

# MARKEDNESS ANALYSIS OF CONSONANT ERROR PRODUCTIONS IN APRAXIA OF SPEECH

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This study applied a markedness analysis of consonant error productions to three adult aphasic patients with apraxia of speech. Single consonants and initial consonant clusters were investigated, employing both naming tasks and spontaneous narrative tasks. Results showed that phonemes of lower complexity values tended to substitute for phonemes of higher complexity values more than the reverse, and successive attempts at self-correction tended to reveal a progression toward the target segment in terms of markedness complexity. Theoretical and clinical implications are discussed.

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## INTRODUCTION

Both researchers and clinicians have struggled for many years with the conceptual issues in apraxia of speech as well as with the development of suitable clinical regimes. Several investigators have described the disorder referred to as "apraxia of speech" as a motor-programming disturbance not primarily due to neuromuscular or higher language functioning deficits and have suggested that the programming of phonemes can be selectively impaired without impairment of language (Johns and Darley, 1970; Deal and Darley, 1972). Martin (1974), however, objected to the term "apraxia of speech" and argued that motor-programming disturbances are inextricably tied to language deficits and cannot be defined except within the framework of aphasia. Several studies in apraxia of speech have employed taxonomic methods of phonemic analysis. Based on these analyses, some investigators have concluded that consonant substitutions are random and unrelated to the target sound (Critchley, 1952; Deal and Darley, 1972). By contrast, investigators employing distinctive feature analyses have indicated that consonant substitutions are systematic and rule-governed (Blumstein, 1973; Martin and Rigrod-

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sky, 1974a, 1974b; Hatfield and Walton, 1975). Recently there have been a few preliminary attempts to apply a markedness analysis to consonant error productions in apraxia of speech (Dunlop and Marquardt, 1977; Wolk, 1978; Marquardt, Reinhart, and Peterson, 1979). The concept of markedness in apraxia is discussed in some detail in Wertz, LaPointe, and Rosenbek (1984). Before considering these studies, however, a brief discussion of markedness is relevant.

Markedness theory is based on the underlying theoretical assumptions of natural phonology (Hyman, 1975). The fundamental principle of natural phonology is that certain segments are more natural than others and that the "naturalness" of segments can be captured through the notion of "markedness." Within this conceptual framework, two phonemes or phoneme sequences are differentiated by considering one of them unmarked (U) for a particular feature and the other marked (M) for that feature. The basic assumption is that the (U) member represents the more natural state and will never contribute to the complexity of a segment. In addition, there is a set of marking conventions that are sensitive to other feature values, both in the same segment and in adjacent segments, so that the complexity of a phoneme is equal to the sum of its marked features. It is expected that (U) segments at any level are common to the languages of the world, are reflected in early language acquisition, are preferred in historical language change, have greater articulatory ease, and are perceptually salient (Hyman, 1975).

In addition to natural segment types, there are also natural phonological rules that lead to preferred (simpler) syllable structure and less marked segments or sequences of segments. Following the same principle as that discussed for (M) and (U) phonemes, the most unmarked syllable type is CV (an initial consonant followed by a vowel). Other syllable types such as CVC are relatively complex, and CCVC and CVCC syllables are still more complex. It has been suggested that different consonant types should be assigned strength values to capture phonological relations between segments, particularly as they function in syllables (Hyman, 1975). The major criticisms of markedness are based on a lack of agreement in the assignment of consistent marked and unmarked values to phonemes (Hooper, 1976; Sommerstein, 1977). In spite of this, Sommerstein (1977) has cited Venneman and Hooper, who feel that "natural phonology must be regarded as one of the most important developments in phonological theory, if not the most important, since GP [generative phonology] itself" (Sommerstein, 1977, p. 237). Furthermore, markedness may indeed have some relevance for the speech clinician.

Klich, Ireland, and Weidner (1979) compared distinctive feature analysis and markedness analysis on nine adult patients with apraxia of speech and found a markedness analysis to be superior in reflecting the nature of the consonant errors. According to Blumstein (1973), a knowl-

edge of both feature specifications and markedness relationships is essential to describe the phonological system of a language.

Marquardt, Reinhart, and Peterson (1979) have carried out a markedness analysis of phonemic substitution errors in apraxia of speech. They found that their patients produced more errors on phonemes high in markedness and that more changes occurred from marked to unmarked, suggesting that the patients' articulatory behavior reveals a systematic effort to reduce the complexity of the articulation required to approximate target phonemes. Marquardt, Reinhart, and Peterson (1979) make a significant comment that at a given time children may not have mastered the skills to produce more difficult phonemic features, while the apraxic adults have lost some degree of ability to coordinate or plan motor speech output. Their study may be considered incomplete, however, in that they used an imitation task only, they investigated only part of the total consonant system of English, thus precluding generalization to the entire phonemic system, and they provided little explanation of how they arrived at their markedness complexity values. Further investigations of articulatory difficulties in adult apraxic patients, employing the framework of natural phonology in terms of markedness, was believed to be needed.

This study was undertaken to explore the applicability of a markedness analysis of consonant error productions to three adult aphasic patients with apraxia of speech, in terms of markedness complexity of errors and successive attempts at self-correction. The author's intention was not to evaluate a particular theory or to determine its validity from a linguist's point of view, but rather to investigate its potential applicability for the speech pathologist concerned with adult aphasic phonological impairment. This article is thus concerned specifically with the area of perceptual investigations in apraxia of speech and will not deal with issues pertaining to acoustic or physiological areas of investigation.

## METHOD

### Subjects

Three adult male aphasic patients were the subjects for this study. All cases were chosen from Johannesburg hospitals and were diagnosed as aphasic by neurologists and speech pathologists. They ranged from age 58 to 73 years with a mean age of 63.3 years. All cases presented a history of left (L) hemisphere cerebrovascular accident (CVA). They demonstrated various degrees of concomitant Broca's aphasia, but in each case phonological deficit predominated. They ranged in months post onset (MPO) from 9 to 24, with a mean of 15.7 months. All cases were native speakers of English and had no previous history of speech or hearing problems, premorbid psychological problems, senility, or mental retar-

Table 1. Description of Cases Used in This Study

	Age	Sex	Etiology	Months post onset (MPO)	Type of aphasia	Home language	Educational level	Premorbid occupation	Handedness	Speech therapy received
Case 1 (A.M.)	58	Male	CVA	24	Broca	English	Std. 6	Plumber	(R)	18 mos.
Case 2 (F.T.)	73	Male	CVA	9	Broca	English	Std. 8	Dispatch manager	(R)	4 mos.
Case 3 (E.J.)	59	Male	CVA	14	Broca	English	Std. 9	Salesman	(R)	12 mos.

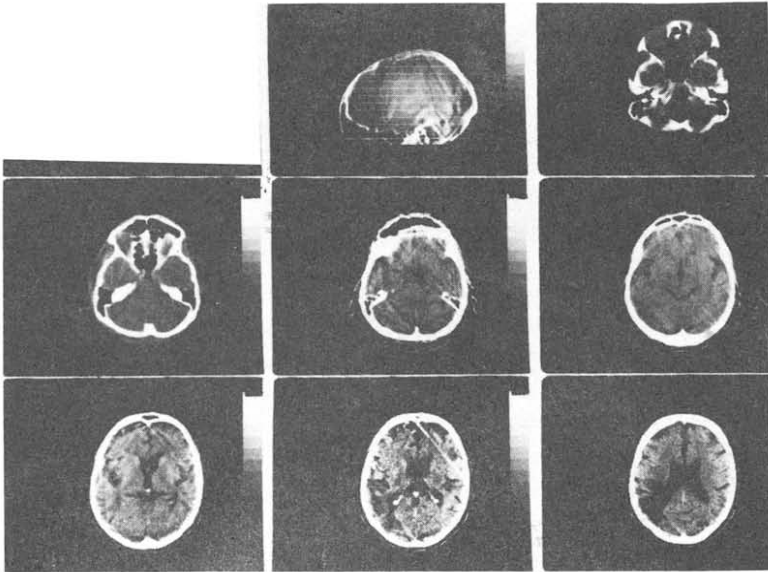
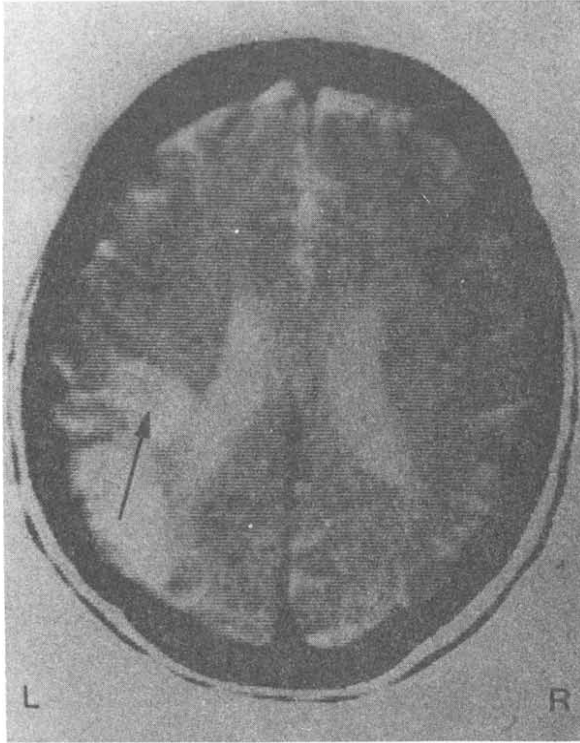
dition. Years of education ranged from 8 to 11 years, with a mean of 9.7 years. Case 1 had the most severe form of apraxia of speech, and case 3 had the least severe disorder, but they were all believed to be representative of mild motor aphasics. Subjects had to have suffered a left (L) cerebral infarct and were required to have reached a point of neurological stability considered as 6 months after the neurological insult (Sarno and Levita, 1971). The cases are summarized in Table 1. Computerized tomographic (CT) brain scans for each case are in Figures 1-3.

### Procedure

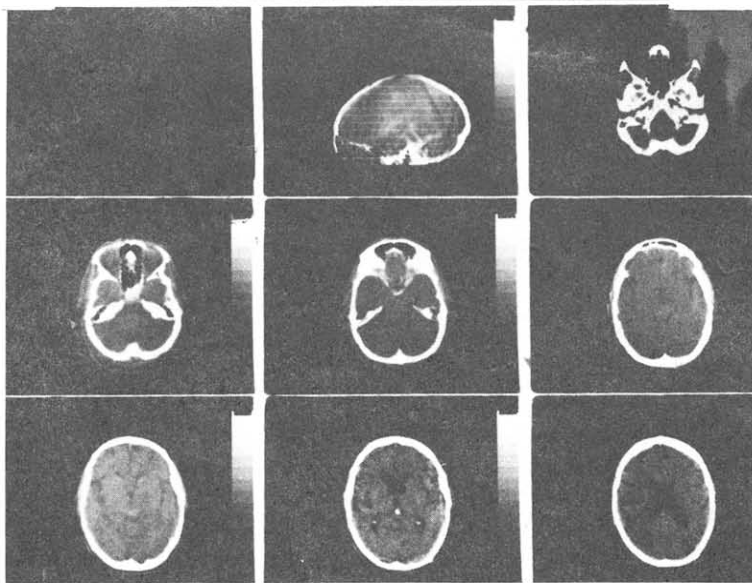
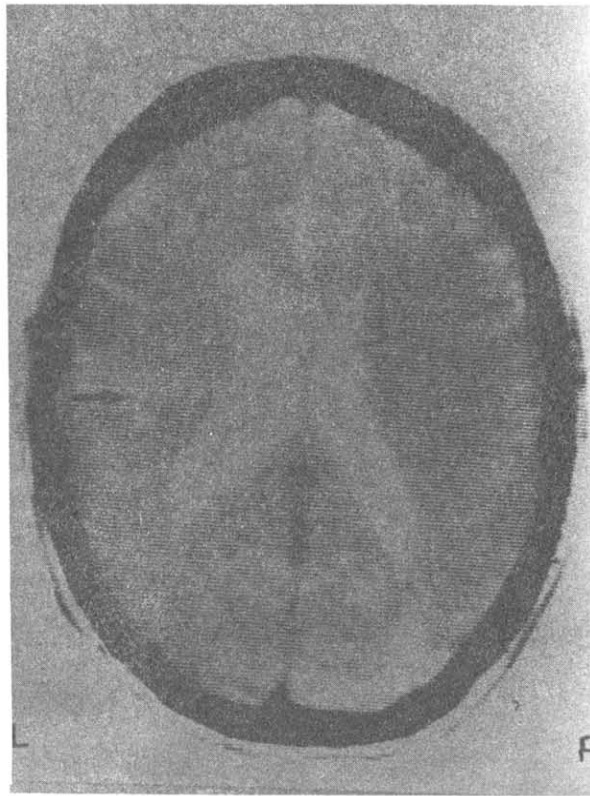
The preliminary tests to determine whether the subjects satisfied the selection criteria are summarized in Table 2. Two approaches were used for elicitation of speech for linguistic analysis: naming tasks and spontaneous narrative tasks.

**Table 2.** Results of Preliminary Tests

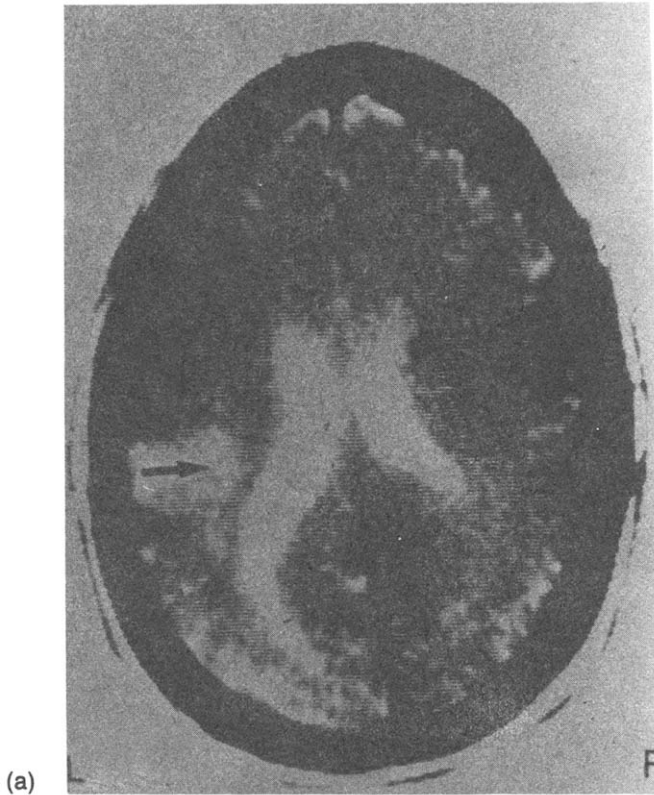
Preliminary test	Case 1 (A.M.)	Case 2 (F.T.)	Case 3 (E.J.)
Boston Diagnostic Aphasia Examination (BDAE)	Score on severity rating scale = 2	Score on severity rating scale = 2	Score on severity rating = 2
Goodglass and Kaplan (1972)			
Token Test	34/36 = 94%	34/36 = 94%	36/36 = 100%
De Renzi and Faglioni (1978)			
Oral Non-verbal Gesture Battery	56/56 = 100%	56/56 = 100%	56/56 = 100%
Moore, Rosenbek, and LaPointe (1976)			
Screening Pure-Tone Audiometric Test	Normal	Normal except 45dB at 4000 Hz bilaterally	Normal
Goldman-Fristoe Test of Auditory Discrimination (Goldman, Fristoe, and Woodcock, 1970)	100%	100%	100%
Discrimination of CVC and CCVC words (designed by the writer)	100%	100%	100%



**Figure 1.** Case 1 (A.M.): CT Scan Showing Cerebral Infarction Involving Mainly the (L) Parieto-Occipital Region and Extending Toward the Island of Reil (Insula) on the Left Side



**Figure 2.** Case 2 (F.T.): CT Scan Showing Cerebral Infarcts in the (L) Parieto-Frontal Region Involving Broca's Area and in the (R) Parieto-Occipital Region



**Figure 3.** Case 3 (E.J.): CT Scan Showing Cerebral Infarction Involving the (L) Parietal Region Extending Toward the Vertex and Inferiorly to the (L) Island of Reil (Insula) and Upper Temporal Lobe

#### *Naming Tasks*

A test in two parts was developed by the writer for use in this study. Part I was designed to test single consonants in initial (I) and final (F) word position, and Part II was designed to test initial consonant cluster sequences. These are included in the Appendix.

*Criteria for selection of words.* Part I of the articulatory test was composed of 89 items carefully selected to elicit all the consonants (C) in English in (I) and (F) word positions. An attempt was made to select items in which the desired consonant in (I) and (F) word position could be elicited simultaneously, thus maximally conserving the total number of picture stimuli required (e.g., initial /d/ is elicited by the picture words "dog" and "duck" at the same time that final /g/ and /k/ are being elicited).



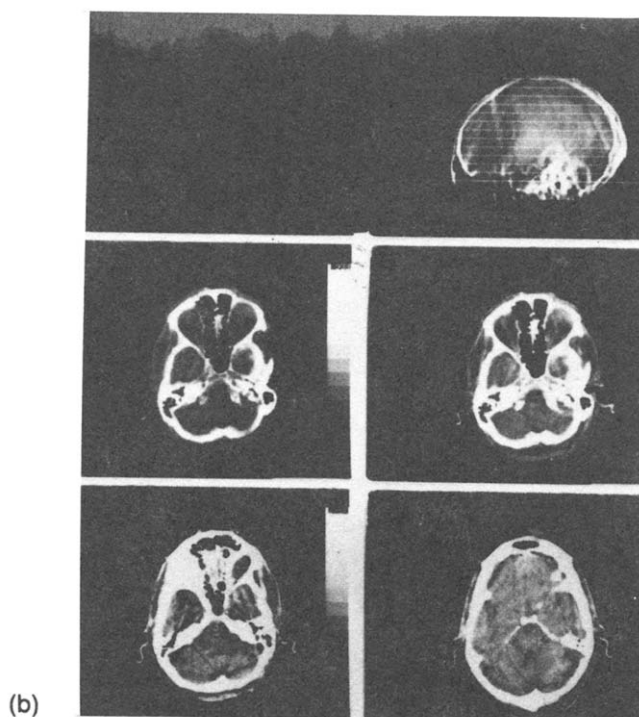


Figure 3. (continued)

Each consonant was elicited at least twice in (I) and (F) word position, ranging between two and four different phonemic contexts. The phonemic environment was varied with respect to both vowels and consonants in the immediate phonemic vicinity. Thus 81 words represented consonants in (I) position, and 70 words represented consonants in (F) position, while the total number of test items was 89.

Part II of the articulatory test was composed of 99 items. Each (I) cluster of English was elicited in at least two stimulus words, ranging between two and four different phonemic contexts.

*Experimental manipulation of words.* Stimulus items were constrained in the following ways: (1) Phonological rules governing the combination and sequencing of phonemes in English were applied. (2) Words that could be pictorially represented were used, because imitation was to be deliberately avoided. (3) Word length and syllable structure were considered; monosyllabic and disyllabic words were included, multisyllabic words were excluded. (4) Morphological endings were excluded when devising the list of single consonants in (F) position to ensure that only phonological

capacities were being tapped, and not other levels (e.g., the morphophonemic level).

The entire articulatory test was thus comprised of 188 stimulus items (Part I = 89; Part II = 99). Each response was elicited twice, to provide an estimate of the subjects' consistency of production of the same sounds in identical environments. Thus both parts of the naming task, naming singletons (NS) and naming clusters (NC), were administered twice to all subjects.

#### *Spontaneous Narrative Tasks*

(1) Thirty minutes of an open-ended conversation concerning the patient's illness, work, hobbies and general issues was elicited. The middle 20 minutes were selected for analysis. (2) Fifty picture cards from the Phonological Process Analysis (PPA) (Weiner, 1979) were selected for the purpose of picture description. (3) Six large, colored picture cards depicting real-life scenes were chosen in order to elicit conversational speech. In addition to (1), (2), and (3), many of the spontaneous speech samples resulted from the subjects' misnaming of test items and interjected spontaneous speech.

*Administration of phonological assessment procedure.* All testing took place in a sound-treated room and was carried out by the writer during several 45-minute sessions. Subjects were tested individually. For the naming tasks, pictures were presented in random order, but attempts were made not to present two words with the same consonant or consonant cluster successively. Part I (NS) and Part II (NC) were administered twice over four sessions, following the same procedure. For the spontaneous tasks, each subject had to describe the 50 picture cards selected from the PPA and to tell a story for each of the six picture cards chosen. Spontaneous narrative tasks were administered once over three or four sessions.

*Response transcription.* All responses were recorded on a high-quality Revox tape recorder (Model 1132, Dolby version). Wherever possible, on-site transcriptions were carried out by the writer, utilizing both visual cues and contextual information. Tape recordings were transcribed by the tester in broad phonetic transcriptions and were used as a comparison with on-site transcriptions. A second transcription of all data was carried out using three transcribers who served as judges. Judges worked independently and then met jointly to resolve any discrepancies, discarding any instances in which no consensus could be reached, providing maximum objectivity and accuracy of recorded data.

### Markedness Analysis

#### *Analysis of Phonemic Errors in Terms of Complexity*

Consonant error productions were subjected to a markedness analysis by applying marked (M) and unmarked (U) values and total complexity values to every consonant and consonant cluster sequence (error and target segments). A "9 Distinctive Feature (DF)" matrix was used, with values available for the following features: consonantal, sonorant, anterior, coronal, continuant, strident, voice, lateral, and nasal. A complexity score was computed by adding the (M) features in each consonant.

The markedness values used were based on those suggested by Cairns (1969) and Chomsky and Halle (1968). They are discussed in an earlier report (Wolk, 1978) and presented in Appendixes A and B.

The following symbols were used to refer to the direction of change in terms of complexity values (p = phoneme; H = high complexity; L = low complexity):

- (p = p) The target segment, or a substitution of equal complexity value to that of the target.
- (H→L) A substituted phoneme or phoneme sequence that has a lower (L) complexity value than that of the target i.e., target → error (H→L).
- (L→H) A substituted phoneme or phoneme sequence that has a higher (H) complexity value than that of the target. It reflects a change from less complex to more complex, i.e., target → error (L→H).

#### *Analysis of Self-Correction*

For each target segment the subjects' successive approximations toward the target were carefully observed, i.e., whether the self-correction process revealed a progression toward the target in terms of markedness complexity. The following three categories were developed for this purpose:

- (1) Progression (Pr): (H→L) → (p = p), (H→L) → (p = p) → (L→H), (H→L) → (L→H)
- (2) Nonprogression (NPr): (p = p) → (H→L), (p = p) → (L→H), (L→H) → (H→L)
- (3) No Change: (p = p) → (p = p), (H→L) → (H→L), (L→H) → (L→H)

In a progression, the subject begins with a less complex segment, progresses to the target segment or one that is equal to the target complexity values, and sometimes "overshoots" the target complexity value, resulting in a more complex segment. These progressions will be referred to as approximations toward the target segment. In a nonprogression, successive attempts proceed in the opposite direction.

Table 3. A Distribution of Phonemic Errors on Target Singletons According to Markedness Complexity, (p=p), H→L), and (L→H)

Complexity Value	Cases	NS→(l)		SS→(l)		NS→(F)		SS→(F)	
		No.	%	No.	%	No.	%	No.	%
p=p	A.M.	205	71.43	199	75.67	186	67.64	129	54.43
	F.T.	213	85.89	181	79.39	156	70.27	98	49.75
	E.J.	163	89.07	127	70.56	142	86.59	108	70.13
H→L	A.M.	46	16.03	37	14.06	72	26.18	99	41.77
	F.T.	26	10.48	33	14.47	61	27.47	94	47.71
	E.J.	13	7.10	39	21.66	22	13.41	44	28.57
L→H	A.M.	36	12.54	27	10.27	17	6.18	9	3.80
	F.T.	9	3.63	14	6.14	5	2.25	5	2.54
	E.J.	7	3.83	14	7.78	0	0	2	1.30
Total (N)	A.M.	287	100	263	100	275	100	237	100
	F.T.	248	100	228	100	222	100	197	100
	E.J.	183	100	180	100	164	100	154	100

Key: NS = Naming Singletons; SS = Spontaneous Singletons; p = phoneme; L = low complexity; H = high complexity; (p=p) = target segment or substitution of equal complexity value to that of target; (H→L) = substitution of lower complexity value than that of target; (L→H) = substitution of higher complexity value than that of target.

### Scoring

The scoring procedure for the markedness analysis, including the model for assigning complexity values to single consonants and initial consonant cluster sequences, is described in an earlier report (Wolk, 1978, p. 88).

## RESULTS AND DISCUSSION

### Analysis of Phonemic Errors in Terms of Markedness Complexity

Table 3 and Table 4 show that in each case a large number of utterances on all tasks consisted of phonemes and phoneme sequences in which the value of the features in the target segments were retained ( $p=p$ ). It is clear, however, that when a change occurred, target segments were more commonly replaced by segments of lower complexity rather than segments of higher complexity ( $H \rightarrow L$ ). For example, in Table 3 on SS in the (F) word position for Case 1 (A.M.), out of a total of 237 utterances, 99 (41.77%) were replaced by less complex segments ( $H \rightarrow L$ ) and only 9 (3.80%) were replaced by segments of higher complexity ( $L \rightarrow H$ ). The remainder (54.43%) revealed no change ( $p=p$ ). Similar proportions can be seen on singletons in the (I) and (F) word positions for all cases. In Table 4, on NC for Case 2 (F.T.), out of a total of 347 utterances, 116 (33.42%) were replaced by less complex segments ( $H \rightarrow L$ ) and only 8 (2.31%) were replaced by segments of higher complexity ( $L \rightarrow H$ ). The remainder (64.27%) revealed no change ( $p=p$ ). Similar proportions can be seen on NC and SC for all cases. A larger number of total utterances

**Table 4.** A Distribution of Phonemic Errors on Target Consonant Clusters According to Direction of Change, ( $p=p$ ), ( $H \rightarrow L$ ), and ( $L \rightarrow H$ )

Complexity value	Cases	NC		SC	
		No.	%	No.	%
$p=p$	A.M.	282	52,81	185	62,71
	F.T.	223	64,27	204	78,16
	E.J.	193	74,81	155	69,20
$H \rightarrow L$	A.M.	198	37,08	86	29,15
	F.T.	116	33,42	51	19,54
	E.J.	56	21,71	64	28,57
$L \rightarrow H$	A.M.	54	10,11	24	8,14
	F.T.	8	2,31	6	2,30
	E.J.	9	3,49	5	2,23
Total (N)	A.M.	534	100	295	100
	F.T.	347	100	261	100
	E.J.	258	100	224	100

Key: NC = Naming Clusters; SC = Spontaneous Clusters;  $p$  = phoneme; L = low complexity; H = high complexity.

**Table 5.** Example from Case 1 (A.M.) of a 9 Distinctive Feature (DF) Matrix Computed for the Singleton /dʒ/ in Initial Word Position, and Its Various Substitutions

/dʒ/ = (4) total complexity

Feature	dʒ	k	tʃ	r	m	g	s	d
cons	U	U	U	U	U	U	U	U
son	M	M	M	M	U	M	M	M
ant	M	M	M	U	U	M	U	U
cor	U	U	U	U		U	U	U
cont	U	U	U	M	M	U	M	U
stri	M	U	M	U	U	U	M	U
voice	M	U	U	U	U	M	U	M
lat								
nas	U	U	U	U	M	U	U	U
Complexity	4	2	3	2	2	3	3	2

(N) occurred on naming tasks (NS and NC) than on their respective spontaneous tasks (SS and SC). This shows that more attempts at self-correction occurred on a voluntary-purposive naming task and fewer in connected speech.

Table 5 presents an example from Case 1 (A.M.) of a 9 Distinctive Feature (DF) matrix computed for singletons and clusters to show analyses of phonemic errors in terms of markedness complexity. Table 6 shows that Case 1 (A.M.) showed a tendency for segments of lower complexity to replace target segments. For example, the phonemes /r, m, d, k/ with complexity values equal to 2, and /s, g, tʃ/ with complexity values equal to 3, were frequently substituted for the target singleton /dʒ/ with a complexity value equal to 4.

**Table 6.** /dʒ/ in Initial Word Position, and its Various Substitutions

Target word	Utterance	Total C	M/U
1. giraffe	r	2	H→L
	m	2	H→L
	g	3	H→L
2. juice	s	3	H→L
	d	2	H→L
	d	2	H→L
	dʒ	4	p=p
3. jug	k	2	H→L
	tʃ	3	H→L
4. jersey	dʒ	4	p=p

Key: Total C = total complexity; p = phoneme; H = high complexity; L = low complexity; Pr = progression; NPr = Nonprogression.  
From: Naming Tasks NS.

It is therefore evident that when Case 1 (A.M.), Case 2 (F.T.), and Case 3 (E.J.) phonological errors reflected a change in markedness complexity, they were likely to reflect a change in the direction from more complex to less complex. The data does not support a statement that these cases' articulation errors *always* reflect a change from more to less complex, but they do suggest that when a change occurs it is *more likely* that the direction will be from more complex to less complex. The total number (N) and percentage of times that features change from (H→L) far exceeds the number of times the errors reflect changes in the opposite direction (see Table 6). This tendency is seen to occur consistently on all tasks and corroborates previous reports, although the complexity values used in these studies all varied (Blumstein, 1973; Wolk, 1978; Klich, Ireland, and Weidner, 1979; Marquardt, Reinhart, and Peterson, 1979). Marquardt et al. (1979) propose a correlation between directional changes in markedness with ease of articulation. They interpreted their findings as a systematic effort to reduce the complexity of articulatory gestures required to produce phonemes.

Though not the major tendency, there were changes in each case from lower to higher complexity, which does not support the general hypothesis. This was predominant for the feature voice (v), a finding consistent with Klich et al. (1979) and Marquardt et al. (1979). Marquardt et al. (1979) propose that possible contextual effects may be one source for this finding. This is explained by Smith and Ruder (1975), who have suggested that context may significantly affect segmental markedness for voicing. For example, sequences with voiced → voiceless clusters are more complex and require more physical effort because two adjustments of the larynx are required for production of the cluster. Other explanations for the change (L→H) in this study may be offered, such as consonant harmony and the interchange of /l/ and /r/ where /l/ has a complexity value equal to 1 and /r/ has a complexity value equal to 2.

### Analysis of Self-Correction

Table 7 and Table 8 summarize successive attempts at the target segments on singletons and clusters respectively. Totals (N) in these tables reflect the total number of test items on which the cases produced successive attempts at self-correction. In each case a large number of approximations reflected no change in complexity. Either another segment of equal complexity value to that of the target was substituted, or the same segment was merely repeated several times. When a change occurred, however, there was a consistent tendency for a progression (Pr) to occur rather than a nonprogression (NPr). That is, initially a segment of lower complexity was replaced, followed by successive attempts at self-correction, which revealed a steady increase in complexity until the target was

Table 7. Successive Attempts at the Target Singleton in Terms of Markedness Complexity

Direction	Cases	NS--(I)		SS--(I)		NS--(F)		SS--(F)	
		No.	%	No.	%	No.	%	No.	%
Progression (Pr)	A.M.	14	33.33	11	28.21	23	51.11	31	68.89
	F.T.	7	25.00	9	26.47	21	53.85	17	54.84
	E.J.	7	63.63	6	46.15	11	100.00	8	72.74
Nonprogression (NPr)	A.M.	12	28.57	8	20.51	8	17.78	5	11.11
	F.T.	7	25.00	3	8.82	4	10.26	5	16.13
	E.J.	3	27.27	1	7.69	0	0	1	9.09
No change	A.M.	16	38.10	20	51.28	14	31.11	9	20.00
	F.T.	14	50.00	22	64.71	14	35.89	9	29.03
	E.J.	1	9.09	6	46.15	0	0	2	18.18
Total (N)	A.M.	42	100	39	100	45	100	45	100
	F.T.	28	100	34	100	39	100	31	100
	E.J.	11	100	13	100	11	100	11	100

Key: NS = Naming Singletons; SS = Spontaneous Singletons.



**Table 8.** Successive Attempts at the Target Cluster in Terms of Markedness Complexity

Direction	Cases	NC		SC	
		No.	%	No.	%
Progression (Pr)	A.M.	48	48,00	23	45,09
	F.T.	44	56,41	17	50,00
	E.J.	23	62,16	6	50,00
Nonprogression (NPr)	A.M.	17	17,00	10	19,61
	F.T.	5	6,41	4	11,76
	E.J.	5	13,51	2	16,67
No change	A.M.	35	35,00	18	35,30
	F.T.	29	37,18	13	38,24
	E.J.	9	24,33	4	33,33
Total (N)	A.M.	100	100	51	100
	F.T.	78	100	34	100
	E.J.	37	100	12	100

Key: NC = Naming Clusters; SC = Spontaneous Clusters.

reached ( $H \rightarrow L$ )  $\rightarrow$  ( $p = p$ ). Sometimes the substitutions reflected a segment of higher complexity overshooting the target complexity value ( $H \rightarrow L$ )  $\rightarrow$  ( $L \rightarrow H$ ). This tendency was consistent over all tasks except for Case 2 (F.T.) on NS in the (I) word position, where no tendency in one direction over another could be observed. The trend was more pronounced for clusters than for singletons.

A striking example of the tendency for a progression to occur rather than a nonprogression is illustrated in Table 7 for Case 3 (E.J.) on NS in the (F) word position. Here out of a total of 11 test items representing singletons in the (F) word position in which successive attempts at self-correction were made, 100% revealed a progression toward the target segment. Similarly, in Table 8 for Case 2 (F.T.) on NC, there was a total of 78 target words representing initial consonant clusters on which successive attempts were made at self-correction. Out of these, 44 (56.41%) represented a progression toward the target, while 5 (6.41%) represented a nonprogression. The remainder, 29 (37.18%), reflected no change in complexity. Thus in all cases successive attempts at self-correction do not appear to be random. They commonly reveal a progression toward the target segment in terms of markedness complexity ( $H \rightarrow L$ )  $\rightarrow$  ( $p = p$ ).

Some examples from Case 1 (A.M.) of initial consonant clusters and their various substitutions are provided in Table 9. The first example of the word "spread," which clearly demonstrates the process of self-correction for the cluster /spr/, can be examined to highlight the present findings. The initial attempt is /pr/ with a complexity value equal to 4, the second attempt is /fr/ with a complexity value equal to 6, and on the

**Table 9.** Some Examples from Case 1 (A.M.) of Initial Consonant Clusters and Their Various Substitutions, to Show the Process of Self-Correction

Target word	Error segment	Total complexity	M/U
spread	<i>/spr/ = (8) Total Complexity<sup>a</sup></i>		
	pr	4	H'→L } Pr
	fr	6	H→L } Pr
	spr	8	p = p } Pr
scratch	<i>/skr/ = (9) Total Complexity<sup>a</sup></i>		
	kr	5	H→L } Pr
	str	7	H→L } Pr
	skr	9	p = p } Pr
screw	sl	7	H→L } Pr
	str	7	H→L } Pr
	skr	9	p = p } Pr
	skr	9	p = p } Pr
	skr	9	p = p } Pr
shrub	<i>/ʃr/ = (9) Total Complexity<sup>b</sup></i>		
	sp	3	H→L } Pr
	br	5	H→L } Pr
	br	5	H→L } Pr
	br	5	H→L } Pr
	skr	9	p = p } Pr
fly	<i>/fl/ = (5) Total Complexity<sup>b</sup></i>		
	w	1	H→L } Pr
	pl	3	H→L } Pr
string	<i>/str/ = (7) Total Complexity<sup>b</sup></i>		
	st	3	H→L } Pr
	tr	4	H→L } Pr
	str	7	p = p } Pr
strap	sn	4	H→L } Pr
	sn	4	H→L } Pr
	sl	7	p = p } Pr
	str	7	p = p } Pr
	str	7	p = p } Pr

<sup>a</sup> = From: Spontaneous Tasks.<sup>b</sup> = From: Naming Tasks.

third attempt the target sement /spr/, which has a total complexity value equal to 8, is reached.

The findings for all cases thus provide evidence for a pattern of successive attempts at self-correction, showing a definite link or "relatedness" between error production and desired production. These cases appear to feed back their own phonological productions, compare them to

the original targets, and then induce an improved approximation to the target. This corroborates the findings of Joannette, Keller, and Roch-Le-cours (1980), who further suggest that the targets must be adequately represented to permit these operations. The present findings do not lend support to Johns and Darley (1970), who characterize the variability of phonemic productions in apraxia of speech as unrelated, additive substitutions, repetitions, and blocks, groping through repeated efforts toward the correct production. These results of self-correction are believed to be extremely significant for the following reasons:

- (1) Successive attempts at self-correction provides an opportunity to observe dynamic linguistic processing or the "internal functioning" of the phonological system operating in each case.
- (2) They provide further information about perception. The fact that these patients are able to monitor their own output shows that to some extent the perceptual mechanism is functioning. But why does this process of self-correction result in further substitution errors? That is, why do these patients follow an initial attempt at a target production with further error utterances rather than stop? It might be plausible to suggest that proper auditory feedback for monitoring ongoing speech is disturbed, a hypothesis supported by Ireland, Klich, and Panagos (1977). That is, there may be a subtle deficit in the sensorimotor feedback loop.

It is important to bear in mind the level of reference previously identified by the investigator, which in the analysis of self-correction, for example, was the progression or nonprogression toward the target segment in terms of markedness complexity. That is, the third category, "no change," was developed to accommodate responses that did not fit into the body of reference previously identified. In each case the subject did not stop. Either another segment of equal complexity value to that of the target was substituted, or the same segment was merely repeated several times. Therefore, one may infer from this behavior that the patient must be attending to something but that possibly for this task the attention of the investigator did not parallel the attention of the speaker because of the previously identified level of reference. Thus one can conclude only that there was a greater tendency in each case to show a progression rather than a nonprogression toward the target segment, and that further study would be needed in order to fully understand the area of "no change" which occurred in each case. A review of initial consonant clusters from the data of all cases shows that similar substitution errors tended to occur on different clusters comprising the same elements. Table 10 illustrates an example of this phenomenon from Case 3's (E.J.) data on the following three cluster segments: /st/, /tr/, /str/.

The data in this study refer to the speech samples of three adult aphasic

**Table 10.** Example from Case 3 (E.J.) of Three Different Initial Consonant Clusters Comprising the Same Phonemes [*/st/* = (3), */tr/* = (4), */str/* = (7)]

Target word	Error segment	Total complexity	Direction of change	
<i>/st/</i> stove	k	2	H→L	
	st	3	p = p	
	stamps	t	H→L	
	stove	s	H→L	
	st	3	p = p	
<i>/tr/</i> tried	tʃ	3	H→L	
	trunk	tʃ	H→L	
	tractor	tʃ	H→I. Pr	
	try	t	H→L	
	trying	t	H→L	
	tram	pr	4	p = p
		tr	4	p = p
	tractor	d	2	H→L
	train	tr	3	H→L
	trees	s	3	H→L
		tr	4	p = p
	<i>/str/</i> strap	dr	5	H→L
str		7	p = p	
straw		ʃ	H→L	
straw		sk	H→L	
straight		s	3	H→L

Key: p = phoneme; H = high complexity; L = low complexity; Pr = progression; NPr = nonprogression.

In summary, the errors are */st/*: s/st, t/st, k/st; */tr/*: s/tr, t/tr, tʃ/tr, pr/tr, d/tr; and */str/*: s/str, st/str, sk/str, ʃ/str, dr/str.

From: Naming Tasks.

patients. They cannot form the basis for any extensive comparison with the development of speech in children, but it is interesting to note that the findings do correlate with Cairns (1975), who found that children's substitution errors may be characterized by a shift toward a lower complexity value for a particular feature. The findings concerning the aphasics in this study further correspond with those of McReynolds, Engmann, and Dimmitt (1974), who characterized substitutions of children with articulation errors in terms of marked and unmarked values. Their results imply that when a change occurs it is more likely that the direction will be from more complex to less complex. (It should be noted, however, that some of the overall complexity values in the present study differed from those used in the study by McReynolds et al.) Panagos, Quine, and Klich (1979) contend that structural complexity may contribute to overall hierarchical complexity, in turn causing children to simplify their speech. Similarly, the finding that these aphasic adults substitute segments and syllable structure of lower complexity value for those of higher complexity

value shows some link with various theories postulated about articulatory effort (Locke, 1972; Parnell and Amerman, 1977). Before one could make any statement about this with confidence, however, future research to generate an ease-of-articulation hierarchy is needed.

The overall results seem to contribute to previous support for Stampe's hypothesis of "centrality of processes" (Macari, 1978). An important limitation of these findings is that Stampe's argument is based primarily on evidence from speech production with very little that can be said about perception. Recently, however, Macari (1978) illustrated that these processes do seem to be true mental operations, which he suggests might also be functional in perception.

## CONCLUSION

A markedness analysis of consonant error productions showed that there is systematic rule-governed behavior to the apraxic impairment in these three adult aphasic patients. For all cases many error utterances consisted of phonemes and phoneme sequences in which the values of the features in the target segments were retained ( $p=p$ ). When a change occurred, however, substitution errors were more likely to reflect a change from more complex to less complex. That is, segments of lower complexity tended to replace those of higher complexity more than the reverse ( $H \rightarrow L$ ). Successive attempts at self-correction did not appear to be random. In each case it was possible to establish patterns of self-corrections, reflecting a progression toward the target segment in terms of markedness complexity values.

This study attempted to extrapolate from theories within the broad framework of natural phonology for these adult aphasic cases, as it was originally developed to explain acquisition of phonology in the child. From the conclusion that these aphasic cases manifest a general tendency to replace segments and syllable structure of lower complexity for those of higher complexity, it may be possible to speculate about the nature of phonological breakdown for the patients of this study. Where the child learns to inhibit natural segments and to expand the repertoire of feature contrasts in the acquisition of his system, these adult aphasics may fail to suppress the earlier tendencies as a result of neurological disruption. This may be viewed as "disinhibition," whereby the aphasic adult is unable to inhibit natural phonological processes. In a sense this may be seen as related to the regression hypothesis commonly discussed and originally proposed by Jakobson (1968). However, it must be stressed that it is seen in terms of general patterns or trends, not in terms of specific phoneme production. This explanation bears some relation to many of the early theorists, particularly Pick (cited in Critchley, 1952), who considered that the essential cause of the general defect in aphasic patients

was a lack of inhibition. He also draws a parallel with normal states of disinhibition caused by exhaustion and stress, which tend to produce similar lapses in speech.

A markedness analysis may facilitate an assessment of phonemic errors in terms of their marked and unmarked segments, graded on a continuum of relative complexity values. Here phonological errors are assessed within a contextual framework, thus encouraging a certain amount of flexibility in relation to different phonemic environments. Furthermore, an evaluation of successive attempts at the target segment in the process of self-correction may, first, enable the clinician to determine the relative point at which the patient is in terms of recovery, and, second, provide insight into predictable phonemic error patterns and vulnerability to change. The relative complexity values (the scales provided in the Appendix) may facilitate the hierarchical arrangement of speech sounds and clusters on which remediation of feature contrast processes can be based. It may be useful to highlight the production of phonemes within a contrastive framework, as discussed by Luria (1970), yet this may be defined within the scale of complexity postulated in markedness theory. Central to the concept of "naturalness" is the discoverable "path" from input to output, within complex sound changes (Darden, 1974). For example, in the case of a reduced cluster b/br, distinctive theory would require a jump from br → b, whereas markedness theory provides an explanation for the entire process, possibly from br → bl → b in terms of complexity values. Markedness may thus provide the intermediate steps necessary for prediction of error patterns, evaluation of progress, and accurate planning of steps toward rehabilitation. Further research is needed to explore the value of markedness, aimed at improving both diagnostic and therapeutic efficacy in apraxia of speech.

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**Appendix A. M/U Values for All Consonants in English, Using a 9 Distinctive Feature Matrix**

Feature	p	b	f	v	θ	ð	t	d	ʃ	ʒ	tʃ	dʒ	m	n	ŋ	l	r	w	y	h	k	g	s	z
Consonantal	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Sonorant	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Anterior	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	M	M	M	M	M	M
Coronal					U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Continuant	U	U	M	M	M	M	U	U	U	U	U	M	M	M	M	M	M	M	M	M	U	U	U	U
Strident	U	U	U	U	U	U	U	U	M	M	M	M	U	U	U	U	U	U	U	U	U	U	M	M
Voiced	U	M	U	M	U	M	U	M	U	M	U	M	U	U	U	U	U	U	U	U	U	M	U	M
Lateral																+	-							
Nasal	U	U	U	U	U	U	U	U	U	U	U	U	M	M	M	U	U	U	U	U	U	U	U	U
	6U	5U	5U	4U	6U	5U	7U	6U	4U	3U	5U	4U	5U	6U	5U	7U	6U	6U	6U	5U	6U	5U	5U	4U
Complexity	1	2	2	3	2	3	1	2	4	5	3	4	2	2	3	1	2	1	2	2	2	3	3	4

**Appendix B. Complexity Values for Each Initial Consonant Cluster in English**

Cluster	Complexity value	
r blends	pr	4
	br	5
	tr	4
	dr	5
	kr	5
	gr	7
	fr	6
	θr	7
	ʃr	9
	l blends	pl
bl		4
kl		4
gl		5
fl		5
s blends	sm	4
	sn	4
	sp	3
	st	3
	sk	4
	sl	7
	sw	7
Other 2-element blends	tw	3
	kw	4
3-element blends	spl	7
	spr	8
	str	7
	skr	9
	skw	7

**Appendix C. Naming Task—Part I: Stimulus Items to Test Single Consonants of English in the Initial and Final Word Position**

	Initial	Final		Initial	Final
m	man	thumb		feather	giraffe
	milk	tram		fish	
	mouth	drum	v	vase	*five
	monkey	pram		vest	store
n	knife	pen		violin	twelve
	nose	train	θ	thumb	teeth
	nurse	gun		thimble	mouth
ŋ		ring		thin	cloth
		swing		thick	
		string	ð	these/those	*lathe
		cup		this/that	*bathe
p	pig	zip	s	sock	house
	pot	rope		soap	horse
	pen	sheep		silver	dress
	pipe	crib		salad	nurse
b	ball	scrub	z	zebra	cheese
	bird	*tub		zoo	nose
	butter	*bib		zip	vase
	book	hat	ʃ	sheep	fish
t	tie	shirt		shirt	squash
	torch	pot		shoe	splash
	teeth	rabbit		ship	brush
	table	bird	ʒ		*beige
d	dog	bride			*rouge
	duck	spade	h	hat	
	doll	salad		house	
	dice	duck		horse	
k	cat	book		hammer	
	cage	block	w	wool	
	cup	sock		whistle	
	keys	pig		watch	
g	gun	dog		wash	
	girl	frog	j	yacht	
	garage	jug		yellow	
	game		tʃ	chair	watch
r	ring			cheese	torch
	radio			chain	church
	rabbit	ball		church	scratch
l	lamp	wool	dʒ	jug	cage
	lemon	snail		giraffe	*badge
	leaf	girl		juice	fridge
	lorry	knif		jersey	bridge
f	fork	leaf			
	fire				

\* Words not included previously under initial position.

Total = 89.

**Appendix D. Naming Task—Part II: Stimulus Items to Test  
Initial Consonant Clusters of English**

pr	prize pram present	kl	clock clown cloth	sm	smoke smell smile
br	bread brush bride bridge	gl	climb gloves glass glasses	sp	spoon spade spider
tr	tree train tractor tram	fl	flag fly flour flower	st	spanner stove stair(s) stamp
dr	dress drill drum drink	sl	slacks slipper(s) sleep	sk	steak scale skirt skittle(s)
kr	crib crown cricket crayon	sn	snow snake snap(s) snail	spl	ski split splash splinter
gr	grass green grapes fridge	θr	three thread throw	spr	spread spray sprinkle
fr	fridge frog fruit freckle(s)	fr	shred shrub	str	stripes straw string strap
pl	plate plant plane plaster	tw	twig twin twelve	skr	scratch screw scrub
bl	blouse block(s) blanket blazer	kw	queen quickly	sw	swing sweet(s) sweep
		sw	swing sweet(s) sweep	skw	split splash splinter squirrel squash squeezer

Total = 99.

Naming Task—Part I = 89

Naming Task—Part II = 99

Total = 188 Stimulus items