EFFECTS OF FATIGUE PRODUCED BY ISOKINETIC EXERCISE UPON THE COMMUNICATION ABILITY OF APHASIC ADULTS

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For a number of years, clinicians have been concerned with the possible effects of fatigue upon the aphasic patient's communication (Martin, 1962; Buck, 1968). Potential sources of fatigue include not only the physical demands of the patient's rehabilitation program but visits from the family, adjustment to use of the nondominant hand (in cases of hemiparesis), and a reduced capacity for physical exertion resulting from neuromuscular damage. For these reasons, the family, rehabilitation staff members, and others are often advised against placing undue communicative stress on aphasic patients when they demonstrate signs of fatigue, and precautions are normally taken to avoid scheduling language therapy immediately following strenuous activities such as physical therapy. Unfortunately, however, the basis for this has been intuitive or the result of uncontrolled clinical observation without experimental support. Accordingly, it was the principal aim of this investigation to determine the effects of fatigue upon the communication ability of aphasic adults.

Subjects

Subjects for this investigation were 16 aphasic adults (15 males and 1 female) ranging in age (Table 1) from 36 to 66 years (mean, 50.6 years) and in duration of aphasia from 4 to 96 months. All subjects had previously received or were currently receiving speech therapy at the Portland Veterans Administration Hospital. Ratings of severity of aphasia were assigned according to the subjects' previous overall scores on the Porch Index of Communicative Ability (PICA) (Porch, 1967). Subjects attaining overall scores above 13.00, between 11.00 and 12.99, and below 10.99 were rated as mild, moderate, and severe aphasics respectively. Individuals incurring aphasia from causes other than cerebrovascular accident (CVA) or presenting medical history of more than a single CVA were excluded from the study. The only other restrictions were that subjects demonstrate potential for performing (to the best of their ability) the

TABLE 1. Summary of aphasic subjects. 0 = absence of apraxia; + = presence of apraxia. R-E = rest condition administered first and exercise condition second; E-R = exercise condition administered first and rest condition second.

SUBJECT	AGE - SEX (IN YEARS)	DURATION (IN MONTHS)	SEVERITY OF APHASIA	APRAXIA	EXPERIMENTAL ORDER
1	58M	7	moderate	-	R-E
2	49M	6	mild	-	E-R
3	40M	6	severe	-	R-E
4	66M	22	severe	+	R-E
5	54M	8	severe	+	R-E
6	36M	36	moderate	+	R-E
7	56M	8	severe	-	E-R
8	39F	6	mild	-	E-R
9	49M	18	moderate	+	R-E
10	46M	42	severe	+	E-R
11	54M	8	moderate	+	E-R
12	38M	6	moderate	-	E-R
13	58M	4	severe	-	E-R
14	57M	96	moderate	-	R-E
15	52M	4	severe	+	E-R
16	58M	5	severe	+	R-E

exercise and communication tasks described in subsequent sections of this report.

Procedure

Subjects were tested following each of two conditions with the PICA. One PICA was administered immediately following a period of isokinetic exercise with the Cybex machine (Hislop and Perrine, 1967; Thistle, Hislop, Moffroid, Hofkosh, and Lowman, 1967; Moffroid, Whipple, Hofkosh, Lowman, and Thistle, 1969), and the other was administered immediately following a rest period.

Exercise and Rest Periods

Use of the Cybex electromechanical machine supplied an exercise form which simulated a typical therapeutic period for each patient, was suitable over a wide range of physical disability, and provided some degree of objective standardization. This device provides reciprocal dynamic exercises through the full range of motion for muscles extending and flexing a joint. The resistance automatically adjusts to meet the maximum force that can be exerted throughout the range while angular velocity is kept constant. A visible gauge and pen recorder show the force exerted by the muscle throughout the exercise sequence. Exercises selected for this study were knee flexion and extension. These movements utilize the largest muscle groups of the extremities and are among those most frequently stressed in remedial exercise programs.

During the exercise period the patient would first exercise the sound lower extremity through ten full extensions and flexions at an angular velocity of 30 degrees per second, rest one full minute, and repeat the same sequence for 15 minutes. Then the involved lower extremity would be exercised in the same way for an additional 15 minutes. Throughout the exercise period, each subject was supervised closely by the same experienced therapist to assure maximal exertion and complete compliance with instructions. While it was not possible to determine the relative levels of fatigue for individual subjects, it was felt that the exertion involved in this isokinetic exercise period generally equalled that of a normal physical therapy session and would, therefore, simulate the amount of physical fatigue resulting from such therapy. During the rest or control period, the patient was asked to sit, relaxed and comfortable, in the gymnasium for the same length of time as the exercise period.

The other of exercise versus rest conditions preceding PICA testing was assigned on a random basis with the single restriction that for half the subjects, the rest period precede their first PICA test and the exercise period the second, and that these conditions be reversed for the remaining subjects. PICA tests were administered immediately following the exercise or rest periods at approximately the same hour on the same day of two succeeding weeks. The same examiner, an experienced PICA tester, administered the tests following each condition. In each case, the subject was admonished to avoid disclosing to the tester whether or not he had been exercised or rested.

Results

Group means for PICA tests following exercise and rest periods are given in Table 2. Overall mean values for gestural, verbal, and graphic modalities represent averages of gestural subtest means (II, III, V, VI, VII, VIII, X, and XI); verbal subtest means (I, IV, IX, and XII); and graphic subtest means (A, B, C, D, E, and F) respectively. The overall PICA mean represents an average of the 18 subtest means.

The data in Table 2 indicate that, in most instances, subtest and overall means were lower when testing followed exercise than when testing followed rest. Subjects' performances on some PICA subtests, however, appeared to be unaffected by a preceding period of physical exercise. Group means on the two matching subtests of the PICA were identical following exercise and rest periods while means of four other subtests were slightly, but not significantly, higher following the exercise than the rest period.

A mixed model analysis of variance procedure having two error terms was used to analyze the data (Kendall and Stuart, 1961). These analyses were conducted separately for each of the PICA subtests and for the four overall measures to consider the effects of treatment and test order.

Treatment Effects

Results of this investigation indicate that a period of isokinetic exercise preceding language testing has an adverse effect upon the overall communication level of an aphasic adult. Following exercise, subjects' overall PICA scores were significantly lower (see Table 2) than following rest ($F=16.139$; $df=1, 14$; $p<.01$). The findings of this study also suggest that aphasic patients' performance on verbal and graphic tasks is most likely to be influenced by a preceding period of physical exercise. Subjects illustrated substantially lower verbal subtest means following exercise on three of four verbal tasks (see Table 2), and subjects' means for subtest IX were significantly lower following exercise than rest ($F=6.033$; $df=1, 14$; $p<.05$). Although significant decrements were not demonstrated for other individual verbal subtests, the fact that subjects' overall verbal scores were significantly lower following exercise

TABLE 2. Group subtest means; overall gestural, verbal and graphic means, and overall PICA means for tests following rest and exercise conditions.

SUBTEST	TASK	MEAN FOLLOWING REST	MEAN FOLLOWING EXERCISE
Gestural			
II.	Gesturing use of objects.	9.24	8.71
III.	Gesturing use of objects presented by examiner.	10.66	10.56
V.	Reading stimulus cards describing use of objects.	11.37	11.56
VI.	Auditory identification of objects by use.	13.60	13.65
VII.	Reading stimulus cards giving the name of objects.	12.40	12.24
VIII.	Matching pictures to objects.	14.92	14.92
X.	Auditory identification of objects by name.	13.96	13.54
XI.	Matching objects to objects.	15.00	15.00
	OVERALL GESTURAL MEAN	12.64	12.51
Verbal			
I.	Formulating sentences describing use of objects.	6.96	6.56
IV.	Naming objects.	9.48	9.02
IX.	Producing name of object in a carrier phrase.	9.59	9.05*
XII.	Repeating names of objects.	11.98	12.04
	OVERALL VERBAL MEAN	9.50	9.17**

TABLE 2. Continued.

SUBTEST	TASK	MEAN FOLLOWING REST	MEAN FOLLOWING EXERCISE
Graphic			
A.	Writing sentences describing use of objects.	5.38	5.43
B.	Writing names of objects.	7.91	7.34
C.	Writing names of objects spoken by the examiner.	7.94	7.68
D.	Writing names of objects spelled by the examiner.	8.16	7.72
E.	Copying the names of objects.	11.02	10.87
F.	Copying geometric forms	13.60	13.06
	OVERALL GRAPHIC MEAN	9.00	8.68*
	OVERALL PICA MEAN	10.73	10.50**

*Group means significantly different $p < .05$
**Group means significantly different $p < .01$

($F=9.513$; df=1, 14; $p<.01$) reflects the cumulative effects of decreased performance for verbal tasks following the exercise period. Group mean scores on the graphic tests were lower on five of the six tests (see Table 2) following exercise. While none of these differences reached statistical significance, the cumulative result of subjects' poorer performance on graphic tasks following exercise was a significantly lower overall graphic score ($F=5.559$; df=1, 14; $p<.05$).

Test Order Effects

When group subtest means for first and second PICA testing periods were analyzed irrespective of treatment order, subjects were found to have higher scores for their second PICA administration on six of the eight gestural subtests. On two subtests there were no differences. Subjects' mean scores for the second administration of the test were significantly higher for gestural subtest III ($F=9.939$; df=1, 14; $p<.01$), gestural subtest X ($F=6.890$; df=1, 14; $p<.05$), and for the overall gestural mean ($F=13.479$; df=1, 14; $p<.01$). For the verbal and graphic tests, however, subjects demonstrated little improvement from their first to their second test. On only two of four verbal tests and three of six graphic tests did subjects show any test-retest improvement. None of these differences were found to be significant.

Discussion

Effects of Fatigue Upon Aphasics' Communication

The findings of this investigation support previous clinical observations that physical fatigue adversely affects aphasic patients' communication (Buck, 1968; Martin, 1965). Although fatigue effects were not readily demonstrable with respect to group performance on specific PICA subtests, overall PICA measures which take into account an individual's performance on a variety of communication behaviors indicate a period of physical exercise preceding language testing will negatively influence overall communication level. Variation in subjects' overall PICA performance is depicted in Figure 1. Fourteen of the sixteen subjects showed a performance decrement following exercise ($p=.002$). All of the eight nonapraxic patients showed diminished performance ($p=.004$), and six of the eight apraxic patients ($p=.145$) demonstrated similar decrements following exercise.

Findings of this investigation also suggest that physical fatigue will have its most pronounced effect on those tasks normally regarded as being more linguistically complex, namely speaking and writing. Overall verbal and graphic group means were significantly lower when testing followed exercise than when testing followed rest. This result is not surprising since verbal and graphic tasks are normally felt to be more difficult for aphasic patients in that they

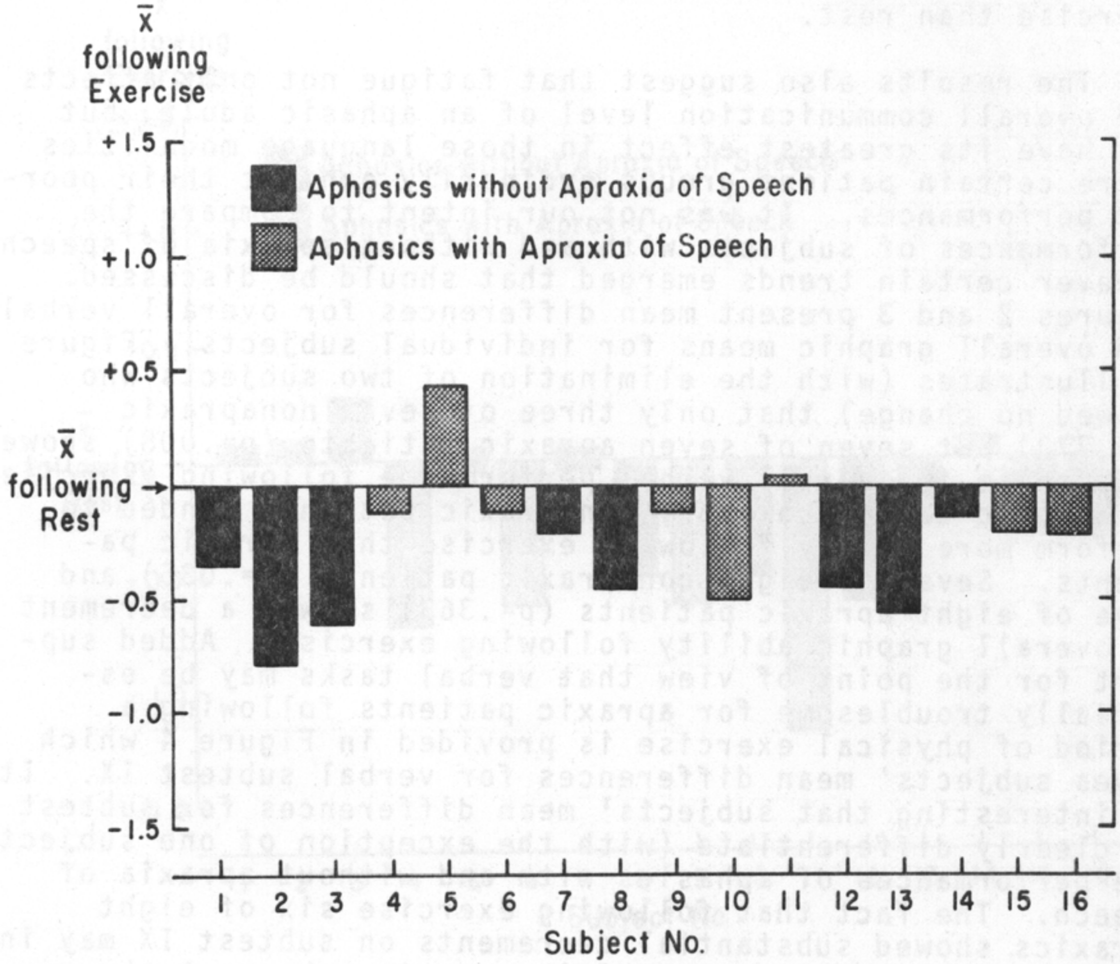

FIGURE 1. Mean differences for individual subjects' overall PICA means. The rest period is the reference point. Positive values indicate improvement following exercise, and negative values indicate poorer performance following exercise.

necessitate use of an active language form and constitute a recall rather than a recognition task for the patient (Schuell, Jenkins, and Jiminez-Pabon, 1964; Keenan, 1968). Gestural tasks, however, seemed little affected by whether testing followed exercise or rest. Variation in subjects' performance following the two experimental conditions was not shown on the matching subjects, however on two other gestural tests, subjects performed slightly better following exercise than rest.

The results also suggest that fatigue not only affects the overall communication level of an aphasic adult, but may have its greatest effect in those language modalities where certain patient groups ordinarily exhibit their poorest performances. It was not our intent to compare the performances of subjects with and without apraxia of speech, however certain trends emerged that should be discussed. Figures 2 and 3 present mean differences for overall verbal and overall graphic means for individual subjects. Figure 2 illustrates (with the elimination of two subjects who showed no change) that only three of seven nonapraxic ($p=.773$) but seven of seven apraxic patients ($p=.008$) showed a decrease in overall verbal performance following exercise. On graphic tasks, however, nonapraxic patients tended to perform more poorly following exercise than apraxic patients. Seven of eight nonapraxic patients ($p=.035$) and five of eight apraxic patients ($p=.363$) showed a decrement in overall graphic ability following exercise. Added support for the point of view that verbal tasks may be especially troublesome for apraxic patients following a period of physical exercise is provided in Figure 4 which gives subjects' mean differences for verbal subtest IX. It is interesting that subjects' mean differences for subtest IX clearly differentiate (with the exception of one subject) the performances of aphasics with and without apraxia of speech. The fact that following exercise six of eight apraxics showed substantial decrements on subtest IX may indicate that verbally constraining carrier phrase tasks may be particularly difficult for the fatigued apraxic patient. It would seem to suggest that verbal performances of apraxic patients and graphic performance of nonapraxic patients would be most sensitive to adverse psychological or physiological conditions.

Learning Effects

Although subjects tended to improve their gestural performance from their first to their second PICA test, significant increases in group means from the first to the second PICA testing period were evidenced for only subtests III and X. The possibility exists that performance on these subtests may be related to variables other than whether or not testing followed exercise or rest periods. Table 1 shows that ten of sixteen subjects participating in the study

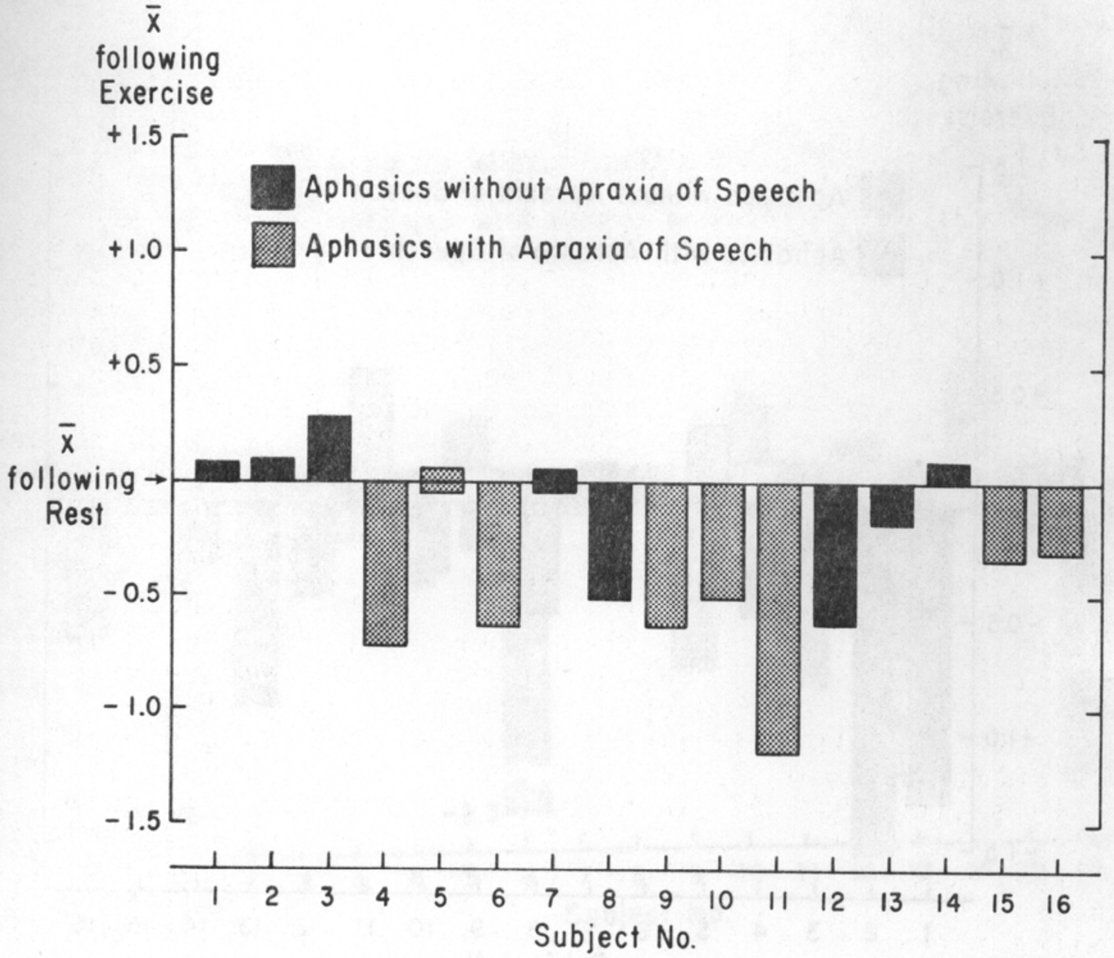

FIGURE 2. Mean differences for individual subjects' overall verbal means. The rest period is the reference point. Positive values indicate improvement following exercise, and negative values indicate poorer performance following exercise.

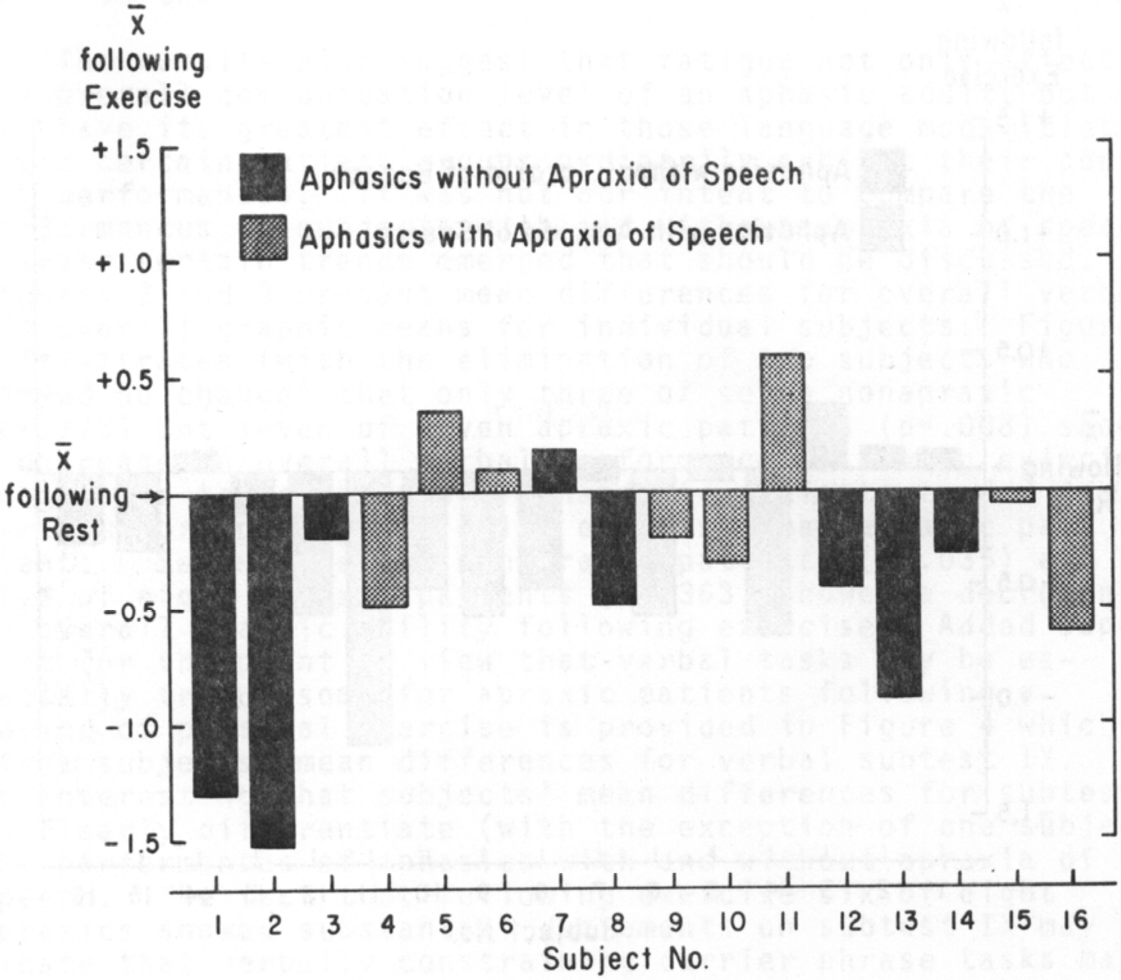

FIGURE 3. Mean differences for individual subjects' overall graphic means. The rest period is the reference point. Positive values indicate improvement following exercise, and negative values indicate poorer performance following exercise.

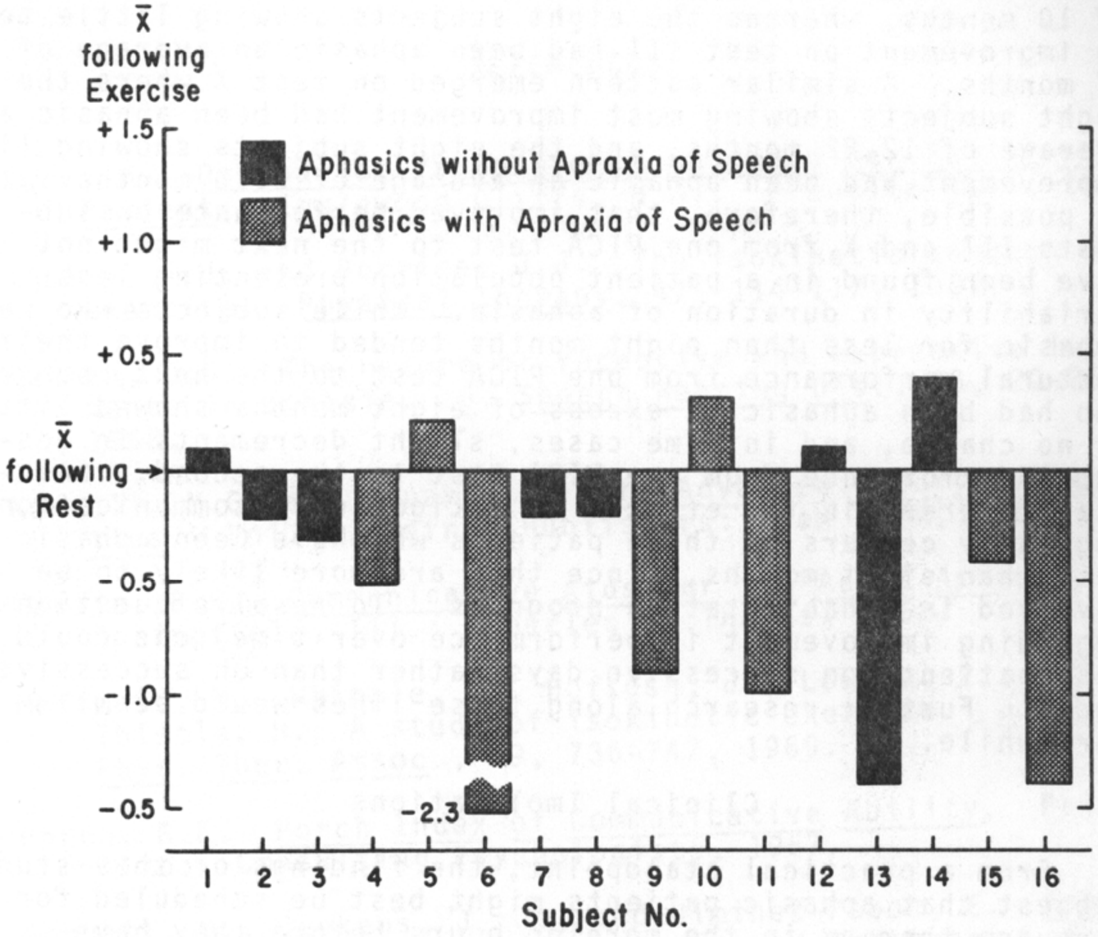

FIGURE 4. Mean difference on PICA subtest IX for individual subjects. The rest period is the reference point. Positive values indicate improvement following exercise, and negative values indicate poorer performance following exercise.

had been aphasic for eight months or less. Such patients could perhaps be expected to illustrate changes in performance, hopefully in the direction of improvement, over time. Subtest III and subtest X involve tasks on which such patients might improve their performance over a one week time interval. When the 16 subjects were ranked (irrespective of treatment sequence) in order of most to least improvement on subtest III it was found that the eight subjects showing most improvement had been aphasic an average of 10 months, whereas the eight subjects showing little to no improvement on test III had been aphasic an average of 27 months. A similar pattern emerged on test X where the eight subjects showing most improvement had been aphasic an average of 12.22 months, and the eight subjects showing little improvement had been aphasic an average of 26.5 months. It is possible, therefore, that improved performance on subtests III and X from one PICA test to the next might not have been found in a patient population presenting less variability in duration of aphasia. While subjects who were aphasic for less than eight months tended to improve their gestural performance from one PICA test to the next, subjects who had been aphasic in excess of eight months showed little or no change, and in some cases, slight decrements in gestural performance from one PICA test to the second. Clinical interest in the effects of fatigue upon communication logically centers on those patients who have been aphasic less than eight months, since they are more likely to be involved in rehabilitation programs. To resolve questions regarding improvement in performance over time, one could test patients on successive days rather than on successive weeks. Further research along these lines would seem worthwhile.

Clinical Implications

From a practical standpoint, the findings of this study suggest that aphasic patients might best be scheduled for language therapy in the morning hours before they have physically exerted themselves. If possible, the clinician should avoid scheduling aphasic patients for evaluation or therapy following strenuous activities such as physical or corrective therapy. Should the clinician, out of necessity, see the aphasic patient following a potentially fatiguing activity, he might take precautions to provide the patient with less difficult material than he normally uses to prevent over-taxing the patient's processing capabilities. Finally, the findings of this study point out the importance of the speech pathologist's role in serving as a member of the rehabilitation team. Since the aphasic adult spends only a small portion of his time with the speech pathologist, it becomes the speech pathologist's responsibility to apprise other clinicians and disciplines as to what to anticipate and to require in terms of communicative effort from a given patient as he moves through his rehabilitative course.

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