

ERROR MIGRATION: FACTOR FOR CONSIDERATION  
WHEN DEVELOPING NORMATIVE PHONOLOGICAL DATA

An Honors Thesis (ID 499)

by

SARA MCDERMOTT

ADVISOR: DR. CHARLES W. MARTIN

A handwritten signature in black ink, appearing to read "Charles W. Martin", is written over a horizontal line. The signature is fluid and cursive, with a long horizontal stroke extending to the right.

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TABLE OF CONTENTS

LIST OF CHARTS..... iii

LIST OF TABLES..... iv

INTRODUCTION..... 1

REVIEW OF THE LITERATURE..... 5

METHOD..... 17

    Selection of Subjects..... 17

    Materials..... 17

    Procedure..... 17

FINDINGS..... 19

SUMMARY AND CONCLUSIONS..... 21

    Summary..... 21

    Discussion..... 21

    Suggestions for Further Research..... 22

    Conclusions..... 23

APPENDIX..... 24

BIBLIOGRAPHY..... 28

LIST OF CHARTS

1. Haelsing & Madison Normative Data on Phonological Processes	Page 28
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LIST OF TABLES

TABLES	PAGE
1. Data Results Form the <u>Goldman-Fristoe Test of Articulation</u> : Normal Subjects	26
2. Summary of Mean Percentage of Occurrence on the Three Articulation Tests used	26
3. Individual error migration Patterns of Subjects	27

## INTRODUCTION

Articulation tests have two basic purposes. The first is to determine the nature of the articulation problem and the second is to determine how extensive the problem is (Mowrer, 1982). Information obtained from an articulation test concerning these two purposes is used to develop a therapy program, provided one is necessary. Many types of articulation tests are available to speech-language clinicians, each generally related in many ways, especially in that the initial, medial, and final positions of phonemes in words are tested. Some tests employ single-word elicitation tasks, while others include procedures to obtain a spontaneous connected speech sample.

The method of eliciting sounds within single words that is most often used requires naming objects in pictures, especially when testing young children (Mowrer, 1982). In tests using the procedure, the client is asked to say the name of the object represented in the picture. Each word represented contains a target phoneme and within the particular test, each phoneme in Standard American English is represented in each of the three basic positions (initial, medial, final). The target sounds are evaluated by the way the client pronounces them. As an example, the Photo Articulation Test developed by Pendergast, Dickey, Selmar, and Soder (1969) "consists of seventy-two color photographs of objects familiar to most children" (Darley, 1979).

As the child names the object in the picture, the clinician evaluates how accurately the target sound is pronounced. Examples of tests that involve single-word elicitation are the Developmental Articulation Test, developed by Hejna (1963) and the Compton-Hutton Phonological Assessment, developed by Compton and Hutton (1978).

Several methods have been used in order to obtain a spontaneous, connected speech sample. One method involves simply engaging a conversation with the client. Asking the client questions about his/her hobbies and interest can elicit a spontaneous sample that is representative of the client's speech. Problems arise if the client is uncooperative or unresponsive (Weiss, 1980). Another method of obtaining a spontaneous, connective speech sample involves the use of pictures to elicit a story from the client. For example, the Goldman-Fristoe Test of Articulation, developed by Goldman and Fristoe (1969), employs pictures to be shown to the client, who in turn tells about the pictures. Each picture usually elicits more than one phoneme; therefore, the time to administer the test is reduced.

A growing body of research literature has questioned the validity of testing articulation with the traditional single word elicitation procedure. Research has indicated that available single word articulation tests are not valid in terms of psychometric criteria. McCauley and Swisher (1984) tested 30 articulation and language tests for preschool children on the basis of 10 psychometric criteria. Results of the analysis

criteria.

Healy and Madison (1984) compared the results of single word articulation tests and connected speech samples in speech delayed children. They discovered both a quantitative and qualitative difference in the errors recorded from the two testing procedures. They questioned whether single word articulation test accurately measure articulation abilities.

Although standardized testing provides the speech pathologist with information regarding error patterns, such standardized procedures may result in an unrepresentative speech sample (Schwartz, 1983). Since a representative sample of speech is necessary for effective remediation of articulatory disorders, the contemporary speech-language pathologist may find it beneficial to compare frequency and type of articulation error, including error migration between single word production and connected speech samples (Healy and Madison, 1983).

Considering the clinical significance of the often observed discrepancy between articulation performance in response to single word stimuli and connected speech samples, there has been limited description of it (Healy and Madison, 1983). The increased frequency of articulation errors as a function of the type of test given has been termed "error migration" (Faircloth and Faircloth, 1970). Current research finding on error migration have shown significant variability (Faircloth and Faircloth, 1970; DuBois and Bernthal, 1978; Johnson, Winney and Pederson, 1980; Healy and Madison, 1983).

The present study seeks to further the line of research of Faircloth and Faircloth (1970), DuBois and Bernthal (1978), Johnson et. al. (1980) and, in particular, Healy and Madison (1983). The focus in this study will be a comparison of both frequency and type of articulation error, including error migration between single word productions and continuous speech samples when vocabulary is held constant.

## REVIEW OF THE LITERATURE

Research has been done comparing single word articulation test results and connected speech articulation results. For this study, previous research has been divided into two major categories: 1) a comparison of normal children's and delayed children's phonological error patterns and 2) a comparison of errors on single word articulation tests and connected speech articulation tests.

### NORMAL VS. DELAYED CHILDREN

Some researchers disagree on whether there is a difference in articulation error patterns between children who differ in overall language performance. Error patterns are incorrect production due to internalized speech sound rules. Holloway and Daniloff (1969) compared articulatory defective children to normal speaking children in the area of syntax. The study used 30 children in grades 1-3 who had severe articulation problems and 30 normal children. Each child had an individual language sample recorded and analyzed for syntax and sentence length. The results revealed a significant difference between the two groups. The articulation problem children had smaller sentence lengths and produced utterances that were less grammatically complete than the normal children's utterances. They concluded that language delay is related to articulation problems. Often,

articulation defective children differ from normal children because of language acquisition problems.

Panagros (1973) made an hypothesis based on the Shriner, Holloway, and Daniloff (1969) study. He knew that children usually learn to say words with one consonant and one vowel first (open syllable). His hypothesis was that language delayed children have articulation problems because they reduce utterances to open syllables, even though they are capable of producing the omitted sound. He believed that language acquisition and articulation interact. No data was provided to support this position empirically.

Oller (1973) found that children with articulation problems usually have similar error patterns. These patterns are different than the ones used by normally developing children. Oller used 5 subjects with articulation problems. He carefully analyzed each of the subject's language samples. He discovered consistencies in the types of errors made, not obvious through other methods of analysis. He concluded that children do formulate sound rules and diagnostics should determine what those rules are. Only then may the teacher correct the erroneous rules.

In the study done by Schwartz, Leonard, Folger, and Wilcox (1980) no substantial differences were found in phonological patterns between normal speaking and language disordered children. This study differed in findings from the one of Oller (1973). The subjects of the two groups were matched on the basis of mean utterance length, sex, and cognitive development. Three

of the children were enrolled in remedial therapy programs at the time of the study. The children ranged in age from two years, seven months to three years, seven months. The researchers determined that the other three children were developing linguistically at a normal rate. This group ranged in age from one year, seven months to one year, nine months. Each of the children had at least 100 non-imitative utterances recorded and analyzed on the basis of phonological processes. A phonological process is a procedure used by children to simplify speech when attempting to produce adult words (Nicolosi, Hurryman, and Kresheck, 1983). The results revealed that the processes evidenced were the same in the speech of normal speaking and language disordered children, with one exception. Two of the normal speaking children evidenced the process of deaspiration while none of the language delayed children used this process. Also, the groups were similar in that for five of the six children, deletion of final consonant was the most frequently used process. The differences included the frequency of occurrence for each process and the amount of children in each group that evidenced each process. However, these differences were not considered to be substantial.

Schwartz, et. al. suggest in conclusion there may be a significant relationship between the acquisition of phonology and the development of other aspects of linguistic behavior. This would account for the difference of findings in the studies that did not control for language delay.

Hodson and Paden (1981) analyzed articulatory errors of 60 "essentially unintelligible" children between 3 and 8 years old. These children had been described as having multiple misarticulations. They were each being seen at the University of Illinois for diagnostics and therapy. The researchers also analyzed articulation errors of 60 normally developing "intelligible" 4 year olds for comparison. Each of the subjects individually responded to the Assessment of Phonological Processes. Verified transcriptions were then transferred to the analysis form of The Assessment of Phonological Processes.

The results of the study revealed that all of the children evidenced phonological processes. The unintelligible children evidenced liquid deviation, cluster reduction, stridency deletion, stopping and assimilation (see Appendix A). Only a few of the intelligible children demonstrated each of these processes. The most severely unintelligible subjects also evidenced velar deviation, backing, final consonant deletion, syllable reduction, prevocalic voicing and glottal replacement. Many of the intelligible children evidenced examples of devoicing of word-final obstruents. Also, some of them produced anterior strident phonemes to replace non-strident interdental. These error closely approximated adult models and the deviations that did occur did not affect intelligibility. Hodson and Paden concluded there are specific error patterns which are predictable in unintelligible speech. Further, they stated that these error patterns differ from the ones used by normally developing

children in both the number and type.

Nelson and Kamhi (1984) compared the relationship of syntax, semantics and phonology in utterances of four normal 2 year old children. Each subject was seen for at least eight sessions. During each session the clinician gave a sentence imitation task with nonsense words, and recorded a spontaneous speech sample. The sentence imitation task was controlled for sentence length and complexity and phonological complexity.

The researchers analyzed the sentence imitation task for the relationship between accuracy of consonant production and sentence complexity and between grammatical errors and the phonological complexity of nonsense words. The Percentage of Consonants Correct in target nonsense words was used to measure consonant production accuracy (Shriberg and Kwiatkowski, 1982). Grammatical errors were measured by the percentage of omissions, substitutions, additions and transpositions.

The researchers found that all four subjects made more consonant production errors as the complexity of the imitative sentences increased. The productions of low phonologically complex nonsense words improved over time, whereas the high phonologically complex words remained in error. Only one subject made more grammatical errors as phonological complexity increased.

The spontaneous speech samples revealed no consistent relationship between sentence length and accuracy of consonant production. The researchers used the number of propositions to

measure semantic complexity. It was found that consonant production was not related to semantic complexity.

The authors suggested in conclusion that phonological accuracy and sentence complexity are the most closely related when the child is going through transitional periods (reorganizing internalized speech production rules). In other words, the length of the utterance can sometimes but not always be correlated with correct consonant production in normal children.

A study was done to analyze the relationship between the phonological processes of final consonant deletion, final cluster reduction and deletion and grammatical morpheme use for bound s/z morphemes and BE verbs (Richardson, Dunn, Davis, Goleski, Lopez and Daly, 1984). A 30-minute connected speech sample was taken from each of ten children enrolled in articulation therapy. The children ranged in age from 3 years, 8 months to 5 years, 10 months.

The researchers found that those children who deleted s/z from content words also deleted s/z morphemes. The researchers found that children who deleted s/z from content words usually deleted "is" and "was" (the s/z forms of BE) in connected speech. However, when more generalized phonological processes (final consonant deletion and final cluster reduction) were analyzed in relation to bound morphemes and BE verbs, no significant correlation were found. The authors suggest that phonological errors can cause grammatical errors where accurate

articulation is necessary. This is the only case the researchers found in which language and articulation errors interact significantly in speech defective children.

Some researchers found differences in error patterns between articulation problem children and normally developing children and some did not find significant differences. More research is needed to determine valid differences or similarities between these two groups.

#### SINGLE WORD VS. CONNECTED SPEECH

In comparing single word and connected speech articulation testing, some researchers found no difference in the results. Others found that connected speech results were more indicative of the child's articulation problem than single word articulation test results. DuBois and Bernthal (1978) tested 10 target phonemes in the same 20 stimulus words elicited by three different speech sampling methods. Eighteen children ranging in age from four to six years old served as subjects. Each of them had demonstrated at least four articulation errors in the screening procedure. In the continuous speech task, the testers instructed the children to tell stories when shown multi-concept pictures. In the modelled continuous speech task, responses were elicited through delayed imitation. Single word responses were elicited through the spontaneous picture naming task.

The researchers counted each error in the data analysis.

Results showed there were significantly more errors in the continuous speech task than in the other two tasks. Also, more errors occurred in the modelled continuous speech task than in the spontaneous picture naming task. The study, though, is limited in interpretation because only the frequency of errors was considered.

Johnson, Winney, and Pederson (1980) did a study comparing both the frequency and type of articulation errors made under two testing conditions. They tested thirty-five children ranging in age from 3.7 to 9.5 years. The children were identified as articulation impaired through at least one phoneme error in a connected speech screening. The researchers used the Goldman-Fristoe Test of Articulation Sounds-in Words and Sounds-in-Sentences to elicit single word and connected speech responses, respectively.

Johnson, et. al. considered each error in the analysis. The results confirmed the DuBois and Bernthal conclusions. There were less errors in single word responses than in connected speech. The results also showed there were significant differences in the type and pattern of errors in the two sampling methods. For example, there were more omission errors in continuous speech. There were more substitution than omission errors in single word responses.

Pollock and Schwartz (1983) analyzed the speech production of one male speech disordered child. Five connected speech samples were used. These had been collected over the period from

age 3 years, 5 months to 7 years, 3 months. The researcher examined the form and complexity of syllable structures in monosyllabic, disyllabic and trisyllabic words. The distribution of phonetic segments in syllable initial and syllable final positions was determined. The analysis focused on the sounds the child was capable of producing rather than whether it was correct by adult standard targets.

Initially, The child had many internal rules that did not allow sounds to occur in certain positions. Later samples showed that these constraints were lifted to allow syllable final consonants, vowel-initial syllables and syllable final clusters. This happened first in monosyllabic words, then in disyllabic words and then partially in trisyllabic words. It was shown that syllable position was an important part of sound acquisition. For a period of time, the child used /d/ and /n/ consistently to begin syllables and did not learn to produce other sounds in that position.

The results indicate that syllable structure and position are important considerations in articulation assessment. Available single word articulation tests do not assess this aspect of speech production.

A study was done comparing the results of one of five single word articulation tests to the results of a 50 utterance connected speech sample (Traweek, Aitken, Daiy, Fomby, Perot, and Sheehan, 1983). Twenty-five children between the ages of 3 and 6 years were used as subjects. The researchers analyzed the

results of the single word and connected speech samples for phonological processes. The results showed that the connected speech sample and the single word responses identified phonological processes equally if the child's speech exhibited a moderate to severe disorder.

Healy and Madison (1984) compared both frequency and type of articulation error between single word production and continuous speech samples when vocabulary is held constant. The researchers used twenty children with ages between 5.4 and 12.8 as subjects. Each of them had demonstrated at least three phoneme errors in conversational speech. Single word responses were elicited through the Weiss Comprehensive Articulation Test (WCAT: Picture Form). The researchers instructed the children to tell a story when shown a multi-concept picture for the connected speech samples. The same phonemes were elicited for each task.

Each single error was considered in the data analysis. Results confirmed that a greater number of errors occur in connected speech than in single words. Errors were further classified as substitutions, omissions, and distortion. The researchers found that connected speech revealed more of each category than single word samples. The major difference between these findings and that of Johnson, et. al. is the proportion of types of errors. For example, Johnson, et. al. showed a higher percentage of omission errors and a lower percentage of distortion errors than Madison and Healy did.

Kenney, Prather, Mooney and Jeruzal (1984) used 30 children

aged 4.4 to 4.8. Each of these children were developing at a normal rate. Eight specific phonemes were elicited through pictures for each of the three articulation tests. The tests consisted of a nonsense test (multisyllabic nonsense utterances), a single word test, and a story-retell test.

The results showed that the preschool children performed similarly in the number and type of articulation errors in the word and story tests. They did make more errors on the nonsense test, though the difference was not statistically significant. The researchers also found that boys produced more errors but fewer omissions than girls. However, this is not the focus of the present study.

Paden and Moss (1985) found no difference in the results of single word and connected speech articulation tests. The three subjects were aged 4.11, 6.11, and 7.6. They were each enrolled for phonological remediation. Single word responses were elicited through the Assessment of Phonological Processes (APP). The researchers obtained a sample of continuous speech for the Natural Process Analysis (NPA). Both of these responses were evaluated separately for the Procedures for Phonological Analysis of Children's Language (PPACL). The researchers arbitrarily decided that a process that occurred at least 50% of the time should be considered a remediation target.

The results revealed no difference in the processes identified through any of the procedures. They suggested that the APP may be the most efficient test tool analyzed because it

took the least time to administer. However, these results are inconclusive because only three subjects were used.

Some of the researchers found that single word articulation tests are accurate in assessing articulation errors. These authors prefer single word tests over connected speech samples because the single word tests are more time efficient. Other researchers found that connected speech samples are more accurate in assessment than single word articulation tests. The literature also reveals contradictory findings in the comparison of error patterns between children who differ in overall language development. Some researchers found differences in error patterns between the normally developing and the language delayed children (Hodson and Paden, 1981; Oller, 1973). Other researchers found similar error patterns between these two groups (Schwartz, Leonard, Folger, and Wilcox, 1980; Nelson and Kamhi, 1984).

The present study was designed to expand upon the studies discussed, especially on the studies done by Healy and Madison (1984) and Kenney, et. al. (1984). A comparison of the results found in two single word tests and one connected speech test will be reported. The subjects will be normally developing preschool children. It is hypothesized there will be a significant difference between the results on the single word tests and the connected speech test. It is further hypothesized there will be differences in the results on the two single word tests.

## METHOD

## SUBJECTS

The subjects in this study were ten preschool children (mean age = 3:6). They were each enrolled in a private preschool. Children were excluded if they exhibited by history or observation any systematic disorder such as developmental delay, cerebral palsy, or cleft palate. Also bilingual children were not used. Each child passed a standard audiometric screening test.

## MATERIALS

Each of the subjects responded to the Goldman-Fristoe Test of Articulation. Half of the subjects, selected at random, responded to two additional articulation tests. These were the Weiss Comprehensive Articulation Test and the Forced-Alternative Test of Articulation (Martin, 1984). Each subject's responses were recorded on the standard score sheet for each test using broad phonetic transcription and were audio recorded.

## PROCEDURE

Each subject's responses were analyzed using a computer-assisted data analysis program, Linguist II. The computerized phonological analysis identifies 21 general simplification processes, their total opportunities of occurrence, total

instances of occurrence, and percent of occurrence. In addition, the computer-assisted diagnostic program performs consonant error analysis for 25 consonants of English. The program reveals the total opportunities for occurrence, total correct, percent correct, frequency of omissions, and specific substitutions for each initial, medial and final position consonant singleton and each initial position two- and three-element consonant cluster component tested. The program also provides quantitative measures representing contrastivity, variability and accuracy for initial, medial and final position consonant singletons.

## FINDINGS

Chart I provides a graphic representation of the normative data developed by Haelsig and Madison (1986) for the phonological processes characteristic of children 3-5 years of age. Results of the current study differed significantly from those norms (see Table I). For example, in the current study, gliding occurred at a mean of 6% of the opportunities available for all of the subjects. In Haelsig and Madison's norms, gliding occurred 52% of the total opportunities. The following five phonological processes, listed in increasing order of significance, had a Z-Value of 1.3-2.97: Labial Assimilation (La), Cluster Reduction (CR), Vocalization (Vo), Syllable Deletion (SD), Gliding (Gl).

Mean percentage of error for each of the phonological processes which could be compared to the norms ranged from 0-8% of occurrence (see Table II). This is significantly different from the norms of 24-52% as provided by Haelsig and Madison (see Table I). It can also be seen from Table II that the three tests differed in mean percentage of occurrence on several of the phonological processes. For example, depalatalization had a mean occurrence of 8% for the two single word elicitation tests (Goldman-Fristoe Test of Articulation, Weiss Comprehensive Articulation Test) and 5% for the conversational speech sample (Forced-Alternative Test of Articulation). Vocalization (Vo) had an occurrence of 3% on the Forced-Alternative Test of Articulation, 4% on the Goldman-Fristoe Test of Articulation, and

5% on the Weiss Comprehensive Articulation Test.

Table III provides the percentage of error for each of the phonological processes for each subject that responded to all three tests. Error migration, as exhibited by the change in the percent of occurrence of the phonological processes, was demonstrated by the data. For example, subject #5 had a 0% of occurrence on velar fronting (VF) for the two single word articulation tests and a 16% occurrence on the connected speech articulation test. This subject had an 11% occurrence of vocalization (Vo) on the Goldman-Fristoe Test of Articulation (GF), a 0% occurrence on the Forced Alternative Test of Articulation (FA), and a 6% on the Weiss Comprehensive Articulation Test (WCAT). Subject #7 had a 0% occurrence of gliding (Gl) on the GF, 2% on the FA, and 10% on the WCAT. Subject #10 had an occurrence of 18% on Affricate assimilation (Aa) on the GF, 7% on the FA, and 14% on the WCAT. However, 3% was the biggest occurrence difference from the three tests for subject #8. This difference occurred in labial assimilation (La), and nasalization (Na). For subject #9, 5% was the biggest difference in occurrence on the three tests. This occurred in labial assimilation.

## SUMMARY AND CONCLUSIONS

## SUMMARY

Ten subjects three and four years old (mean age 3:6) were selected for this study. Each of the subjects responded to the Goldman-Fristoe Test of Articulation. (Goldman and Fristoe, 1969). Half of them also responded to the Weiss Comprehensive Articulation Test (Weiss, 1980) and the Forced-Alternative Test of Articulation (Martin, 1984). The subjects' responses were analyzed with a computer-assisted data analysis program, Linguist II. The results of the analysis were then compared to the normative data developed by Haelsig and Madison (1986) for 3-5 year old children. There was a significant difference between these norms and the results of the present study. Percentage of error for each of the phonological processes for each subject that was given all three tests was also computed. Error migration was demonstrated by the data.

## DISCUSSION

The results of this study support the findings of Healy and Madison (1984), Johnson, Winney and Pederson (1980) and DuBois and Bernthal (1978). Error migration was shown to occur for several of the phonological processes between the two single word and the connected speech articulation tests. More errors occurred in connected speech responses.

The results differed from the findings of Paden and Moss

(1985) and Kenney, Prather, Mooney and Jeruzal (1984). These studies found no difference between errors identified between single word and connected speech articulation tests. The data in the present study shows that some subjects demonstrated a large difference of percentage of occurrence on phonological processes between the two types of tests, while some subjects demonstrated a small difference. This seems to indicate that error migration only occurs in some subjects. This would explain the findings of those studies that indicated no observed difference in results between single word and connected speech articulation tests.

This study furthered the findings of Madison and Healy (1984). It was discovered there was a significant difference in the responses of the present study's subjects and the norms provided by Haelsing and Madison (1986). Also, there were differences in the results between the two single word articulation tests. Specifically, there were differences in the percent of occurrence of glides, labiodentals, deletion of final consonants, and lingua-alveolars detected in the two tests. These differences support the conclusions of McCauley and Swisher (1984) that results will vary across standardized articulation tests due to a lack of validity.

#### SUGGESTIONS FOR FURTHER RESEARCH

The findings of this study could be further verified using a larger number of subjects. This may also indicate which children will exhibit error migration and which will not. Also, more

standardized single word tests could be used for further comparison.

Another study could be done analyzing the phonological processes of a large number of normal children in connected speech. The results may alter the presently established normative data.

#### CONCLUSIONS

This study found a significant difference between the normal subjects used and the presently available normative data (Haelsing and Madison, 1986). Error migration was also found across single word and connected speech samples. Error migration was a frequently observed problem for some subjects; for others, it occurred a few times. It was also found across the two single word tests used in the study. These data indicate error migration may be a factor for consideration when establishing normative data on the development of phonological processes. Further, these data suggest that the establishment of appropriate phonological processes for remediation can be a function of the measurement device used. Suggestions for further research have been indicated to further understand the differences between standardized tests. Further research could also refine the available normative data on phonological processes.

APPENDIX A: DEFINITION OF PHONOLOGICAL PROCESSES - NICOLOSI, HARRYMAN, & KRESHECK (1983).

1. Cluster Reduction (CR): The consonant cluster is produced as a single consonant; e.g., spoon=/pʌn/.
2. Initial consonant deletion (ICD): Reduction of consonant-vowel (CV) or consonant-vowel-consonant (CVC) to a vowel or to a CV; e.g., pig=/ɪg/.
3. Final consonant deletion (FCD): reduction of consonant-vowel-consonant (CVC) to a consonant-vowel (CV) form; e.g., pig=/pɪ/.
4. Syllable deletion (SD): the omission of a syllable in a multi-syllable word; e.g.: baby=/be/.
5. Velar fronting (VF): The tendency to replace velar consonants with alveolar ones; e.g., shoe=/su/.
6. Depalatalization (Dp): replacing a palatal consonant with a non-palatal consonant; e.g., shoe=/mu/.
7. Backing (Bk): The substitution of /k/, /g/, /h/ and glottal stops for non-back phonemes; e.g., tub=/tʌg/.
8. Stopping (St): Replacement of fricatives, and occasionally other sounds, with a stop consonant; e.g.: seat=/tit/.
9. Palatalization (Pa): Replacement of a non-palatal consonant with a palatal consonant; e.g.: man=~~ʃ~~ɹn/.
10. Gliding (Gl): Substitution of /w/ or /j/ (glides) for another sound; e.g., soap=/jɒp/.
11. Vocalization (Vo): a tendency of consonants to be voiced when preceding a vowel; e.g., pen=/bɛn/.
12. Labialization (Lb): Substitution of a labial consonant for a non-labial consonant; e.g., top=/bɒp/.
13. Devoicing of final consonants (DFC): Process whereby a child anticipates the silence following a word and substitutes a voiceless consonant for the final consonant; e.g., bed=/bɛt/.
14. Velar Assimilation (Va): Tendency of apical consonants to assimilate to a following velar consonant; e.g.: duck=/gʌk/.
15. Alveolar Assimilation (Aa): substitution of an alveolar consonant for a non-alveolar consonant to make production similar to another labial consonant in a word; e.g., mutt=/t t/.
16. Nasal Assimilation (Na): Tendency of sound to take on the nasality of a following nasal consonant; e.g., friend=/nɪnd/.

17. Labial Assimilation (La): Substitution of a labial consonant for a non-labial consonant to make production similar to another labial consonant in a word; e.g., top= /bop/.
18. Affrication (Af): The replacement of a fricative with an affricate; e.g., sun=/tsʌn/.
19. Denasalization (Dn): The replacement of a nasal consonant with an oral one; e.g. no=/do/.
20. Deaffrication (Da): The replacement of an affricate with a non-affricate consonant; e.g., church= $\int$ ʃ/.
21. Voicing of initial consonants (VIC): Substitutes a voiced consonant for a voiceless consonant for the first consonant in a word; e.g., peg=/bɛg/.

TABLE I  
DATA RESULTS FROM THE GOLDMAN-FRISTOE TEST OF ARTICULATION: NORMAL SUBJECTS

SUBJECT	AGE	CR	ICD	FCD	SD	VF	Dp	Bk	St	Pa	G1	Vo	Lb	DFC	Va	Ra	Na	La	Af	Dn	Da	VIC
12	3.5	0%	0%	8%	1%	5%	90%	2%	4%	40%	26%	11%	11%	12%	1%	13%	2%	1%	0%	0%	0%	8%
22	4.1	0%	3%	2%	0%	0%	0%	2%	9%	0%	0%	11%	9%	4%	0%	4%	1%	8%	0%	0%	0%	0%
32	3.9	0%	0%	2%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	4%
42	3.11	0%	0%	0%	1%	0%	0%	1%	4%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%
52	3.11	0%	0%	0%	0%	0%	10%	1%	4%	0%	15%	11%	9%	4%	0%	4%	0%	8%	0%	0%	0%	0%
62	3.8	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	3%	0%	0%	0%	0%	1%	0%	0%	0%	0%
72	3.6	0%	0%	2%	0%	0%	0%	0%	2%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%
82	3.8	0%	0%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
92	3.1	0%	0%	5%	2%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%
102	4.3	0%	0%	5%	0%	0%	40%	2%	4%	0%	15%	11%	3%	4%	0%	18%	2%	3%	0%	2%	0%	0%
mean?	3.63	0%	0%	3%	1%	1%	10%	1%	3%	4%	6%	4%	5%	2%	0%	4%	1%	5%	0%	0%	0%	1%
std			1%	2%	1%	2%	18%	1%	3%	13%	9%	4%	4%	4%	0%	6%	1%	4%	0%	1%	0%	3%
HLSIG & MADISON		24%			38%						52%	34%						22%				
Z-VALUE =	1.79				2.47						2.97	2.02						1.3				

TABLE II  
SUMMARY OF MEAN PERCENTAGE OF OCCURRENCE

	*CR	ICD	FCD	*SD	VF	Dp	Bk	St	Pa	*G1	*Vo	Lb	DFC	Va	Ra	Na	*La	Af	Dn	Da	VIC
mean gf	0%	0%	2%	1%	0%	8%	1%	2%	0%	6%	4%	4%	1%	0%	4%	1%	3%	0%	0%	0%	0%
mean fa	0%	0%	1%	0%	0%	5%	0%	2%	0%	6%	3%	3%	2%	0%	2%	0%	3%	0%	0%	0%	3%
mean wcat	0%	0%	1%	0%	1%	8%	1%	3%	0%	8%	5%	4%	3%	1%	2%	0%	5%	0%	0%	0%	0%
grand/mean	0%	0%	1%	0%	0%	7%	1%	2%	0%	7%	4%	3%	2%	0%	3%	0%	4%	0%	0%	2%	0%

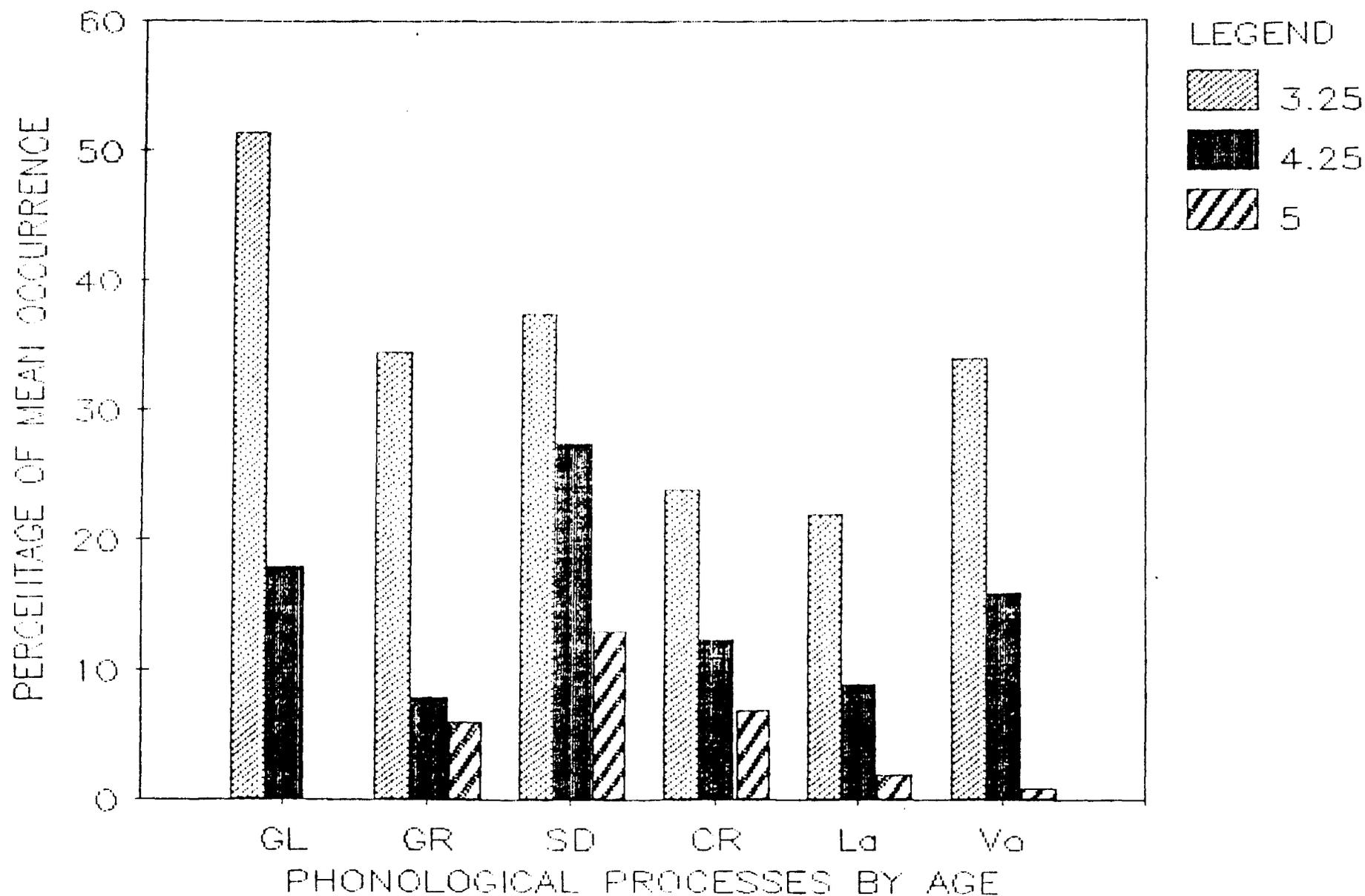
\* = ITEMS TESTED BY HAEISIG & MADISON

TABLE III

## INDIVIDUAL ERROR MIGRATION PATTERNS OF SUBJECTS

SUBJECT	TEST	CR	ICD	FCD	SD	VF	Dp	Bk	St	Pa	GI	Vo	Lb	OFC	Vo	Ra	Na	La	Rf	Dn	Da	VIC
4N	GF	0%	0%	0%	1%	0%	0%	1%	4%	0%	5%	0%	7%	0%	0%	0%	0%	5%	0%	0%	0%	0%
4N	FA	8%	1%	3%	4%	2%	0%	3%	8%	0%	2%	10%	1%	0%	0%	0%	1%	6%	4%	0%	0%	2%
4N	WCAT	0%	0%	0%	0%	0%	0%	0%	4%	0%	1%	0%	7%	2%	0%	0%	0%	7%	0%	0%	0%	0%
5N	GF	0%	0%	0%	0%	0%	10%	1%	4%	0%	15%	11%	9%	4%	0%	4%	0%	8%	0%	0%	0%	0%
5N	FA	0%	0%	3%	2%	16%	0%	5%	8%	0%	5%	0%	5%	1%	0%	9%	0%	9%	2%	0%	0%	0%
5N	WCAT	0%	0%	3%	1%	0%	6%	2%	7%	0%	10%	6%	7%	2%	0%	0%	0%	7%	0%	0%	0%	0%
7N	GF	0%	0%	2%	0%	0%	0%	0%	2%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%
7N	FA	0%	0%	0%	1%	0%	0%	5%	3%	0%	2%	5%	7%	4%	0%	0%	1%	8%	4%	0%	0%	2%
7N	WCAT	0%	0%	1%	1%	0%	0%	1%	3%	0%	10%	6%	4%	13%	3%	0%	1%	8%	0%	0%	0%	2%
8N	GF	0%	0%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8N	FA	0%	1%	2%	3%	0%	0%	2%	3%	0%	2%	5%	3%	0%	0%	0%	3%	8%	2%	0%	0%	2%
8N	WCAT	0%	1%	3%	0%	0%	0%	1%	1%	0%	3%	6%	4%	0%	0%	0%	0%	5%	0%	0%	0%	0%
9N	GF	0%	0%	5%	2%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%
9N	FA	0%	0%	3%	1%	0%	0%	1%	0%	0%	2%	0%	1%	0%	1%	0%	2%	6%	2%	0%	0%	0%
9N	WCAT	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10N	GF	0%	0%	5%	0%	0%	40%	2%	4%	0%	15%	11%	3%	4%	0%	18%	2%	3%	0%	2%	0%	0%
10N	FA	0%	0%	2%	2%	0%	35%	4%	7%	0%	2%	0%	1%	0%	0%	7%	1%	5%	2%	0%	0%	0%
10N	WCAT	0%	0%	0%	0%	3%	43%	0%	1%	0%	10%	13%	1%	2%	0%	1%	0%	1%	0%	0%	18%	0%

1) REVISION AND EXTENSION HAELSIG & MADISON  
 NORMATIVE DATA ON PHONOLOGICAL PROCESSES



G.W. MARTIN / 87

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