Apraxia of Speech in Patients with Broca’s Aphasia: A Study of Phoneme Production Accuracy and Error Patterns

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Phonetic analyses were made of the articulatory errors of ten Broca’s aphasics with apraxia of speech. Presentation mode, phoneme position, and phoneme frequency-of-occurrence were related to phoneme difficulty. Consonant clusters were more difficult than consonant singletons; vowels were easiest. Substitution, addition, and compound errors predominated, while distortions and omissions were much less frequent. A subphonemic feature analysis of substitution and distortion errors showed a majority of errors to be close approximations to target phonemes.

Disturbances of motor speech programming are commonly observed in patients with Broca’s aphasia. Though there is much terminological controversy about these articulatory problems, it is generally agreed that they are distinct from those based on disturbance of neuromotor projection systems (dysarthria) and from those due to sensory or perceptual impairment. The articulatory disturbances of Broca’s aphasics are referred to in this communication as apraxia of speech, following the usage of Johns and Darley (1970).

While apraxia of speech can occur in pure form (Petit-Dutaillais et al., 1954; Darley, 1968; Johns and Darley, 1970), such that the articulatory disturbance is the only demonstrable impairment, pure apraxia of speech is a relatively rare phenomenon. More typically, apraxia of speech in the neurologically impaired adult is seen as an element of an aphasic symptom complex. Alajouanine, Ombredane, and Durane, (1939) and Alajouanine and Lhermitte (1960, 1963) have emphasized that apraxia of speech (in their terms, phonetic disintegration) is often a residual disorder of an initially broader aphasic syndrome. It is the combination of higher-order language impairment with this particular variety of articulatory distur-
bance which constitutes the syndrome of Broca’s aphasia. This syndrome has been well described by Weisenberg and McBride (1935) in their discussion of “predominately expressive aphasia.” Detailed descriptions of the expressive behavior of Broca’s aphasics have also been provided by Goodglass, Quadfasel, and Timberlake (1964), and Benson (1967). Briefly, the syndrome is marked by the following features: (1) disturbed articulatory performance—apraxia of speech; (2) impaired speech prosody; (3) agrammatism—telegraphic-style speech with reduced phrase length; (4) word-finding problems; (5) impaired language comprehension, though often very mild.

Recent contributions to our understanding of apraxia of speech in adults have been made by Fry (1959), Shankweiler and Harris (1966), Shankweiler, Harris, and Taylor (1967), Johns and Darley (1970), Trost (1971), and Deal and Darley (1972). These studies have revealed that: (1) apraxia of speech is a disorder distinct from dysarthria in that apraxic articulatory errors are inconsistent, are largely substitutions rather than distortions, and occur in the absence of any marked primary neuromotor impairment of the vocal tract musculature; (2) apraxic patients tend to have more difficulty in production of initial as compared to final consonant phonemes, and speech initiation latencies are observed in many patients; (3) the nature of phonetic errors does not follow the principle of articulatory regression in that the articulatory errors made by apraxic speakers are not merely articulatory simplifications; (4) apraxic adults tend to be aware of their error productions.

The studies cited above have provided the beginning of a deeper understanding of apraxia of speech. The present study describes the phoneme production accuracy and the patterns of phonetic errors observed in a group of Broca’s aphasics with apraxia of speech. By increasing our knowledge of the phonetic behavior of such patients, it was believed that further insight into the underlying neuropsychological mechanisms of apraxia of speech could be gained.

METHOD

Subjects

The subjects were ten Broca’s aphasics. Characteristics of speech output shown by Goodglass, Quadfasel, and Timberlake (1964) and Benson (1967) to be diagnostically differentiating among types of aphasia served as the major basis for subject classification. Subjects were classified as Broca’s aphasics, reliably and independently, by three experienced speech pathologists who listened to tape-recorded speech samples. The patients ranged in age from 27 to 69 years with a mean age of 55. They were all native speakers of English who demonstrated normal hearing sensitivity for their age, and showed oral language comprehension superior to oral language expression. Cerebrovascular accident was etiological in all cases. The patients were neurologically stable at the time of testing; the time elapsed since onset of aphasia ranged from 5 months to 20 years. Seven subjects were
right hemiplegics, while one had a left hemiplegia which cleared up within the first few weeks post-stroke. In no subject was there evidence of a visual field deficit. Oral-motor and oral-sensory testing of these patients revealed the expected (contralateral) unilateral impairment; no patient showed bilateral sensory or motor impairment. Therefore, it was concluded that the speech articulation deviations of these patients were little, if at all, influenced by dysarthria.1

**Test Composition and Procedures**

Accuracy in production of English singleton consonants, vowels, and consonant clusters was assessed using a single-word articulation test. The test consisted of 130 monosyllabic words. Except for words selected to test consonant clusters, only CVC words were employed. Articulatory responses were elicited using picture stimuli (spontaneous) and also in imitation of the examiner's speech (repetition).2 In the repetition task, the examiner produced each test word three times, and the subject made a single imitative response. If the subject failed to articulate a response he was given the word three more times in succession. If he continued to give no response the item was recorded as such. In the spontaneous task, if the subject could not name an item due to an apparent word retrieval failure, an attempt was made to train him to say the word. Articulation of this word was then retested later in the session.

Twenty-two consonant singletons were tested four times in the initial and four times in the final position in the spontaneous condition; the same was true in the repetition condition. The exceptions to this pattern were phoneme /z/, which was tested in the final position only, and the phoneme /ʌ/ (as in Tumb) which was tested only three times in each position.

Twenty-five consonant clusters (as in Flute and Sprin) were tested in the initial position both spontaneously and in repetition. Twenty-two consonant clusters occurring in the final position (such as lAMP and bulBS) were similarly tested. There were fourteen vowels and diphthongs tested, all in the context of CVC words (such as bEd and mouSe). Again, each word was attempted by the patient spontaneously and in repetition.3

Whole-word narrow phonetic transcriptions were done at the time of testing. In addition, the entire test was recorded on a Uhler Universal 5000 tape recorder and was listened to later in order to refine the phonetic transcriptions. For transcription reliability purposes, a block of ten words was retranscribed for each subject eight months after the initial testing. Of the 200 whole-word transcriptions, 182 (91%) were transcribed identically on the two occasions. The discrepancies between the two transcriptions of the remaining eighteen words never involved more than an allophonic variation of a single phoneme.

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1 It is generally agreed that unilateral oral-motor impairment is typically not associated with chronic, serious dysarthria (Brain, 1952, and Canter, 1967), nor is unilateral oral-sensory impairment (McCall, 1968). Chronic dysarthria as seen in such conditions as pseudobulbar palsy, progressive bulbar palsy, or Parkinson's disease is almost invariably based on bilateral impairment of the motor projection system (upper and lower motor neurons). Apraxia of speech, by contrast, is viewed as a disturbance of the cortical motor association system.

2 A more detailed description of test words, material, and administration can be found in the dissertation on which this paper is based (Trost, 1970), obtainable from University Microfilms, Ann Arbor, Michigan. This same source also provides a complete presentation of the obtained data and the statistical analyses.
RESULTS

Phonemic Production Accuracy

The articulation of this group of Broca's aphasics was influenced by two main types of error responses—inadequate responses and true phoneme errors. Speech dysfluencies noted in the word productions of these patients were not scored as errors; rather, they were regarded as nonphonemic aspects of the apraxia and were separately analyzed as to type, frequency of occurrence, and relationship to articulatory accuracy (Trost, 1970, 1971).

Inadequate Responses

An inadequate response was one which could not be judged phonemically. Five types were observed: (a) random phonemes, where phoneme strings failed to yield any kind of word approximation; (b) perseverative response; (c) paraphasic response, a semantic substitution such as "hat" for coat or "baby" for bib; (d) recurrent utterance; and (e) no response. These inadequate responses occurred significantly more frequently in spontaneous naming than in repetition \( p < .05 \), most likely because of the word-finding problems of the aphasic patients. As is evident, many of these responses were not inadequate at a phonological level; thus, the word pool from which phoneme accuracy and phoneme errors were studied was made up only of adequate responses.

Performance on Singleton Consonants

Individual phoneme difficulty on singletons. Of the total twenty-two singleton phoneme types tested, these aphasics did not produce all phonemes with equal accuracy. Table 1 shows the mean percentage correct (repetition and spontaneous modes combined) on each of the phoneme types. The column headed overall gives these data irrespective of phoneme position or mode of presentation.

The phonemes /v, f, η, ʒ, θ, j/ were the least accurately produced, a finding congruent with those of Shankweller and Harris (1966), and Johns and Darley (1970). Since, as a group, these phonemes do not share identical manner or place features of production, neither place nor manner alone can be implicated in their increased difficulty relative to the other phoneme types.

Whereas phonetic parameters do not seem particularly useful in understanding the relative difficulty of phoneme production for these apraxic patients, relative frequency of occurrence of phonemes in the

More than one phonetic element was tested with a single word production. For example, the word top was used to sample initial /t/ and the vowel /o/.
## TABLE 1
### MEAN PERCENTAGE CORRECT OF PHONEMES

<table>
<thead>
<tr>
<th>Phoneme</th>
<th>Overall</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>/m/</td>
<td>92.6%</td>
<td>92.7%</td>
<td>91.9%</td>
</tr>
<tr>
<td>/n/</td>
<td>85.4</td>
<td>76.6</td>
<td>93.6</td>
</tr>
<tr>
<td>/p/</td>
<td>82.7</td>
<td>83.4</td>
<td>81.3</td>
</tr>
<tr>
<td>/l/</td>
<td>81.5</td>
<td>77.5</td>
<td>85.4</td>
</tr>
<tr>
<td>/r/</td>
<td>80.1</td>
<td>66.1</td>
<td>93.6</td>
</tr>
<tr>
<td>/k/</td>
<td>79.7</td>
<td>77.3</td>
<td>82.1</td>
</tr>
<tr>
<td>/h/</td>
<td>79.6</td>
<td>79.6</td>
<td>-</td>
</tr>
<tr>
<td>/s/</td>
<td>79.6</td>
<td>75.0</td>
<td>81.6</td>
</tr>
<tr>
<td>/t/</td>
<td>79.6</td>
<td>69.8</td>
<td>89.3</td>
</tr>
<tr>
<td>/z/</td>
<td>79.5</td>
<td>DNT</td>
<td>79.5</td>
</tr>
<tr>
<td>/th/</td>
<td>77.3</td>
<td>82.3</td>
<td>71.5</td>
</tr>
<tr>
<td>/tʃ/ (chair)</td>
<td>74.5</td>
<td>68.0</td>
<td>80.4</td>
</tr>
<tr>
<td>/b/</td>
<td>73.6</td>
<td>82.1</td>
<td>63.9</td>
</tr>
<tr>
<td>/w/</td>
<td>73.3</td>
<td>73.3</td>
<td>-</td>
</tr>
<tr>
<td>/g/</td>
<td>71.5</td>
<td>70.4</td>
<td>69.1</td>
</tr>
<tr>
<td>/d/</td>
<td>71.3</td>
<td>72.4</td>
<td>70.1</td>
</tr>
<tr>
<td>/v/</td>
<td>71.0</td>
<td>56.4</td>
<td>84.5</td>
</tr>
<tr>
<td>/ʃ/ (sheep)</td>
<td>70.3</td>
<td>65.7</td>
<td>75.5</td>
</tr>
<tr>
<td>/ŋ/ (ring)</td>
<td>64.6</td>
<td>-</td>
<td>64.6</td>
</tr>
<tr>
<td>/ð/ (jar)</td>
<td>64.1</td>
<td>69.3</td>
<td>57.9</td>
</tr>
<tr>
<td>/θ/ (thumb)</td>
<td>58.2</td>
<td>58.3</td>
<td>58.8</td>
</tr>
<tr>
<td>/j/ (yawn)</td>
<td>49.3</td>
<td>49.3</td>
<td>-</td>
</tr>
</tbody>
</table>
language does. Using Dewey's (in Fletcher, 1953, p. 95) data, based on transcriptions of telephone conversations, one can compare the relative difficulty of production of phonemes by the patients with the relative frequency of occurrence of these same phonemes in spoken English. Because Dewey's data are separate for initial and final position in a word, only the 17 phonemes tested in both positions were included. The Spearman rank-order correlation \( (\rho) \) between difficulty and frequency of occurrence was .51 \((p = < .05)\) for initial phonemes, while the correlation for final phonemes was a striking .83 \((p = < .01)\). Thus, just as difficulty in word retrieval has been shown to be related to word frequency of occurrence (see, for example, Wepman et al., 1956), we see here that difficulty of phoneme production is similarly influenced by phoneme frequency of occurrence.

**Phoneme accuracy and phoneme position.** This analysis compared the group's percentage correct on each initial singleton with the percentage produced correctly on each final singleton consonant. The product-moment correlation between relative difficulty of phonemes produced in the initial versus the final position was low and not statistically significant \((r = .22)\). This indicates that the order of difficulty of phonemes in different positions was not comparable. This is partially explainable on the basis of different frequencies of occurrence in the language for a given phoneme. The above relationship held for both repetition and spontaneous modes. Though not to a statistically significant degree, there was a tendency for these patients to be less accurate with initial consonants (73.2% correct) than with final consonants (78.3% correct). This tendency is consistent with the findings of Shankweiler and Harris (1966), Hécaen (1969), and Johns and Darley (1970). From the linguistic regression hypothesis of Hughlings Jackson (Taylor, 1958) and more recently as applied by Jacobson (1956) and Wepman and Jones (1964), one would anticipate that final consonants—being acquired later in childhood than initial sounds—would be more difficult. The present evidence, particularly when considered in conjunction with related findings presented by Fry (1958) and by Shankweiler and Harris (1966), contradicts the regression hypothesis at the phonological level.

**Phoneme accuracy and presentation mode.** A subject's performance on singleton consonant phonemes kept the phonemes in essentially the same order of difficulty whether the presentation required repetition or spontaneous production \((r = .83; p = .001)\). This relationship maintained for both initial \((r = .77; p = .001)\) and final \((r = .78; p = .001)\) singletons. While phonemes retained essentially their same rank order whether subjects responded in repetition or spontaneously, a greater proportion were produced correctly in the repetition condition \((p = .002)\). This held for both initial and final positions. This finding suggests that adults with
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apraxia of speech can benefit from speech models, and is consistent with
the findings of Johns and Darley (1970).

Performance on Consonant Clusters

As with singletons, the subjects showed a wide range in accuracy of
consonant cluster production. Overall, percentage correct for individual
subjects varied from 14.4% to 86.2% with a standard deviation of
28.8%.

Cluster accuracy and cluster position. The comparison of initial and
final clusters is quite tenuous, since many of the clusters tested in one
position were not tested in the other position. There was, however, a
trend for final consonant clusters to be produced with somewhat greater
accuracy than initial clusters, similar to the pattern found for singleton
consonants.

Cluster accuracy and mode of presentation. In production of clusters,
subjects maintained essentially the same status whether presentation
was in repetition or was spontaneous ($r = .91; p = .001$). The pattern is
similar to that reported for singleton consonants. But, whereas repetition
of singleton consonants was significantly better than spontaneous pro-
duction, there was virtually no difference in cluster accuracy when the
two modes were compared. The mean for repetition was 48.4% as com-
pared with the spontaneous mean of 46.8%: the obtained $t$ was not sig-
nificant. This may reflect the relative complexity of cluster versus sin-
gleton production. The patient who errs on a cluster may not find an
auditory model to be of sufficient aid for accurate production. By con-
trast, an auditory model may well offer cues sufficient to lead to correct
singleton production.

Performance on Vowels

Vowels were not subjected to as detailed analysis as were consonant
singletons and clusters. Rather, percentage correct on vowels for each
subject was computed; this percentage was based upon the number of
correct productions out of the number of adequate productions for repe-
tition and spontaneous modes combined.

Subjects fell into two main groups, those who made few or no vowel
errors and those who made a substantial number of them. Eight subjects
scored better than 88% correct; and of these, three subjects made no
vowel errors at all. Two subjects accounted for most of the vowel
errors. Since these two subjects were among the five most severely
apraxic patients in the group, it may be that marked difficulty on vowels
in addition to consonants is a severity indicator of apraxia of speech.
The nature of the majority of errors made on vowels suggested that
vowels were misarticulated in relation to articulatory difficulty on con-
tiguous consonants; that is, difficulty in articulating the CV or VC transition and/or in selecting the correct consonant phoneme(s) seemed to cause the vowel nucleus to become distorted. There were no instances where a vowel error constituted the only error in production of a monosyllabic word.

**Relationships between Accuracy on Singletons, Clusters, and Vowels**

The aphasics had most difficulty on clusters (47.9% correct), less difficulty on singletons (75.4% correct), and least difficulty on vowels (89.9% correct). These observed differences in relative difficulty were all statistically significant. In addition, subjects who did well with consonant singletons were the same subjects who did well with consonant clusters (r = .94). However, singleton consonants were consistently easier to produce than were clusters (p = .001). No subject showed deviation from this pattern.

**Phoneme Production Error Patterns**

Of the total singleton phoneme productions which could be judged—adequate responses—roughly 25% were produced in error. Singleton productions were viewed according to conventional error categories and also with respect to subphonemic feature relationships between error sounds and their target sounds. Consonant clusters were analyzed according to conventional error categories. Because phoneme position and presentation mode did not affect the distribution of error types, consonant errors in both the initial and final positions and in repetition and spontaneous production were pooled for this analysis.

**Analysis According to Conventional Error Categories**

*Singleton consonants.* Of the total 2943 phonemes which were judged, 715 were produced in error. These errors distributed themselves among five categories: (a) simple substitution, as in /t/ for /p/; simple distortion, as in /s/ for /q/; omission, as in /ɔɡ/ for /dɔɡ/; addition, as in /fl/ for /l/; and compound error, as in /sw/ for /ʃ/. (The simple distortion category also included instances of “silent articulation,” where a subject produced a visibly recognizable speech gesture but failed to carry the sound production to completion.) Compound errors were distinguished from phoneme additions in that the substituted phonemes in a compound error did not include the target phoneme, whereas in an addition the substitution consisted of the target phoneme plus additional phoneme(s).

As illustrated in Table 2, substitutions accounted for more of the total errors made than did the other four categories combined. The primacy of substitution errors in apraxic speech is in general agreement with the
findings of Johns and Darley (1970). This, in addition to the fact that distortions accounted for less than one-tenth of the total errors, clearly distinguishes apraxic speech from adult dysarthric speech phonetically.

Consonant clusters. The group produced a total of 886 adequate cluster tokens of which roughly 52% were incorrectly articulated. Seven major categories accounted for all of the specific error types produced. These were substitution, distortion, omission, addition, combined (such as substitution plus omission and/or distortion), metathesis (phoneme reversal), and transition (including intrusive schwa, glottal stop, prolongation, and articulatory hiatus).

Of the total errors made on clusters, the most common error types were those of omission and of combined errors, as is shown in Table 3. Distortions, metathesis, and additions were infrequent error types, together accounting for roughly only 10% of the total errors.

For both omission and substitution errors, the large majority involved only one element of the cluster. Errors of pure transition represented 12.9% of the cluster errors produced; however, when all errors involving a transition were computed for the group, it was found that approximately one-third included articulatory transition difficulty.
With regard to position of occurrence, the error categories of substitution, distortion, and addition showed roughly proportional representation in initial as compared to final position. The subjects did, however, more often omit elements of final clusters than of initial clusters. Errors of pure transition were almost three times as frequent in the initial (17.3%) as compared to the final (6.5%) position.

**Subphonemic Feature Analysis**

Of 715 phoneme errors made on singleton consonants, only 519 were appropriate for this analysis since errors of omission or addition, compound errors, and silent articulations are not analyzable in this fashion. The 519 errors were studied to determine the extent to which the patients' errors approximated the target phonemes in terms of subphonemic feature components of speech production.4

A four-feature system of *place*, *manner*, *voicing*, and *oral-nasal* was used to quantify the degree of error (subphonemic feature distance) for all substitutions and distortions. The place dimension classified each error as *bilabial*, *dental*, *alveolar*, *palatal*, *velar*, or *glottal*. There were six manner categories based upon degree of articulatory constriction: *stop/nasal*, *affricate*, *fricative*, *lateral*, *glide*, and *vowel*. Voicing was either *voiced* or *voiceless*. Oral-nasal was either *oral* or *nasal*. Thus, substitution of /t/ for /p/ is an error in *place* only; /g/ for /k/ is a *voicing* error; /w/ for /b/ is a *manner* error; /b/ for /m/ is a pure *oral-nasal* error. Many errors involved more than one feature; for example, /f/ for /k/ is an error of two features — *manner* and *place*— while /dʒ/ for /t/ is a three-feature error — *place*, *voicing*, and *manner*. An example of a four-feature error is /h/ for /ml.

**Subphonemic feature distance.** Figure 1 shows that these ten patients rarely were so off target as to produce four-feature errors. Slightly better than half of their total 519 errors were only one feature removed from the target phoneme.

One- and two-feature errors together accounted for approximately 88% of the errors, while roughly 11% involved three features. While one- and two-feature errors occurred with nearly equal frequency in the initial position, one-feature errors were by far the most common error in the final position. These findings indicate that the majority of phoneme errors made by these apraxic speakers tended to be reasonable, in that

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4 The term *subphonemic feature* describes, in conventional phonetic terms, the particular speech gestures of spoken American English consonants. It is not to be equated with "distinctive" feature systems such as those described by Fant (1960) and Jacobson, Fant, and Halle (1969).
they were fairly close to target. Final phonemes would appear somewhat easier to approximate than initial phonemes. It would not be wise, however, to assume that all of the articulatory productions made by these aphasics were attempts to program the target sound. A minority of errors were probably rather random articulatory efforts. The three- and four-feature errors probably represent many such "blind" articulatory attempts.

Contribution of each of four features to errors made. In addition to studying subphonemic feature distance of error sounds from target sounds, it was of interest to determine if the four different subphonemic features were of equal difficulty or whether certain features were involved more often than others. The comparison of percentages of errors made on each of the four features is given in Table 4, which shows a

<table>
<thead>
<tr>
<th>Subphonemic feature</th>
<th>Contribution to total errors&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>60.9%</td>
</tr>
<tr>
<td>Manner</td>
<td>53.1</td>
</tr>
<tr>
<td>Voicing</td>
<td>36.1</td>
</tr>
<tr>
<td>Oral–Nasal</td>
<td>6.2</td>
</tr>
</tbody>
</table>

<sup>a</sup>These percentages total more than 100% because many of the articulatory errors observed involved more than one feature.
relatively high occurrence of place of articulation errors. Manner errors were also quite commonly observed, while voicing errors were less frequent. The oral-nasal feature made the least contribution.

**Direction and degree of error.** Error productions were analyzed to determine (a) the direction of error for voicing (voiced for voiceless, or voiceless for voiced) and for oral–nasal (nasal for oral, or oral for nasal), and (b) the degree of error within the separate categories of place and manner. For errors in place distance the following scheme was used:

<table>
<thead>
<tr>
<th>Bilabial</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
</table>

Thus, a substitution of a dental for a bilabial was considered an error of one place, while substitution of a palatal for a bilabial was a place distance error of three places. A somewhat parallel scheme was used for degree of error in manner (oral articulatory constriction):

<table>
<thead>
<tr>
<th>Complete</th>
<th>Affricate</th>
<th>Fricative</th>
<th>Lateral</th>
<th>Glide</th>
<th>Vowel</th>
</tr>
</thead>
</table>

Substitution of a fricative for an affricate was one degree off in manner, while a vowel for a stop/nasal (complete constriction) constituted the maximum error of five degrees.

**Place errors.** The obtained place distance data are quite similar to those obtained in the overall subphonemic feature distance of error sounds from target sounds. Figure 2 shows that when subjects made place errors, the errors tended to be close approximations to the target place. Slightly more than half of the errors involving place were off target by only one place, while about a third were two places in error. This pattern held for both initial and final positions with a tendency for

![Fig. 2. Distribution of errors by place distance.](image-url)
the subjects to make a slightly greater proportion of close approximations to correct place in final phonemes.

Manner errors. The degree of approximation of manner errors to correct degree of articulatory constriction did not show as systematic a pattern as did place errors. Figure 3 illustrates that subjects produced noticeably more errors which were two degrees off in manner than they did one-degree errors. Substantially fewer errors were three and four degrees off in constriction.

Voicing errors. Of the total voicing errors made by the group, roughly two-thirds (67.5%) were substitutions of voiceless-for-voiced while about one-third (32.5%) were substitutions of voiced-for-voiceless consonants. Since four of the ten subjects made few or no voicing errors, the data on voicing derives largely from six subjects. The predominance of voiceless-for-voiced substitutions was somewhat more striking in the final position than in the initial position. Since the four subjects who made few or no voicing errors were among the five least severely apraxic patients, it may be that marked difficulty in encoding the voicing feature is (also) a severity indicator in speech apraxia.

Oral-nasal errors. These aphasics made very few oral-nasal errors; in fact, four subjects made no such errors. Of the nineteen total errors made, there was an almost equal occurrence of oral-for-nasal and nasal-for-oral errors.

DISCUSSION

The accuracy of production of monosyllabic words produced by this group of Broca's aphasics was influenced by two main types of error responses—inadequate responses and true phoneme errors—on consonant singletons, clusters, and vowels.
The fact that inadequate responses (those which could not be judged phonemically) occurred significantly more often in spontaneous naming than in repetition suggests that word-finding difficulty makes some contribution to the emission of such responses. Moreover, frequent inadequate responses may be a severity indicator of apraxia of speech, since the three subjects who produced no inadequate responses were the same subjects who ranked highest in phoneme production accuracy. One diagnostic implication of this finding is that the analysis of the articulatory disturbance in Broca's aphasics can be somewhat contaminated if these inadequate responses are not separated out, but rather are judged at a phonological level.

While presentation mode had little effect upon the relative difficulty of individual phonemes or clusters, the findings that (a) a greater number of accurate articulations occurred in the repetition mode and (b) initial singletons and clusters were more difficult for these aphasics than were finals, in combination with available speech latency data (Trost, 1970, 1971), suggests that it is in the act of speech initiation that apraxia of speech poses its greatest hazard to motor speech. Moreover, the confirmation of previous findings of Shankweiler and Harris (1966) and Johns and Darley (1970) that substitutions are the predominant error type on singleton consonants with distortions making a rather minor contribution, and the observation that these patients attain greater speech accuracy when given a production model both serve to distinguish apraxia of speech from dysarthria.

Perhaps one of the most interesting findings to emerge from this study is that, with respect to subphonemic feature components of articulatory production, the consonant phonemic errors made by this group were, for the most part, good approximations to their target phonemes. This finding suggests that there is a certain lawfulness to the apraxic impairment in Broca's aphasics, particularly as concerns place of articulation. This interpretation contrasts with that of Shankweiler and Harris (1966) who emphasize "an apparent unrelatedness of many of the substituted sounds to their targets." This led them to hypothesize that there is a disorganization of phonological encoding in these patients. The present authors view the problem more as a reduction in the discriminative selection and precision requisite to motor speech encoding than as a disorganization of the encoding process for phonological units. Most likely, if the data of Shankweiler and Harris were subjected to subphonemic feature analysis, as utilized in the present study, the same interpretation of lawfulness in the speech errors of their five apraxic patients would emerge. It will be important in future research to investigate the phonetic behavior of posterior aphasics with literal paraphasic errors (Wernicke's and conduction aphasics). It has been suggested that these patients are not nearly so
phonetically "logical" in their articulatory errors as are the type of patients studied in the present investigation (Canter, 1969).

The distribution of place errors was remarkably similar to that observed for subphonemic feature distance while manner defied such systematic description. This could mean that while manner, as viewed here, does have considerable heuristic value for purposes of speech-sound classification, this way of viewing manner may not be psychologically real. Moreover, the parameters employed by the speech scientist are perhaps not the same as those psychological parameters employed by the central nervous system in encoding manner of speech production.

The findings of this study must be viewed with reference to certain limitations. Primary among these is the small sample size. Thus, it cannot be assumed that the speech error patterns manifested by these patients are necessarily characteristic of all Broca's aphasics, nor of the less frequently observed adult with pure apraxia of speech. Also, because speech praxis was assessed in patients' productions of monosyllabic words which required either a spontaneous or repetition response, the sampling of speech production does not necessarily simulate communicative language. The encoding mechanisms underlying naming and speech repetition may be different from those requisite to formulation of spontaneous communicative language.

SUMMARY

The articulatory accuracy and error patterns of a group of Broca's aphasics are described, and some cardinal characteristics of apraxia of speech are presented. The findings of the study suggest the following conclusions.

(1) Articulation of these patients is influenced by two main types of responses: inadequate responses, which are not comparable to or analyzable as phonological errors, and true phoneme errors.

(2) Phoneme production accuracy is influenced by presentation mode and by phoneme position. Repetition is easier than spontaneous naming, and there is a trend for final consonants to be easier than initial consonants.

(3) Phoneme frequency-of-occurrence influences consonant phoneme production accuracy: phonemes with relatively high frequency of occurrence in spoken English tend to be more accurately articulated while phonemes with relatively low frequency of occurrence tend to be least accurately produced.

(4) Vowels are produced significantly more accurately than are singleton consonants, which, in turn, are produced more accurately than are consonant clusters.

(5) Substitutions, additions, and compound errors comprise the great
majority of errors made on consonant singletons, with distortions and omissions contributing relatively little to total errors made.

(6) Subphonemic feature (place, manner, voicing, oral–nasal) analysis of substitution and distortion errors shows a majority of errors to be close approximations (one- or two-feature errors) to target sounds.

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REFERENCES


