STATISTICAL AND CLINICAL PROCEDURES FOR PREDICTING RECOVERY FROM APHASIA

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INTRODUCTION

The few attempts to predict the amount of communicative recovery an aphasic patient may expect have resulted more in tantalizing the aphasia therapist than providing concrete solutions to the problem. Schuell, for example, (1965) has stated,

> "Predicting the course of the disorder is important in relation to long-term planning for the aphasic patient....well-studied patterns of aphasic deficit should be expected to carry reliable prognoses for recovery of language functions, and they do. (Schuell, 1965, p. 6)."

Schuell's optimism suggested that there were answers to the frequently asked questions about whether or not the patient will get better, when he will get better, and how much better he will become. She pioneered early work on predicting how effective a patient will be in his life situation with a given amount of aphasic involvement and she later evolved five major and two minor prognostic groups for patients who were neurophysiologically stable. Unfortunately there has been little research directed at predicting eventual levels of recovery in the acute patient.

There have been a handful of studies on the influence of speech and language therapy on recovery from aphasia, and there have been numberous reports on the variables which may influence recovery. Although Kenin and Swisher (1972) and others have studied the pattern of recovery in aphasia, until recently no one, with the exception of Schuell, has attempted to predict the exact amount of recovery one might expect an aphasic patient to make. Schuell's prognostic statements although innovative were largely adjectival---"excellent", "maximal", "limited but functional", etc.

Predicting the course of aphasia is particularly important immediately post-onset. This is the time when families must make plans, and it is the time when the speech pathologist is most accountable. Schuell (1965) believed that it was not possible to predict the course and outcome of aphasia unless the patient was neurologically stable. She suggested an arbitrary limit of three months was necessary before a patient's performance was sufficiently consistent to render predictions reliable. Therefore, her prognostic data cannot be applied immediately post-onset.

A study by Porch, Wertz, and Collins (1973), using PICA scores obtained at one month post onset, attempted to predict the aphasic patients' recovery levels at 3, 6, 9, and 12 months post onset. The results suggested that it may be possible to predict, with a high degree of accuracy, the aphasic patients potential for recovery of communicative ability. Although the N was small in this initial study, the results were provocative in their diagnostic and therapeutic implications.

Since accurate predictions of eventual recovery levels, based on a large sample of aphasic patients, would be extremely useful in patient management and in assisting families to make plans, we have attempted to predict three, six, and twelve month recovery levels for a random sample of aphasic patients based on their one, three, and six month post-onset PICA scores. The purposes of this paper are three-fold: 1, to present our approach for attacking the problem of predicting recovery from aphasia; 2, to present the results of a study which employed this approach; and 3, to suggest modifications in our initial methods which, we hope, will permit the aphasiologist to predict a patient's ultimate recovery level using initial test results.

Methods

The key to any study of recovery is the experimenter's ability to measure sensitively enough to quantify small changes in the patient's status and to use measuring instruments that are highly reliable and stable so that whatever changes are measured are in fact changes in the patient rather than in some other variable. Our analyses were based on the PICA (Porch Index of Communicative Ability), a test developed ten years ago primarily as an instrument for quantifying communicative deficit.

Figure 1 shows a typical score sheet for a completed test. As you can see there are 18 subtests revolving around

FIGURE 1 EXAMPLE OF SCORE SHEET

Porch Index of Communicative Ability

BY BRUCE E. PORCH, PH.D.

SCORE SHEET

Name N. M. Case No. 122 Test No. 11

Date 8-23-65 By BEP Time 1:01 to 2:38 Total Time 97 MIN.

Test Conditions Standard

Patient Conditions (L) used

TIME	1:01	1:30	1:33	1:36	1:45	1:48	1:49	1:50	1:51	1:55	–	1:56	1:58	1:59	2:09	2:17	2:28	2:34
ITEM	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	A	B	C	D	E	F
1. Tb	7	8	9	7	12	9	12	15	6	13	15	7	(5)	6	6	6	7	13
2. Cg	5	7	7	4	7	13	12	15	7	13		6		6	6	6	11	13
3. Pn	7	11	11	13	12	15	12	15	9	15		15		6	(5)	8	11	13
4. Kf	5	9	11	5	12	13	12	15	5	15		5		6	(5)	5	11	13
5. Fk	11	7	11	6	11	15	12	15	6	15		6		(5)	(5)	6	13	11
6. Qt	7	8	7	11	12	15	12	15	12	15		14		5	6	6	13	11
7. Pl	6	12	11	7	11	15	12	15	7	15		14		5	(5)	6	13	11
8. Mt	7	11	11	7	12	15	12	15	7	15		14		(5)	(5)	7	11	11
9. Ky	7	11	7	15	12	15	12	15	7	15		15		7	7	8	13	13
10. Cb	11	9	12	6	12	15	12	15	4	15		15		7	6	6	11	13
MODALITY	VRB	GST	GST	VRB	GST	GST	GST	GST	VRB	GST	GST	VRB	GPH	GPH	GPH	GPH	GPH	GPH
MINUTES	29	3	3	9	3	3	1	1	4	1	–	2	1	10	8	11	6	4
MEAN SCORE	7.3	9.3	9.7	8.1	11.3	14.0	12.0	15.0	7.0	14.6	15.0	11.1	5.0	5.8	5.6	6.4	11.4	12.2

Response Levels:

Overall 10.09 Gestural 12.61 Verbal 8.38 Graphic 7.88

Note: 44 % 48 % 39 % 54 %

HI = 47 % LO = 42 HI-LO = +5

ten common objects. A matrix of 180 numbers are obtained which describe behavior multidimensionally through the use of a binary choice scoring system which is very reliable. By deriving means of each subtest, you obtain the subtest scores which then can be analyzed in a variety of ways, either in terms of the modality involved in each subtest or by computing other types of modality or overall means. The subtests for each modality are totalled to yield modality means and the total for all 18 subtests is the overall score for the battery. One other measure that we used is the high-low gap. We take a mean of the 9 highest subtest means that the patient yields, and the mean of the 9 lowest subtest means that the patient yields and derive the difference between the two. The 9 highs are a type of maximum performance and, as an indication of the brain's cybernetic potential, are prognostic.

Figure 2 shows a recovery curve for a patient. This is the type of graph we use clinically to show recovery of a patient over time with the months post-onset shown on the abscissa and the percentile status of the patient shown on the ordinate. This is a typical recovery curve for a thrombotic patient; that is, a negative function curve that plateaus at 6 months post-onset. Here you can clearly see the large high-low gap during the early course of recovery and how it gradually closes until he reaches his maximum performance.

Our reference points for the purposes of the predictive study then were the following: 1) the overall score which was the mean of the 18 subtest scores; 2) the mean of the 8 gestural subtests; 3) the mean of the 4 verbal subtests; 4) the mean of the 6 graphic subtests; 5) the mean of the 9 highest subtests; and 6) the difference between the mean of the 9 highest subtests and the 9 lowest subtests.

One more point might be made to help you interpret these numbers. You can think of these means as points along a 15 point scale of goodness with 15 being normal and 1 being maximally impaired. When these numbers are converted to percentiles, it provides a method by which any patient or group of patients can be compared with all other left hemisphere lesion patients. For instance, a patient who has an overall percentile at the 60th percentile is less involved than 60% of a large random sample of aphasic patients with left hemisphere lesions. So scores compare the patient to the relatively normal level of 15 and percentiles compare the patient to other aphasic patients. With that introduction let us turn to the study itself.

We searched our clinic records for patients who had confirmed unilateral left hemisphere lesions, a confirmed etiology, and at least two PICAs administered at appropriate times during their course of diagnosis and treatment. Biographical, medical, diagnostic, and treatment information on these patients were coded and submitted to computer analysis in the Central Neuropsychiatric Research Laboratory in Perry Point, Maryland.

Porch Index of Communicative Ability

APHASIA RECOVERY CURVE

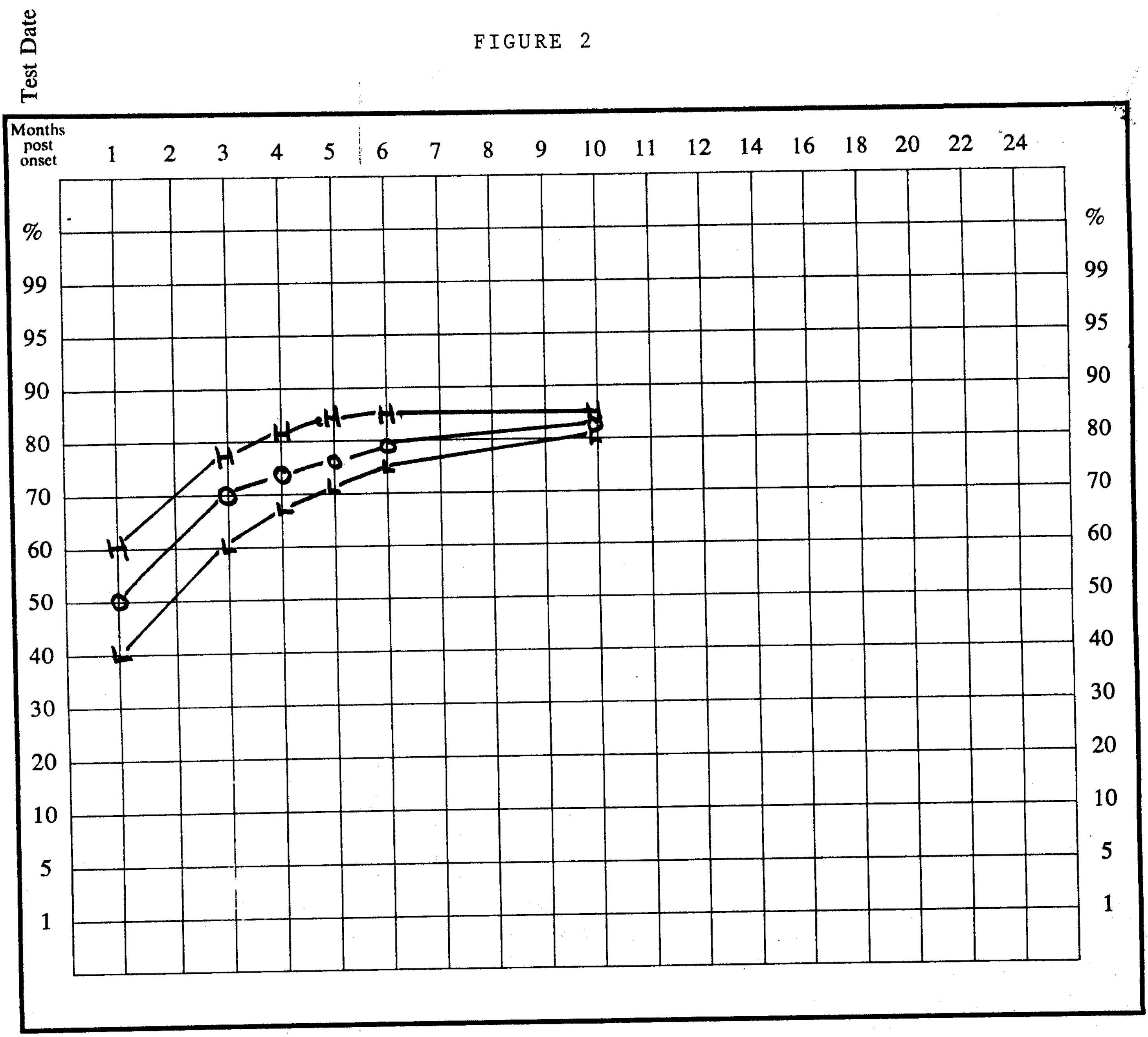
(Percentiles)

Name J.S. Case No. 123

Birthdate 7-16-23 Race CAUC. Onset 7-1-70

DX. Type (L) CVA Site (L) MIDDLE CEREB. ART.

FIGURE 2



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Our initial interest was in patients who had received speech and language evaluations at four points in time---one month post-onset, three months post-onset, six months post-onset, and twelve months post-onset. From a sample of 243 patients, we found only 93 patients who had received tests at at least 2 of these points in time, a finding which has since led us to make our testing schedule more stringent. Of these, 63 patients had received evaluations at one and three months post-onset, 28 patients had evaluations at one and six months post-onset, 21 patients had evaluations at one and twelve months post-onset, 17 patients had evaluations at six and twelve months post-onset, 17 patients had evaluations at three and twelve months post-onset, and 30 patients had evaluations at three and six months post-onset.

Six different etiologies are represented in this sample. Seventy-three patients suffered thrombo-embolic accidents, 7 were traumatic, 3 were neoplastic and post-surgical, 5 suffered cerebral hemorrhage, 1 suffered an aneurysm and was post-surgical, 3 suffered AV malformations and were post-surgical, and 1 suffered anoxia.

We first attempted to predict the patients overall score at three months post-onset using scores obtained at 1 month post-onset. Descriptive data on this sample of 63 patients with tests at those dates showed a mean age of 51.71 is revealed, with a range of from 15 to 77. PICA scores obtained at 1 month post-onset reveal a mean of 9.51 for overall, 11.47 for gestural, 8.32 for verbal, 7.62 for graphic, 12.09 for the nine highs, and a mean high-low gap of 5.18. The mean overall score actually obtained on this sample was 11.45.

Using a stepwise multiple regression analysis, a "weight" was determined for each of the 6 prediction variables, overall, gestural, verbal, graphic, highs, and high-low gap at one month post onset. The ability of each of the variables plus the regression weights to predict scores at 3 months post-onset was determined through multiple correlation coefficients obtained for each of the variables, when correlated with the actual obtained score. In this procedure, an analysis of covariance using all variables first selected the most significiant contributors to each prediction; succeeding analyses of covariance revealed the next best predictor, and so on, until all predictors were included in the multiple regression equation.

The multiple correlation coefficients, for the three month prediction based on 1 month post-onset scores, indicate that most of the predictive power is contained in the gestural scores: thus, when ($Overall_3$ = (.44) $Overall_1$ + (.39) $Highs_1$ + (2.43), the patient's actual gestural scores at one month post-onset are multiplied by the regression weight, .39, added to the overall score which is multiplied by a regression weight of .44, and finally added to the constant, or intercept, of 2.43, the resulting predicted score shows an extremely high ($p < .001$)

correlation with the patients' actual obtained overall score at 3 months post-onset (R = .91). Thus, the gestural and, to a lesser extent, the overall score at 1 month post-onset are most useful in predicting 3 month post-onset overall scores.

The procedure just described was used to predict overall scores at 6 and 12 months post-onset. Although the sample size changed, and, as you will see, the predictors changed order in their effectiveness to predict, for simplicity's sake we'll simply describe the population, the variables used in prediction, and the multiple regression coefficient for each of the five remaining prediction groups.

The group descriptive data for the 1 to 6 months post-onset prediction was based on an N of 28. The mean age was 54.50, with a range of from 16 to 73. PICA scores obtained at one month post-onset reveal a mean overall score of 9.60, a gestural mean of 11.60, a verbal mean of 8.48, and a graphic mean of 7.55. The mean of the 9 high subtest means was 12.26, and the mean high-low gap was 5.29. The mean overall score obtained at 6 months post-onset was 12.24.

The results of the multiple regression analysis showed that $Overall_6 = (-.80)\ Gestural_1 + (1.54)\ Highs_1 + (2.57)$, gestural scores at one month post-onset were again more useful in prediction, with the 9 highs being somewhat less useful. The predicted overall scores at 6 months post-onset show a correlation with the actual overall scores obtained at 6 months post-onset of .85. ($p < .001$).

The 1 to 12 months post-onset prediction group had an N of 21, a mean age of 57.71, and a range of 45 to 79 was obtained. PICA scores obtained at one month post-onset reveal a mean overall score of 8.92, a mean gestural score of 10.85, a verbal mean of 7.47, and a graphic mean of 7.26. The mean of the 9 high subtest means was 11.56, and the mean high-low gap was 5.28. The mean overall score obtained at 12 months post-onset was 11.98.

In this analysis, the gestural scores were again most predictive, with the highs being somewhat less predictive ($Overall_{12} = (-.62)\ Gestural_1 + (1.33)\ Highs_1 + (3.25)$. The predicted overall scores at 12 months post-onset show a correlation with the actual scores obtained at 12 months post-onset of .89, using only the two strongest predictors, gesturals and highs.

In the 3 to 6 month post-onset prediction group, the mean age of the 30 subjects in this group was 54.27, with a range of from 26 to 79. PICA scores obtained at 3 months post-onset reveal a mean overall score of 11.06, a mean gestural score of 12.79, a mean verbal score of 10.43, and a mean graphic score of 9.04. A mean of 13.29 was obtained for the

9 high subtest scores, and the mean high-low gap was 4.89. The actual overall score obtained at 12 months post-onset was 12.06.

The results of the multiple regression analysis, ($Overall_6$ = (.42) $Overall_3$ + (.19) $Verbal_3$ + (.22) $Highs_3$ + (2.33), indicate that the overall scores were the most predictive of the overall scores at 6 months post-onset, with highs slightly less predictive, and verbal scores contributing the least weight to the prediction. Predicted scores based on these three variables show a correlation of .94 with the actual scores obtained at 6 months post-onset.

The group descriptive data for the 3 to 12 months post-onset prediction and an N of 17 with a mean age of 53.94, with a range of from 33 to 79. PICA scores obtained at 3 months post-onset reveal a mean overall score of 11.56, a mean gestural score of 13.11, a mean verbal score of 11.36, and a mean graphic score of 9.62. The mean of the 9 high subtest means was 13.41, and the mean high-low gap was 4.89. The actual mean overall score obtained at 12 months post-onset was 12.77.

The results of the multiple regression analysis, ($Overall_{12}$ = (.70) $Gestural_3$ + (.29) $Highs_3$ + (-.41), reveal that 2 variables, the gestural and the 9 high scores, were most significant, with the gestural scores being the more powerful predictor. The correlation of the predicted score with the actual score obtained at 12 months post onset was .91 ($p < .001$).

In the 6 to 12 month prediction group, there was a sample size of 17 and a mean age of 57.71 was obtained, with a range of from 45 to 79. PICA scores obtained at 6 months post-onset reveal a mean of 11.97 for overall scores, 11.33 for gestural, 11.80 for verbal, and 10.24 for graphic. The mean of the 9 high subtest means was 13.94, and the mean high-low gap was 3.88. The mean overall score obtained at 12 months post-onset was 12.47.

The multiple regression analysis results, ($Overall_{12}$ = (1.23) $Overall_6$ + (-.26) $Verbal_6$ + (.72), reveal that the 2 most important predictors were the verbal and the overall scores. The multiple correlation revealed an R of .97 when only these two variables were considered in the prediction equation.

The results of these analyses are exciting to us. They indicate that it is, indeed, possible to predict eventual recovery levels with a high degree of accuracy. Using a much larger sample, we hope to generate predictive data which will enable the clinician to predict eventual recovery levels, with a high degree of confidence, using a simplified prediction formula, for the myriad of aphasic syndromes, etiologies, and time post-onset.

In the interim, however, I find that simple and fairly accurate predictions can be made using available data and a formula based on PICA theory.

Generally called the HOAP, or High Overall Prediction, the formula allows the clinician to predict the patients' eventual recovery levels, up to and possibly beyond, 6 months post onset. Appendix B of the PICA manual, Volume 2, contains recovery curve percentiles for high, low, and overall scores. These mean scores and percentiles, based on 280 left-hemipshere brain damaged patients, contain a great deal of predictive information. The highs are thought to be prognostic, and the lows diagnostic. A simple and accurate prediction of the patients expected recovery level can be made by using this table. For example, given an overall score of 8.37 at one month post-onset, by finding the appropriate score in this column, the overall column, and then going across to the corresponding high score, and then finding an equivalent score in the overall column of 11.27, a fairly accurate prediction of the patients recovery level at three and six months can be made. In fact, recovery levels at 12 months can be predicted with only a slight drop in accuracy, and the same procedure can be used to predict 6 and 12 month post-onset overall scores using 3 months post-onset overall scores. To test this procedure, a series of correlations were computed using the same patient samples used in the multiple regression analysis. The results of these correlations are shown in Figure 3. For these correlations, the HOAP slope predictions at one, three, and six months post-onset were correlated with the actual obtained scores (overall) at 3, 6, and 12 months post-onset. The significant correlations indicate that it is possible to predict recovery levels using this procedure.

Summary of Results

Our analyses reveal high multiple correlations, indicating that it is possible to make accurate predictions of a patient's potential recovery at three, six, and twelve months post-onset using data obtained at one, three, and six months post-onset. Prediction is best for six to twelve month prediction ($R = .97$), slightly less for the three to six month prediction, ($R = .94$), about the same for the one to three and three to twelve, ($R = .91$), slightly less for the one to twelve ($R = .89$), and "worst" for the one to six ($R = .85$).

The most potent variables in the one to three month post-onset prediction are the overalls and high scores; for the one to six, the highs and gesturals, as well as for the one to twelve; for the three to six, the overall, verbal and highs; for the three to twelve, the gesturals and highs; and for the six to twelve, the overalls and verbals.

Figure 3

PREDICTING RECOVERY FROM INITIAL TEST DATA

MULTIPLE REGRESSION ANALYSES AND HOAP SLOPE CORRELATION COEFFICIENTS

Predictor	Prediction	(R) Multiple Correlation Coefficient Selected Variables	(R) Multiple Correlation Coefficient All Variables	HOAP R	N
1 MPO Overall and 9 Highs	3 MPO OA	.91	.91	.90	63
1 MPO Highs and Gestural	6 MPO OA	.85	.88	.80	28
1 MPO Highs and Gestural	12 MPO OA	.89	.93	.84	21
3 MPO Overall, Verbal, and Highs	6 MPO OA	.94	.95	.93	30
3 MPO Gestural and Highs	12 MPO OA	.91	.91	.90	17
6 MPO Overall and Verbal	12 MPO OA	.97	.98	.96	17

Finally, the results of the HOAP slope analysis indicate that it, too, is highly predictive of eventual recovery levels, particularly at three and six months.

These are the results of our preliminary analyses. They are based on a retrospective look at data collected over a period of time. The data come from a random sample of aphasic patients who demonstrate a variety of etiologies and a range of severity of aphasia. First, the analysis of these data has led us to the important conclusion that these results suggest that the aphasiologist is capable of predicting a patient's potential for recovery early after onset. Secondly, this study has clearly demonstrated the importance of regular and orderly testing at one, three, six, and twelve months post onset.

There is a need to identify those variables which account for the unexplained proportions of variance. We speculate that three variables will account for most of the unexplained variance; etiology, severity, and the effects of treatment.

Currently, we are engaged in a longitudinal study of aphasia which we hope will elaborate and refine our initial results. We plan to follow a large number of patients over the next five years. Comprehensive biographical, medical, speech and language testing, and treatment data are being collected. The patients will be evaluated at specified intervals---one, three, six, and twelve months, and every six months thereafter. A battery of additional speech and language measures has been added to the PICA, making the speech and language sample more comprehensive. The large "N" is necessary, because we hope to develop correction factors for our predictive equations. Once the data are collected, we plan a retrospective look to determine which variables will give us our best predictions. After the equations are formulated, correction factors for age, education, coexisting motor speech disorders, etc. will be applied to refine our prediction.

Finally, if it is determined that we are able to make accurate predictions, we plan to institute a clinical trials investigation with another group of patients. Using the equations developed in the retrospective study, we will predict recovery levels for the patients in the clinical trials study and see if our predictions are met.