# Patterns of Articulatory Behavior in Selected Motor Speech Programming Disorders

Michael Collins
Wm. S. Middleton Memorial Veterans Hospital, Madison, Wisconsin

Denise Cariski
University of Wisconsin Hospital, Madison, Wisconsin

Dana Longstreth and Jay Rosenbek
Wm. S. Middleton Memorial Veterans Hospital, Madison, Wisconsin

## INTRODUCTION

Probably we should not, Procrustes-like, force all patients with phonetic or phonemic disturbances subsequent to brain-damage into a single syndrome. From time to time, however, each of us working clinically is enervated by the rarefied atmosphere surrounding discussions about types of articulatory deficits in brain-damage, and whether apraxic articulatory errors are different from literal paraphasias, and whether phonetic and phonemic errors can be differentiated. Yet after only brief respite, during which we may say we do not care, we return to such discussions because our practice as well as our philosophy require it.

Treatment cannot be powered by simple description, or at least cannot be efficiently powered. Treatment requires knowledge or hypotheses about why a patient sounds as he does. Along with Perkins and Curlee (1969), we recognize the complexities and pitfalls in specifying causality. Nonetheless, the potential therapeutic advantages justify trying to find out if a pattern of errors is neuromotor or aphasic, or whether--to use Lenneberg's (1967) terms--it results from disturbed physiological or linguistic processes. We already know or have strong hunches about some error patterns. For example, the errors in apraxia of speech seem to result from impaired skilled movements and are audible manifestations of damage to a physiological process. Literal paraphasias, as they appear in Wernicke's aphasia, seem to result from disrupted linguistic processes.

Hypotheses such as these guide our treatment. Those believing that apraxia of speech is a neuromotor speech disorder rely on the drill of rigorously ordered movement sequences. Linguistic processes are not ignored but are made to subserve movement. The approach to paraphasia is radically different. It is more pragmatic and directed at linguistic processes such as word selection. Movements are not emphasized and may even be ignored.

Predictably, some patients fail to conform to our notions, and when they do, treatment wavers until considerable diagnostic therapy has been done. This report was motivated by two such nonconforming patients--one seemed to be neither traditionally apraxic nor aphasic; the other seemed more apraxic than aphasic but was not classically apraxic. These nonconformers we compared to a clearly apraxic patient, one who had been under our care for a year, who had been exhaustively tested and treated, and whose characteristics were well known. In making the comparisons of these three patients, we had two purposes. The first was to see if a scoring system of our invention would differentiate them on the basis of their speech performance. The second was to measure how the three responded to four therapeutic conditions. It was hoped that the findings might lead to or support speculations about why the two atypical patients sounded as they did, thereby improving our management of their deficits.

## THE PATIENTS

Three left-hemisphere, brain-damaged men were studied. Each was right-handed and had been in treatment for more than a month after receiving an extensive battery of diagnostic tests, including the Porch Index of Communicative Ability (PICA) (Porch, 1971); a form of the Token Test (DeRenzi and Vignolo, 1962); the Word Fluency Measure (Borkowski, Benton, and Spreen, 1967); the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass and Kaplan, 1972); a shortened form of Schuell's Minnesota Test for Differential Diagnosis of Aphasia (MTDDA) (Schuell, 1965); a standard speech sample (Wertz and Rosenbek, 1971) and tests of oral and limb apraxia. Selected data are shown in Appendix A. Complete speech-language test data are available upon request.

Briefly, Patient One had apraxia of speech with minimal aphasia and was severely nonfluent. He understood, could write sentences, and read for enjoyment; but his speech was labored as he groped toward articulatory targets that he recalled but could not consistently reach. He was not agrammatic, had no dysnomia, and recognized and tried (usually successfully) to correct his errors. He had a moderate, oral, nonverbal apraxia. Patient Two seemed neither classically apraxic nor aphasic but was much more fluent than Patient One. Reading was reasonably well preserved; but writing, even copying, was significantly impaired. He was dysnomic, but not agrammatic. He had some difficulty in understanding, but was functional in the hospital. His imitative and spontaneous speech, while generally fluent, contained approximately equal numbers of substitutions, including many assimilative errors. He recognized these errors and tried almost compulsively to correct them. He had severe, oral, nonverbal apraxia. Patient Three was distinctly nonfluent and generally resembled Patient One except that he had more aphasia across all modalities and many of his imitative and spontaneous speech attempts contained wide-of-the-target substitutions and often ended in unintelligible, perseverative struggle. He recognized some but not all these errors and tried to correct them. He had a moderate, oral, nonverbal apraxia.

## PROCEDURE

The Scoring System. A sixteen-point scoring system (see Appendix B) was created primarily to describe the articulatory and prosodic errors we had been hearing clinically, not only in these three patients, but in those who had come before. Heuristically, it is a scale of goodness. That is being tested now.

Experimental Conditions. To provide data for the response profiles and to measure how the three patients might perform differently in various therapeutic conditions, twenty words (different for each patient) equated for frequency of occurrence and difficulty were randomly assigned to one of four conditions. Condition One (Aloud Rehearsal) required the clinician to first say the word once and then for the patient to way the word as many times as possible (although speed was not emphasized) for ten seconds. Condition Two (Silent Rehearsal) required the clinician to say the word first and the patient to "mouth it" or whisper it for ten seconds, and then say it aloud once on a signal from the clinician. Condition Three (Reading) required the clinician to say the word and then provide the patient with the word written on a card. The patient was to remain silent for ten seconds, all the time looking at the word, and then say it once aloud on a signal from the clinician. Condition Four (Masking) was like Condition Three except that binaural white noise masking at 70 dB HL was provided during the ten second silent period. At the end of 10 seconds, the masking was turned off and the patient said the word. In Condition One the first response after the ten second production interval was scored. In each of the other three conditions,the patient's first response after the ten second interval was scored.

All words were randomly presented; responses were tape recorded and scored later with the 16-point system. All scoring was done by one of the authors (D.L.). When the judge could not decide if a response was recognizable as required by scores 7 and 6, the judgment of a naive listener was accepted. Intra-judge reliability, measured by rescoring a randomly selected 20 percent of the responses one month after original scoring, was .91.

Patient One was tested five times with one set of words. Patient Two was tested four times, twice with one set of words and twice with another. Patient Three was tested three times with one set. The word lists were different for each patient, in an effort to get words that were neither too hard nor too easy. Pilot testing had demonstrated that Patients One and Three were frustrated by words appropriate to Patient Two. Performance across the four conditions was collapsed to yield a typical profile of the response types for each patient. In addition, performance in each of the four conditions was analyzed to determine which conditions were most favorable to speech adequacy.

## RESULTS

The response profiles for Patients One and Three were similar, but very different from Patient Two's profile. Overall, Patient One's responses (Figure 1) were never normal, but were always recognizable, despite frequent substitutions, distortions, and prosodic disturbances. Fifty percent (50%) of his responses received a score of 6 (sound substitution(s), omission(s), or addition(s), with distortion(s) or prosodic disturbances. Word remains recognizable). Seventeen percent (17%) received a score of 12 (distortion and prosodic disturbance). Eighteen percent (18%) received a score of 14 (normal except for prosodic disturbance). Overall, eighty-seven percent (87%) of Patient One's responses contained prosodic disturbances and/or distortions. He was definitely nonfluent.

In contrast, Patient Two's responses (Figure 2) were sometimes unrecognizable, sometimes normal, and were most frequently marred by a variety of substitutions, omissions, and additions. Most responses of all types were free of distortion and prosodic disturbance except for slowed rate. Specifically, twenty percent (20%) of his responses were 15's (normal except for slowed rate). Thirty-one percent (31%) were 7's (sound substitution(s), omission(s), or addition(s), without sound distortions(s) or prosodic disturbances, but with mild to moderate changes in articulation and/or pause time. Word remains recognizable). Twenty percent (20%) of his responses

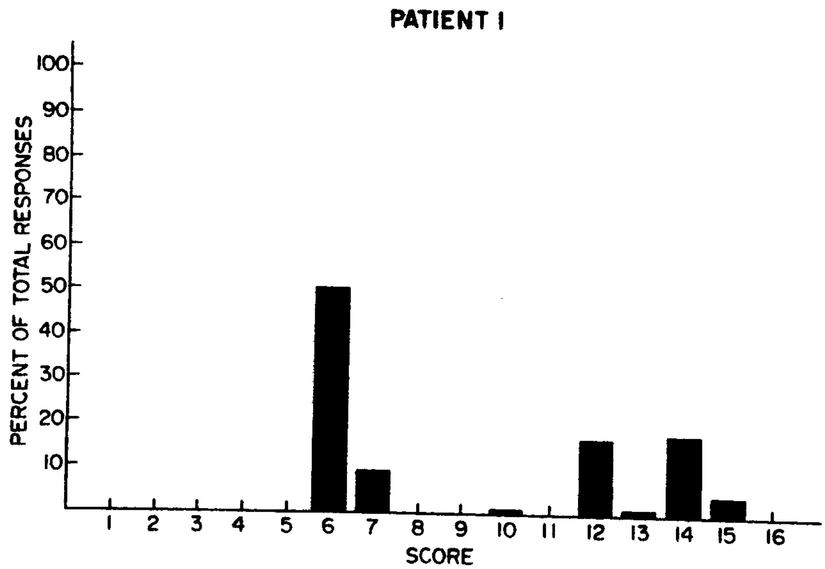


Figure 1. Percent of each response type for Patient 1. See Appendix B for explanation of scoring system.

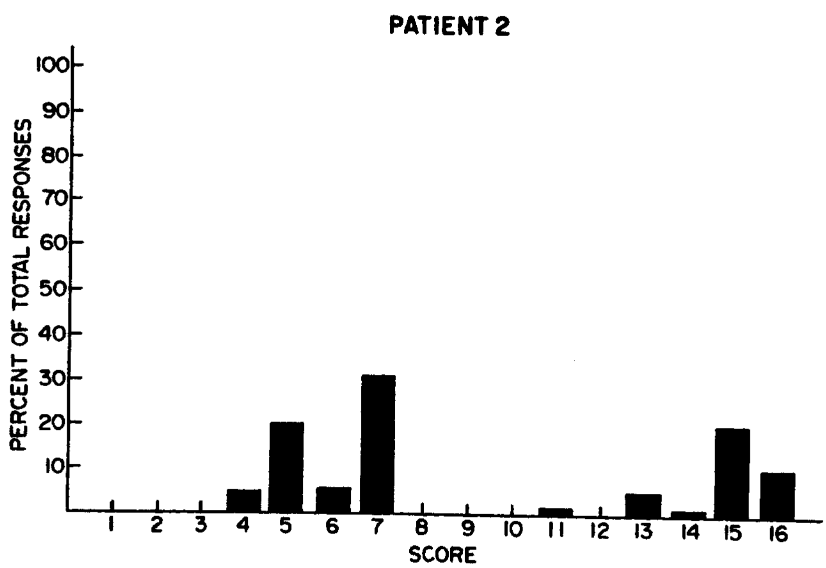


Figure 2. Percent of each response type for Patient 2. See Appendix B for explanation of scoring system.

received a score of 5 which is the same as score 7, except that the word is unrecognizable. Ten percent (10%) of his responses were normal (score 16). He was definitely fluent overall.

Patient Three's responses (Figure 3) were a mix of recognizable and unrecognizable words characterized by sound substitutions, omissions, additions, distortions, and prosodic disturbances. Forty-eight percent (48%) of his responses received a score of 6 (sound substitution(s), omission(s), or addition(s) with distortion(s) or prosodic disturbances. Word remains recognizable). Twenty-three percent (23%) of his responses received a score of 4 which is the same as a score of 6 but the word is unrecognizable. Sixteen percent (16%) of his responses received a score of 14 (normal except for prosodic disturbance). Thus ninety-seven (97%) of his responses contained prosodic disturbances and/or distortions He was nonfluent. Figure 4 is a composite of the three patients' response types, and highlights the similarity of Patients One and Three.

Next, we determined each patient's average score for each of the four stimulus conditions. Patient One (Figure 5) was most successful under Condition Three, Reading, with a mean score of 11.48; followed in order by Condition One, Aloud Rehearsal, with a mean score of 8.96; Condition Four, Masking, with a mean score of 8.08; and Condition Two, Silent Rehearsal, with a mean score of 7.32.

Patient Two (Figure 6) did best under Condition One, Aloud Rehearsal, with a mean of 9.5. The second best condition was Condition Three, Reading, with a mean score of 8.7; followed by Condition Two, Silent Rehearsal, with a mean score of 6.3; and finally Condition Four, Masking, with a mean score of 6.2.

Patient Three (Figure 7) was most similar to Patient One. His most successful condition was also Condition Three, Reading, with a mean score of 9.33; followed by Condition Four, Masking, with a mean score of 7.40; Condition One, Aloud Rehearsal, with a mean of 7.07; and Condition Two, Silent Rehearsal, with a mean score of 6.6. Figure 8 displays the average score for each of the three patients in each of the four conditions.

In order to determine statistical significance, a single factor analysis of variance for repeated measures was performed for each subject. The F value for Patient One was significant at $p < .01$ and for Patient Two at $p < .10$. To determine which condition means differed significantly, Duncan's multiple range tests (Bruning and Kintz, 1968) were completed. For Patient One the only significance was between Condition Three (reading) and all other conditions ($p < .01$). For Patient Two significant differences were obtained when Aloud Rehearsal was compared to Silent Rehearsal and Masking ($p < .05$) and when Reading was compared to Silent Rehearsal and Masking ($p < .10$). Other comparisons were not significant.

## DISCUSSION

Professions seem to rock back and forth, sometimes not too gently, between grouping and splitting. Presently, it appears that momentum has swung aphasiology more toward splitting. Even previously unassailable syndromes such as Wernicke's aphasia (Hier and Mohr, 1977) and Broca's aphasia (Luria and Hutton, 1977) are being divided. Not surprisingly perforations are showing up in more controversial syndromes such as apraxia of speech and conduction aphasia (Shallice and Warrington, 1977); (Kertesz and Phipps, 1977). Frequently clinicians, whether they recognize it or not,

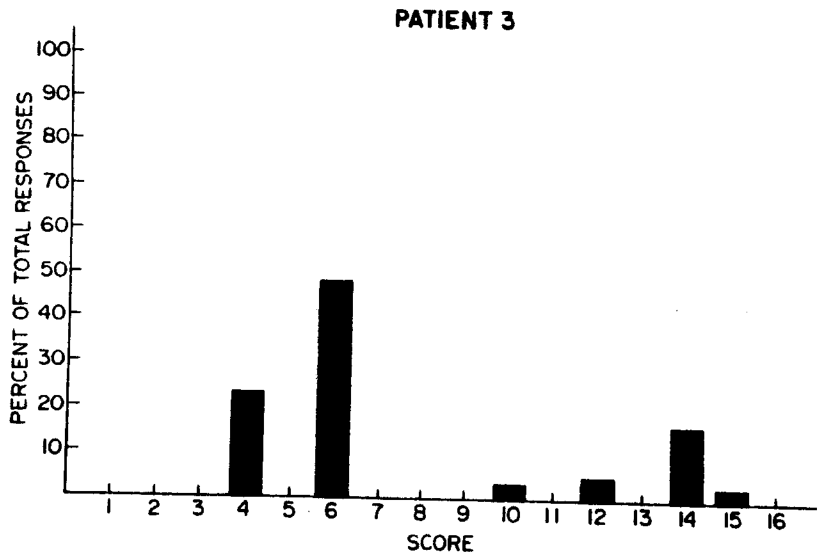


Figure 3. Percent of each response type for Patient 3. See Appendix B for explanation of scoring system.

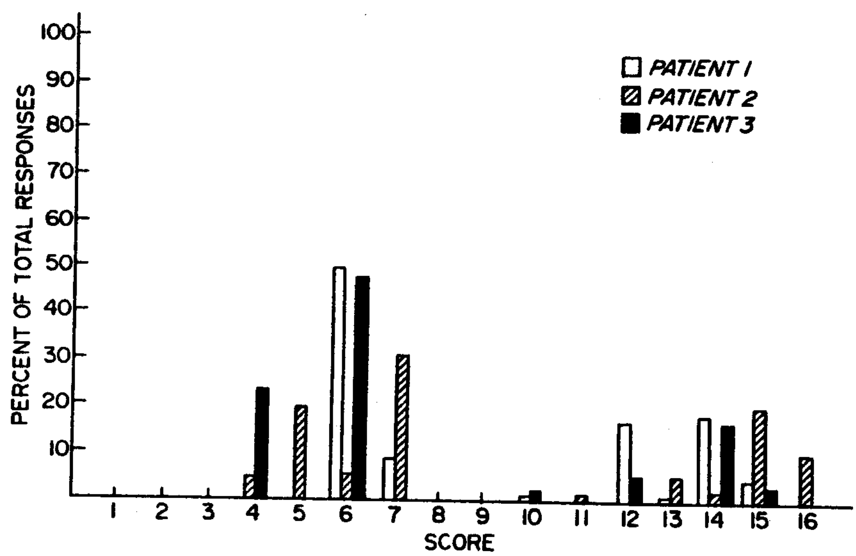


Figure 4. Percent of each response type for the three patients. See Appendix B for explanation of scoring system.

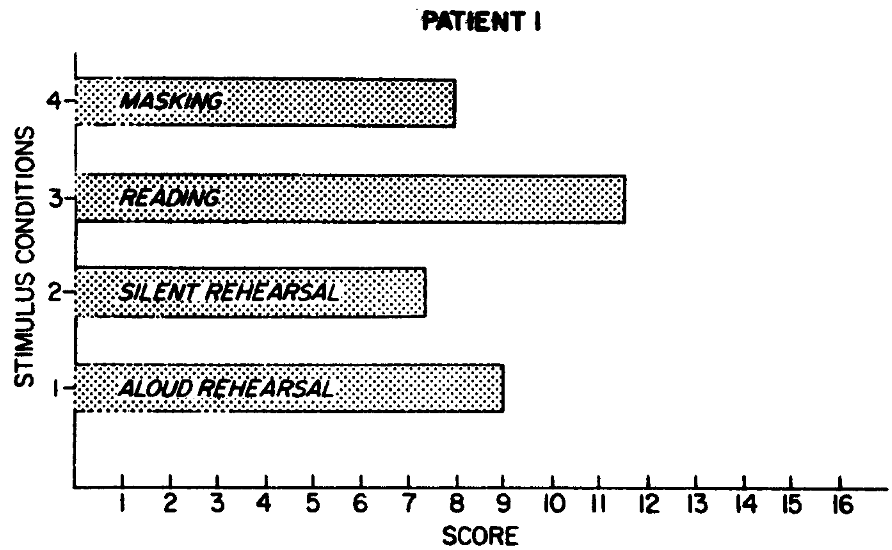


Figure 5. Mean score in each stimulus condition for Patient 1. See text for explanation of stimulus conditions. See Appendix B for explanation of scoring system.

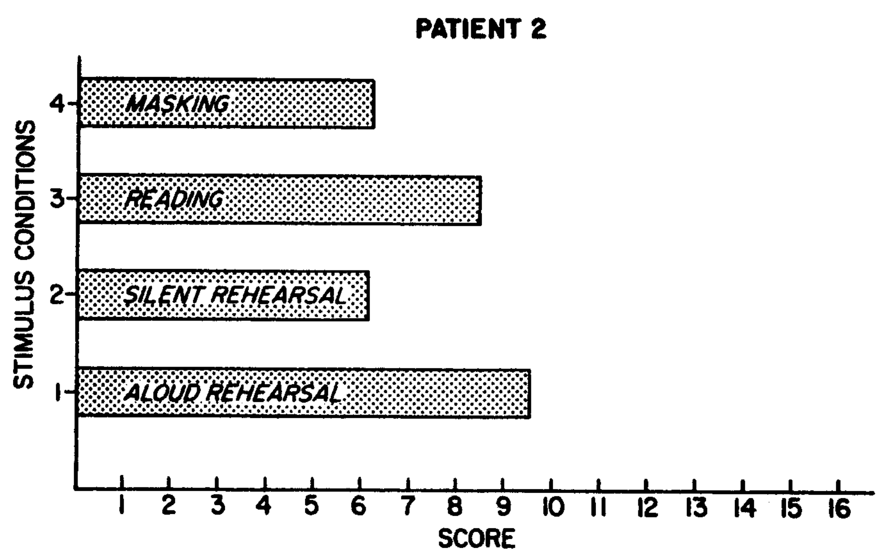


Figure 6. Mean score in each stimulus condition for Patient 2. See text for explanation of stimulus conditions. See Appendix B for explanation of scoring system.

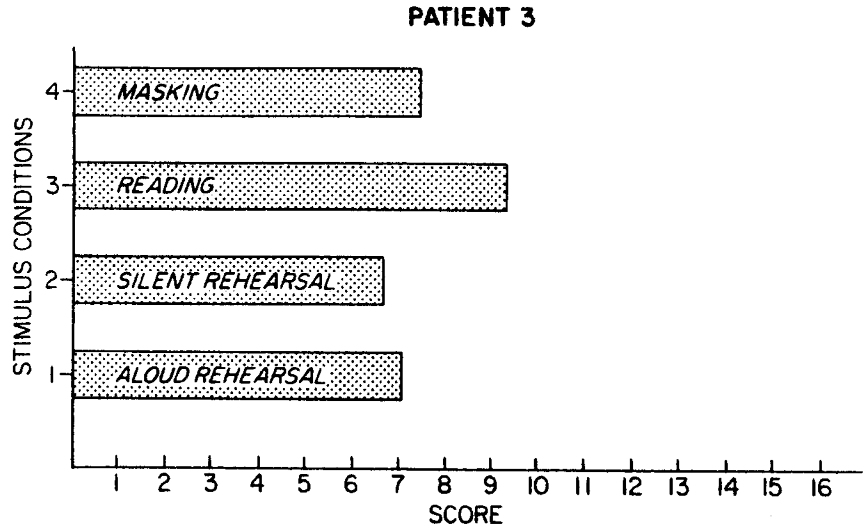


Figure 7. Mean score in each stimulus condition for Patient 3. See text for explanation of stimulus conditions. See Appendix B for explanation of scoring system.

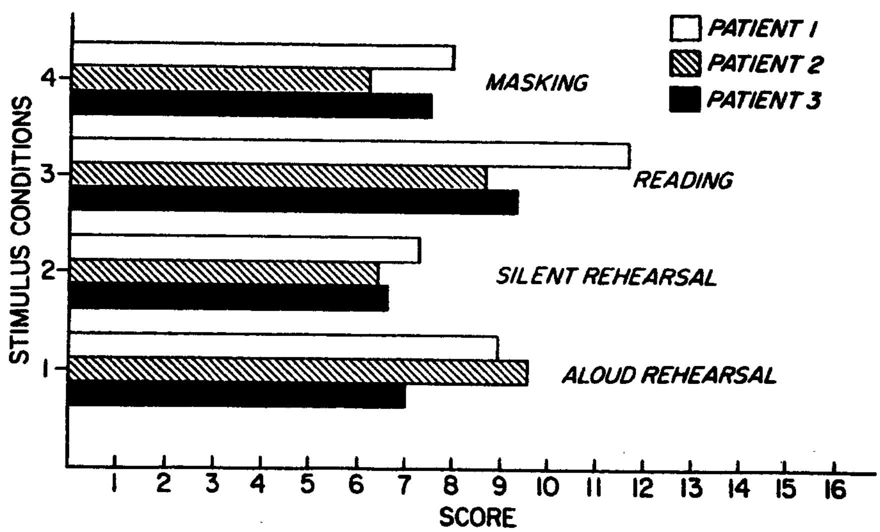


Figure 8. Composite of the mean scores in each stimulus condition for the three patients. See text for explanation of stimulus conditions. See Appendix B for explanation of scoring system.

become the heartiest splitters of all as they try to focus a patient's treatment and explain successes and failures.

The first split we made of these three patients was to place two of them in the traditional apraxia of speech group and one of them (Patient Two) outside that group. The two apraxic patients were similar rather than identical because Patient Three was more variable, being more accurate sometimes and farther from the target at others. Our feeling clinically was that, in part, the differences were because Patient Three was not as good as Patient One at coping with and modifying his apraxia. Three would charge into each utterance; One would approach each one only after careful planning. Faced with an error, Three would struggle all the harder; One would stop, reconsider, and try again. We are tempted to speculate that had Patient One been blessed with Patient Three's residual mechanism, he would have sounded very good indeed.

It was interesting to see how Patient Two, who was not classically apraxic, would look decked out in a selected few of modern aphasiology's more popular labels. He was reasonably fluent except during his flurries of errors, periods of conduite d' approche, and when he seemed to increase articulation and pause time in anticipation of difficulty. The speech pattern hints at a conduction aphasia yet his imitation, if anything, was a bit better than his spontaneous speech. If he is a conduction aphasic patient then, he is probably closer to the _efferent conduction aphasia_ of Kertesz and Phipps (1977) than to their _afferent conduction aphasia_. On the other hand, held up to Luria and Hutton's system (1977), he seems more like their afferent (kinesthetic) motor aphasic with a parietal lesion than their efferent (kinetic) motor aphasic.

It is not merely a question of semantics. "Merely" and "semantics" do not fit comfortably in the same sentence, anyhow. Labels, if they are good, carry with them suggestions about underlying mechanisms. For example, according to Green and Howes (1977), the disturbance in conduction aphasia is "predominately in some mechanism of speech output" (p. 125)--a mechanism which they admit is poorly understood. A complication is that other mechanisms to explain some of the symptoms of conduction aphasia, including impaired memory (Shallice and Warrington, 1977), have also attracted followers. Luria, writing with Hutton, is faithful to his career-long belief that symptoms should be explained as well as described and speculates that the afferent (kinesthetic) syndrome results from "an apraxis of the speech apparatus" (p. 137).

As noted before, we wanted in this work to do more than describe, and we reasoned that the responses of these three patients during various stimulus conditions might provide therapeutic data and perhaps further illuminate the disturbed mechanisms underlying the symptoms. Three trends in these responses may be useful to one or both of these purposes. Reading was significantly the best mode for Patient One, the classically apraxic speaker. The other apraxic talker also did best with read stimuli, but the superiority was not statistically significant. Based only on Patient One, then, it appears that having the apraxic patient read is good, a reassuring finding in light of the apraxic patient's insatiable appetite for practice, which is often fed by language master programs and word lists. The reason why the apraxic patient benefited from Reading may be no more sophisticated than total time. He had ten seconds to look at what he was going to say. Since they were not significant, the data from the Masking condition (a condition we thought might inhibit rehearsal during Silent Reading, thereby telling us more about silent reading as a treatment) are uninterpretable.

Patient Two found Aloud Rehearsal easier than Reading but not significantly so. Indeed for him Aloud Rehearsal and Reading may have been of almost the same potency. While we need more data, it may turn out that patients like these three respond to the same kind of treatment even though they sound much different.

Finally, Silent Rehearsal was least helpful for the two apraxic patients and next to the least for Patient Two. And, for all three, Silent Rehearsal was less powerful than Rehearsal Aloud, suggesting--if it can be shown significant in subsequent studies--that patients like these three benefit not just from exposure to stimuli but from practice requiring them to coordinate respiratory, laryngeal, velopharyngeal, and upper airway systems.

Increasingly, it is popular and fruitful to look toward normal motor control for models and methods to help us understand abnormal control. Kent's (1976) model of neuromotor speech control may be useful to subsequent study of patients like our three because it allows for and even predicts the differences; especially between Patients One and Two; and explains why all three might be struggling with expressive or motor deficits. Kent says, "the two major control problems in the production of speech are: 1) the seriation of the control elements (whatever they may be), and 2) the neuromuscular, or articulatory, representation of these elements" (p. 79). The first deals "with temporal structure and the other with position or spatial structure" (p. 79). We think of the elements as 1) the ordering of 2) specific shapes. Patients One and Three had difficulty with both shapes and their ordering. For example, both patients had a number of sound distortions (impaired shapes) and assimilations (impaired ordering). Patient Two, on the other hand, had almost no difficulty with shapes, but serial ordering was very difficult for him, as witnessed by a large number of assimilative errors and almost no distortions.

Without extensive testing, we cannot be sure--and perhaps not even then--but it seems possible that our three patients have impaired neuromotor speech control. The differences in symptoms result from involvement of different portions or levels of the control process. Responses to treatment, if that treatment is completed according to the requirements of single-case design research, may help us find out.

## REFERENCES


Borkowski, J.G., Benton, A.L., and Spreen, O. Word Fluency and Brain Damage. Neuropsychologia, 5, 135-140, 1967.

Bruning, J.L. and Kintz, B.L. Computational Handbook of Statistics. Glenview, Illinois: Scott, Foresman, and Company, 1968.

DeRenzi, E. and Vignolo, L.A. The Token Test: A sensitive test to detect receptive disturbances in aphasics. Brain, 85, 665-678, 1962.

Goodglass, H. and Kaplan, E. The Assessment of Aphasia and Related Disorders. Philadelphia: Lea and Febiger, 1972.

Green, E. and Howes, D.H. The nature of conduction aphasia: A study of anatomic and clinical features and of underlying mechanisms. In H. Whitaker and H.A. Whitaker (Eds.), Studies In Neurolinguistics. Volume 3. New York: Academic Press, 1977.

Hier, D.B. and Mohr, J.P. Incongruous oral and written naming. Evidence for a subdivision of the syndrome of Wernicke's aphasia. Brain and Language, 4, 115-126, 1977.

Kent, R.D. Models of speech production. In N. Lass (Ed.), Contemporary Issues In Experimental Phonetics. New York: Academic Press, 1976, 79-104.

Kertesz, A. and Phipps, J.B. Numerical taxonomy of aphasia. Brain and Language, 4, 1-10, 1977.

Lenneberg, E.H. Biological Foundations of Language. New York: John Wiley and Sons, Inc., 1967.

Luria, A.R. and Hutton, J.R. A modern assessment of the basic forms of aphasia. Brain and Language, 4, 129-151, 1977.

Perkins, W.H. and Curlee, R.F. Causality in Speech Pathology. Journal of Speech and Hearing Disorders, 34, 231-238, 1969.

Porch, B.E. Porch Index of Communicative Ability. Palo Alto, California: Consulting Psychologists Press, 1971.

Schuell, H. Minnesota Test for Differential Diagnosis of Aphasia. Minneapolis, Minnesota: University of Minnesota Press, 1965.

Shallice, T. and Warrington, E.K. Auditory-verbal short-term memory impairment and conduction aphasia. Brain and Language, 4, 479-491, 1977.

Wertz, R.T. and Rosenbek, J.C. Appraising apraxia of speech. Journal of Colorado Speech and Hearing Association, 5, 18-36, 1971.

## DISCUSSION

Q: Is the scale ordinal?

A: We are not sure. We created it to extend from normal (16) to no response. Whether intervening scores are ordered according to goodness, we do not know. We are testing that now.

Q: I'm looking for some kind of unification of these patients. Did they all have prosodic errors?

A: No. Patient Two did not seem to have prosodic disturbances except during a flurry of articulation errors when only rhythm was sometimes disturbed, whereas prosody was consistently disturbed in Patient One's speech.

Q: There's an article by Buckingham in a recent Brain and Language. He's making some interesting observations about the two varieties of apraxia. You might want to mention it.

A: Right. I think that we saw some relationship between our two types of patients and the two types that he was discussing. One has the feeling that our patient One might have had a "center" lesion because, while he did do better in some conditions than others, there was a similar character about all his speech and we could never help him talk normally. The patient with the parietal lesion had some periods when he talked very well. One is tempted to speculate that his was a disconnection syndrome, or perhaps he had a lesion in a different center. We were, in fact, thinking about interpreting some of the data--the differences in reading for example--in those terms but thought we didn't have enough data to do so in the manuscript.

Q: I think another point in the Buckingham article and one that is underscored by some of your data is that a lot of behavior of these people may in fact be task dependent. Buckingham makes a point that much of that data collected in the past has been from imitative tasks only, and he cautions us about conclusions based only on imitation.

A: As well he should.

Q: Did you tabulate errors for patient One versus patient Two on the basis of initial versus final errors?
A: No, we did not.

Q: I think that's a related comparison. Based on Burns and Canter's data and those of others, I would predict your first patient would make errors initially and patient Two would make more in word-final position.
A: That's an interesting idea.

Q: In looking at the difference between silent rehearsal and spoken rehearsal you're assuming that when you tell someone to rehearse silently that he does so. Did you measure whether or not your patients were indeed able to rehearse silently?
A: Yes, they were able to rehearse silently.

Q: Did they hear the word in the reading condition?
A: Yes, the word was first spoken by the clinician and then a card was held up with the word written on it.

Q: How long was the person allowed to look at it?
A: For 10 seconds.

Q: Isn't that silent rehearsing of the word?
A: There was no outward sign of silently rehearsing it. We did not allow them to read by moving their lips.

Q: Were any of them given the PICA?
A: Yes, we have those results.

Q: What were the PICA overalls for One and Two?
A: Patient Two's overall was at the 47th percentile. Patient One's was at the 73rd percentile.

## APPENDIX A

Descriptive data for Age, Sex, Etiology, Time Post-Onset, Handedness, Localization, and Method of Localization for each patient.

| | Age | Sex | Etiology | Time post onset | Handedness | Localization | Method of localization |
|---|---|---|---|---|---|---|---|
| Patient 1 | 54 | Male | Left CVA | 3 yrs., 7 mo. | Right | Fronto-parietal | Neurological examination |
| Patient 2 | 71 | Male | Left CVA | 1 1/2 mo. | Right | Parietal | C-T Scan |
| Patient 3 | 66 | Male | Left MCA thrombosis | 1 yr., 2 mo. | Right | Fronto-parietal | C-T Scan |

## APPENDIX B

## SCORING SYSTEM

16. Normal

15. Normal except slow because of changes in articulation and/or pause time.

14. Normal except for prosodic disturbance (pitch, loudness, stress, effort).

13. Distortion.

12. Distortion and prosodic disturbance

11. Self-correction

10. Self-correction except for prosodic disturbance

9. Self-correction except for distortion

8. Groping which does not cross phoneme boundaries and which is followed by the correct response.

7. Sound substitution(s), omission(s), or addition(s), without sound distortion(s) or prosodic disturbances, but may have mild to moderate changes in articulation and/or pause time. Word remains recognizable.

6. Sound substitution(s), omission(s), or addition(s) with distortion(s) or prosodic disturbances. Word remains recognizable.

5. As in 7 above except word is unrecognizable.

4. As in 6 above except word is unrecognizable.

3. Verbal paraphasia, self-corrected.

2. Verbal paraphasia.

1. No response, or rejection, or unintelligible, undifferentiated response.