Error Patterns in Apraxia of Speech

Clarence A. Bowman and Linda S. Althoff
Illinois State University, Normal, Illinois

Nancy Anderson
Mennonite Hospital, Bloomington, Illinois

Numerous descriptions of articulatory impairment associated with left-anterior cortical lesions have appeared in the literature. While these descriptions generally have remained consistent, considerable disagreement continues to surround the underlying nature of the disorder. Darley (1982) wrote that these patients exhibit an articulatory impairment "because of a cerebral lesion that prevents his executing voluntarily and on command the complex motor activities involved in speaking, despite the fact that muscle strength is undiminished." Darley has applied the term apraxia of speech to this disorder and defined it as a disorder of motor speech programming manifested primarily by errors in articulation and secondarily by compensatory alterations of prosody.

Several investigators have suggested that the presence of linguistic regularities in the errors of patients with apraxia of speech argues for a linguistic interpretation of the disorder. Lesser (1978) wrote that "if the disorder is a complete breakdown of organization then we would not expect to find linguistic regularities in the kinds of errors made but would predict the inconsistency in errors on which Darley comments." Blumstein (1973) studied patients diagnosed as having Broca's, Wernicke's or conduction aphasia and concluded that all 3 types of aphasia showed similar patterns in their errors. She found that in general, errors produced by conduction and Wernicke's aphasic patients were not qualitatively different from those of Broca's aphasic patients. These findings support the theory that linguistic regularities may underlie aphasic misarticulations.

Johns and Darley (1970) evaluated the misarticulations of 10 apraxic patients and found "variability of phonemic production; unrelated and additive substitutions, repetitions, and blocks; groping through repeated efforts toward right production." They further stated that these errors "are alterations of volitional articulation which fit well within the generic term apraxia."

Given the importance of the inconsistent nature of the disorder, the present investigation was designed to measure error variability through a phonological process analysis. The purpose of this study was to determine whether phonological errors consistently remain within error process categories during a repeated measures analysis. Based on evidence which suggests that apraxic patients apply phonological processes to modify the number of contrastive elements in utterances (Bowman, Hodson and Simpson, 1980), it was hypothesized that these patients may apply variable phonetic targets yet remain within consistent process categories.

METHOD

Eight left-brain damaged (vascular) subjects with a diagnosis of apraxia of speech based on Darley (1968) criteria were selected. All subjects exhibited a clinical pattern that was commensurate with a diagnosis of Broca's aphasia based on results of the Boston Diagnostic Aphasia Examination, the Aphasia Language Performance Scales or the Minnesota Test for Differential Diagnosis of Aphasia. A modified version of the Assessment of Phonological Processes was used to obtain 3 separate evaluations of spontaneous productions of 53 mono- and multisyllabic utterances from which percentage of occurrence scores for the following 10 phonological processes were derived: 1) reduction of syllables; 2) reduction of consonant clusters; 3) omission of prevocalic obstruent singletons; 4) omission of postvocalic obstruent singletons; 5) omission of nonsyllabic sonorant singletons; 6) deletion of stridency; 7) stopping of continuants; 8) fronting of velars; 9) gliding of prevocalic liquids; and 10) vowelization of syllabic liquids. Frequency of occurrence scores for the following 16 less frequently occurring process categories were obtained:

1. Palatalization
2. Depalatalization
3. Prevocalic voicing
4. Postvocalic devoicing
5. Labial assimilation
6. Velar assimilation
7. Nasal assimilation
8. Metathesis
9. Epenthisis
10. Vowel deviations
11. Prevocalic devoicing
12. Affrication
13. Deaffrication
14. Alveolar preference
15. Velar preference
16. Stridency addition

During the three evaluations, each subject was required to name spontaneously 53 common pictures. The target words included all American English consonants as singletons both prevocalically and postvocalically (except for /w/, /j/, and /h/ which were prevocalic) and 31 common pre- and postvocalic consonant clusters. Responses were transcribed (broad) from audio tapes by two trained judges. Whenever discrepancies occurred, audio tape recordings were replayed until agreement was reached.

Transcriptions were transferred to an analysis form which provided columns for specifying occurrences of the phonological processes. Each word was scored by the senior author according to Hodson's procedure to indicate all of the processes affecting the production (e.g., when a subject said /kwɪŋ/ for string, the following columns were checked: cluster reduction-loss of obstruent segment of the cluster; stridency deletion-/s/ omission; liquid gliding-substitution of glide /w/ for /r/; and velar assimilation-regressive influence of /ŋ/ on /t/). Subsequently, the repeated measurement component of the investigation allowed for comparison of error patterns from three evaluations. The three productions of each target word were compared to determine if the processes affecting production remained constant even if phoneme changes occurred across measures.

RESULTS

Numerous studies have established the concept of phonemic variability in apraxic patients. The present investigation confirmed those findings. While phonemic variability exists, the application of a phonological process

analysis in this study revealed the presence of an underlying linguistic component. The overall finding was that, while individual misarticulations were highly variable during the 3 evaluations, there was a remarkable tendency for the errors to remain within the same phonological process category. For example, stridency was deleted from the target /s/ in the stimulus squirrel by substituting /t/ during one measure and upon subsequent testing the phonemes /b/ and /d/ were substituted. An analysis of these errors in traditional articulatory terms would fail to expose the unitary nature of the 3 substitutions, which in this instance represents the consistent application of two phonological processes, stridency deletion and continuant stopping.

Table 1 shows that 34 target words contained errors on all 3 measures. Within these 34 targets, 32 phonological processes were applied consistently on each measure. Sixteen processes were applied on 2 of 3 trials and 11 processes occurred on only 1 of 3 trials. Forty eight processes occurred in target words on at least 2 of the 3 trials.

Table 1. Target words with errors on 3 trials.

Total number of words	Processes applied on 3 trials	Processes applied on 2 of 3 trials	Processes applied on 1 of 3 trials
34	32	16	11

Table 2 shows that 20 target words contained errors on 2 of 3 trials. Twenty-two processes were consistently applied on both trials while 14 processes occurred on 1 of 2 trials. Thirty-seven target words contained errors on only 1 trial.

Table 2. Target words with errors on 2 trials.

Total number of words	Processes applied on 2 trials	Processes applied on 1 of 2 trials
20	22	14

Further analysis revealed that several processes were frequently applied by all subjects. These processes included stridency deletion, continuant stopping and cluster reduction. While all subjects utilized these three processes to a great degree, considerable variability existed between subjects. Each subject tended to operate within an individualized system in which certain "preferred" processes were applied. This finding does not diminish the significance of our overall conclusion, since all subjects exhibited the tendency to apply relatively consistent phonological processes during phonemic errors.

DISCUSSION

These findings have considerable importance for the understanding of the nature of apraxia of speech. However, caution must be applied in generalizing from these data. This study is part of a larger investigation in which the number of subjects will be considerably larger. Perhaps with more subjects error patterns will more clearly emerge. A second limitation of this study was the predominant use of mild apraxic patients. Further study is needed to confirm these findings in patients with widely different performance levels. Thirdly, the analysis presented here was based only on intelligible responses. Ten responses were "thrown out" due to the inability of the investigators to distinguish between severe misarticulations and naming errors.

These data could be interpreted as suggesting the presence of a linguistic component in apraxic misarticulations. Further study will be needed to confirm these findings and to establish overall patterns and trends. It seems clear that some modification of the concept of phonemic variability is needed. While variability of phonemic production exists, the errors contain a systematic component that is revealed through a phonological process analysis. Traditional articulatory analysis techniques are unable to establish dominant patterns that are revealed through more sensitive procedures. These findings challenge the concept of phonemic variability as supporting a motor programming interpretation of apraxia. The presence of linguistic regularities suggests the need for further investigations into the strategies employed by apraxic patients to modify contrastive elements in their utterances.

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Q: I like your approach, it's a nice contribution to the literature to look at the linguistic taxonomy. I get a little concerned about differences across phonological processes. What about the fact that 3 or 4 processes account for most of the errors? Some researchers have talked about the need for quantitative as well as qualitative criteria for establishing when is a process actually a process. Given all of that, what percentage of errors accounted for most of the errors and what is your feeling about the psychological reality of these processes both in adults and children? Do we need such an extensive system since one of the principles of linguistic analysis is efficiency?

A: Analysis of a group of apraxic patients has shown that they exhibit a tendency to use 3 or 4 processes predominantly. Beyond the 3 or 4 processes derived from group data, individual subjects tend to employ individualized systematic strategies for reducing the number of contrastive elements in their utterances. We consider each patient's system in order to determine if the errors represent an underlying process.

Q: There is a difference between a strategy and a process. In order to apply this taxonomy there has to be consistency across patients. If everyone has individualized processes, then we really don't have a process.

A: The patients are using identifiable processes to change their utterances and whether the processes vary across subjects is really not an issue.

Q: I think it is an issue since the idea of a process is based on simplification of the adult norm and processes which are consistent across a population. It seems to infer that there is a psychological reality to all of this. There is a lack of data to support various process approaches.

A: If a patient uses a process that affects a group of sounds, this would support the idea that processes represent a mechanism for altering the number of contrastive elements in an utterance.

Q: I don't think that you can apply the criterion from a normal population to a brain-injured population. Kaplan talks about the creation of new behaviors in the brain-injured that may not occur in the normal population.

Q: There may be individualized patterns in the brain-injured. But I think that we need to be careful. We need to think about when is "a process a process." One instance of a simplification doesn't mean that you have a process for an individual or a group. We need to come to agreement on how often a process must occur before we call it a consistent process.

Q: What would your data have looked like if you could conclude that the problem was motor programming?

A: We would have found that the errors had no relationship to one another and that the processes would have been variable across measures.

Q: Why would that finding implicate a motor programming disorder?
A: Since the errors represent the application of systematic strategies for changing utterances, this would indicate the presence of linguistic regularity.

Q: A motor programming problem could still have a consistent bases.
A: The literature that supports the motor programming interpretation has defined this disorder as not having a linguistic basis in part becuase of the appearance of random errors. As Lesser (1978) said, consistent regularities can be interpreted as revealing the presence of a linguistic disorder.

Q: I think that people are seduced and tempted into finding linguistic regularities and then concluding the underlying mechanism. As you mention, the literature does argue that if you find linguistic regularities maybe you can make a conclusion about the underlying nature of the disorder. People have found linguistic regularities in the disorders of stuttering, in motor speech disorders like some of the dysarthrias and in the speech of cleft palate children. I don't think that because you can demonstrate linguistic regularity that one can be seduced into believing that you have discovered the underlying nature.
A: The presence of phonemic variability has been interpreted by some supporters of the motor programming view to suggest an underlying apraxia of the speech mechanism. Darley, Aronson, and Brown (1969) wrote that apraxia of speech is a disorder of faulty programming of movements and sequences of movements for speech. We disagree with that definition on the grounds that the production of sound by the speech mechanism may operate on a rule-ordered linguistic system. Given such an interpretation, we do not separate the organization of movements for speech production from the phonological system. Impairment of the ability to select and sequence phonemes, in our view, reflects another level of aphasic involvement.