971). These measurements have indicated that although the differences arenot perceived by adults, underlying clusters are distinguished by duration and offglides from underlying single stops. Another process which occurs frequently (not only in clusters) is velar-dental interchange. Smith cites many instances of anticipatory assimilations for single consonants as does Ingram.

In Stage 3, clusters appear with various types of substitutions. Greenlee(1974) and Olmsted (1971) give the following examples:

r → w	brown	[bwaɷn]
l → w	sleep	[fwip]
r → l	bread	[blɛd]

Greenlee (1974) also reports that early recognition of a cluster may simply be coarticulation of the stop, e.g. affrication and palatalization. She cites the following examples:

cracker	[kxakxa]	Hildegard	1;7	[x] = velar fricative
train	[tʃ am]	Edmond	2;1	

In addition, she cites a few examples of children who avoided clusters by metathesis, as in blue becoming [bu:l](Smith, 1973). Another example of a possible cluster underlying a surface single consonant is when a child produces a voiceless nasal for an /s/ + nasal, e.g.[n̥oɷ] for snow. Both Greenlee (1973) and Smith (1973) have made such observations on their two subjects, e.g.

Snap	[n̥æp]
Snip	[n̥ɩp]

These were both produced by Greenlee's subject at age 3;0. Schwa insertion as a method of breaking up consonant clusters, is reported in the literature as a minor process and occurs only after a few clusters are evident in the child's speech. This may be a very short lived and minor process for normal children.

Abnormal Studies

Curtiss (1977) discusses various phonological rules of her subject, Genie. Genie simplified initial consonant + liquid (r, l) clusters by deleting the liquid as most normal children do. She then acquired an /r/ and still later an /l/. At a much later time, this deletion rule was lost and Genie began using schwa insertion as a major strategy to break up C + liquid clusters. /s/ clusters were first simplified by /s/ deletion and then later by this same schwa insertion rule:

play → [pəleɩ]
smoke → [səmoʊk]

However, Curtiss notes that Genie used deletion of /s/ more frequently than schwa insertion

Lorentz (1976) reporting on Joe, a child with a deviant phonological system, listed the following errors:

sw → f	st → s
sm → f	sk → ks
sp → f	
sn → s + Ṽ	

Thus, Joe, as distinguished from many normal children, tended to have rules which deleted the "unexpected" number of the cluster, while at the same time preserving some aspect of that deleted consonant into the one remaining. Thus, smoke → [foʊk] by deletion of the /m/ but assimilates the /s/ to the labial /f/ thereby retaining the labial feature of the /m/.

Compton (1976) and Oller (1973) both reporting on deviant phonologies report the same type of rules as normal children use. In addition, Compton notes an additional important rule of deaspiration. He states that many children keep words from becoming homophonous by the use of this rule. For example,

pin is realized as [pʰɪn]

but spin is realized as [p˭ɪn]

This may demonstrate that the child has an underlying representation of a consonant cluster for "spin" and not for "pin" or it may demonstrate that the child has a lexical contrast between /p/ and /pʰ/.

Compton lists the following most commonly occurring deviant phonological rules (20% or greater) for initial consonant blends of children with severe articulatory disorders. This will be compared with the data in the present study.

Table 57. Compton's Most Commonly Occurring Deviant Phonological Rules for Initial Consonant Clusters (1976, p. 90)

I Liquids in Blends:

1. $\begin{bmatrix} r \\ l \end{bmatrix} \rightarrow \emptyset = 60\%$

(a) $[r] \rightarrow \emptyset = 20\%$

(b) $[l] \rightarrow \emptyset = 15\%$

(1, 1a, 1b together) = 95%

2. $\begin{bmatrix} r \\ l \end{bmatrix} \rightarrow [w] = 15\%$

(a) $[r] \rightarrow [w] = 15\%$

(b) $[l] \rightarrow [w] = 15\%$

(2, 2a, 2b together) = 45%

Consonants and Glides after /s/:

3. $\begin{bmatrix} +\text{stop} \\ -\text{voice} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{stop} \\ -\text{voice} \\ -\text{aspir.} \end{bmatrix}$ = 20% (pseudodeviant rule, i.e., /s/ is omitted)

4. $[w] \rightarrow \emptyset = 25\%$

III /s/ in Blends:

5. $[s] \rightarrow \emptyset \ / \underline{\quad} \ [+\text{cons.}] = 80\%$

(a) $[s] \rightarrow \emptyset \ / \underline{\quad} \ \begin{bmatrix} +\text{cons.} \\ -\text{nasal} \end{bmatrix} = 15\%$

(5, 5a together) = 95%

6. $[s] \rightarrow [f] \ / \underline{\quad} w = 20\%$

7. $[s] \rightarrow [\int] \ / \underline{\quad} l = 25\%$

4.11 Comparison With Normal Studies

Templin's data: Templin states that normal children have acquired 16 initial clusters by age four. These 16 plus two others, /fr/ and /gr/ at age 4½ years would seem to be the easiest clusters followed by the others by age 6-7 years. Table 58 lists the consonant clusters in order of Templin's acquisition data along with the percent correct for the subjects in this study.

Table 58. Comparison of Initial Consonant Acquisition by Subjects In Present Study With Templin's Age of Acquisition Study

Cluster	Age of acquisition (Templin)	% correct in present study
s + nasal	4	19.34%
s + stop	4	14.33%
stop + liquid	4	pl 46.3% bl 40.0% gl 37.96% kl 25.45% dr 20.0% br 18.75% kr 17.07% tr 12.5% pr 0.0% kw 85.0% tw 47.8%
stop + liquid (gr)	4;6	gr 14.6%
f + liquid	fr 4;6 fl 5	fr 5.45% fl 5.56%
s + liquid	sw 7 sl	sw 16.67% sl 12.04%
θ + liquid	θr 7	θr 14.6%

If we use 75% as the required percentage for acquisition we see that none of the clusters have been acquired by this population except for /kw/ at 85% correct. Furthermore, the only clusters that seem easier than the others by virtue of percent correct are stop + lateral and the stop + glide clusters. The /r/ clusters and the fricative clusters are all clustered around from 15-20% correct with the /f/ + liquid clusters only at the 5-6% correct level. It is also interesting

Thus, according to the above interpretation, the deleted consonant was marked about half the time and unmarked the other half. However, if we look at this in terms of the information that the deleted consonant provides, we can see a better interpretation. Take the C + liquid clusters for example; it is important to make distinctions between /pl/ and /pr/ for words such as pleasant and present--thus the liquid provides us with important information. However, it is not quite so critical as the initial consonant which could be any number of stops or fricatives, making the distinction between train, crane, drain, grain, brain, etc. Now look at the /s/ + stop or nasal clusters. There is only one fricative which could be in front of those stops and nasals--an /s/. Therefore, it is not critical in terms of distinctions between words. The child may be keeping the distinction by timing, i.e. leaving a pause for the missing /s/ before she produces the stop or nasal; or making the distinction between spin and pin using the initial consonant, /p/ vs. /p^h/. Thus, the /s/ is not very important and it is therefore deleted. Thus, we can predict that the /s/ will be deleted not because it is marked but because it is unmarked. The analysis presented so far, parallels information the literature reports on for normal subjects.

Ingram (1976), Greenlee (1973) and others have cited various assimilation rules present in dealing with clusters. The subjects of this study also used a number of the same types of assimilation rules. Usually, the assimilation involved a type of labialization of a phoneme and/or a weakening of a stop. For example, the following types of substitutions occurred:

to note that none of the /pr/ clusters were correct.

In terms of Greenlee's stages of acquisition, the subjects of the present study seem to be in Stages 2 and 3, deleting or substituting one member of the cluster. If we look at the analysis in terms of whether the deleted member is "marked or unmarked" according to Chomsky-Halle, the following pattern emerges. Chomsky-Halle (1968, p. 413) state that the least marked consonants are /p, t, k, s, n/--thus I am assuming that glides and liquids are more marked than these segments. In terms of a cluster, one remark must be noted. Chomsky-Halle state that before a consonant, the segment should be [+continuant]. Thus, I would assume that before a nasal or stop, the /s/ would be unmarked for continuancy and would be less marked than the nasal or stop since /s/ is the only consonant that could occur in that position. Table 59 shows the analysis using the above marking conventions.

Table 59. Analysis of Deletion in Initial Consonant Clusters Using Marking Conventions

Cluster (excluding 3 consonant clusters)	Deletion of marked member (# of responses)		Deletion of unmarked member (# of responses)	
C + liquid	liquid → Ø	342	C → Ø	11
stop + glide	glide → Ø	8	stop → Ø	5
/s/ + nasal	nasal → Ø	15	/s/ → Ø	142
/s/ + stop	stop → Ø	27	/s/ → Ø	233
/s/ + glide	glide → Ø	61	/s/ → Ø	26
	Total	453		417
	Percent	52.07%		47.93%

br, pr, tr, gr → Φw
dr → fw

What is happening in the above examples, is that the stop weakens to some type of fricative but also changes place of articulation to agree with the following labial /w/. Thus the phoneme /Φ/ occurs which is not an English phoneme. Assimilations also occur with fricatives, with /θ/ and /s/ becoming [f] before /w/. The /w/ may be underlying or it may have resulted from liquids changing to [w]. In many of the above cases the glide is then deleted, and we are left with some type of labial fricative, e.g.

plane → [pweɪn] → [Φweɪn] → [Φeɪn].

Greenlee (1973) reported that affrication or coarticulation of two consonants may be evidence of an underlying cluster. Some of the subjects in the present study affricated certain clusters. Sometimes the following sound was omitted and sometimes changed to a [w]. Thus we have the following in Table 60.

Table 60. Types of Affrication Rules in Initial Consonant Clusters

Affrication rules	# of responses
s → tʃ /__w	31
b → dz/__r	2
d → {dz, dʒ}/__r	3
t → {ts, tʃ}/__r	23
g → dʒ /__l*	6

*This rule was more of an assimilation to the following fricative and occurred only in the word glasses [dʒætʃ əz].

Another rule cited earlier is velar-dental interchange. This occasionally took place with these subject and usually occurred before /r/ as in drink → [grɩŋk] and train → [kreɩn].

4.12 Comparison With Abnormal Studies

Two rules which have been reported over and over again in the deviant populations are lisping--both frontal and lateral. The subjects of this study also used these processes. Lateral lisps occurred with three of the subjects. Frontal lisps were more prevalent accounting for 84 substitutions in initial /s/ clusters.

Compton (1976) cites /s/ deletion as occurring 80% before a stop and 15% when the consonant is a nasal. The subjects in the present study used /s/ deletion 67% before a nasal and 72% before a stop and accounting for 70.36% of the deletions before a stop or a nasal. He doesn't mention /s/ deletion before a glide presumably because it does not reach the 20% level. The subjects of the present study used this rule 16.67% of the time, which is approaching the 20% level. Compton also notes that deaspiration of a stop following /s/ deletion is a fairly common rule for his subjects occurring 20% of the time. Out of the total possible responses after /s/ deletion, the subjects of the present study used deaspiration 82.53% of the time showing that these subjects were distinguishing between an initial cluster and a single consonant or had a lexical distinction between /p/ and /p^h/. In addition a few of the subjects devoiced nasals after /s/ deletion as had been noted by Smith (1973).

Compton also cites glide deletion after /s/ as a common rule occurring 25% of the time. The subjects of the present study used this rule 37.65% of the time rather than deleting the /s/. Thus, /sw/ and /sl/ showed different patterns from /s/ + nasal or stop clusters. In the former the liquid or glide was deleted more often, in the latter, the /s/.

Two other rules which Compton cites as prevalent for his population are 1) s → f/__w (20%) and 2) s → ʃ/__l (25%). Since not many of the subjects in this study could produce a correct /l/ in second position (i.e. /l/ deletion occurred), the second rule did not occur very much--only 10 responses or 9.26%. The first rule was quite prevalent, occurring 15 times with /w/ still present and 24 times when the /w/ had been deleted accounting for 24% of the responses.

Looking at initial liquid clusters, we see that Compton's subjects used liquid deletion 95% of the time and substitution of [w] for /r/ or /l/ 45% of the time. The subjects of the present study deleted /r/ 27.5% of the time and /l/ 40.18% of the time. Glide substitution occurred 48% of the time for /r/ and 22% of the time for /l/. I did not figure my percentages exactly as Compton did. He counted the number of responses for subjects who deleted both /r/ and /l/ and then those who only deleted /r/ and those who only deleted /l/, etc. I counted the number of responses rather than looking at subjects. The subject analysis will be presented in Chapter 6. However, we can see that these are approximately the same percentages as Compton arrived at. The one difference that I found is that the present subjects deleted /l/'s much more than /r/'s and that gliding occurred for /r/'s more than for /l/'s. Compton has more deletions for /r/'s than /l/'s and approximately the same percentage for gliding rules.

4.2 Liquids

For a more thorough review of the literature on liquids, see the previous sections on consonant clusters. In addition to that Compton (1976) lists some common rules for initial and final liquids. Table 61 presents Compton's rules in comparison with the present study. Compton does not discuss final liquid vocalization as a common rule for his population. Ingram (1976) does cite it, however, as a prevalent rule for normal children. We can see that the data in the present study involve similar rules but with different percentages. In the present study, /l/ was substituted for by two different segments [w] and [j] totalling 43.37%. Compton, however, found that /l/ was substituted for only by [w] 40% of the time and was deleted in initial position 20% of the time.

Table 61. Comparison of Present Study With Compton's (1976) Study (pp. 89, 91) for Liquids

Compton's rules	% of occurrence	Present study: % of occurrence
Initial position		
5. [r, l] → w	40% ⎤	l → w 14%
	⎬ 95%	r → w 79.54%
a) r → w	55% ⎦	
6. l → ∅	20%	l → j 29.37%
Final position		
14. l → ∅	75%	l → ∅ 34.62%
		l → vowel 46.15%
		r → vowel 75.92%

There were no initial /l/ deletions in the present study. Compton's high percentage of final /l/ deletion could be because he chose different words from school and smile. If smile had not been a stimulus in the present study the deletion may have been higher. It is surprising that Compton did not find the /l/ → /j/ as a major rule since other studies have talked about this. It is also surprising that he did not find liquid vocalization as a major rule since it seems so widespread for this population as well as for the normal population.

4.3 Affricates and Fricatives

Templin (1957) lists affricates and fricatives according to the age at which 75% of children tested produced them correctly. Table 62 shows such a list with percentages from the present study at the right.

Table 62. Comparison of % Correct for Affricates and Fricates of Present With Templin's Study

Phoneme	Age acquired (Templin, 75%)	% correct, present study
#f-	3;0	+ 93.26
-f-		+ 83.33
-f#		+ 74.31
**#h-		+ 95.73
-s-	3;6	(+) 60.95
-z-		- 33.65
#s-	4;0	+ 73.33
#ʃ-		- 43.03
-ʃ#		- 22.94
-v-		+ 69.81
#dʒ-		- 40.78
-s#	4;6	(+) 49.66
-ʃ-		- 29.8
#tʃ-		(+) 51.81
-tʃ-		- 38.68
-tʃ#		- 24.53
-dʒ-	5;0	- 17.78
#θ-	6;0	- 33.02
-θ#		- 5.5
#v-		+ 71.43
-v#		- 32.08
#ð-		- 28.04
-ð-	7;0	- 19.42
#z-		- 42.99
-z#		- 43.12
-ʒ-		- 23.47
-dʒ#		- 21.29
-ð#		- 4.81

KEY: + = 70% or more correct
(+) = 50-69% correct
- = less than 50% correct

**/h/ is included as a fricative here to match Templin's study

One question of interest is whether linguistically deviant children acquire sounds in the same order as do normal children acquiring sounds. In order to do this we must also consider the source of the acquisition data. Templin ignores the fact that all English sounds are not of equal frequency since she elicited each sound in one word only. Olmsted (1971) avoided this by using the spontaneous speech of 100 children, ages 1;3-4;6 years. Olmsted not only looked at order of acquisition but also distinctive feature errors of place, friction, voicing and nasality. We will look at this more closely in Chapter 6.

In regards to order of acquisition, Olmsted defined a sound as acquired if more subjects in an age group attempted and correctly pronounced a sound 50% more than subjects that did not. His data are shown in Table 63 and is quite similar to Templin's data. However, there are a few differences which may be important.

Table 63. Sounds Acquired and Not Acquired by Age 4;0 According to Olmsted (1971)
If no position is marked, all environments are referred to.

	Acquired by age 4;0	Not acquired by age 4;0
Affricates	-tʃ#, -dʒ-	#tʃ-, -tʃ- #dʒ-, -dʒ#
Fricatives	f, -θ-, -θ#, s, ʃ v, -z-, -z#	ð, #θ- #z-, -ʒ-, -ʒ#

The differences lie in the ages of acquisition of /v/ and /z/. Templin states that initial and final /v/'s are not acquired until age 6;0 but Olmsted found that /v/'s in all positions were acquired by age 4;0.

If we look at the data from the present study, we can see that /v/'s have a higher percentage correct than some of the sounds in the 4;6 age range. Also, the /z/'s have a much higher percentage than the other members of their group. If we order all the phonemes in the present study we find the following order in Table 64. In Templin's groupings, we can assume that a sound that is acquired at an earlier age is easier in some sense (both perceptual and in production) than a sound acquired at a later age. Since all of the present study 's subjects are over the age of 5;0, we can only make tentative conclusions regarding easier and more difficult sounds in relation to age.

It appears that initial /tʃ/, initial /v/ and final /s/ and /z/ are in a different order than in Templin's study. Thus, the above phonemes were correct more often than earlier learned sounds in Templin's study. In contrast, initial /dʒ/ and initial and final /ʃ/ were ordered later in the present study than in Templin's. Initial /z/ was not learned until 7;0 years of age in Templin's study, yet for the present study it is ordered thirteenth, above the more difficult sounds in the last grouping. Thus, medial and final /ʃ/, final /tʃ/, and /θ/ and intervocalic /dʒ/ appear in a lower ranking than in Templin's study by age. Some of the orders of acquisition have been maintained according to Templin while others have not and it is difficult to speculate exactly why.

Table 64. Phonemes in Present Study Ranked in Order of Percent Correct and Compared With Templin's Acquisition Order By Age

Order agreement with Templin study by group	Present study		Templin's study	
	Phoneme	% correct	Phoneme	Age
+	#h**	95.73	h	3;0
+	#f-	93.26	f-	
+	-f-	83.33	-f-	
+	-f#	74.31	-f	
+	#s-	73.33	s-	3;6-4;0
-	#v-	71.43	-s-	
+	-v-	69.81	-v-	
+	-s-	60.95	-z-	
-	#tʃ-	51.81	ʃ-	
-	-s#	49.66	-ʃ	
-	-z#	43.12	dʒ-	
-	#ʃ-	43.03	-s	4;6-5;0
-	#z-	42.99	-ʃ-	
-	#dʒ-	40.78	tʃ-	
+	-tʃ-	38.68	-tʃ-	
-	-z-	33.65	-tʃ	
-	#θ-	33.02	-dʒ-	
+	-v#	32.08	-v	6;0
-	-ʃ-	29.8	ð-	
-	#ð-	28.04	θ-	
-	-tʃ#	24.53	-θ	
-	-ʒ-	23.47	v-	
-	-ʃ#	22.94	-ð-	7;0
+	-dʒ#	21.29	-dʒ	
+	-ð-	19.42	-ʒ-	
-	-dʒ-	17.78	z-	
-	-θ#	5.5	-z	
+	-ð#	4.81	-ð	

**/h/ is included as a fricative to agree with Templin's study.

Ferguson (1972) compared Olmsted's (1971), Snow's (1963) and Bricker's (1967) studies and came up with three groups of fricatives which are acquired in the following order, the order within the groups being unspecified: first /f s ʃ/, then /v z/ and finally /θ ð and ʒ/. Ferguson states that this order is consistant with Jakobson's predictions. Jakobson asserts that the dental fricative is acquired before the labiodental /f/, but the groups considered as a whole do not falsify his claim. However, in both Templin's study and Olmsted's study as well as the present study, the /f/ is acquired before the /s/. The present study does not find the same order for the groups of fricatives. Rather both /f/ and /v/ are acquired before /ʃ/, the subjects apparently having more difficulty with the palatal fricative than normal children do. See Table 65 below.

Table 65. Acquisition of Fricatives: Ferguson vs. Present Study

Ferguson's groups	Present study
f, s, ʃ	f, s, v
v, z	z, ʃ
θ, ð, ʒ	θ, ð, ʒ

Other than the /ʃ/, the same ordering for the present study and Ferguson's groups holds.

In terms of substitutions, Jakobson (1968) predicts that the child first substitutes homorganic stops for fricatives. Snow (1963) in a study of 438 first grade children found that fricatives and affricates have a larger number of substitutions and a more diverse range of substitutions than any other class of consonants. Bricker (1967) and Olmsted (1971) both present data on types of substitutions. Ferguson summarizes all three studies and gives the composite pattern of favored substitutions. Table 66 shows this composite along with data from this study.

The present study also finds a diverse range and number of substitutions regarding fricatives as did Snow. For example, /ð/ has 13 different substitutions, /v/ has 12, /θ/ has 14, /s/ has 11, /z/ has 15, etc. There are some differences in the most prevalent substitutions for certain fricatives. For /f/, the subjects of the present study substituted equal percentages of both [s] and [v]--[v] occurring almost exclusively in the initial position and [s] in medial and final positions. The same predictions are found for /s/, /ʃ/, /v/, /ð/ and /θ/. However, for /z/, voiced [ð] accounted for most substitutions, followed by [dʒ] and finally by [s]. For /ʒ/ the main substitution was a [z] rather than the [dʒ] found in the other studies. This could have been because the present study concerned itself with intervocalic position exclusively for that phoneme.

In addition to the substitutions noted for normal children these subjects also produced a number of lateral distortions of their sibilants. This seems to be characteristic only of abnormal populations.

Table 66. Comparison of Substitutions for Fricatives Found In Studies by Bricker, Snow, and Olmsted With Those Found In Present Study
Percentages calculated on total number of substitutions for a particular phoneme.

Target phoneme	Substitution based on Snow, Bricker, Olmsted	Substitutions in present study with % occurrence	
f	s	s v t	(20%) (29%) (15.5%)
s	distortions, θ, ʃ	θ lateral /s/ ʃ tʃ t	(50%) (14.5%) (9.9%) (9.9%) (7.6%)
ʃ	s, tʃ	s lateral distortion ts tʃ	(72%) (7.5%) (5.99%) (5.2%)
v	b	b f	(49.5%) (18%)
z	s	ð dʒ s lateral /z/	(33.7%) (10.6%) (9.4%) (9.4%)
ð	v, d	d v z j	(44.1%) (26.6%) (10%) (7.4%)
θ	f, s	f t s	(47.56%) (20.7%) (17%)
ʒ	dʒ	z dʒ	(39.7%) (13.7%)

Jakobson predicted that homorganic stops would be substituted for the fricatives more than any other substitution. This is true in this study only in the [b] for /v/ substitution and the [d] for /ð/ substituion and shows up as second in frequency for the [t] for /θ/ substitution although this is true only for initial position. In addition, Jakobson predicts that the affricates /tʃ/ and /dʒ/ are more difficult than fricatives and are acquired later. The data here as well as the data from Ferguson (1972) show that it is often affricates that substitute for the fricatives and that they are acquired, at least in initial position, before some of the fricatives. In fact, in the present study, /tʃ/ is acquired before /ʃ/ and they are at the same place of articulation. Menn (1971) has also noticed that her subject acquired affricates before the homorganic fricative was acquired, specifically /tʃ/ before /ʃ/. She had also acquired a dental set, /ts/ and /dz/.

Ferguson states (p. 662):

> As with other sounds, substitutions for fricatives are normally less marked than the model phoneme. They fall into three types: tighter closure (stops and affricates) e.g. ð → d, looser closure (liquids and glides) e.g. v → w, acoustically similar fricatives (place of articulation or lack of stridency) e.g. θ → f.

He goes on to say that substitutions of tighter closure tended to be more frequent in initial position. Looking at the pattern for our data we can see the same type of thing.

Table 67. Percentage of Occurrence of Different Categories of Substitutions for Fricatives for Present Study

Environment	Substitutions for fricatives			
	Stops	Affricates	Fricatives	Liquids/Glides
Initial position	35.35	9.77	52.87	2.01
Intervocalic position	22.28	8.41	60.4	8.91
Final position	16.03	5.67	78.3	0.00

Table 67 shows that although fricatives tended to be substituted for other fricatives more often than any other category, stops and affricates did tend to be substituted in the initial position more than in intervocalic and final position. In final position, fricatives were substituted 78% of the time for other fricatives.

Ingram (1975) studied children's acquisition of fricatives and affricates. He outlined four stages: Stage 1: avoidance of adult words containing fricatives or affricates; Stage 2: substitution of a homorganic stop; Stage 3: increased use of some kind of fricative or affricate often mispronounced but with substitutions of other fricatives and affricates; Stage 4: all but dental fricatives and /ʒ/ produced correctly. Stage 4: correct production. The subjects of the present study fall somewhere inbetween Stages 3 and 4 with most of them in Stage 3 if we look back at Table 62 representing percentage correct for fricatives, and Table 67 above.

4.31 Comparison With Abnormal Studies

Ingram (1976) shows the distribution of and summarizes the most common phonological processes discussed in various studies of 17 deviant children. Although many of the processes were the same ones that normal children use, there were some which were quite unusual. Table 68 lists the various phonological processes summarized by Ingram.

Table 68. Common and Unusual Phonological Processes Used by 17 Deviant Children as Summarized by Ingram (1976)

Common phonological processes among 17 deviant children	
Process	# of children using process
Cluster reduction	13
Stopping	13
Depalatalization	12
Fronting	12
Gliding	11
Deletion of final C	8
Voicing processes	7
Assimilation in clusters	6
Velar assimilation	5

Unusual phonological process among 17 deviant children	
Lisping	s → θ
Tetism	f → t
Lateral lisp	s → s̭
Nasal preference	w → m
	l → n
Fricative preference--a tendency to retain fricative and affricates absence of reduplication	

Farwell (1972) found corresponding instances of Ingram's 1975 study with regards to the acquisition of fricatives and affricates. The purpose of her study was to find out if the order of acquisition of sounds of children enrolled in an aphasia class was the same as normal children and if the same phonological rules were used by both groups. She found that for the individual fricative phonemes, the deviant children followed the normal progression in the acquisition of sounds as stated by Templin (1957) but they were behind in terms of chronological age. However, she could not determine if the phonological processes used were the same as normal children's.

A number of other studies have attempted to determine whether a child is delayed or deviant phonologically. Edwards and Bernhardt (1973) as well as Renfrew (1966) have discussed the fact that the deviant child may show the same processes as a normal child, but may keep them and persist in using them beyond the time that a normal child would drop them. Thus, for normal children, final consonant deletion drops out after about the 50th word; however, many authors have noted the persistence of the open syllable for deviant children. Edwards and Bernhardt state (p. 48):

> The phonologies written for these children are not entirely similar to those for "normal" children, even those who are much younger. Normal children who exhibit processes like prevocalic voicing generally do so at a stage before they have two and three syllable words. The children in this study have multisyllabic words, and yet they still have the rather infantile process of prevocalic voicing. There are several such examples where processes common in young children are found along with processes characteristic of older children.

Lorentz (1976) and Compton (1975) both agree that the phonology written for a child with deviant articulation would not be equivalent to that written for a normally developing child at the same stage of development.

Weber (1970) studied 18 children with moderate to severe articulation disorders. The processes which seemed to be most prevalent in their speech were fronting of velars and palatals and stopping of fricatives. This agrees with Menyuk's (1968) study in which she found that the distinctive features which the deviant children had most difficulty with were [+strident], [+continuant], and [-anterior]. The stopping of fricatives would account for the [+strident] and [+continuant] feature values being missing and the process of fronting would account for the [-anterior] feature value being missing.

Ingram (1976) has shown that mentally retarded children including Down's Syndrome use substitution patterns similar to those of normal children's speech. Specifically they use the following rules for fricatives and affricates:

1. stopping of fricatives: f → t
2. depalatalization (fronting of palatals) ʃ → s
3. deletion of final consonant
4. final consonant devoicing
5. loss of affrication

Bangs (1942) studied 53 subjects who were residents of a custodial school. Ingram has summarized Bangs' findings in terms of phonological processes in Table 69. Bangs also notes that 35% of the final errors were omissions which may be a significant factor in the speech of the retarded. In the present study, deletion of final fricatives was important only for the voiced fricatives. /z/ was deleted 17.4% of the time, /v/, 12.3% and /ð/ 20.2% of the time.

Table 69. The Most Common Substitution Processes for Affricates and Fricatives of 53 Mentally Retarded Children Based on Bangs 1942, and Summarized by Ingram, 1976.

Processes		Position (% of children using process)		
		Initial	Medial	Final
Labialization	θ → f	49	38	36
Stopping	v → b	23		
	θ → t		32	9
	ð → d		43	
	s → t	13		
Fronting	ʃ → s		15	15
	ʧ → ts		13	
Devoicing	z → s	11	-	-
Mixed	θ → s	-	21	13

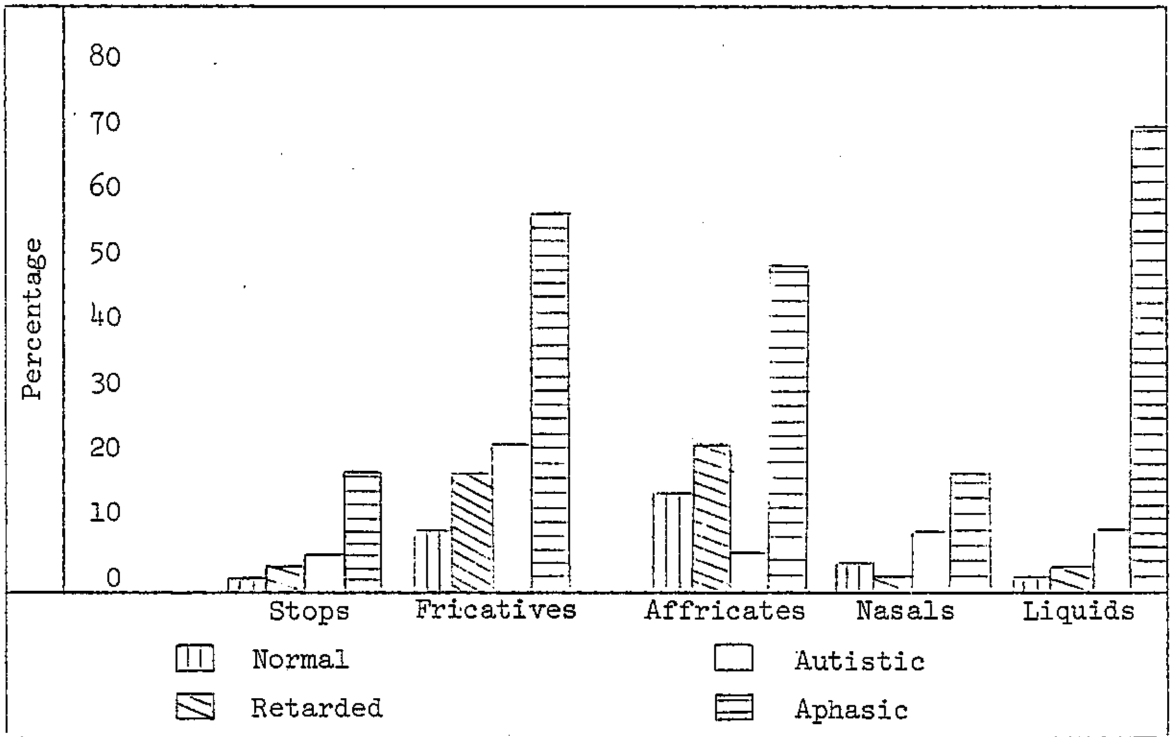
A study by Pierce and Bartolucci (1976) attempts to identify the linguistic competence of autistic children in contrast to that of normal and mentally retarded subjects. One of the three characteristics used to identify autistic children concerned language:

> 3) Language deviance characterized by abnormally slow development or loss of previous speech habits, by obvious echolalia and the inaccurate use of personal pronouns (p. 189).

Mean I.Q. scores for the autistic children were 61 and for the mentally retarded subjects, 59.5. The results indicated that the mentally retarded group made significantly more affricate than stop, nasal or liquid errors. The autistic children are particularly deficient in the production of fricatives and liquids, and differed significantly from the normal group in the production of liquids.

When we compare the results of this study with that one we see the following results:

Figure 1. % Errors In Phonological Production by Phoneme Class
Normal, retarded, autistic data from Piece and Bartolucci.
Aphasic from present study.



The graph reveals that the subjects in the present study made more errors; however, this may be a statistical confounding since Pierce and Bartolucci do not give the total number of responses in their analysis. Secondly, liquids are the most in error for this population as they were for the autistic group; however, so were affricates and fricatives with a small number of nasals and stops being produced incorrectly. Thus, a particular diagnostic pattern for aphasic children does not seem to emerge for this population.

4.32 Comparison With Other Studies of Phonological Processes

Compton (1976) lists the most commonly occurring deviant phonological rules for initial and final consonants in 20 children that he studied. Table 70 shows the processes for affricates.

Table 70. Compton's Most Commonly Occurring Deviant Phonological Rules for Affricates (1976)
These values represent the total composite percent occurrence for the general form of the phonological rules (designated by numerals) and the more specific or restricted forms (designated by subrules a, b, c, etc.) subsumed under the general rules. Each general rule and its accompanying subrules are mutually exclusive for each child.

Initial position	Final position
3. [tʃ → t / dʒ → d] = 55% ; a. dʒ → d = 20% ; (3 and 3a together) = 75%	10. [tʃ → ʃ / dʒ → ʒ] = 20%
4. tʃ → ʃ = 20%	

Ingram (1976) discusses two processes which interact: stopping and fronting. Thus, it may be hypothesized that /tʃ/ and /dʒ/ may first be fronted to [ts] and [dz] and then may be stopped or changed to [t] or [d]. However, stopping may be the only rule to occur here. In the present study, the most common processes affecting affricates is shown in Table 71.

Table 71. Most Common Phonological Processes for Present Study for Affricates
Percentage occurrence based on total number of possible occurrences of phonemes.

Process	Initial position	Intervocalic position	Final position	Stopping	Fronting
[tʃ dʒ] → [ts dz]	3.79%	15.23%	30.84%	-	14.83%
[tʃ dʒ] → [s z]	8.54%	21.19%	22.43%	-	15.71%
[tʃ dʒ] → [t d]	27.85%	19.87%	.94%	17.62%	17.62%
[tʃ dʒ] → [-cont -alveolar]	all positions = 3.67%			3.67%	-
[tʃ dʒ] → [ʃ ʒ]	all positions = 6.3%			-	-
			Total	21.29%	48.16%

As revealed in Table 71, fronting is indeed a major strategy for affricates. However, in final position the favored phonemes are /ts/ and /dz/, alveolar affricates, followed by /s/ or /z/. However, in initial position, although fronting is still important, it occurs along with stopping; thus the favored phonemes are /t/ and /d/. For intervocalic position, they are almost equally distributed between the three-alveolar affricates, fricatives and stops. Comparing the present study with Compton's study, we can see that although stopping is most prevalent for initial position (33.86%) it does not reach the 55% mark cited by Compton. In fact, most of the initial affricates were correct--/tʃ/ being correct 51.8% and /dʒ/ being correct 40.78% of the time. Stopping was almost nonexistent in final position, perhaps meaning that in final position it is easier for this population to produce fricatives and affricates rather than stops. Compton also states that in initial position /tʃ/ became [ʃ] 20% of the time. This was not done by the subjects of the present study, only using this rule 6.3% for all three positions and most often in final position. However, it may be that many of the subjects for this study are also fronting the /ʃ/ and /ʒ/ to [s] and [z] since this rule was used 15.71% in final position and fronting was a major strategy for this population occurring 48% of the time.

Now, let us turn to the most commonly occurring deviant phonological rules for fricatives as listed by Compton (1976) as shown in Table 72. In discussing these rules for the present study, we will first look at the stopping rules, next the fronting rules, the affrication rules and lastly, the devoicing rules. We will then turn to the unusual phonological rules which Ingram discusses as shown in Table 68 on page 109.

Table 72. Compton's Most Commonly Occurring Deviant Phonologically Rules for Fricatives In Initial and Final Positions (1976)

Initial position

Process	No.	Rule	Percentage	Combined
Stopping processes	8.	$\begin{bmatrix} f \\ v \end{bmatrix} \rightarrow \begin{bmatrix} p \\ b \end{bmatrix}$	= 25%	= 80%
	a.	$v \rightarrow b$	= 80%	
	9.	$\begin{bmatrix} \theta \\ ð \end{bmatrix} \rightarrow \begin{bmatrix} t \\ d \end{bmatrix}$	= 55%	= 100%
	a.	$ð \rightarrow d$	= 45%	
	10.	$\begin{bmatrix} s \\ z \end{bmatrix} \rightarrow \begin{bmatrix} t \\ d \end{bmatrix}$	= 15%	= 50%
	a.	$s \rightarrow t$	= 20%	
		$z \rightarrow d$	= 15%	
	13.	$ʃ \rightarrow t$	= 25%	
	11.	$z \rightarrow s$	= 40% (devoicing)	
	12.	$z \rightarrow dʒ$	= 20% (affrication)	
	15.	$ʃ \rightarrow tʃ$	= 20% (affrication)	
	14.	$ʃ \rightarrow s$	= 20% (fronting)	

Final position

Process	No.	Rule	Percentage	Combined
Stopping processes	5.	$\begin{bmatrix} +\text{frict} \\ -\text{labial} \end{bmatrix} \rightarrow \begin{bmatrix} t \\ d \end{bmatrix}$	= 20%	= 35%
	a.	$\begin{bmatrix} +\text{frict} \\ -\text{labial} \\ -\text{voi} \end{bmatrix} \rightarrow t$	= 15%	
	6.	$\begin{bmatrix} f \\ v \end{bmatrix} \rightarrow \begin{bmatrix} p \\ b \end{bmatrix}$	= 20%	= 55%
	a.	$v \rightarrow b$	= 35%	
	7.	$\begin{bmatrix} \theta \\ ð \end{bmatrix} \rightarrow \begin{bmatrix} f \\ v \end{bmatrix}$	= 35%	
	8.	$z \rightarrow s$	= 35% (devoicing)	
	9.	$\begin{bmatrix} ʃ \\ ʒ \end{bmatrix} \rightarrow \begin{bmatrix} s \\ z \end{bmatrix}$	= 35% (fronting)	

Table 73. Percent Use of Stopping Rules for Fricatives Based On Total Number of Possible Phonemes
Percent occurrence of stopping rules in relation to the total number of errors (both substitutions and deletions) is reported in the last column.

Phoneme	Substitution and Environment			Total % occurrence	% of total errors
	Initial	Intervocalic	Final		
f	p - 1.1%	- t - 1.85%	- t - 1.85%	2.48%	18.75%
v	b - 24.29% k - 1.43%	b - 11.32% d - 8.49%	b - 24.53% d, p - 10.38%	26.95%	61.29%
θ	t - 30.19% d - .94%		t - 1.84%	16.28%	20.12%
ð	d - 57.94%	d - 31.07% ? - 3.88%	d - 6.73%	32.44%	40.54%
s	t - 0%	t - 2.86%	t - 4.83%	2.94%	7.25%
z	d - 1.87% g - .94%	d - 5.61% t - .94%	d - 5.5%	4.96%	8.25%
ʃ	t - .61%	t - 3.97%	t - 1.84%	2.12%	3.17%
ʒ		d - 7.14% t - 1.02%		8.16%	10.67%
			Total	11.92%	20.66%

If we can look at the stopping rules, we can see that the only continuants which are stopped over 20% of the time are /v/, /θ/ and /ð/. /θ/ was changed to a stop almost exclusively in initial position. Since there were very few errors for /f/, the stopping rules occurred only 2.48% of the time which does not compare to Compton's 25%. However, if we look at stopping in relation to other types of errors for /f/, we see that they occurred 19% of the time which does approach

Compton's 25% level. Neither were the /s/, /z/ or /ʃ/ stopped as much as in Compton's study. It will also be noted that in the majority of cases in Table 73, manner was the only feature changed, voicing remaining essentially constant. In addition, the fricatives were replaced in the majority of cases by their homorganic stops, or by the stop in the closest position to the fricative's place of articulation.

Turning now to Table 74, we can see that the subject's of the present study seem to use fronting rules as major strategies.

Table 74. Fronting Processes for Fricatives In Present Study Based On Total Number of Possible Phonemes for Each Phoneme Category Percent occurrence of stopping rules in relation to the total number of errors (both substitutions and deletions) is reported in the last column.

Process	Environment and % of occurrence			Total % of occurrence	% of total errors
	Initial	Intervocalic	Final		
ʃ → {s, ts / t}	45.50% .61% 46.11%	50.33% 3.97% 54.30%	53.21% 1.84% 55.05%	51.29%	76.76%
ʒ → {z, s, dz / d, t}		34.69% 8.16% 42.85%		42.85%	56%
			Totals	49.71%	72.42%

Fronting was used 51% of the time for /ʃ/ and 42.9% of the time for /ʒ/ and 50% overall. Compton, however, found that his subjects used fronting only 20% of the time in initial position and 35% of the time in final position. This means that for the palato-alveolar fricatives, fronting is a more prevalent rule than stopping for the present population. Whereas stopping accounted for only 3% of the errors for /ʃ/

and 10.7% of the errors for /ʒ/, fronting accounted for 72.4% of the total possible errors for /ʃ/ and /ʒ/ combined.

The next processes to discuss are those of affrication as shown in Table 75.

Table 75. Affrication Processes for Fricatives in Present Study Based On Total Number of Possible Phonemes for Each Phoneme Category
Percent occurrence of stopping rules in relation to the total number of errors (both substitutions and deletions) is reported in the last column.

Process	Environment and % of occurrence			Total % of occurrence	% of total errors
	Initial	Intervocalic	Final		
s,ʃ → ts,tʃ	2.75%	8.2%	7.87%	6.27%	11.37%
z,ʒ → dz,dʒ	22.43%	4.88%	0%	10.9%	12.64%
			Totals	7.61%	11.87%

Compton found that both /z/ and /ʃ/ were affricated approximately 20% of the time. In this study, only the voiced fricative /z/ was affricated over 20% of the time--or 22.43% in initial position. Note also that voicing remains unchanged. For the remainder of the fricatives, we can see that affrication was a minor process accounting for only approximately 12% of the errors for these four fricatives.

Finally, let us look at devoicing rules. Compton mentions two different rules: 1) z → s, 40% in initial position and 2) z → s, 35% in final position. It seems strange that /z/ would be devoiced more in initial position than in final position, since final consonant devoicing is a very common rule in languages around the world. In fact, his findings are not replicated here. Only consonants in the final position were devoiced to any extent as Table 76 shows.

Table 76. Devoicing Rules for Voiced Fricatives
Percentage occurrence calculated for final position only.

Process	# of responses and environment: Initial	Intervocalic	Final	Total % of occurence in final position
z → s	0	1	14	12.84%
z → [-voi] (place and manner changed)	0	9	4	
			18	16.51%
v → f	1	3	16	15.09%
v → [-voi] (place and manner changed)	1	0	11	
			27	25.47%
ð → [-voice] (place changed)	4	5	9	8.65%

Thus we can see that /z/ was devoiced 16.5% in final position, /v/ 25.5% and /ð/ only 8.65%. Percentages were not calculated for the other positions since the numbers were very small.

Other rules: Compton has an additional substitution rule for dental fricatives which occurs 35% of the time in final position only: θ → f; ð → v. In the present study, two substitutions for dental fricatives were common--labio-dental and alveolar fricatives.

Table 77. Substitutions for Dental Fricatives

Process	Environment and % of occurrence			Total % of occurrence	% of total errors
	Initial	Intervocalic	Final		
θ → f	19.81%		52.29%	36.28%	44.83%
θ → s	5.66%		20.18%	13.02%	16.09%
ð → v	0%	17.48%	50%	22.29%	27.03%
ð → z	1.87%	5.83%	14.42%	7.33%	8.88%

Thus, by far the most prevalent substitution is the/θ/→[f](52%) and /ð/→[v](50%)in final position. However, in initial position /θ/→ [f] almost 20% of the time. The second rule, /θ/ → [s] and /ð/ → [z] is prevalent in final position only occurring 20.2% and 14.4% respectively. Stopping rather than these rules is the prevalent process in initial position.

Two other processes which are deviant and which Ingram speaks of are lisping processes-- both frontal and lateral lisping. A frontal lisp or /s/ → [θ], /z/ → [ð], occurred in 18.1% of all possible cases accounting for 36.15% of the total errors for /s/ and /z/. Lateral lisping (a lateral escape of air on all sibilant sounds) occurred on only 6.91% of all possible cases of /s, z, ʃ, ʒ/ and accounted for 11.9% of the total errors for those four phonemes. This parallels the literature reporting these types of errors for articulation defective children.

In addition to his substitution rules, Compton also lists some deletion rules for final consonants. Ingram (1976) states that final consonant deletion is a common phonological process among young children. Compton's rules and percentages are listed in Table 78 along with the percentages from the present study.

Table 78. Comparison of Percentage of Occurrence of Final Deletions: Present Study vs. Compton, 1976

Compton's processes with % of occurrence	Processes in present study with % of occurrence
13. d. s → ∅ ⎤ e. z → ∅ ⎦ 10%	s → ∅ 4.83% z → ∅ 17.43%
12. [+cont]** → ∅ 10% ⎤	[+cont] → ∅ 10.5%
a. $\begin{bmatrix} +\text{cont} \\ +\text{voi} \\ -\text{labial} \end{bmatrix} \rightarrow \emptyset$ 20% ⎦ 30%	$\begin{bmatrix} +\text{cont} \\ +\text{voi} \\ -\text{lab} \end{bmatrix} \rightarrow \emptyset$ = 18.43%
	$\begin{bmatrix} +\text{cont} \\ +\text{voi} \end{bmatrix} \rightarrow \emptyset$ = 16.61%

**Note: Compton uses the feature + frict, however, I have changed it to +cont to be consistent.

As we can see, our percentages agree with Compton's findings final deletions. It is evident also that final voiced fricatives are deleted more frequently than final voiceless as shown earlier in Table 72, page 117.

Table 79 on the next page summarizes the percentage of occurrence of various phonological processes for affricates and fricatives. The first number is based on the total possible occurrence of a phoneme. The second number is the % of errors, both deletions and substitutions that a particular process accounts for. Thus we can see that deletion is not a major factor in accounting for errors of these phonemes. never accounting for more than 10% of the possible errors. Stopping seems to be a major process for /v/, /ð/ and the affricates followed by /θ/ and

/f/. Fronting is the most common process for the palato-alveolars accounting for from 56-76% of the possible errors. Affrication and lateral lisping account each for about 10-15% of the errors for the four sibilant phonemes. Frontal lisping accounts for approximately 48% of the errors for the /s/ phoneme and 28% for the /z/ phoneme. A major process for /θ/ seems to be the substitution of [f] for the /θ/ accounting for 45% of the errors. Devoicing seems to be an important process in final position only as we discussed earlier.

Table 79. Percentage of Occurrence/Percentage of Errors of Phonological Processes for Affricates and Fricatives

Phoneme	Deletion	Types of errors and processes with % of occurrence and % of total errors							
		Stopping	Fronting	Affrication	Lisping Lateral	Lisping Frontal	Devoicing final	Labial-ization	Other
[tʃ dʒ]	1.6/2.3	21.3/30.9	48.2/69.9	-	-	-	-	-	-
f	1.2/9.4	2.5/18.8	-	-	-	-	-	-	-
v	4.6/10.5	27.0/61.3	-	-	-	-	25.5/21.8	-	-
θ	5.1/6.3	16.3/20.1	-	-	-	-	-	36.3/44.8	13/16 (s)
ð	8.3/10	32.4/40.5	-	-	-	-	8.7/3.5	22.3/27	7/9 (z)
s	2.1/5.1	2.9/7.3	-	5.3/13	5.6/13.8	19.4/47.8	-	-	-
z	5.9/9.8	5.0/8.3	-	7.7/12.9	5.0/8.3	16.7/27.8	16.5/9.3	-	-
ʃ	2.8/4.2	2.1/3.2	51.3/76.8	7.1/10.6	7.8/11.6	2.8/4.2	-	-	-
ʒ	2.0/2.7	8.2/10.7	42.9/56	9.2/12	11.2/14.7	5.1/6.7	-	-	-

4.4 Stops and Nasals

Templin (1957) lists the ages at which stops and nasals should be acquired. This is shown in Table 80.

Table 80. Age of Acquisition of Stops and Nasals According to Templin (1957)

Phoneme category	Age acquired	Phonemes
Nasals	3;0	m, n, ŋ
Stops	3;0	p t-, -t
	4;0	k b d g
	6;0	-t-

Thus, all stops should be acquired by age 4;0 with the exception of intervocalic /t/. Intervocalic /t/ is not really a stop in American dialects, a fact which Templin may or may not have been aware of; certainly she never mentions it. In intervocalic position, /t/ often becomes a tap or flap, phonetically [ɾ]. Thus, it is not certain what Templin meant when she stated that intervocalic /t/ was not acquired--did she mean the flap [ɾ] was not acquired or was she listening for the nonoccurring intervocalic /t/ in the environment V__V̆. Sander (1961) determined ranges from the median age of customary articulation until the age where 90% of all children are customarily producing the sound. He arrived at essentially the same conclusions as Templin except that some of the sounds should be occurring earlier than she reported. Table 81 shows Sander's age range.

Table 81. Age Range for Acquisition of Stops and Nasals According to Sander (1961)

Phoneme	Age range for acquisition in years
p, m, h, n, w	1;6-3;0
b	1;6-4;0
k, g, d	2;0-4;0
t, ŋ	2;0-6;0

Thus, we see that /t/ and /ŋ/ have a four year age range in which children are learning to produce them in different environments.

Ingram (1976) in discussing various early studies notes that an early process with some children is initial consonant voicing and later, final consonant devoicing. Although this study did not find true consonant voicing in initial position, it did find that many of the subjects did not aspirate initial voiceless consonants. Since to English speakers (including linguistic investigators) unaspirated voiceless consonants sound very similar to voiced consonants, this may be the same process referred to in the literature as initial consonant voicing. Here we will call it "deaspiration".

Ingram also notes another common process of regressive assimilation of alveolar consonants to following velars. He terms it "back assimilation," e.g. talk → [kuk], dog → [gɔk] (Ingram, 1974a).

In Compton's (1976) study of abnormal language, he found the following most commonly occurring deviant phonological rules for stops and nasals.

Table 82. Most Common Phonological Rules for Stops and Nasals (Compton, 1976)

Initial position	Final position	
1. $\begin{bmatrix}+\text{stop}\\-\text{frict}\\-\text{voi}\end{bmatrix} \rightarrow [-\text{asp}] = 65\%$ (deaspiration)	11. $\begin{bmatrix}+\text{stop}\\-\text{frict}\end{bmatrix} \rightarrow \emptyset$ 20%	40%
2. $\begin{bmatrix}\text{k}\\\text{g}\end{bmatrix} \rightarrow \begin{bmatrix}\text{t}\\\text{d}\end{bmatrix} = 40\%$ (fronting)	a. $\begin{bmatrix}+\text{stop}\\-\text{frict}\\-\text{labial}\end{bmatrix} \rightarrow \emptyset$ 20%	
	13. $\begin{bmatrix}+\text{cons}\\+\text{alv}\end{bmatrix} \rightarrow \emptyset$ 10%	50%
	a. $\begin{bmatrix}\text{d}\\\text{n}\end{bmatrix} \rightarrow \emptyset$ 10%	
	b. [n] $\rightarrow \emptyset$ 10%	
	c. [t, d] $\rightarrow \emptyset$ 10%	

Curtiss (1977) in discussing her subject, Genie, states the following types of rules for stops and nasals:

1. Deaspiration of initial voiceless consonants
2. Final consonant deletion
3. Final consonant devoicing (obstruents only)
4. Fronting
5. Denasalization
6. Nasalization of vowel preceding nasal

Tallal and Piercy (1975) have done considerable research on speech perception impairment in children with developmental dysphasia. In general, she has found that these children make significantly more errors than normal children on identifying stop-consonant sequences, especially in consonant clusters. She concludes,

> Those speech sounds incorporating rapid spectral changes which are critical for their perception are most difficult for dysphasic children to perceive and are also most often misproduced by these children. (p. 3)

She found that stop consonants were more impaired than nasals and vowels and particularly stops in clusters.

We can compare the present study with the studies cited above. Deaspiration accounted for only 4.21% of the possible initial voiceless consonants; however, this accounted for all the errors but 4 in initial voiceless stops. Compton arrives at a 65% figure which seems quite high. One can only assume that his subjects must have had many more errors on stops than the children of the present study. Compton also states that his subjects deleted 40% of final stops while the present study indicates only 17.2% of the final consonants were deleted. However, if we look at the alveolar final consonants, we find that 33.25% of those were deleted which is nearer to the 40% level. This also agrees with our previous discussion on alveolars being deleted more in final clusters; it seems that they are also deleted more as single consonants.

In looking at nasals, we can see that final /n/'s in the present study are deleted 14.7% of the time which is slightly more than the 10% Compton shows. Our study also shows some use of denasalization, fronting and intervocalic glottalization for nasals. No back assimilations were noted for either stops or nasals.

4.5 Glides (Approximants)

Not much literature has been written about these phonemes since they are usually acquired early and with very few interesting errors.

Smith (1976) notes that his son used both [l] and [ɾ] for the /j/ phoneme as in yolk → [lo:k] or [ɾo:k] (p. 78). His son, however, had almost no difficulty with /w/, using an occasional [v] as a substitution which occurs only 1.85% in the present study as well. The initial substitution of [ʔ] for /j/ in the present study could also be handled as an initial consonant deletion. Initial /j/ was also found in Smith's study. The same thing can be said for initial /h/. The [ʔ] could also be considered by some to be an initial deletion regardless of the hard attack which characterizes the [ʔ]. Smith's son did delete initial /h/ in many of his words.

CHAPTER 5

ANALYSIS OF DISTINCTIVE FEATURE ERRORS

5.0 Introduction

Several studies of the distinctive feature errors of children with functional articulation disorders have been conducted. Menyuk (1968), in a distinctive feature analysis of the consonants of normal and deviant children, found three distinctive feature values lacking in the deviant group: [+strident], [-anterior] and [+continuant]. Thus, the children used the processes of stopping of fricatives which would account for the lack of the first and third feature values and fronting which would account for [-anterior] being missing. McReynolds and Huston (1971) studied distinctive feature errors of 10 children and suggested that markedness of features may be a valid measure for predicting distinctive feature errors of consonants since a marked feature specification implies greater articulatory complexity than its unmarked counterpart. (However, cf. the previous discussion on the arbitrariness of marking conventions.)

Singh and Frank (1972) analyzed substitution errors of articulation in 90 children and reached the following conclusions:

1) the most recently acquired phonemes are substituted most often
2) phonemes used as substitutes are most often the ones that were learned earliest
3) the plosion feature is the most frequent substitution for other manner features such as frication and nasality
4) the plosion feature is not commonly replaced
5) friction and nasality features do not substitute for each other

6) place feature is substituted by the closest, more frontal place in the same manner of articulation (e.g. t/k, s/ʃ, θ/s, f/θ)

7) if the closest more frontal feature has not yet emerged in the same manner, then there is a change in both the place and manner (e.g. t/ʃ, instead of s/ʃ)

8) voiceless more frequently substitute for the voiced phonemes than vice versa.

In their study, Singh and Frank only included as substitutes those phonemes which are a part of the English language. Therefore, if [ɸ] or [ʔ] were used as substitutes, these were counted as distortions and not analyzed.

Compton (1975) reached similar conclusions about substitution errors in a longitudinal study. He found that: 1) there were more substitutions along the place continuum than the manner continuum, with the substitutions generally being a shift to a more forward place of articulation; 2) when substitutions of manner occurred, place was usually held constant, most often on the alveolar ridge.

5.1 Present Study

As can be seen from Table 83, the majority of errors in the present study involved the features of coronality, back, consonality, round and high. The changes involved were from [+coronal] to [-coronal] and from [+consonantal] to [-consonantal]. This accounts for all of the errors of /l/ and /r/ becoming vowels in final position and as syllabic consonants, and thus also involves a change in backness and often roundness, liquids becoming [ə] and [oo]. However, single feature value substitutions can be usefully compared only when they involve the substitutions in the same major class of C (consonant), V (vowel), L (liquid) or G (glide). As soon as a liquid becomes a glide, there are implications such that a change from [+vocalic] to [-vocalic] also requires [+consonantal] to [-consonantal], etc.

Table 83. Hierarchy of Distinctive Feature Errors

Feature change				# of responses
1.	+cor	→	-cor	2007
2.	-back	→	+back	1790
3.	+cons	→	-cons	1658
4.	-round	→	+round	1214
5.	-high	→	+high	946
6.	+ant	→	-ant	886
7.	+voc	→	-voc	769
8.	-ant	→	+ant	719
9.	+stri	→	-stri	637
10.	+high	→	-high	529
11.	-tense	→	+tense	503
12.	+lat	→	-lat	454
13.	+cont	→	-cont	452
14.	-stri	→	+stri	300
15.	-cont	→	+cont	278
16.	+voi	→	-voi	267
17.	-cor	→	+cor	182
18.	-lat	→	+lat	178
19.	+nas	→	-nas	108
20.	+back	→	-back	99
21.	-voi	→	+voi	79
22.	-voc	→	+voc	31
23.	-low	→	+low	26
24.	-cons	→	+cons	20
25.	-nas	→	+nas	12
26.	+round	→	-round	4
27.	+low	→	-low	1
28.	-tap	→	+tap	1
	TOTAL			14,150

Table 84 shows the asymmetries in feature value errors with most + features changing to - features rather than vice versa. This "formal" finding, of course, simply reflects the features chosen, since if the inventory of features selected [±stop] rather than [±continuant] the values would be reversed. There are approximately twice as many errors of [+continuant] changing to [-continuant] as there are the reverse. This would agree with Menyuk's study which found the [+continuant] feature value missing. The same is true for stridency--[+strident] tends to become [-strident] which involves many frontal lisps. Menyuk (1968) also reported that the [+stridency] feature value was missing for deviant children. One would not expect that /s/ would change to /θ/ in normal children since /θ/ is highly "marked" compared with /s/. In fact, according to Jakobson (1968), /s/ is the least marked fricative. However, it is not just a matter of the feature stridency since /f/ and /v/ are both [+strident] and most of the children had no difficulty with these two fricatives. The difficulty may be a combination of perceptual confusion, production difficulty and phonemic organization since the place of articulation is similar for /θ/ and /s/, but /f/ does not require fine coordination of tongue muscles.

Voicelessness tended to substitute for voicing more than vice versa, a fact which was also found in the study by Singh and Frank (1972). Also, nasals tended to become denasalized rather than vice versa. Because /l/ tended to become a glide, the features values of lateral and vocalic tended to become minus. The previous studies indicated that a more frontal place of articulation tended to take place. In the present study, however, [+anterior] became [-anterior] more than vice versa. The reason for this was in the high number of laterals which became back vowels. [-high] became [+high] more than vice versa which may mean that more back consonants were produced, or more glides, /j/ and /w/ both being [+high]. This will be discussed in the finer analysis below.

Table 84. Asymmetry in Feature Value Errors

Feature	Change	# of responses	Possible responses	% of responses	% of total errors (14150)
coronality	+ → −	2007	10,673	18.8	14.18
	− → +	182	7,058	2.6	1.29
back	+ → −	99	3,674	2.7	.7
	− → +	1790	14,057	12.7	12.65
cons	+ → −	1658	17,044	9.7	11.72
	− → +	20	687	2.9	.14
round	+ → −	4	417	1.0	.03
	− → +	1214	17,314	7.0	8.58
high	+ → −	529	4,820	11.0	3.74
	− → +	946	12,911	7.3	6.69
ant	+ → −	886	10,729	16.7	6.26
	− → +	719	7,002	10.3	5.08
strident	+ → −	637	4,050	15.7	4.5
	− → +	300	13,681	2.2	2.12
*tense	+ → −	−	−	−	−
	− → +	503	−	−	3.56
lateral	+ → −	454	1,307	34.7	3.21
	− → +	178	16,424	1.1	1.26
cont	+ → −	452	8,196	5.5	3.19
	− → +	278	9,535	2.9	1.97
voice	+ → −	267	9,908	2.7	1.89
	− → +	79	7,823	1.0	.56
nasal	+ → −	108	2,355	4.6	.76
	− → +	12	15,376	.08	.084
low	+ → −	1	164	.6	.007
	− → +	26	17,567	.2	.18
tap	+ → −	−	−	−	−
	− → +	1	−	−	.007
vocalic	+ → −	769	3,266	23.6	5.44
	− → +	31	14,456	.2	.22

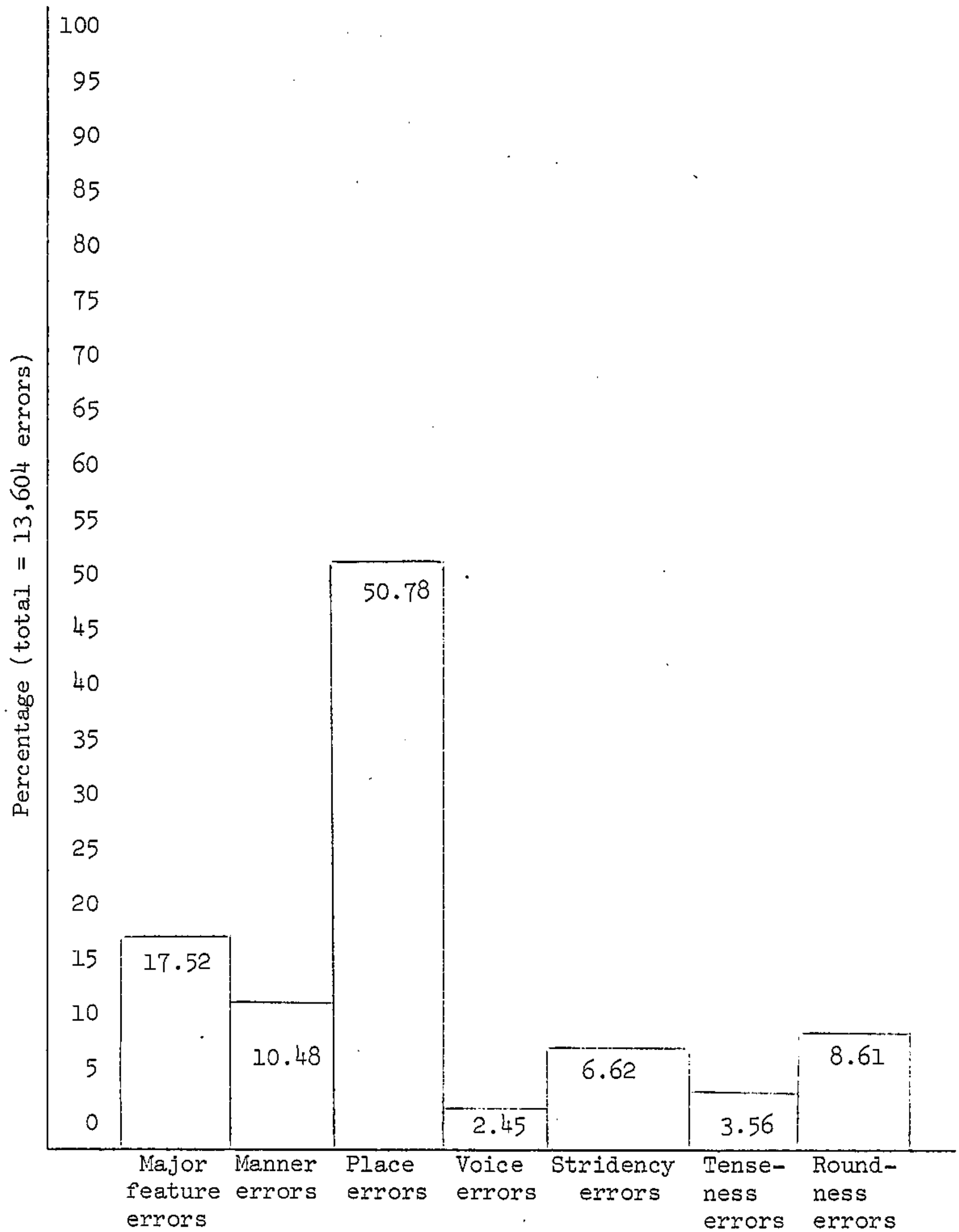
*Note: [tense] was used only when a liquid became a back round vowel [oɷ].

We can see from Figure 2 that the majority of errors occur with place features accounting for 50.78% of the errors. Major feature errors ([±cons], [±voc]), were second with 27.5% of the total. Compton found that place of articulation errors occurred more frequently than manner errors, and this study agrees. Singh and Frank found that the plosion feature most frequently substituted for other manner features such as friction and nasality features; this is also supported by the present study.

Figure 3 shows that 6 feature errors account for 27.24% of the errors with 3 feature errors accounting for 15.67% of the errors. Some explanation of the above analysis is necessary since it does not agree with some previous studies. In the present study, all of the errors were grouped together including the errors in single consonants and in clusters. In addition, syllabic liquids and nasals were also included. The inclusion of liquids and syllabics somewhat distorts the analysis. Therefore, the following analysis separates the liquids and glides from the true consonants and a better comparison with other studies can be made.

The large number of [+coronal] to [-coronal], [+consonantal] to [-consonantal], [-back] to [+back] and [-round] to [+round] errors must be accounted for. In addition, the large number of 6-feature errors should be accounted for since most other studies found mainly 1, 2 and 3 feature errors (Compton, 1975; Singh and Frank, 1972).

Figure 2. Percentage of Errors of Distinctive Features



Major class errors include: cons, voc
Manner errors include: cont, nas, lat, tap
Place errors include: high, back, low, ant, cor

Figure 3. Number of Feature Errors/Percent Occurrence

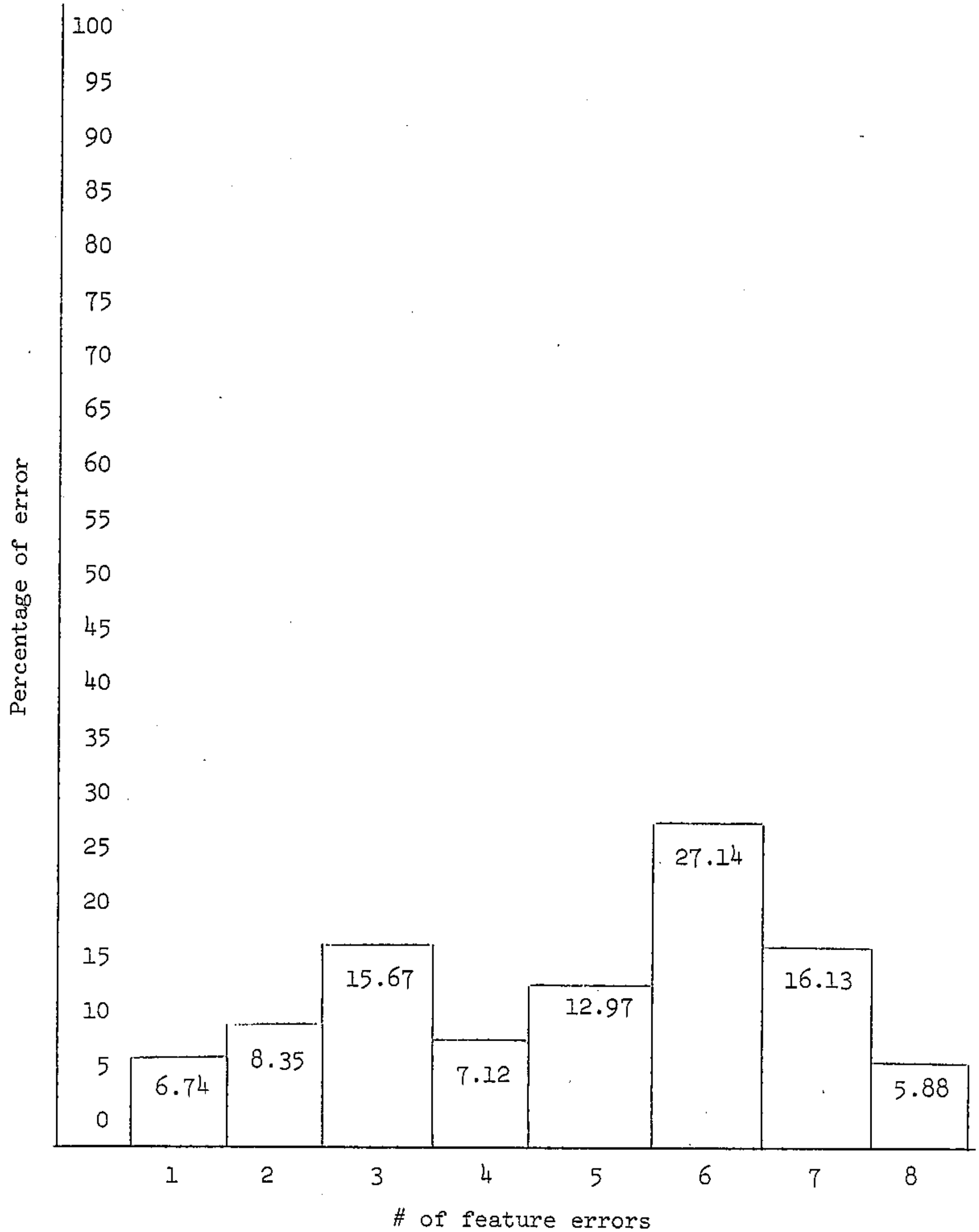


Table 85 shows a substitution matrix for liquids and glides. Syllable final liquids and liquids in final clusters were most often substituted for by some type of back vowel. This type of substitution would account for 811 of the 4, 5, and 6 feature substitutions since:

$$[l] \rightarrow [ꝏ] \qquad [l] \rightarrow [ə] \qquad [r] \rightarrow [ꝏ]$$

$$\begin{bmatrix} +\text{cons} \\ +\text{voc} \\ +\text{ant} \\ +\text{cor} \\ -\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{cons} \\ -\text{ant} \\ -\text{cor} \\ +\text{back} \\ +\text{round} \\ +\text{tense} \end{bmatrix} \qquad \begin{bmatrix} +\text{cons} \\ +\text{ant} \\ +\text{cor} \\ -\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{cons} \\ -\text{ant} \\ -\text{cor} \\ +\text{back} \end{bmatrix} \qquad \begin{bmatrix} +\text{cons} \\ +\text{cor} \\ -\text{high} \\ -\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{cons} \\ +\text{back} \\ -\text{cor} \\ +\text{round} \\ +\text{tense} \end{bmatrix}$$

Table 85. Phoneme Substitution Matrix for Liquids and Glides This includes all positions (Initial, Intervocalic and Final) as well as syllabic liquids [r̩], [l̩] for liquids. Initial position only for glides.

	Substitution Errors												
Target phonemes		r	l	w	j	h	ʔ	g	d	n	v	ꝏ	ə	Total
	r		17	596			8					216	269	1106
	l	6		96	45		21	1	2	1		287	39	498
	w										3			3
	j		10				6							16
	h						7							7
Total		6	27	692	45	0	42	1	2	1	3	503	308	1630

Also, there is a higher frequency of /r/ and /l/ changing to the glides, /w/ or /j/. This also involves a six or seven feature value change including the change of [+coronal] to [-coronal] and [-high] to [+high].

$$\begin{matrix} l & \rightarrow & w \\ \begin{bmatrix} \text{+cons} \\ \text{+voc} \\ \text{+ant} \\ \text{+cor} \\ \text{-high} \\ \text{-back} \end{bmatrix} & \rightarrow & \begin{bmatrix} \text{-cons} \\ \text{-voc} \\ \text{-ant} \\ \text{-cor} \\ \text{+high} \\ \text{+back} \\ \text{+round} \end{bmatrix} \\ & & \text{7 features} \end{matrix} \qquad \begin{matrix} r & \rightarrow & w \\ \begin{bmatrix} \text{+cons} \\ \text{+voc} \\ \text{+cor} \\ \text{-back} \\ \text{-high} \end{bmatrix} & \rightarrow & \begin{bmatrix} \text{-cons} \\ \text{-voc} \\ \text{-cor} \\ \text{+back} \\ \text{+high} \\ \text{+round} \end{bmatrix} \\ & & \text{6 features} \end{matrix}$$

This is apparently a simple change in terms of perceptual quality and may be explained in the light of formant structure. /w/ may be thought of as a nonsyllabic version of the round vowel /u/ and /ɹ/ as in "red" may be thought of as a nonsyllabic version of the rhotacized vowel in "fur". In initial position, /r/ is often rounded; acoustically, approximants have a formant structure similar to that in vowels, but changing more rapidly. Thus, the /w/ may involve the same formant structure as the /u/, except for omitting the lowering of the third and fourth formants which is characteristic of /r/. However, looking at feature changes, it involves so many features that it appears to be a highly complex and "unnatural" change. Therefore, these substitutions may obscure feature generalizations involving manner, place and voicing of true consonants only.

However, a few generalizations can be made concerning liquids. The only substitutions for /r/ in syllable initial position were [w] and [?] with [?] occurring almost exclusively in intervocalic position. /l/ had a number of substitutions including the glides, [w] and [j], and also other stops including [?]. This substitution occurs in reverse with [l] substituting for /j/ 10 times. It is interesting that /r/ and /l/ substituted for each other only in initial clusters.

Table 86 shows a phoneme substitution matrix for true consonants. The substitutions were counted for all 16 subjects in initial, intervocalic and final positions and the total number of substitutions of each individual phoneme is given in Table 86. The phonemes that were replaced, i.e. target phonemes, are on the vertical axis and the substituting phonemes on the horizontal axis.

The 2,455 phoneme substitutions of Table 86 are analyzed into 3,343 feature substitutions in Tables 87 , 88 and 90. There are more place feature substitutions than manner or voice which would agree with previous studies.

Manner substitutions . In the manner category, nasals and liquids rarely substitute for other categories. Of the 1038 manner replacements, 510 or 49% were by stops, 211 or 20% by fricatives, 171 or 16.5% by affricates, 119 or 11.5% by glides, and the rest by nasals and one tap.

Table 86. Phoneme Substitution Matrix for True Consonants [+cons, -voc]
(Substitutions for nasals were [p⁻] and [t⁻] = unaspirated)

Target Phonemes	tʃ	dʒ	ts	dz	θ	ð	f	v	Φ	x	s	z	ʃ	ʒ	p	b	t	d	k	g	m	n	ŋ	h	w	j	ɾ	l	r	?	Total
	Substitutions																														
tʃ			52								57	1	28				42		5					1						1	187
dʒ	4		1	49		3					6	43	1	21		5	8	71		15				1						3	231
θ	2		5				103		2		29						47	1	4					4	1	1					199
ð							13	61			4	23						100				2		5		17	1	3		4	233
f			1		10	2		22	4		18				3		9								2						71
v		2					20				4	2			7	55		5	1						5	1			1	8	111
s	25		24		224		58		14	2		1	35	1			10		8					3		2					407
z		17		8	5	54					27			7			1	14		1		5		7		11				3	160
ʃ	16		16		12						193						9					1		3							250
ʒ		9			1	4	1				5	29	3				1	6						1		6					66
p							1	2	2							7	22			2	2									4	42
b				2		1	1	5	5						6		2	1		2	2	1				2				7	37
t	8		19		2	1	2		7		9		1					2	22	12	1			4	3	10			4	36	143
d		2		2			3	1				1				2	18		1	10				2	3	11		2		19	77
k	2								1		1						22			2				1		3		1		8	41
g		10		1	2				2		1					9		9	20											13	65
m								1							4⁻	27						11	9		1					3	56
n																	4⁻	10			12		6		3	5		1		15	56
ŋ						1																22									23
Total	57	40	118	62	254	66	202	92	37	2	354	100	68	29	20	105	195	219	61	44	17	42	15	32	18	69	1	7	5	124	2455

Table 87. Errors Involving Manner Features

	Error							
Target	Oral stop	Nasal	Fricative	Affricate	Liquid	Glide	Tap	Total
Oral stop		6	49	46	7	39	0	147
Nasal	63		2	0	1	9	0	75
Fricative	297	8		125	4	69	1	504
Affricate	150	0	160		0	2	0	312
Totals	510	14	211	171	12	119	1	1038

For the purposes of this discussion oral and nasal stops are considered as separate classes. An examination of the substitution errors shows that of 2,172 nasal targets 75 errors or 34.5% produced oral segments, whereas there were only 14 nasals which were substituted for non-nasal segments which accounts for only .1% of the total oral targets (11,369). One can conclude from this asymmetry that nasality is indeed a "marked" feature.

Similarly, since of a total of 6,736 stop targets, non-stop substitution errors occurred 147 times or 2.2%, as opposed to stops replacing other manners of articulation a total of 510 times or 7.5%, it would appear that the suggestion that for true consonants [-continuant] is "unmarked" holds true. It is even more evident when we consider only the fricative category. Of the 3,952 target fricatives, 297 are stop errors, 8 are nasal, and 125 are affricates coming to a total of 430 [-continuant] errors or 10.9%. Stops also substitute for fricatives and affricates rather than vice versa, with 49 and 46 exceptions respectively.

Of the 681 target affricates, 312 or 45.8% are replaced, mostly by stops and fricatives. It is interesting to note that since they were replaced by stops and fricatives almost equally, this might be considered "cluster simplification" rather than simply feature changes, i.e. either the deletion of the fricative portion of the cluster (affricate to stop) or the stop portion of the cluster (affricate to fricative). However, affricates did tend to substitute for fricatives which cannot be considered any type of simplification. Of the 3,952 target fricatives, 125 or 3.2% were replaced by affricates. Glides tended to substitute for stops and fricatives slightly more than for nasals and affricates. These observations also agree with the study by Singh and Frank (1972) who found that in general stop replaces nasals and fricatives; and that nasals and fricatives do not replace each other. They did not include affricates in their study.

Place substitutions. Singh and Frank (1972) found that a feature of place is substituted for by the closest more fronted feature of place in the same series (manner); alveolar for back, labial for alveolar in the stop and nasal series; alveolar for back, interdental for alveolar, labial for interdental in the fricative series. Labial stops replace labial fricative except for /f/ which posed 33% of the exceptions, changing instead to an alveolar stop.

Table 88. Errors Involving Place Features

	Error						
Target	Labial	Interdental	Alveolar	Palato-Alveolar	Velar	Glottal	Totals
Labial		13	78	6	14	22	133
Interdental	180		215	20	4	4	423
Alveolar	109	286		139	60	73	667
Palato-alveolar	6	20	591		20	4	641
Velar	12	1	57	15		21	106
Totals	307	320	941	180	98	124	1970

Of the 583 targeted interdentals, 423 or 72.5% were in error, alveolars substituting 215 times or 36.9% and labials substituting 180 or 30.9% of the time. The labial substitutions were mostly [f] and [v]. Twice [ɸ] substituted for /θ/ but only in clusters. In general these changes involved only a few features in terms of Chomsky-Halle features, e.g.

$$\begin{bmatrix} +\text{ant} \\ +\text{cor} \\ -\text{stri} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{cor} \\ +\text{stri} \end{bmatrix}$$

θ, ð f, v

The feature of voice was also changed thirteen times, /f/ → [ð]. One change involved a 6-feature change, /θ/ → [w].

Singh and Frank (1972) stated that labial should substitute for interdental unless the child does not have the predicted phoneme change in his repertoire and then the closest stop is substituted, i.e. /t/ or /d/. However, in the present study, [s, z] also substituted for interdentals as did the [t, d] even though the subjects could produce the labial fricatives correctly. The following Chomsky-Halle features are involved; in most cases voicing remains constant, changing in only 5 cases.

$$\begin{bmatrix} +\text{ant} \\ +\text{cor} \\ +\text{cont} \\ -\text{stri} \end{bmatrix} \rightarrow [+\text{stri}] \qquad\qquad \begin{bmatrix} +\text{ant} \\ +\text{cor} \\ +\text{cont} \\ -\text{stri} \end{bmatrix} \rightarrow [-\text{cont}]$$

θ, ð   s, z   θ, ð   t, d

Of the 5,281 targeted alveolars there are 667 or 12.6% errors. Interdentals substituted for 286 or 5.4% of the errors and palato-alveolars for 139 or 2.6% of the errors. Labial substituted for alveolar in 109 or 2.1% of the cases. However, all but 23 of these occurred in clusters thus involving some type of assimilation, e.g. $\left.\begin{matrix} t \\ s \end{matrix}\right\} \rightarrow f/\_\_/w/$

Singh and Frank (1972) state that interdental substituted for alveolar in the fricative series and this was also found in this study occurring 283/286 as substitutes for fricatives and 3 times as substitutes for the alveolar stops /t, d/. The change of alveolar to interdental involves the following features in Chomsky-Halle terms:

$$\begin{bmatrix} +\text{ant} \\ +\text{cor} \\ +\text{stri} \end{bmatrix} \rightarrow [-\text{strident}]$$

s, z   θ, ð

Occasionally voicing also changes (θ/z, 2) and manner changes three times; this still involves just a few features.

A surprising substitution in light of the Singh and Frank (1972) study, is the substitution of palato-alveolars for alveolars. These errors are accounted for in the following manner: [j] substitutes for alveolar stops and fricatives 39 times; [ʃ, ʒ] substitute for alveolar fricatives in 44 cases; [tʃ, dʒ] substitute for alveolar stops and fricatives in 52 cases. Thus we have a change of manner as well as place in most of these substitutions. In the case of the /j/ substitution we also have a change in consonality as shown below.

$$\begin{bmatrix}\text{+cons}\\ \text{+ant}\\ \text{+cor}\\ -\alpha\text{cont}\\ \alpha\text{nas}\end{bmatrix} \rightarrow \begin{bmatrix}\text{-cons}\\ \text{-ant}\\ \text{+cont}\\ -\alpha\text{nas}\\ \alpha\text{cont}\end{bmatrix} \qquad \begin{bmatrix}\text{+cons}\\ \text{+ant}\\ \text{+cor}\\ \alpha\text{stri}\\ \alpha\text{cont}\end{bmatrix} \rightarrow \begin{bmatrix}\text{-ant}\\ \text{+stri}\\ \text{-cont}\end{bmatrix}$$

t, d, n   j   t, d   tʃ, dʒ
s, z   s, z

These changes are rather high feature values of 5 changes. However, the change from /s, z/ to [ʃ, ʒ] is as follows: and is a low change although in the wrong direction, i.e. back rather than front.

$$\begin{bmatrix}\text{+ant}\\ \text{+cor}\end{bmatrix} \rightarrow [\text{-ant}]$$

s, z   ʃ, ʒ

Velar and glottal substitutions account for only a small percent (1.1% and 1.4% respectively) of the total number of targeted alveolars.

Of the 3,379 targeted labials, only 133 or 3.9% were in error, the main substitution being by alveolars (78 or 2.3%).

The change was from /f/ and /v/ to [s] or [z] or from /b, p, m/ to [t, d, n]. Alveolar fricatives substitute for labial fricatives in 24 cases, alveolar stops for labial fricatives in 14 cases and alveolar stops for labial stops and nasals in 37 instances. The changes involve the following Chomsky-Halle features:

$$\begin{bmatrix}\text{+ant}\\ \text{-cor}\end{bmatrix} \rightarrow [\text{+cor}] \qquad \begin{bmatrix}\text{+ant}\\ \text{-cor}\\ \text{+cont}\\ \text{+stri}\end{bmatrix} \rightarrow \begin{bmatrix}\text{+cor}\\ \text{-cont}\\ \text{-stri}\end{bmatrix}$$

f, v   s, z
b, p, m   t, d, n   f, v   t, d

Interdentals substituted in 13 or .4% of the cases although this substitution involves 2 features as can be seen below:

$$\begin{bmatrix} +\text{ant} \\ -\text{cor} \\ +\text{stri} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{cor} \\ -\text{stri} \end{bmatrix}$$

f, v θ, ð

Of the 1204 palato-alveolar targets, 641 or 53.2% were in error with the major substitutions being alveolars (591 or 49%). This substitution agrees with the findings of Singh and Frank since they say that [s] normally replaces /ʃ/. They also say that if the child does not have an /s/ in his repertoire, the predicted substitution would be the closest stop or [t]. Alveolar fricatives substituted for the palato-alveolar ones in 227 cases, voicing held constant in all but 5 cases for the present study. Alveolar stops substituted for the palato-alveolar fricatives only 16 times, while alveolar affricates substituted for the palato-alveolar affricates in 102 cases with alveolar fricatives substituting in 107 instances and alveolar stops in 121 cases. Thus, affricates tended to become alveolar with a change in manner to fricative or a change to a stop involving the feature of stridency. The following Chomsky-Halle features are involved:

$$\begin{bmatrix} -\text{ant} \\ +\text{cor} \\ -\alpha\text{cont} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ant} \\ \alpha\text{cont} \end{bmatrix} \qquad \begin{bmatrix} -\text{ant} \\ +\text{cor} \\ +\text{stri} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ant} \\ -\text{cor} \\ -\text{stri} \end{bmatrix}$$

tʃ, dʒ s, z, ts, dz tʃ, dʒ t, d

Of the 3,094 velar targets, only 106 or 3.4% were in error with alveolar substitutions accounting for 57 or 1.8% of these velars. In 31 of these cases there was no change in manner, e.g. /k, g/ → [t, d]. This change involves the following Chomsky-Halle features:

$$\begin{bmatrix} +\text{back} \\ +\text{high} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{back} \\ -\text{high} \\ +\text{ant} \\ +\text{cor} \end{bmatrix}$$

k, g t, d

This change of 4 features values occurs in child language acquisition, called "fronting" by Ingram (1974b).

In summary, we see that interdentals were in error 72.5% of the time, palato-alveolars 53.2%, alveolars, 12.6%, labials, 3.9% and velars 3.4%. Thus, labials and velars seem to be the least marked followed by alveolars, palato-alveolars and interdentals.

Let us now look at the features which substitute for the other features to see if the same hierarchy will hold. Alveolars substituted 941 times for other place features. This represents 11.4% of the other place features possible (8,260). Labial substitutions account for 3.02% (307/10,162), interdental for 2.5% (320/12,958), palato-alveolar for 1.5% (180/12,337), velar for .94% (98/10,447) and glottal for 92% (124/13,541). Thus, palato-alveolar, velar and glottal substitute the least for other place features. Singh and Frank (1972) predicted that they would not substitute at all since they are articulated further back in the oral cavity. Velar substitutions occurred mostly for alveolars and mostly in clusters (52/53). Velars also substituted for palato-alveolar affricates in 20 instances and they may be viewed as clusters also. Thus, in clusters, it seems that velars may substitute for alveolars and palato-alveolars. See Table 89 for a summary of substitution errors.

Table 89. Percentage of Feature Errors and Percentage of Substitutions for Other Features

Feature	% of errors	% of substitution for other feature
Interdentals	72.5	2.5
Palato-alveolars	53.2	1.5
Alveolars	12.6	11.4
Labials	3.9	3.2
Velars	3.4	.94
Glottals	-	.92

Glottal stops substituted for other segments 124 times or .92%. They substituted for alveolars, labials and velars which would involve the following Chomsky-Halle features:

$$\begin{bmatrix} +\text{ant} \\ +\text{cor} \\ \alpha\text{voi} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{ant} \\ -\text{cor} \\ -\text{voi} \\ +\text{back} \\ -\text{cont} \\ -\text{stri} \\ -\text{nas} \end{bmatrix} \qquad \begin{bmatrix} +\text{cor} \\ +\text{stri} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{cor} \\ -\text{stri} \\ -\text{cont} \\ +\text{back} \\ -\text{voi} \end{bmatrix}$$

t, d, n, s,
z, θ ,ð

ʃ, ʒ,
tʃ, dʒ

Thus, this type of change involves from 4 to 7 features. Yet, this substitution occurs frequently for this population in intervocalic position, especially alveolars.

Table 90 presents the voicing errors.

Table 90. Errors Involving Voicing

Target	Error: Voice	Error: Voiceless
Voice		251
Voiceless	84	

The direction of voicing changes in this study is the same as that found by Singh and Frank (1972). Of the 7,710 targeted voiceless segments, voiced segments substituted 84 or 1.09% of the time while voiceless segments substituted 251 times for the 5,831 voiced segments or 4.3% of the time, suggesting that [+voiced] is the marked feature value.

5.2 Summary

1. Although the feature values of [+strident] and [+continuant] were not lacking in this population, the subjects did tend to replace [+strident] by [-strident] more than vice versa, and to replace [+continuant] by [-continuant] more than vice versa. This agrees with Menyuk's findings.

2. Place substitutions accounted for 50.8% of the total number of possible distinctive feature errors. In looking at the liquids and glides, we can see that the [+coronal] feature was replaced by [+back] and [+high] features in the majority of cases accounting for all of the instances in which liquids become [w] and back vowels. Therefore, it may be inferred that coronality is a difficult feature only for liquids.

3. For true consonants ([+consonantal], [-vocalic]) we find the following manner substitutions: affricates showed the highest percentage of errors with 45.8% of them replaced by either stops or fricatives. 10.9% of the total number of possible fricatives were replaced by [-continuant] segments. Stops replaced other manner features 7.5% of the time but were rarely replaced. Nasals and liquids rarely substituted for other manner types.

4. The following generalizations are true of place substitutions for true consonants. The highest frequency of errors occurred in

interdentals with 72.5% errors, with palato-alveolars next in frequency with 53.2% errors. A place feature is substituted for by the closest most fronted segment with the following exceptions: alveolar substituted for interdental in 36.9% of the cases and velar tended to substitute for alveolar in clusters. Palato-alveolars substituted for alveolars in 2.6% of the cases. Glottal and velar substitutions accounted for only a small percent of the total number of possible places while alveolars substituted the most, 11.4% for other place features. These place substitutions thus agree with the findings of Singh and Frank (1972) and to some extent with Menyuk (1968) that the feature value [-anterior] was lacking since [+anterior] (labial, interdental, alveolar) substitutions account for 1568/13,541 or 11.6% of the targeted places and 79.6% of the total place errors (1970), while [-anterior] accounted for only 3% of the targeted places.

5. [-voice] tends to substitute for [+voice] rather than vice versa.

6. For true consonants, substitutions tend to involve 1-4 feature value changes. Occasionally, when a glide or glottal substitutes for a true consonant, substitution errors with 5, 6, and 7 features result. However, for the liquids, it is common for the substitutions to involve 5-7 feature errors since glides and vowels substitute for these sounds.

FOOTNOTES TO CHAPTER 5

1. In this table, the lateralized production of fricatives and affricates were not counted as separate substitutions but were included in the same manner category. For example, if [s̬] a lateralized /s/ was substituted for /s/, the lateralization was not counted as a substitution error; these were merely omitted from the analysis. If [s̬] was substituted for /ʃ/, it was included in the /s/ substitution category rather than making a separate category of lateralized substitutions, since we have already discusses lateral productions in the previous chapters.

CHAPTER 6

ANALYSIS BY SUBJECT

6.0 Introduction

Each subject's responses were analyzed as to the categories of phonological segments or units produced. Preferred syllable structure by subject was also investigated. One question of interest was how consistent an individual subject was in the repetition of the same items.

One interesting finding was that the differences between subjects did not depend on either age or reading ability, although there was some trend in this regard. The two youngest subjects, #1 (4-8 years) and #2 (5-0 years), together with #12 (7-8 years) produced the greatest number of errors. The age trend is revealed, however, by the fact that subjects #14, #15, #16, all 9 or more years, did produce the highest percent of correct forms. Table 91 lists the subjects ranked according to percentage of correct responses. In addition, Tables 51 and 52 in Chapter 4 and Appendices III and IV give a detailed account of each subject's performance on all productions, in terms of percentage correct, incorrect, and types of "rules" used by each subject.

Table 91. Percentage of Correct Responses Listed by Subject

Subject	Total possible	% correct	Age
16	820	70.61	9-4
11	813	69	7-6
14	832	66.47	9-0.
15	1082	63.68	9-0
6	811	62.89	6-9
5	1279	60.52	6-5
8	813	58.67	7-0
10	1344	56.62	7-4
13	784	54.46	8-2
3	838	53.1	5-7
4	719	49.79	5-9
7	806	49.13	6-10
9	1137	48.29	7-2
12	783	45.21	7-8
2	796	41.09	5-0
1	789	38.03	4-8

The literature reports that aphasic children are inconsistent in that on one day they will complete a task correctly whereas on the next day, they will not. It is not quite clear what criteria are used to decide overall consistency. For this population, an average of 51.5% of the productions were 100% consistent, i.e. some of the subjects produced the utterance in the same way in all repetitions. This does not mean that the child was consistently correct, but rather that for these words, the same correct or incorrect productions were repeated for the three to five repetitions. Ten out of sixteen subjects were 100% consistent for over half their productions. 38.5% of the productions were 50-75% consistent, meaning that perhaps 2 out of 3 times the same utterance was produced, but a different one for the third attempt, e.g. <u>stop</u> → [tap], [tap], and [sap]. An average of 7.9% of the utterances showed no consistency, being produced differently each time, e.g. <u>stop</u> → [stop], [tap], [sap]. Only 3 subjects showed over 14% of their productions to be different on each repetition. Two of these subjects, #2 and #4, were among the youngest of the group.

Since no quantitative analysis of other populations regarding consistency has been published, it is not possible to compare this group with other subjects.

There was generally greater inconsistency for the 3 syllable words than for disyllables or monosyllables, and disyllables were more inconsistent than monosyllables.

The main finding, however, was that the subjects differed greatly. While all subjects simplified clusters, the simplifying "mechanisms" were not identical across the group, i.e. each subject had her/his own "strategies" and error patterns, as will be seen in the discussion below.

6.1 Subject #1 (4-8 years)

This subject produced only on initial cluster, bw, and one final cluster type (nasal + voiceless stop) with two actually occurring final clusters, mp and ŋk. He simplified initial clusters by either /s/ deletion, liquid deletion or initial stop deletion before /r/. Final clusters were simplified by deletion of the final consonant and/ or by vocalizing a post-vocalic /l/. He correctly produced final syllabic [r̩] and [n̩] but vocalized final /r/. He substituted glides [w, j] for initial /r, l/, respectively. He used initial stopping for affricates and lateralized all sibilants. In addition, he tended to voice inital voiceless stops and denasalize initial nasals. He is in Ingram's Stage 3 (see Chapter 4) in acquisition of fricatives and affricates as shown by the following table.

Table 92. Subject #1. Substitutions for Fricatives and Affricates

Target	Initial substitutions	Final substitutions
f	v, w	f, s̪
v	v	b, Ø
θ	h, z̪	Ø, s̪, f
ð	t, s̪	Ø, z̪
s	s̪	s̪, ʃ̪
z	z̪	Ø, z̪
ʃ	s̪, ʃ̪	ʃ̪, tʃ̪
tʃ	t	s̪, ʃ̪, tʃ̪
dʒ	d	ʒ̪

In terms of syllable structure he changed 54% of syllable structure involving #CC or CC# to CVC, and 43.5% to open syllable structure.

6.2 Subject #2 (5-0 years)

This subject could produce final nasal cluster types and the stop + fricative [ks] cluster. He used several different rules for reducing final clusters: double consonant deletion (30%); /r/ deletion (38%); /l/ vocalization (40%); final consonant deletion (22%). Thus he seemed to have great difficulty with syllables ending in final CC# with only 18% being correct and the rest changed to either CVC or CV syllables. For initial clusters, he produced Cw clusters and /sl/ clusters with several rules used for simplifying: gliding (51%); liquid deletion--stop + liquid (41%) and /s/ + liquid (53%).

In addition he produced /s, z/ with a frontal lisp, substituted glides for the liquids, and vocalized all final syllabic and nonsyllabic liquids. In terms of fricatives, he either substituted [f] for /θ/ or omitted it and substituted [j] for /ð/. He fronted final palato-alveolar affricates to alveolar ones (i.e. ts, dz). He is one of the few subjects who used final consonant devoicing to any great extent, e.g. 44% of the time.

6.3 Subject #3 (3-7 years)

This subject did not produce initial /s/ + stop clusters (using /s/ deletion to reduce them) nor fricative + /l/ clusters (using liquid deletion). He used liquid deletion (41%) and gliding (51%) when producing initial stop + liquid clusters. He had an unusual rule, [l] → [r], in 30% of the initial /l/ clusters. In final clusters, he produced /rC/ but not /lC/ using /l/ vocalization 80% of the time and final C deletion 25% of the time. This production of /r/'s but no /l/'s in final clusters and /l/'s but not /r/'s in initial clusters is an interesting aspect of inconsistent production. Final consonant devoicing was used 50% of the time in final clusters and 52% overall including single phonemes. /sk/ was produced as [ts] in 14% of the cases. This can be due to metathesis, followed by assimilation: sk → ks → ts.

He used fronting of palato-alveolars to alveolars 91% of the time and substituted alveolar fricatives for affricates in initial position. Dental fricatives were produced as [f, v] in final position and stopped in initial position. Liquids were vocalized in final position and substituted by [w] in initial position.

6.4 Subject #4 (5-9 years)

This subject produced only initial stop + /w/ clusters and nasal + C final clusters. He used liquid deletion and gliding to produce initial stop + liquid clusters and /s/ deletion for /s/ + C clusters. For final clusters he deleted final consonants (50%) and deleted /r/'s

(65%) and vocalized /l/ (62%). He fronted palato-alveolars (70%) of the time and stopped initial dental fricatives and affricates. He substituted glides for liquids initially and vocalized them finally. In addition, final consonant deletion occurred 15% of the time, with additional difficulty with sounds in intervocalic position, glottal replacement occurring 11% of the time. In addition, he changed CC# to CVC 53% of the time.

6.5 Subject #5 (6-5 years)

This subject could not produce initial /s/ + stop clusters deleting the stop in 89% of the cases. In addition she used lisping on all /s, z/ phonemes. She produced 35% of initial liquid clusters correctly and used both liquid deletion and gliding as error patterns. In final clusters, she produced all but final /sk/ and /rC/ using final consonant deletion 41% of the time and /r/ deletion 61% of the time. She also tended to devoice final consonants in final clusters (20%). Palato-alveolars were produced correctly and dental fricatives were substituted by [f] in final position. Final liquids were vocalized and initial ones produced correctly.

6.6 Subject #6 (6-9 years)

The only final clusters produced by this subject were final nasal clusters and final /ks/ reducing other final clusters by final consonant deletion (75%), /r/ deletion (89%) and /l/ vocalization (47%). The only initial clusters he did not produce correctly were /s/ + consonant. He reduced all /s/ + stop and /sw/ clusters by deleting the /s/ and some /sl/ clusters by /l/ deletion. In addition, gliding was used 37% of the time to reduce liquid clusters. A frontal lisp was used in all productions of /s,z/ with only these and the dental fricatives being in error (θ, ð → f, v). This subject was the most consistent of all the subjects, producing 74% of the words with 100% consistency.

6.7 Subject #7 (6-10 years)

In contrast to #6 who ranked 5th in correct production, this subject, only one month older ranked 12th in correct production. He produced no final liquid clusters using final consonant deletion 90% of the time with final alveolar clusters, /r/ deletion 67% and /l/ vocalization 53% of the time. In initial clusters, he produced only stop + $\{{l \atop w}\}$ using /r/ gliding 67% and liquid or glide deletion about 30% of the time. He used /s/ deletion 100% to reduce those clusters. Final liquids were vocalized and w substituted for /r/ in initial position. He fronted all palato-alveolars to alveolars (94%) producing the affricates as fricatives [s, z] in initial position and as affricates [ts, dz] in final position. In addition, he tended to deaspirate initial voiceless stops (40%) and delete final stops (10%).

6.8 Subject #8 (7-0 years)

This subject occasionally produced 3 final clusters (nasal, stop + fricative, and rC) but mainly used the following strategies to reduce them: final consonant deletion for reducing nasal clusters, but /r/ deletion and /l/ vocalization when reducing liquid + C clusters. In addition, he used a process of palatalization and affrication of final sk and ks clusters by an idiosyncratic rule. Fricatives also tended to be affricated with both /s,ʃ/ becoming [tʃ] and /z, ʒ/ becoming [dʒ]. In initial clusters, 86% of the liquid clusters were simplified by gliding, and /s/ + stop clusters by /s/ deletion. Other /s/ clusters, i.e. sw and sl, had an affricated s as in [tʃw] for [sw]. Initial liquids became glides and final liquids became vocalized. He also fronted palatals about 40% of the time, but also palatized /s/ as stated above 44% of the time.

6.9 Subject #9 (7-2 years)

This subject produced only two initial clusters, stop + {w r} using gliding to reduce other clusters. In addition, he had unusual substitutions in initial clusters with [l] → [r] (19%) and initial /d, t/ → [g, k] before /r/. He used /s/ deletion in /s/ + stop clusters but used /l/ deletion for sl clusters. In sw clusters,[s]became[k]75% of the time, showing both stopping and backing. In terms to final clusters he could not produce /lC/ using final consonant deletion 68% of the time to reduce final clusters. He produced CVCC syllable structure correctly only 19% of the time changing it to CVC 48.5% of the time.

He showed an interesting pattern for final fricatives, substituting an alveolar fricative for all other final fricatives. He is in Ingram's Stage 3 for fricative and affricate acquisition as shown in the following table.

Table 93. Subject #9. Substitutions for Fricatives and Affricates

Target	Initial substitutions	Final substitutions
f	f	s
v	b	d, s, z
θ	t	s, ∅
ð	d	z, s
s	d	s, ʃ
z	ð, dʒ, dz	z
ʃ	ʃ, s	s
tʃ	tʃ, s	s, ts
dʒ	dʒ	s, dz

In addition, he used glottal substitution or glide substitution for many intervocalic sounds (b, v, t, d, z, l, ð, g) 27% of the time and final consonant deletion 32%. He also showed difficulty with all velars and all final stops except /b/ tending to either delete them or front them to alveolars. Liquids were substituted by glides in initial position, but produced correctly as final syllabics.

6.10 Subject #10 (7-4 years)

This subject frequently produced all but final fricative + stop [sk] clusters. He occasionally reduced final clusters by using either final consonant deletion, /r/ deletion or /l/ vocalization. He metathesized final fricative + stop clusters, [sk] to [ks]. He deleted /s/ in initial /s/ + stop clusters. However, in sw and sl clusters, he substituted [f] for /s/, and then often deleted the /w/. However, by substituting the [f] he retained the roundness feature of the /w/ and thus made a distinction between sing [sɩŋ] and swing [fɩŋ]. He also had some difficulty with stops in clusters, substituting, [k, g] for /t, d/ in tr and dr clusters.

He appears to be in transition between Ingram's Stage 2 and 3 in the acquisition of initial fricatives and affricates as can be seen by the following table, with stopping and fronting being used.

Table 94. Subject #10. Substitutions for Fricatives and Affricates

Target	Initial substitutions	Final substitutions
f	f	f
v	b	f, p
θ	f, t	f, s
ð	d	v, f
s	s	s
z	z	z, s
ʃ	s	s
tʃ	t	ts, s
dʒ	d	z

Glottal replacement in intervocalic position was used 21% of the time for /n, l, dʒ, ʒ, t, d/. Liquids were vocalized in final position and /r/ substituted by [w] in initial position. Final consonant devoicing was used 32% of the time mostly for fricatives and affricates.

6.11 Subject #11 (7-6 years)

This subject ranked 2nd in his overall correct production of segments and clusters. In final clusters, he was unique in that he deviated from both normal development and all other subjects of the present study. He produced final nasal and liquid clusters but not stop + fricative or fricative + stop clusters. In other words, he produced final clusters if they contained a [+sonorant] segment. Final consonant deletion was his major rule (38%) for reducing final clusters. In initial clusters, he used gliding and /s/ deletion the majority of the time. However, 25% of the time he deleted the nasal in /s/ + nasal clusters, with substitution errors occurring in stops or nasals in the initial clusters. He exhibited a lateral lisp on all sibilants, especially palato-alveolars with dental fricatives becoming alveolars.

6.12 Subject #12 (7-8 years)

Subject #12 stood out from the rest of the subjects in that he did not produce any final clusters and only tw in initial position. He used double consonant deletion in 33% of the cases and final consonant deletion in 33% of the cases and final consonant deletion in 50.6% of the cases. He used liquid, glide and /s/ deletion in all initial clusters. He changed 57.3% of #CC and CC# to CV syllable structure and 44% to CVC syllable structure. He was in Ingram's Stage 3 for initial fricatives and affricate acquisition but in Stage 2 for final ones as can be seen from Table 95.

Table 95. Subject #12. Substitutions for Fricates and Affricates

Target	Initial substitutions	Final substitutions
f	f	∅
v	v	b, ∅
θ	t, f	∅, t
ð	d, z	∅
s	s	∅
z	ð	∅
ʃ	ʃ, s	∅
tʃ	tʃ, t	s
dʒ	d	∅

He produced only final [m, l, r, p, b, t, k, n, l, r] using final consonant deletion over 50% of the time. He was the only subject who could not produce [n] consistently changing it to [r], an extremely idiosyncratic rule. [s] occurred finally phonetically only as a substitution for /tʃ/.

The fact that he could produce [s]# as a substitute for /tʃ/ but not as the realization of /s/ shows that the problems displayed cannot be simply accounted for as phonetic or production difficulties. Rather they reveal, in addition, phonological problems (cf. Stampe, 1969, on this question).

6.13 Subject #13 (8-2 years)

This subject produced two final cluster types (nasal, stop + fricative) and three initial cluster types (stop + $\{{r \atop w}\}$, fricative + w). /r/ deletion and /l/ vocalization were used to reduce final cluster, but, also, penultimate consonant deletion rather than final consonant deletion was used for stop + fricative and fricative + stop cluster. This is a deviation from the other subjects who tended to use final consonant deletion. She also was like subjects #8, #10 and #15 in that she used affrication in final consonant clusters. In initial clusters, deletion was used with liquids, glides and /s/ deletion with /s/ clusters. In terms of syllable structure, 96% of her CVC syllable structures were preserved but she reduced almost all other structures to CVC syllables. She vocalized 72% of final liquids and used gliding in initial position. Most initial fricatives were correct, but all final fricatives were stopped, placing her in Ingram's Stage 2 for final fricative acquisition.

6.14 Subject #14 (9-0 years)

This subject produced all initial clusters to some extent and 50% of the CCCVC syllables were produced correctly. No other subject achieved any percentage correct on this syllable structure. Gliding and /l/ deletion were used for initial clusters with /l/ as a means of simplifying them. For final clusters, final consonant deletion (31%), /r/ deletion (94%) and /l/ vocalization or /l/ deletion (67%) were used to simplify. In addition, sk clusters were metathesized to ks. He used fronting to produce palato-alveolars, producing [s] for /ʃ/ and [ts] for /tʃ/. Final liquids were vocalized and [w] was substituted for /r/ initially. Dental fricatives became [f, v] or [s, z] depending on position.

6.15 Subject #15 (9-0 years) and #16 (9-4 years)

These two oldest subjects had essentially the same error patterns except that #16 produced more segments correctly. Both used gliding over 65% of the time for initial clusters, with #15 also using /s/ deletion 75% of the time. #15 tended to delete the glide in /sw/ clusters with #16 producing them with an error in the /s/. Both vocalized final liquids and substituted [w] in initial position. Both tended to front palato-alveolar fricatives and #15 also fronted affricates. #16 could produce dental fricatives correctly, while #15 substituted [f] or [d] for them. #16 was also one of the few subjects who had difficulty with final stops, either deleting them or substituting for them, but was the only subject who produced a final fricative + stop cluster, i.e. sk.

6.16 Summary

We can summarize some of this information by saying that, in general, it appears that the subjects who produced the fewest correct clusters were also the ones who had the more different error types in attempting them. For example, the subjects who could produce at least 3 initial and 3 final clusters seemed to use the same rules to reduce the remaining incorrect clusters; however, the subjects who produced fewer correct clusters also were more variable, inconsistent, and individualistic in terms of errors regarding the clusters they could not produce. Certain clusters show inconsistent results. Acquisition of rC and lC clusters does not seem to be a function of age but of individual subject; for one subject, rC might be the first cluster produced while for another of the same age, lC might be the first cluster produced.

The literature on normal acquisition reports that final consonant deletion occurs mainly with voiced stops in nasal clusters while with voiceless stops, the nasal tends to be deleted (Smith, 1973; Ingram, 1976). Thus, the subjects of this study (except for #2 and #12) differed from the normal subjects.

In initial clusters, the first ones occurring seem to be <u>bw</u>, <u>pw</u> and <u>tw</u>. If a fricative + /w/ cluster was produced it was restricted to the labial fricative <u>fw</u>. No subject produced <u>sw</u> and not <u>fw</u>, but if they produced <u>sw</u> they also produced <u>fw</u>. This may mean that <u>fw</u> is an easier cluster than <u>sw</u> for this population.

Some types of unusual substitutions have already been noted in the discussion of each subject. However, some processes which have been reported in the literature as occurring frequently with normals and also other deviant populations did not seem to occur with any great frequency here. They are metathesis, spirantization (l $\rightarrow$ z) fronting of velars, denasalization and initial and intervocalic voicing. Although one or two subjects used some of these rules, they did not occur to a great extent. Perhaps the reason for this is that this population is too old to be compared with younger children. Lateralization of fricatives and affricates occurred for only two subjects; frontal lisps occurred with three subjects. Back assimilation and fronting of velars were not used more than just occasionally. Affrication of fricatives did occur to some extent with seven subjects and occasionally for five more.

In summary, we can see that the subjects all used rules for reducing clusters and producing affricates and fricatives which have been reported in the normal and abnormal literature. No particular rule stands out as evidence of categorizing these children as "aphasic." In fact, each subject seemed to use his/her own error patterns and cannot be grouped entirely with other subjects. While two subjects may use the same rule for simplifying initial clusters, they may use different rules for producing affricates and fricatives and may in fact be in different acquisition stages. Although many subjects utilized a CV syllable structure, CVC was also prevalent, thus making it difficult to even classify these children as deviant in terms of Renfrew's (1966) "persistence of the open syllable." No factors other than age in extremes, i.e. youngest and oldest, could be found to account for the children's errors. For example, Subject #12 who was worst in terms of the number of errors, was considered apraxic; but so was the oldest subject, who made the least errors! All we can conclude is that these subjects are at least 50% consistent in their errors, that they do utilize rules to account for the discrepancy between their production and those of adults and that some of them utilize deviant patterns such as lisping and lateralization as do other deviant populations cited in the literature.

CHAPTER 7

SUMMARY AND IMPLICATIONS

7.0 Distinctive Feature Errors

Since the development of distinctive feature theory and its incorporation into the theory of generative phonology (Jakobson, Fant and Halle, 1963) (Chomsky and Halle, 1968) there has been much interest in whether normal and abnormal speech production (and perception) can be better understood using a feature analysis. In this study, it was shown that this abnormal population did produce the same types of feature errors as children normally acquiring phonological systems. However, the analysis of distinctive feature errors (cf Chapter 5) may in fact obscure some general trends. For example, it was pointed out in Chapter 5 that the most frequent errors involved the features coronality, back, consonantal, round and high. But it was the vocalization or syllabification of /l/ and /r/ in final position which resulted in the high percentage of the changes from [+coronal] to [-coronal] and from [+consonantal] to [-consonantal]. These segmental changes also simultaneously involve a change in backness and often roundness with the liquids becoming [o̤o] and [ə].

In addition, 27% of all the errors involving liquids included "rules" with 6 feature value. Thus, if one uses only a feature analysis, and particularly the feature set used here, the pattern of substitutions seems to be distorted. It seems, then, that feature value substitutions are meaningful primarily when error substitutions occur in the same major class of consonants, vowels, liquids, or glides.

Place substitutions accounted for 50.8% of all distinctive feature errors, replicating the findings of Singh and Frank (1972). In addition, a place of articulation feature is substituted by the closest, more fronted feature, e.g. /t/ for /k/, /p/ for /t/. This lends some support to Ladefoged's linearly valued place feature (1971). Exceptions to this are noted in Chapter 5. When manner substitutions are examined, affricates were mispronounced 45.8% of the time being substituted by stops or fricatives. If affricates are analyzed as clusters then these errors can be analyzed as cluster reductions.

Note that a cluster analysis on the phonetic level neither supports nor negates analyzing affricates as phonological single segments. The data such as those discussed in this thesis and elsewhere suggest strongly that a distinction must be made between phonological representation and phonetic articulation. As was discussed in Chapter 6, the fact that one subject could produce [s]# as a substitute for [tʃ] but not as the realization of /s/ shows that this is not a phonetic or production difficulty but rather a phonological problem. Other evidence from the present study in support of this occurred in /sw/ clusters vs. /s/ as a single segment. Many of the subjects produced <u>swing</u> as [fɩŋ] and <u>sing</u> as [sɩŋ], thus keeping these two words distinct without needing to produce a cluster. Thus, for <u>swing</u>, the roundness feature is copied in the initial fricative so that the /w/ can be deleted without any information being lost.

Fricatives tended to be replaced by stops (i.e. change from [+continuant] to [-continuant]); the reverse seldom occurred. [+voicing] to [-voicing] occurred rather than vice versa. These asymmetric errors support the notion that there will be a tendency to go from more to less marked segments or feature values.

7.1 "Realization Rules" or Regular Substitutions

All subjects used some type of cluster reduction for both initial and final consonant clusters. In general, for all final consonant clusters except liquid + stop, the subjects used final consonant deletion as the main rule for reducing these clusters (44.3%). As discussed above, this is somewhat in opposition to trends noted for normal children.

In final liquid clusters, /r/ deletion and /l/ vocalization account for 75% of the errors; final consonant deletion occurred 25% of the time. This agrees with the literature which has reported the deletion or substitution of the "marked" member of the cluster. However, more study on final consonant cluster acquisition is warranted since the most correct clusters for the present population were nasal clusters and /ks/ clusters. The asymmetry between the correctness of the /ks/ clusters and the errors in /sk/ clusters was discussed above. It may be hypothesized that a stop + fricative cluster is easier to produce than a fricative + stop cluster. However, this is counter to Greenberg's (1965) prediction that a fricative + stop final cluster is more prevalent in the languages of the world than a stop + fricative.

In initial cluster production, the subjects of the present study seem to be in Ingram's Stages 2 and 3, deleting or substituting one member of the cluster. Liquid deletion and /s/ deletion before stops or nasals were the two most frequent simplifying techniques used by this population; this has also been reported in the literature for both normal and abnormal populations.

Many of the same types of assimilation rules in clusters were used as those reported by Ingram (1976) and Greenlee (1973, 1974). However, few of the subjects devoiced nasals following /s/ deletion which was a prevalent rule noted by Smith (1973); it may be that this population is too old to compare with a young normal child. Variation, of course, probably occurs for normals. It would not be surprising for some to delete after the phonological nasal devoicing rule, and others to delete prior to the operation of this rule showing that the rule is productive in performance. With liquids, gliding occurred for /r/'s more than for /l/'s. The subjects seemed to either produce /l/ correctly or delete it, rather than change it into a [w]. However, for /r/, gliding was used 48% of the time.

The results of the present study on initial and final liquids parallel those reported in the literature (Compton, 1976; Ingram, 1976). Liquids became glides in initial position, with /l/ tending to become [j] and /r/ always becoming [w]. Liquid vocalization was a major rule for producing final syllabic and nonsyllabic liquids in this population.

In regards to the acquisition of affricates and fricatives, these subjects deviated from the normal population. In the present study, both the /f/ and /v/ were acquired before /ʃ/, the subjects apparently having more difficulty with the palatal fricative than normal children do. As to fricatives, as mentioned above, stopping occurred only for /f/ and dental fricatives. Fronting was used over 50% of the time for /ʃ/ and 43% of the time for /ʒ/. Devoicing occurred mainly in final position for fricatives. Another prevalent rule for dental fricatives was /θ/ → [f] or [s] in final position. The [f] substitution occurred about 52% of the time, while the [s] occurred about 20% of the time.

Two deviant processes discussed by Ingram (1976) are lisping processes--both frontal and lateral. These types of errors occurred for this population on par with that reported in the literature for other abnormal populations.

7.2 Comparison of Phonological Theories As "Explanations" or "Predictions" for This Study

7.21 Jakobson's Predictions

Jakobson (1968) suggested that in the acquisition of phonology there are structural laws or linguistic universals that underlie language change. Although Jakobson divided phonological development into two periods, 1) prelanguage babbling and 2) language acquisition proper, we will be discussing only the second period. At the onset of the second period, Jakobson posited various stages of development that are determined by an inherent universal hierarchy governed by structural laws of "irreversible solidarity." These laws determine the hierarchical structure of the acquisition of sounds. For example, Jakobson stated that "the existence of an entity Y in a phonemic system implies the existence of an entity X in that same system" (Jakobson, 1971, p. 19). He presented a universal order of acquisition along both a tonality axis (resonance features) and along a sonority axis (secondary consonantal source features); however, he did not discuss interrelationships between these two. Moreover, he did not consider position of a sound in a word, stress or intonation. He does suggest that infrequent sounds in the world's languages are acquired later than frequent sounds. For example, voiceless stops would be acquired earlier than ejectives.

We cannot say anything of value concerning stops, nasals and glides since most of the subjects in the present study had already acquired most of them and no pattern of development could be determined. However, Jakobson does imply that w and h are acquired late, a claim which would not be substantiated by the fact that these sounds were among the most correct for this population. If they were acquired later, one might predict that they would have been more in error, although this, of course, is not necessarily implied.

However, we can make some statements concerning affricates and fricatives. First, let us look at Jakobson's claims:

1) In general, stops are acquired before fricatives which implies that a child will acquire all his stops before acquiring all his fricatives. This claim arises from the fact that stops are more frequent in the world's languages and less "marked" phonologically.

2) In particular, the dental fricative /s/ is acquired before the labiodental /f/; /ʃ/ comes after both the stops /k, g/ and the front fricatives /f, s/, i.e. s → f → k, g → ʃ.

3) Homorganic stops would be substituted for fricatives more than any other substitution.

4) Affricates are more difficult (i.e. more complex and therefore more marked) than fricatives and are acquired later.

Looking at Jakobson's number 1 claim, we can see that this is borne out by the present study. Fricatives were indeed more in error than stops and no subject had acquired all fricatives before his stop series. However, in terms of substitutions for stops (#3), homorganic stops were substituted only for /v/, /ð/ and less frequently for /θ/. The dental fricatives /θ, ð/ are rare in the languages of the world and thus Jakobson would predict are acquired later. This is, in fact, substantiated by the present study in that only one of the subjects had complete mastery over these fricatives.

Jakobson stated in #2 that /s/ would be acquired before /f/; however for this population, /s/ was more in error than /f/. /f/ had been acquired by more subjects than /s/ which disputes this claim. We did find, however, that the palato-alveolar /ʃ/ was more difficult (i.e. more in error) than either /f/ or /s/ and that most subjects seemed to acquire the front fricatives before /ʃ/ or /ʒ/.

Jakobson's prediction that affricates /tʃ/ and /dʒ/ are more difficult and thus acquired later was not substantiated by this study. In the present study, they are acquired, at least in initial position, before some of the fricatives. In fact, in the present study, /tʃ/ is acquired before /ʃ/ although both segments occur at the same place of articulation. The subjects tended to substitute alveolar affricates [ts] and [dz] for final affricates /tʃ/ and /dʒ/ showing that it may be more the place that is in error rather than the manner of production. In initial position, fronting and stopping were both used resulting in [t] and [d] being produced instead of /tʃ/ and /dʒ/. Thus, the subjects of this study could produce [ts, dz, s, z] but not the palato-alveolar [tʃ], [dʒ] and [ʃ], and [ʒ]. It was also found that fricatives are acquired as individual segments rather than by a spread of a feature of frication or continuancy across a class of segments. This agrees with Ferguson (1972). We also found a greater percentage of fricatives in final position than fricatives in initial position as Ferguson predicted.

In general, for all sounds, initial position was more often correct than final position. For stops, intervocalic position was the most unstable, i.e. the most incorrect, especially for the alveolar stops, /t, d/. Since Jakobson did not discuss individual phonological organization nor position within a word, we must turn to different theories to account for this.

7.22 Ferguson's "P-G" Gap Universal

Ferguson (1975) proposes a phonological universal that states that /p/ and /g/ are the least stable of the core stop inventory of /p, t, k, b, d, g/ in human languages. He cites evidence from the Stanford Phonology Archive that of 377 languages, 88 have a gap in the stop series--40 lack /g/ and 36 lack /p/. Evidence from phonological development of English-speaking and Spanish-speaking children shows that /p/ and /g/ are the least stable of their stop consonants (Ferguson, 1975).

Since most of the subjects of the present study correctly produced stops, this proposed universal could not be looked at in any depth. However, the two subjects who had difficulty with stops in intervocalic and final positions produced most errors on /p/ and /g/. One subject produced no intervocalic /p/'s correctly and only 6% correctly /g/'s. The other subject had a slight tendency to produce more incorrect intervocalic /p/'s and /g/'s but other stops were very much in error also, so this subject gave no evidence concerning this proposed universal. A much younger population would have to be studied for any conclusions to be made.

7.23 Stampe's Predictions

David Stampe (1969) proposes a natural phonological theory which assumes that a child has a universal and innate system of phonological processes which expresses the full set of restrictions of the human speech capacity. He defines a phonological "process" as a rule that "results in the merger of a potential phonological composition into that member of the opposition which least tries the restrictions of the human speech capacity" (Stampe, 1969, p. 443). Thus the child is born with an entire set of restrictions that are the most natural in the languages of the world, i.e. final consonant devoicing and voicing in voiced environments. S/he then learns to modify these restrictions based on the adult phonetic output s/he hears by 3 processes: 1) total suppression of a process, e.g. total suppression of final voiced consonants based on the innate process of final consonant devoicing; 2) limitation of processes or the partial suppression of some part of a process by limiting the segments to which it applies or by limiting the contexts. For example, limiting final consonant devoicing to fricatives while allowing final voiced stops; 3) ordering of processes where one process is blocked by the application of another process.

Thus, the child learns to pronounce the correct adult form through the use of these three processes.

In support of Stampe's view, the subjects of the present study tended to voice initial fricatives and devoice final fricatives before the voice opposition was fully acquired. This conclusion might be due to misperception on my part, however. The initial fricatives could have been lenis and unaspirated voiceless rather than voiced; since no spectrographic or other experimental analysis was performed we cannot be conclusive in this.

There is more support for Stampe's theory if we look at final consonant clusters of individual subjects. Some subjects suppressed all final clusters, some allowed only nasal clusters, some nasal clusters and stop fricative clusters and finally all final clusters were allowed. Thus a child would suppress all final clusters, then limit the suppression to only the fricative stop at the end of the stage.

Another example of partial suppression is the fact that many of the subjects could not produce consonants in the palato-alveolar region. Thus, they suppressed [tʃ, dʒ, ʃ and ʒ]. Later, this might be partially suppressed in that palato-alveolar affricates were permitted but not fricatives. An example of limiting the context occurred when subjects could produce initial affricates but not final affricates, limiting final position to stops and fricatives only.

7.3 Summary

In summary, we can say that no specific identifying patterns of disorder could be seen for this group of children as a whole. Each subject performed in an idiosyncratic manner so no conclusions as to the diagnostic category of "aphasia" could be made. However, their errors were not random and they all used rules normal children do when acquiring sounds. They also used various abnormal rules such as lisping and affrication. Thus, it is necessary to analyze each child's phonological pattern to determine any therapy goals and make any predictions as to prognosis. The next step in research is to compare these errors in words in isolation to the errors in conversational speech to determine what differences, if any, exist. This will be forthcoming. We can state that children with abnormal phonology can provide the same types of evidence in terms of stages of acquisition of sounds, rules and rule patterns in terms of acquisition of phonology as can normally developing children. The phonological theories that account for normal phonology can also be used to account for abnormal phonology--a different acquisition theory need not be advanced.

BIBLIOGRAPHY: REFERENCES CITED

Baltaxe, C. M. 1969. Translation of N. S. Trubetzkoy: the Principles of Phonology. University of California Press, Berkeley.

Bangs, J. 1942. "A clinical analysis of the articulatory defects of the feebleminded." Journal of Speech and Hearing Disorders, Vol. 7, pp. 343-56.

Berko, J. 1958. "The child's learning of English morphology." Word, Vol. 14, pp. 150-77.

Bodine, A. 1974. "A phonological analysis of the speech of two Mongoloid (Down's Syndrome) boys." Anthropological Linguistics, Vol. 16, pp. 1-14.

Bricker, William A. 1967. "Errors in the echoic behavior of preschool children." Journal of Speech and Hearing Research, Vol. 10, No. 1.

Cairns, Charles E. 1969. "Markedness, neutralization and universal redundancy rules." Language, Vol. 45, No. 4, pp. 863-885.

Chomsky, N. and Halle, M. 1968. The Sound Pattern of English. New York: Harper and Row.

Compton, A. J. 1970. "Generative studies of children's phonological disorders." Journal of Speech and Hearing Disorders, Vol. 35, pp. 315-39.

Compton, A. J. 1975. "Generative studies of children's phonological disorders: a strategy of therapy." In S. Singh (ed.), Measurements in Hearing, Speech and Language. Baltimore: University Park Press.

Compton, A. J. 1976. "Generative studies of children's phonological disorders: clinical ramifications." In D. Morehead and A. Morehead (eds.), Normal and Deficient Child Language. Baltimore, University Park Press.

Crocker, J. R. 1969. "A phonological model of children's articulation competence." Journal of Speech and Hearing Disorders, Vol. 34, pp. 203-13.

Curtiss, Susan. 1977. Genie: A Psycholinguistic Study of Modern-Day "Wild Child". New York: Academic Press.

Edwards, M. L. 1970. "One child's acquisition of English liquids." Papers and Reports on Child Language Development, Vol. 3, pp. 101-109.

Edwards, M. L. 1973. "The acquisition of liquids." In G. Drachman (ed.), Working Papers in Linguistics, Vol 15, pp. 1-54. Ohio State University.

Edwards, M. L. 1974. "Perception and production in child phonology: the testing of four hypotheses." Journal of Child Language, Vol. 1, pp. 205-19.

Edwards, M. L. and Bernhardt, B. 1973. "Phonological analyses of the speech of four children with language disorders." Unpublished paper, Stanford University, Stanford, California.

Eisenson, J. 1972. Aphasia in Children. New York: Harper and Row.

Farwell, Carol B. 1972. "A note on the production of fricatives in linguistically deviant children." Papers and Reports on Child Language Development, Vol. 4, pp. 93-102.

Farwell, Carol B. 1976. "Some strategies in the early production of fricatives." Papers and Reports on Child Language Development, Vol. 12, pp. 97-104.

Ferguson, Charles. 1972. "Fricatives in child language acquisition." Proceedings of the Eleventh International Congress of Linguistics (Bologna-Florence).

Ferguson, Charles, 1975. "Sound patterns in language acquisition." In Dato, D. P. (ed.), Developmental Psycholinguistics: Theory and Applications. Georgetown University Round Table on Languages and Linguistics.

Ferguson, C. and Farwell, C. 1975. "Words and sounds in early language acquisition: English initial consonants in the first 50 words." Language, Vol. 51.

Ferguson, C. and Garnica, O. 1975. "Theories of phonological development." In E. Lenneberg and E. Lenneberg (eds.), Foundations of Language Development. UNESCO.

Fromkin, Victoria A. 1970. "The concept of 'naturalness' in a universal phonetic theory." Glossa, Vol. 4, pp. 29-43.

Greenberg, Joseph H. 1965. "Some generalizations concerning initial and final consonant sequences." Linguistics, Vol. 18, pp. 5-34.

Greenberg, J. 1966. Universals in Language. Cambridge, Mass.: M.I.T. Press, second edition.

Greenlee, M. 1973. "Some observations on initial English consonant clusters in a child two to three years old." Papers and Reports on Child Language Development, Vol. 6, pp. 97-106.

Greenlee, M. 1974. "Interacting processes in the child's acquisition of stop-liquid clusters." Papers and Reports on Child Language Development, Vol. 7, pp. 85-100.

Hooper, J. B. 1973. "Aspects of natural generative phonology." Unpublished Ph.D. dissertation. University of California, Los Angeles.

Ingram, D. 1972. "Phonological analysis of a developmentally aphasic child." Mimeographed. Stanford University, Stanford, California.

Ingram, D. 1974a. "Phonological rules in young children." Journal of Child Language, Vol. 1, pp. 49-64.

Ingram, D. 1974b. "Fronting in child phonology." Journal of Child Language, Vol. 1, pp. 233-41.

Ingram, D. 1975. "The acquisition of fricatives and affricates in normal and linguistically deviant children." In A. Caramazza and E. Zuriff (eds.), The Acquisition and Breakdown of Language. Baltimore: Johns Hopkins University Press.

Ingram, D. 1976. Phonological Disability in Children. Elsevier: New York.

Jakobson, R. 1968. Child Language, Aphasia, and Phonological Universals. The Hague: Mouton.

Jakobson, R. 1971. Studies on Child Language and Aphasia. The Hague: Mouton.

Jakobson, R., Fant, G. and Halle, M. 1963. Preliminaries to Speech Analysis. Cambridge, Mass.: M.I.T. Press.

Kornfeld, J. 1971. "Theoretical issues in child phonology." Papers from the Seventh Regional Meeting, Chicago Linguistics Society, pp. 454-68.

Ladefoged, P. 1971. Preliminaries to Linguistic Phonetics. Chicago: University of Chicago Press.

Leopold, W. 1947. Speech Development of a Bilingual Child. Vol. 2, pp. 207-256. Evanston: Northwestern University Press.

Lightner, T. M. 1965. "Segmental phonology of contemporary standard Russian." Unpublished doctoral dissertation, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Lorentz, J. 1976. "An analysis of some deviant phonological rules of English." In D. Morehead and A. Morehead (eds.), Normal and Deficient Language. Baltimore: University Park Press.

Lorentz, J. 1974. "A deviant phonological system of English." Papers and Reports on Child Language Development, Vol. 8, pp. 55-64.

McReynolds, L. and Huston, K. 1971. "A distinctive feature analysis of children's misarticulations." Journal of Speech and Hearing Disorders, Vol. 36, pp. 155-66.

Menn, L. 1971. "Note on the acquisition of affricates and fricatives." Papers and Reports on Child Language Development, Vol. 6, pp. 87-95.

Menyuk, P. 1968. "The role of distinctive features in children's acquisition of phonology." Journal of Speech and Hearing Research, Vol. 11, pp. 138-46.

Menyuk, P. 1971. "Clusters as underlying single segments: evidence from children's production." Paper presented to the International Congress of Phonetic Sciences (Montreal).

Morehead, D. and Ingram, D. 1973. "The development of base syntax in normal and linguistically deviant children." Journal of Speech and Hearing Research, Vol. 16, pp. 330-52.

Moulton, William G. 1976. In D. S. Harrison and T. Trabasso (eds.), Black English: a Seminar, pp. 149-70. New York: John Wiley and Sons.

Moskowitz, A. 1970. "The two-year old stage in the acquisition of English phonology." Language, Vol. 46, pp. 426-41.

Moskowitz, A. 1971. "Idiomatic phonology and phonological change." Mimeographed. University of California, Los Angeles.

Moskowitz, A. 1972. "The acquisition of fricatives: a study in phonetics and phonology." Mimeographed. University of California, Los Angeles.

Oller, D. K. 1973. "Regularities in abnormal child phonology." Journal of Speech and Hearing Disorders, Vol. 38, pp. 36-47.

Oller, D. K. and Kelly, C. A. 1974. "Phonological processes of a hard-of-hearing child." Journal of Speech and Hearing Disorders, Vol. 39, pp. 65-74.

Olmsted, D. 1971. Out of the Mouth of Babes. The Hague: Mouton.

Panagos, J. 1974. "Persistence of the open syllable reinterpreted as a symptom of language disorder." Journal of Speech and Hearing Disorders, Vol. 39, pp. 23-31.

Pierce, S. and Bartolucci, G. 1976. "Phonological production and perception in verbal, autistic, normal and mentally retarded subjects." Papers and Reports on Child Language Development, Vol. 12, pp. 189-198.

Postal, P. 1968. Aspects of Phonological Theory. New York: Harper and Row.

Renfrew, C. E. 1966. "Persistence of the open syllable in defective articulation." Journal of Speech and Hearing Disorders, Vol. 31, pp. 370-73.

Salus, P. H. and Salus, M. W. 1974. "Rule ordering in child phonology." Canadian Journal of Linguistics, Vol. 19, No. 1.

Sander, E. K. 1961. "When are speech sounds learned?" Journal of Speech and Hearing Disorders, Vol. 37, pp. 56-63.

Schane, S. A. 1967. "On the nonuniqueness of phonological representations." Paper presented to the December meeting of the Linguistic Society of America.

Singh, S. and Frank, D. C. 1972. "A distinctive feature analysis of the consonantal substitution pattern." Language and Speech, Vol. 15, No. 3.

Smith, N. 1973. The Acquisition of Phonology: a Case Study. Cambridge, England: Cambridge University Press.

Snow, K. 1963. "A detailed analysis of articulation responses of normal first grade children." Journal of Speech and Hearing Research, Vol. 6, pp. 277-90.

Stampe, D. 1969. "The acquisition of phonetic representation." Papers from the Fifth Regional Meeting, Chicago Linguistic Society, pp. 443-54.

Stampe, D. 1972. "A dissertation on natural phonology." Unpublished Ph.D. dissertation. University of Chicago, Chicago, Illinois.

Tallal, P. and Piercy, M. 1973. "Developmental aphasia: impaired rate of nonverbal processing as a function of sensory modality." Neuropsychologia, Vol. 11, pp. 389-98.

Tallal, P. and Piercy, M. 1974. "Developmental aphasia: rate of auditory processing and selective impairment of consonant perception." Neuropsychologia, Vol. 12, pp. 83-93.

Tallal, P. and Piercy, M. 1975. "Developmental aphasia: the perception of brief vowels and extended stop consonants." Neuropsychologia, Vol. 13, pp. 69-74.

Templin, M. 1957. "Certain language skills in children: their development and interrelationships." Institute of Child Welfare Monograph, Vol. 26. Minneapolis: The University of Minnesota Press.

Velton, H. 1943. "The growth of phonemic and lexical patterns in infant language." Language, Vol. 19, pp. 281-292.

Waterson, N. 1971. "Child phonology: a prosodic view." Journal of Linguistics, Vol. 7, pp. 170-221.

Weber, J. 1970. "Patterning of deviant articulation behavior." Journal of Speech and Hearing Disorders, Vol. 35, pp. 135-41.

West, J. J. and Weber, J. L. 1973. "A phonological analysis of the spontaneous language of a four-year old, hard-of-hearing child." Journal of Speech and Hearing Disorders, Vol. 38, pp. 25-35.

APPENDIX I. Available Test Scores on Subjects

Subject	Age	PPVT	ACLC				NSST		WRAT			Oral Apraxia	Wepman	MLU
			1	2	3	4	R	E	Rd.	Sp.	Arith			
1	4-8	78	100	73	43	54	↓10	↓10				Yes		3.67
2	5-0	64	80	70	60	10	-	↓10						3.7
3	5-7	85	-	-	-	-	↓10	↓10	K.6	K.4	I.5			4.5
4	5-9	68	95	90	57	41	↓10	↓10				Yes		3.7
5	6-5	CNT	86	50	30	20	-	-						4.7
6	6-9	-	-	-	-	-	-	-	K.9	1.0	K.4			4.8
7	6-10	56	84	100	90	70	↓10	↓10	1.0	1.1	K.2			4.1
8	7-0	97	100	100	75	83	↓10	↓10	K.8	1.2	1.0			6.25
9	7-2	-	88	80	50	20	↓10	↓10						4.26
10	7-4	-	-	-	-	-	↓10	↓10	1.1	1.2	1.9		12/30 X	5.25
11	7-6	73	84	52	55	20	↓10	↓10				Yes		4.36
12	7-8	75	-	-	-	-	↓10	↓10				Yes		4.6
13	8-2	89	82	80	60	30	↓10	↓10	1.0	1.0	K.9			3.64
14	9-0	90	-	90	90	70	↓50	↓10	1.3	1.8	.4			5.4
15	9-0	-	100	100	100	80	↓10	↓10	1.0	1.0	1.0		22/30 X	4.6
16	9-4	87	-	100	60	90	↓10	↓10	K.9	1.0	1.0	Yes		3.9

PPVT = Peabody Picture Vocabulary Test; ACLC = Assessment of Children's Language Comprehension (%)

NSST = Northwestern Syntax Screening Text (%ile); WRAT = Wide Range Achievement Test (Grades)

Wepman = Wepman Auditory Discrimination Test (Error Score); MLU = mean length of utterance

CNT = could not be tested

APPENDIX II

Stimulus Words

1. balloon
2. bath
e. belt
4. biggest
5. block
6. box
7. boy
8. breathe
9. brush
10. build
11. cage
12. cake
13. candle
14. card
15. carrot
16. cast
17. catching
18. cheese
19. chicken
20. clown
21. coat
22. coffee
23. cold
24. cookie
25. crib
26. cup
27. cutting
28. dishes
29. dog
30. drink
31. duck
32. ear
33. eat
34. elephant
35. eraser
36. feather
37. fish
38. flower
39. food
40. fork
41. fox
42. frog
43. game
44. ghost
45. giraffe
46. glasses
47. glove
48. grass
49. gum
50 gun
51. hammer
52. hand
53. heart
54. juice
55. jump
56. king
57. kitten
58. knife
59. knock
60. lamp
61. left
62. mask
63. match
64. measuring
65. melt
66. milk
67. mother
68. mouth
69. nose
70. oven
71. page
72. pajamas
73. park
74. penny
75. pig
76. plane
77. present
78. puzzle
79. queen
80. rabbit
81. raining
82. refrigerator
83. rock
84. rug
85. saddle
86. sand
87. school
88. sheep
89. shirt
90. skate
91. sleep
92. slide
93. smile
94. smooth
95. snake
96. snow
97. spider
98. splashing
99. spoon
100. sticky
101. stove
102. string
103. sweater
104. swimming
105. swing
106. sugar
107. table
108. teacher
109. television
110. thank-you
111. there
112. this/that
113. thumb
114. three
115. tiger
116. toe
117. tongue
118. train
119. treasure
120. tub
121. twin
122. vase
123. violin
124. wagon
125. washing
126. witch
127. yard
128. you
129. zebra
130. zipper