Slope and Variability of Performance on Selected Aphasia Treatment Tasks

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Problem

Aphasiologists need information on reacquisition rates of language skills in order to evaluate the effect of individualized language intervention programs, and in order to obtain and communicate prognostic information. For these reasons, a primary purpose of this study was to collect data that quantitatively described two configuration characteristics reflected in the performance of aphasic individuals undergoing treatment on selected language rehabilitation tasks. The data configuration characteristics we studied were slope or rate of performance change and variability, or fluctuations in performance from session to session.

METHOD

Subjects. Five male veterans, all right-handed, were diagnosed as aphasic by speech and language testing and the judgment of a certified speech and language pathologist. The Porch Index of Communicative Abilities (Porch, 1967) and the picture presentation task of the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1972) were included in the initial evaluation in order to classify the subjects according to the severity and fluency of their aphasia. In Table 1, the subjects are described according to these and other relevant variables.

Data Collection. Individualized treatment programs were developed for each subject, scoring systems were designed for all treatment tasks, and two to 14 baseline scores were measured for each task in order to establish initial performance levels and eliminate tasks with ascending baseline scores. Two to four tasks were selected for each subject's treatment program, and a total of 16 treatment tasks were included in the data analysis. Treatment was scheduled for two to four sessions per week, depending on subject availability. Performance was measured by percentage scores for 14 consecutive treatment sessions. These scores were plotted in real time using one graph for each task, and analyzed according to the following procedures to measure performance slope and variability:

Slope. A performance slope, or trend line, is a line that represents the central tendency of a set of sequential points. In this case it represents the acquisition rate of a treated communication task. In cases where the horizontal axis represents time and vertical axis represents score (as in this study and for most performance data), greater magnitude of slope indicates faster change in performance and a lesser magnitude of slope indicates a slower change in performance (Figure 1).

The data were analyzed according to the quarter intersect method which we described two years ago (Matthews and LaPointe, 1981). This was done in order to estimate a trend line for each set of treatment data. A protractor was used to measure degrees of slope and the Table of Natural Trigonometric Functions (Byers, 1976) was consulted in order to quantify the slope.

Table 1. Patient Variables.

Variable	F.P.	F.B.	R.E.	D.M.	H.E.
Fluency	Nonfluent	Fluent	Fluent	Nonfluent	Fluent
Severity	Moderately impaired	Mildly impaired	Mildly impaired	Severely impaired	Functional
Description of Aphasia	Severe verbal formulation difficulty and severe phonologiselection and sequencing difficulties, occasional verbal paraphasia, neologistic margon, mild auditory comprehension deficit.	Moderate phonological selection and sequencing impairment.	Mild fluent aphasia mild auditory comprehensive deficit, word finding difficulties, apraxia, conduction aphasia.	Severe receptive deficit, severe to profound expressive difficulties, severe apraxia.	Mild to moderate auditory and visual comprehen and word finding difficulties
Associated Defects	Hemiparesis of the right leg, paralysis of right arm.	Right sided weakness.	Resolved right hemiparesis.	Right hemiplegia.	Right hemiparesi
Age at Onset	56 years	52 years	48 years	45 years	69 years
Premorbid Education	Business School	Grade 9	Grade 12	Grade 12	Dental School
Premorbid Intelligence	Normal	Normal	Normal	Normal	Superior
Premorbid Language Function	Normal	Normal	Bilingual English/Spanish	Normal	Superior
Occupation	Business administrator in construction	Beer distributor	Power plant project officer (Navy)	Machinist	Dentist
Social Milieu	Married, 5 grown children	Married, 2 teenagers at home	Married, 8 year old son at home	Married, 5 children D.M. in convalescent home	Bachelor, home f the elderly
Medical History	Hypertension, cardiac history, rheumatic arthritis	Hypertension, cardiac failurel, TIA	Not remarkable	Hypertension	Not remarkable
Associated Illness During Recovery	Compactions	None reported	None reported	Polycystic kidney disease (required dialysis)	Diabetes
Cause of Aphasia	Left CVA, 5/80	Left MCA, thrombotic CVA, 4/79	Left CVA, 11/79	Left CVA, 11/80, left hematoma surcigally removed, subarachnoid hemorrhage, ruptured Berry aneurysm	Left CVA, 9/80
General Location of Lesion	Left hemisphere	Broca's area (neurology report 9/79)	Left hemisphere	Left temporoparietal region	Left hemisphere
Time Post-Onset (at initiation of treatment)	9 months	2 years	2 years	7 months	8 months

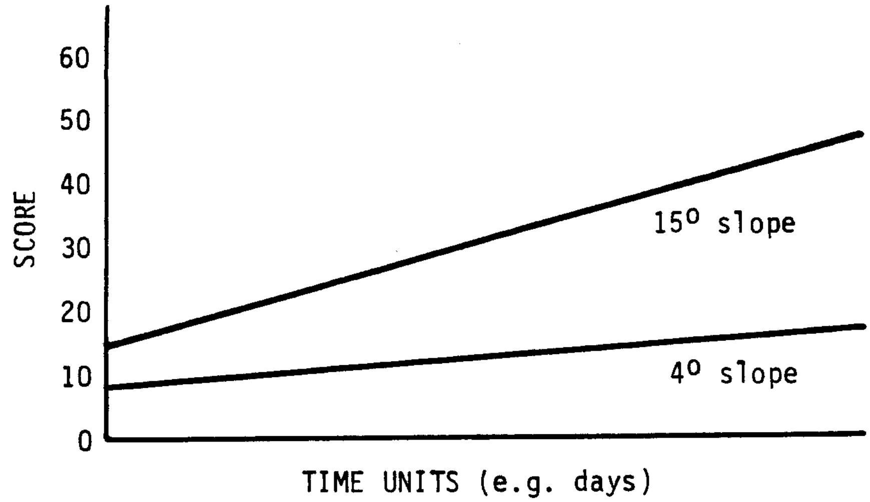

Figure 1. Performance slope--a line that represents the acquisition rate of treated communication tasks.

Variability. Mean bounce and total bounce are two types of variability. Mean bounce is computed by calculating the average difference between consecutive scores (Table 2). In column one, the data pairs are identified. Corresponding scores are shown in column two in the form of subtraction examples. For example, note the top row of column two is 53 minus 50. The adjacent values are substracted and each difference is listed in column three. For this example, the 53 minus 50 of column two equals the three in the third column. The difference between all adjacent pairs are added; and the sum, or total difference appears at the bottom of column three. In this example, it is 152. The average difference between adjacent pairs is then calculated by dividing the total difference by the number of pairs, or number of scores minus one. That is shown at the bottom of the table as mean bounce.

Table 2. Mean Bounce - computed by calculating average difference between consecutive scores.

Data Pair	Subtraction	Difference
1 & 2	53 - 50	3
2 & 3	53 - 50	3
3 & 4	80 - 53	27
4 & 5	80 - 70	10
5 & 6	70 - 66	4
6 & 7	80 - 66	14
7 & 8	80 - 80	0
8 & 9	80 - 60	20
9 & 10	90 - 60	30
10 & 11	90 - 77	13
11 & 12	77 - 70	7
12 & 13	87 - 70	17
13 & 14	87 - 83	4
	Total Difference	152

$$\text{Mean Bounce} = \frac{\text{Total Difference}}{\#\text{ Scores} - 1} = \frac{152}{} = 11.7$$

Total bounce, the second variability measure, represents the overall variation in score for several consecutive treatment sessions. The procedure for calculating total bounce involves constructing the trend envelope, as described by Matthews and LaPointe in 1981, and then measuring the envelope's vertical width.

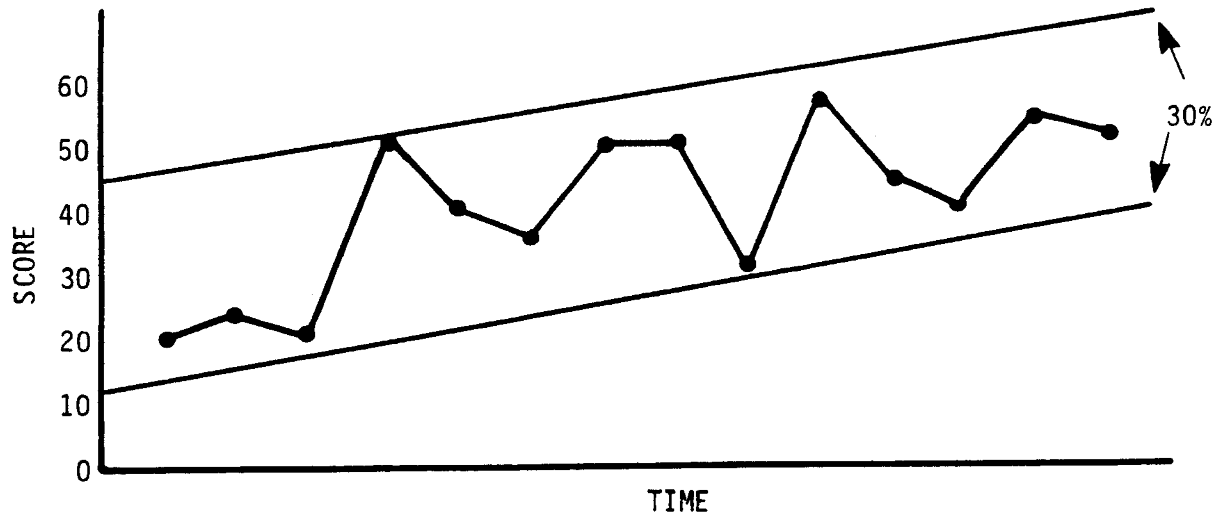

Figure 2. Total bounce--the overall variation in score for several consecutive treatment sessions.

RESULTS

A summary of these three data configuration quantities: slope, mean bounce, and total bounce, as extracted from our sixteen treatment data sets, are displayed in Table 3. The average difference between consecutive scores (mean bounce) ranged from four to 16.2 percentage points, with a mean of 7.88; while overall variation, or total bounce, ranged from 12 to 41 percentage points, with a mean of 26.6.

Slope ranged from a disappointing -3° to +7.5°, with a mean of +3°. To allow you to appreciate visually the magnitude of these rates of change, these slopes are pictured in Figure 3. Note that the lowest slope went in the wrong direction and indicated a negative progression for one patient. With the passage of time, it became clear that this particular gentleman was suffering from a progressive degenerative disease concomitant to his aphasia. Though he was not an ideal subject to include in a study of treatment effect, our plotting of his performance deterioration tipped us off to a nonstable neurologic condition and added documentation and input to his subsequent medical management.

Clinical Implications. We believe that more information is needed in order to determine patterns of distribution of slopes for aphasia treatment tasks, but we also are able to draw some conclusions from these data. For example, although an increase in score was the goal of each task, some negative and zero slopes occurred. These descending slopes are generally incompatible with a reasonable clinical objective; however, they can serve as indicators of inappropriate tasks or a deteriorating medical condition, as in the case of the patient just mentioned.

Table 3. Data configuration quantities for each task as measured by a fourteen-point trend envelope.

Task	Patient	Mean Bounce (%)	Slope (score/time)	(Approximate Degree Equivalent for Slope Measurement)	Total Bounce (% range)
1	F.P.	5.8	.09	(5°)	25
2	F.P.	13.0	.08	(4½°)	41
3	F.P.	7.0	.08	(4½°)	30
4	F.P.	5.3	.02	(1°)	20
5	F.B.	10.9	.08	(4½°)	30
6	F.B.	4.2	.07	(4°)	13
7	F.B.	4.9	.02	(1°)	22
8	F.B.	8.5	.09	(5°)	27
9	R.E.	5.7	-.02	(-1°)	30
10	R.E.	4.2	.04	(2½°)	12
11	D.M.	11.5	.13	(7½°)	38
12	D.M.	12.3	.11	(6½°)	40
13	H.E.	4.0	.05	(3°)	21
14	H.E.	5.5	.04	(2½°)	15
15	H.E.	16.2	.00	(0°)	40
16	H.E.	7.2	-.05	(-3°)	22
RANGE		4 - 16.2%	-.05 - .13		12 - 40
MEAN		7.88%	.05	3°	26.6
STANDARD DEVIATION		3.00%	.047	~2.6°	9.3
MEDIAN		5.75%	.045	~2.6	26

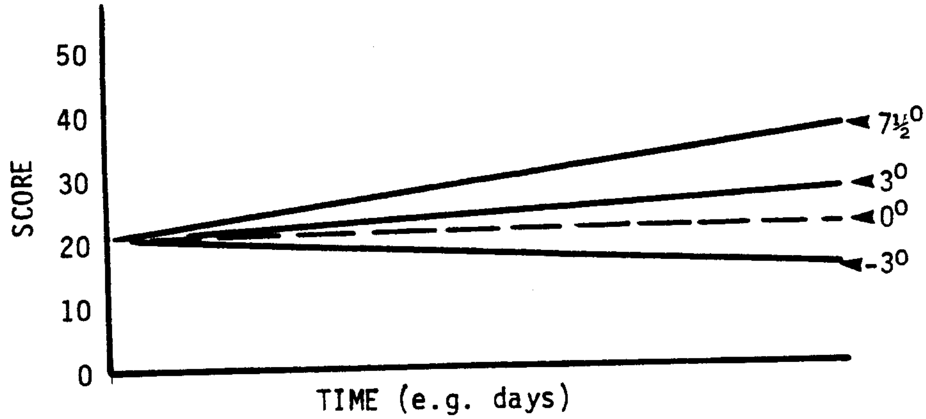

Figure 3. Data configuration and degree of slope.

Further, a lower limit may exist for productive positive slopes. For example, a slope of .025, or 1.5°, was derived from the fraction 1/40, which means that when degree of slope equals 1.5°, a 10% gain in score is achieved every 40 calendar days. Depending on the amount of time available, the goal of the task, the patient's interest in the task and ultimate objective, and other factors of cost effectiveness, tasks that progress with slopes shallower than 1-1/2° may be reevaluated and perhaps regarded as having an unacceptable rate of change in performance.

Examination of the slopes measured in the present study may provide a foundation for further study of the reacquisition rates that may be expected in aphasia treatment. The steepest recovery slope in the present study, 7.5°, reflected a 20% gain in score every 15 days. Perhaps in stable patients, it is unreasonable to expect faster performance gains than that. In this study most of the positive slopes ranged between 2.5° and 5.5°, indicating that a 10% gain in score was typically achieved in 11 to 25 days for the tasks and patients studied. Some tasks reflected greater progress, but they were exceptions.

In order to aid in the estimation of the duration of time needed to increase a performance score by 10% increments, Table 4 was developed. Table 4 reproduces a portion of the Table of Natural Trigonometric Functions (Byers, 1976) and it may be useful in order to estimate the number of days or time units needed to achieve a score change of 10% increments.

Although further data collection is needed, our results suggest that over a period of 14 treatment sessions, an average difference in consecutive scores that exceeds 13 percentage points is unusual and may indicate that the task and scoring system should be reevaluated to determine their value to the patient, especially when slope is shallower than 1.5°.

The average difference between consecutive scores or mean bounce, may be higher than anticipated for aphasia treatment. In our study, the range of difference between consecutive scores was 4 to 16.2 percentage points; and overall variability of performance or total bounce, ranged from 12 to 41 percentage points. Replication using a large number of patients who vary in type and severity of aphasia, variations in treatment emphasis, and consideration of other subject variables will provide more comfortable normative data for predicting session-to-session variability in treatment.

Table 4. Non Crystal Ball Predicting: sessions needed for X percent change (1° - 15° slopes).

Degree	Slope (tangent)	10% (Cotangent)	20%	30%	40%	50%	60%	70%	80%	90%	100%
1°	0.017	57	115	172	229	286	344	401	458	516	573
2°	0.035	28	57	86	115	143	172	200	229	258	286
3°	0.052	19	38	57	76	95	114	134	153	172	191
4°	0.07	14	29	43	57	72	86	100	114	129	143
5°	0.087	11	23	34	46	57	69	90	91	103	114
6°	0.105	10	19	29	38	46	57	67	76	86	95
7°	0.123	8	16	24	32	41	49	57	65	73	81
8°	0.14	7	14	21	28	36	43	50	57	64	71
9°	0.158	6	13	19	25	32	38	44	51	57	63
10°	0.176	6	11	17	23	28	34	40	45	51	57
11°	0.194	5	10	15	20	26	31	36	41	46	51
12°	0.213	5	9	14	19	24	28	33	38	42	47
13°	0.23	4	9	13	17	22	26	30	35	39	43
14°	0.249	4	8	12	16	20	24	28	32	36	40
15°	0.268	4	7	11	15	19	22	26	30	33	37

The descriptive data derived from this study can increase our understanding of variability and rates of reacquisition within treated language tasks, and demonstrates the utility of the quarter intersect method to language performance in aphasia. As data accumulates, we're sure that some of these preliminary efforts will seem tentative and embryonic. However, we must begin to map the territory of reacquisition rates in aphasia treatment so we can more accurately answer the questions: "How long must this go on?" "And how far will it get?"

DISCUSSION

Q: Barb, I'm sure you're aware that the use of this system or other systems for measuring patient behavior is pretty much dependent on the reliability with which you are able to measure the dependent variables. I was curious about the dependent variables for the five patients that you described. That is, what were your treatment tasks and how did you measure them?

A: The treatment tasks were developed on an individual basis for the patients studied. They were tasks that were designed to meet their individual needs. Treatment tasks ranged from a simple pointing tast to a task that required a patient to discriminate between very specific morphosyntactic structures.

We measured progress according to PICA scoring in some cases; and in some cases we used a plus/minus system; and in other cases we developed a multidimensional system that probed exactly what we were looking for in that patient--for example a five point scale. We used the clinician's judgment as to the validity of the scales that we used.

Q: Am I correct in assuming that you're assuming linear change? And are you really getting linear changes for all the tasks you're seeing or are you getting curvilinearity?

A: There was a curvilinear function for several of the tasks. However, we found that nine of the sixteen tasks were best represented by a straight line. We'd like to look into that a little more and see what the reasons were, but I think it may be due to the short duration of treatment. We may see more curvilinearity with more time.