# Statistical Prediction of Change in Aphasia: Clinical Application of Multiple Regression Analysis

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Methods for predicting change in aphasia are few. Two approaches, prognostic variables and behavioral profile, are popular. A third approach, statistical prediction, is the subject of this paper.

The prognostic variable approach requires the clinician to compare a given patient's biographical, medical, and behavioral characteristics against how these variables are believed to influence change in aphasia. However, the coexistence of conflicting variables, for example an extensive lesion (a negative sign), a young patient (a positive sign), make a prognostic decision difficult. Even when all variables are favorable, the ultimate level of change predicted is limited to an adjective--good, favorable, guarded, or poor.

The behavioral profile approach involves evaluating the aphasic patient with a variety of communicative tasks, constructing a performance profile, and comparing this profile with change made by previous patients with a similar profile. Difficulties arise when a patient's performance cannot be classified into a single prognostic category. And, again, predicted change is limited to descriptive adjectives.

The third approach, statistical prediction, involves the use of multiple regression techniques to predict performance on a specific measure of aphasia at different points in time postonset. Statistical prediction has the advantage of predicting a quantified score for an individual patient rather than relying on what is known about aphasia, such as in prognostic variables, or forecasting change for an individual patient based on what has been observed in previous patients, as with behavioral profiles. Three preliminary efforts with statistical prediction by Porch, Wertz, Collins, and Friden (1973, 1974, In Press), indicated that multiple regression techniques may be used early and accurately to predict change in aphasia. The authors, however, restrict their results to demonstrating that the method is feasible, and suggest that their formulae are not ready for clinical application.

The purpose of this paper is to discuss the clinical application of multiple regression formulae provided by Porch et al., (In Press) to predict change in language abilities for a sample of aphasic patients at different points in time during the first year postonset.

## Methods

We used multiple regression equations provided by Porch et al., (In Press) to predict change in aphasia for 90 patients who had suffered a left hemisphere thromboembolic CVA and had received at least two evaluations during their first year postonset. Six prediction groups were examined, based on when the Porch Index of Communicative Ability (PICA) (1967) was administered. Sixty-nine of our patients received evaluations at one and three months postonset; 63 received evaluations at one and six months postonset; 44 received evaluations at one and 12 months postonset; 65 received evaluations at three and six months postonset; 45 received evaluations at

three and 12 months postonset; and 50 received evaluations at six and 12 months postonset. Some patients are represented in more than one prediction group, because they received three or more evaluations during the first year postonset.

Formulae provided by Porch et al., (In Press) indicate that significant predictors include one or more of the following: age and gestural, verbal, and graphic PICA modality means. They concluded that their formulae were not ready for clinical application. We tested the validity of this conclusion by using their multiple regression formulae to predict for our sample of patients. The relationship between the Overall PICA scores predicted by the equations and the scores obtained indicates the precision of prediction.

The appropriate weights were included in equations for each of our patients. For example, for patients who received evaluations at one and three months postonset, the following formula was used.

> Predicted Overall PICA Score at 3 MPO = -.02 (age at MPO) + .45 (Gestural Modality Mean at 1 MPO) + .08 (Verbal Modality Mean at 1 MPO) + .25 (Graphic Modality Mean at 1 MPO) + 4.45.

For this group, all predictors--age and gestural, verbal, and graphic PICA modality means--were included in the equation. Equations for the other prediction groups included one or more of the same predictors. A predictor is included in the equation only when it increases predictive precision significantly.

Pearson product-moment correlations were computed between the predicted Overall score and the Overall score obtained. In addition, correlated t tests were computed for each prediction group to determine whether the predicted PICA Overall mean was significantly different from the PICA Overall mean obtained.

## Results

Mean predicted scores, mean obtained scores, and correlations computed between the two scores are shown in Table 1.

Table 1. Correlations between mean predicted and obtained Overall PICA scores for six prediction groups.

| Prediction (In MPO) | N | r | $\bar{x}$ Predicted Score | $\bar{x}$ Obtained Score | Difference |
|---|---|---|---|---|---|
| 1 - 3 | 69 | .84* | 11.16 | 11.22 | -.06 |
| 1 - 6 | 63 | .75* | 12.07 | 11.93 | +.14 |
| 1 - 12 | 44 | .65* | 12.45 | 12.16 | +.29 |
| 3 - 6 | 65 | .85* | 12.19 | 11.84 | +.35** |
| 3 - 12 | 45 | .67* | 12.28 | 12.15 | +.13 |
| 6 - 12 | 50 | .81* | 12.14 | 12.15 | -.01 |

*Significant at $p < .001$
**Significant at $p < .002$

Correlations range between +.65 and +.87. All are significant ($p < .001$). Correlated t tests between the mean predicted Overall score and the mean Overall score obtained indicate one significant difference in the six prediction groups. In the three MPO predicting six MPO group, the predicted score was significantly different ($p < .002$) from the obtained score. On the basis of these results, one might consider the weights generated by Porch et al., (In Press) ready for clinical application.

However, statistical significance does not always insure clinical significance, and group data often mask individual differences. To assess clinical significance, we converted the Overall predicted and obtained scores to percentiles and computed the percent of patients in each prediction group who received a score within + or - five percentile units of their obtained score, the percent for whom we over-predicted by five percentile units, and the percent for whom we under-predicted by five percentile units. These results are shown in Table 2.

Table 2. Percent of each prediction group obtaining an Overall PICA score within + or - five percentile units, over five percentile units, and under five percentile units, of the predicted Overall PICA score.

| Prediction Group (In MPO) | N | Percent of Group | | |
|---|---|---|---|---|
| | | Within ± 5%ile | Over 5%ile | Under 5%ile |
| 1 - 3 | 69 | 39 | 28 | 33 |
| 1 - 6 | 63 | 35 | 46 | 19 |
| 1 - 12 | 44 | 34 | 41 | 25 |
| 3 - 6 | 65 | 32 | 52 | 16 |
| 3 - 12 | 45 | 36 | 38 | 26 |
| 6 - 12 | 50 | 62 | 18 | 20 |

Only one prediction group, six MPO predicting 12 MPO, contained a majority of patients who obtained a score within + or - five percentile units of the predicted score. Approximately two-thirds of the patients in each of the other five groups obtained scores of either more than or less than five percentile units of the score predicted.

## Discussion

The primary purpose of this paper was to determine the clinical applicability of multiple regression analysis for predicting change in aphasia. Our results lend credence to the contention of Porch et al., (In Press) that multiple regression analysis is a potentially useful means of predicting change. In addition, we support the caution they counsel. The technique is not ready for clinical application.

The original equations developed by Porch et al., (In Press) yielded significant and high multiple correlations. Using these equations, we

obtained significant Pearson correlations between predicted and obtained scores for our group of patients. Therefore, we support the potential power of multiple regression analysis as a predictive tool.

However, in five of our six prediction groups, a majority of patients obtained PICA Overall scores that differed from their predicted scores by + or - five percentile units. Prediction was best when predicting over shorter periods, for example one predicting three MPO, and during periods when change is less rapid, for example six predicting 12 MPO.

Improved prediction may require testing the predictive potency of additional variables which might influence an aphasic patient's performance over time. Only four were included in the Porch et al., (In Press) equations--age and gestural, verbal, and graphic PICA modality means. Further, if treatment has an influence on change in aphasia, it must be considered in the multiple regression analysis. All but five of our patients were treated, and the treated patients received therapy that varied widely in length, frequency, and content. It is possible that different equations will be necessary depending on whether a patient is treated or not, the amount of treatment administered, and perhaps, when treatment is administered. Finally, the initial efforts of Porch et al., (In Press) require replication with larger samples of aphasic patients.

Presently, aphasiology is lacking in its ability to select appropriate treatment candidates, plan realistic social and occupational goals for patients, justify the expense of treatment, and answer a patient's and his family's questions about the future. Statistical prediction appears to be a feasible means of predicting improvement or the lack of it, and the path to making it clinically applicable is probably worth the plodding.

## References


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## Questions and Answers

Q: How many patients had transcortical motor aphasia?
A: I don't know.

Q: Did you care?
A: No. In this particular study we were interested in assessing overall communicative ability, which is what the PICA purports to assess. So we were not interested in just verbal communication, and type of aphasia was not important in assessing the overall communicative ability.

Q: Do you think it would improve the formulae to add a weight for type of aphasia?

A: After listening to some of the papers presented yesterday it possibly could.

Comment: Or it very possibly might not. I was wondering whether you had thought about that and wanted to include it in this study.

A: Not this particular one.

Comment: The various predictors in this equation come from the PICA and the inclusion of each depended upon whether it increased the precision of prediction significantly. If it did not, it was not included in the equation. It may seem a little circular to use PICA predictors to predict PICA scores. Perhaps we need independent criteria. The difficulty we might find with transcortical motor aphasia is determining what it is and when it is present.

Comment: Prognosis, I take to mean, is whether or not somebody is going to improve. I don't know that this looks at prognosis or is a prognostic indicator. I think that you are looking at performance in terms of percentiles and there have been questions raised as to its validity. Your data may be valid for changes in test scores but I'm not sure it has anything to do with changes in functional performance. Therefore, you have to be very careful how you define the term "prognostic tool."

Comment: You have a good point and we've thought about this. When you use the equations to predict a score for an individual, let's say he is going to be 12.10 at six MPO. What does that mean to him? It's a good question. I hope that we get closer to finding out what that means. At the same time, I feel that this sort of data-based prognostic indicator has its place. For third party payers for instance. Also you can convert the scores to percentiles to get an idea of performance. I would use statistical prediction of change in behavior with reservations. However, I do feel it has its place.

Comment: I think you're quite right, especially in terms of third party payers but that's an administrative issue. That's a separate issue from the study of the patient, the study of therapy and study of clinical function. I think there's a mistake that can be made in mixing up administrative needs with scholarly endeavors.

Comment: I also think you can use a number to help complete a total picture when counselling a family or a patient.

Q: Do you think you would get different results if you broke down gestural scores? I know what verbal scores are and what graphic scores are, but what's gestural?

A: As we know, gestural is a combination of reading and listening. It's a good point. We did not generate the equations in this study. We just wanted to test the clinical applicability of the equations, so we plugged in data that we had from our patients into the equations to see how well they work.

Comment: I have directed this question to Porch and have not gotten a satisfactory answer.

Comment: I don't agree that either of the previous comments were "good" points. The first implies that a significant change in an Overall PICA score does not represent a significant change in aphasia. Therefore, the PICA cannot be used as a prognostic tool. I do not know how one argues with that point of view. Many believe that a PICA Overall score represents severity of aphasia, and an increase in a patient's PICA Overall score represents improvement. Holland has reported a significant relationship between PICA performance and performance on the CADL, supposedly a measure of "functional" communication. Thus, some believe the PICA can be used to predict a patient's future communicative ability -- his prognosis.

The second comment expresses dissatisfaction with what constitutes the Gestural Modality mean on the PICA. Certainly, a lot of behaviors are combined to obtain this score. For the study reported, however, this is not important. What was sought was a means of predicting a patient's future. One looks for the best predictors, and the Gestural Modality mean was a significant predictor for all predictive groups. It increased predictive precision more than age or Verbal or Graphic Modality means. In a multiple regression analysis, one is not interested in what constitutes a predictor, one only wants to know whether including the predictor in the equation significantly increases prediction.

Q: Some of the patients varied by more than ± five percentile units. What was the range?

A: The range for some of the patients was very wide. The difference between the mean predicted and obtained scores ranged from 0 to 46 percentile units. Prediction was more precise when predicting over shorter periods of time, for example one predicting three MPO, and during periods when change is less rapid, for example six predicting 12 MPO. We also calculated the percent of each prediction group obtaining Overall PICA scores within ± 10 percentile units of the predicted score. On the average, 66% of the predicted scores were within ± 10 percentile points of the obtained score. This is why we think the equations are not yet ready for clinical application.

Q: Was there any difference between patients who were treated and not treated?

A: We couldn't retrieve that information and the treatment had varied widely. There were five who had not been treated and that wasn't enough to show anything. That is an interesting question. I just don't have an answer right now.

Comment: We must use our tools to test out our assumptions. You're talking about changes in particular test performance. You must use these results carefully in relation to real life decisions about how we are going to treat these patients, and whether they're going to be in treatment.