

The Hand Dynamometer as a Neuropsychological Measure

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The sensitivity of the hand dynamometer to the presence of brain damage and to its lateralization was evaluated and compared with that of the Tapping Test and the Tactual Performance Test. Four groups of 25 subjects each were studied (control, right-hemisphere damage, left-hemisphere damage, and bilateral damage). Measures of performance on each test included those of each hand taken separately as well as their sum. To identify the lateralization of brain lesions, a method was developed that used the control group as a basis for comparison and that simultaneously considered the relative performances of each hand on each task. All test variables discriminated between the control and brain-damaged groups at high levels of statistical significance. Furthermore, the dynamometer discriminated between these groups as well as did the Tapping Test and Tactual Performance Test. Finally, the dynamometer correctly identified the lateralization of brain lesions in more instances than either of the other tests. It is concluded that the hand dynamometer is a neuropsychological measure of considerable promise.

Many years ago, Halstead (1947) demonstrated that assessment of voluntary motor movement could be useful in evaluating the integrity of brain functions using such measures as the Tapping Test and the Tactual Performance Test. Reitan (1966) expanded the use of these measures by demonstrating that differences in performance between the two hands are related to the relative functioning capabilities of the two cerebral hemispheres. Thus, by examining level of performance and by comparing the two sides of the body, these tests of motor speed and

agility were established as reliable indicators of the integrity of brain functions.

Clinicians have realized that intensity or strength of voluntary motor activity might also be a reliable indicator of brain functions, and many use some strength-of-grip measure in neuropsychological assessment. Such use has led to an establishment of its clinical value as well as to a listing of the dynamometer by Reitan and Davison (1974) as a neuropsychological measure. On a research basis, Reitan (1974) demonstrated that the strength of grip of young brain-damaged and nonneurological children (ages 5-8) differs only slightly. Boll (1974), in working with older children (ages 9-14), found much more striking differences. No parallel studies have been done with adults that have directly compared brain-damaged persons with nonneurological controls, and none have evaluated the dynamometer with respect to the correct placement of lateralized lesions. The present study addresses these areas and evaluates the utility of the hand dynamometer in comparison with two other better established neuropsychological measures (Tapping Test, Tactual Performance Test).

This project was supported by National Institutes of Health Contracts N01-NS-0-2281 and N01-NS-6-2341 and by National Institutes of Health Grant NS 04053 awarded by the National Institute of Neurological and Communicative Disorders and Stroke, U.S. Public Health Service, Department of Health, Education, and Welfare.

The author gratefully acknowledges the contribution of Ralph M. Reitan to this study by providing the data for the neurological groups.

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Method

Subjects

Four groups of adults (ages 15 and over) were formed, with each group consisting of 25 persons. Subjects in the control group had negative neurological histories. They had never had any disease that might have affected the nervous system (meningitis, encephalitis, polio, diabetes, rheumatic fever, scarlet fever, etc.), and they had no histories of high fever, partial drowning, exposure to gas, heat exhaustion, fainting spells, or head trauma. They were recruited from a variety of community resources including churches, schools, and employment agencies.

Three groups of brain-damaged persons were selected on the basis of the primary location of brain damage (right hemisphere, left hemisphere, both cerebral hemispheres). In each group, there were 5 individuals with intrinsic brain tumors, 11 with a history of head trauma, and 9 with cerebral vascular problems. Neurological diagnoses were established by anamnestic information, angiography, pneumoencephalography, electroencephalography, skull x-rays, neurosurgical findings, and autopsy.

Across all groups, a subject-by-subject matching procedure was maintained for the variables of sex (there were 20 males and 5 females in each group), race (all subjects were Caucasian), and handedness (all subjects were right-handed). Within the brain-damaged groups, the subject-by-subject matching procedure included the general type of neurological difficulty (neoplastic, traumatic, vascular). Finally, within each set of 4 persons (1 from each group), matching was completed as closely as possible for age and years of formal education, with the result that each group averaged approximately 41.14 years of age and 10.68 years of education.

As part of their neuropsychological evaluations, all subjects were administered the dynamometer, the Tapping Test, and the Tactual Performance Test. Attention was given to the exact administrative procedures suggested by Reitan with a strong emphasis on maximal performance. To assess strength of grip, the Smedley Hand Dynamometer was used, which registers strength in kilograms. Two trials were given in alternating fashion for each hand beginning with the right (preferred) hand, and the average of the two trials was used as the final score for each hand.

Because the Tactual Performance Test provided a total time score summing all trials (including right hand, left hand, and both hands), summary scores (right plus left) for the Tapping Test and the dynamometer were also provided in addition to the usual scores for each hand alone.

Analyses

To evaluate the discriminability of the tests, univariate analyses of variance were run across all four groups for each test variable, and evaluations of significant differences between groups were assessed by the Newman-Keuls procedure (Winer,

1971). In these analyses, homogeneity of variance was maintained by converting all data to normalized standard scores with a mean of 50 and a standard deviation of 10. Performances on the Tactual Performance Test were considered on a minutes-per-block basis.

The effectiveness of each of the three tests in implicating lateralized damage was assessed using only the subjects with lateralized lesions. The performance by the left (nonpreferred) hand was divided by the performance of the right (preferred) hand so that in each instance a left-to-right comparison in performance could be made with a single score. The mean and standard deviation of this score for the control group were computed, and 1 standard deviation on either side of the mean was arbitrarily selected as the limit of normal performance. The performance of each individual in the right and left brain-damaged groups was then compared with this standard. If the performance for any brain-damaged patient on each of the three measures considered separately indicated that the right hand was not performing as well as would be expected in comparison with the performance of the left hand, the left cerebral hemisphere was considered to be implicated by that measure, and vice versa. Chi-square statistics were applied to the subjects who were classified by this procedure.

Results

The discriminability of each neuropsychological variable considered on a group-by-group basis is given in Table 1. Highly statistically significant differences across the groups were found with respect to every variable, and the control group did better than all brain-damaged groups in every instance. The dynamometer discriminated between the normal and brain-damaged groups as well as did either of the other tasks.

The lateralization data are presented in Table 2. If performance fell within the normal (1 standard deviation) range, neither hemisphere was considered implicated and placement was made in the "neither" group. When one hemisphere or the other was implicated, all three tests classified a majority of individuals correctly, and the dynamometer correctly classified the largest number.

Discussion

The high level of discriminability demonstrated by the dynamometer between normal and brain-damaged subjects was unexpected. It is true that the brain-damaged groups had

Table 1
Data on All Test Variables for All Groups

Test and variable	Control		Right damage		Left damage		Bilateral damage		F
	M	SD	M	SD	M	SD	M	SD	
Dynamometer									
Right hand	48.12 ^{b,c,d}	13.39	33.94 ^a	12.07	31.42 ^a	16.85	36.16 ^a	9.37	7.73
Left hand	44.86 ^{b,c,d}	12.15	21.42 ^{a,c,d}	15.18	37.21 ^{a,b}	12.75	32.44 ^{a,b}	11.83	13.73
Total (right + left)	93.96 ^{b,c,d}	25.12	55.36 ^{a,c,d}	22.24	68.61 ^{a,b}	26.48	68.60 ^{a,b}	19.61	10.43
Tapping									
Right hand	53.44 ^{b,c,d}	6.23	41.76 ^a	9.00	37.00 ^a	17.28	40.36 ^a	11.21	9.64
Left hand	49.60 ^{b,c,d}	5.37	30.72 ^{a,c}	14.30	39.24 ^{a,b,d}	11.50	34.60 ^{a,c}	10.28	17.11
Total (right + left)	103.04 ^{b,c,d}	10.43	72.48 ^a	20.27	76.24 ^a	26.08	75.44 ^a	18.97	11.96
Tactual Performance									
Right hand	.76 ^{b,c,d}	.50	4.42 ^a	5.54	5.70 ^{a,b}	6.03	2.54 ^{a,c}	3.28	12.25
Left hand	.64 ^{b,c,d}	.37	6.83 ^{a,c,d}	6.85	2.77 ^{a,b}	4.69	2.45 ^{a,b}	3.30	8.53
Both hands	.39 ^{b,c,d}	.21	4.24 ^a	5.94	2.27 ^a	4.29	1.59 ^a	3.15	8.13
Total (all trials)	.59 ^{b,c,d}	.32	4.14 ^{a,d}	5.25	2.63 ^a	4.18	1.74 ^{a,b}	2.16	11.07

Note. *F* statistics were computed on the basis of *T* scores. All *F*s were significant at the .001 level. *n* = 25. Superscripts designated groups with statistically different performances (*p* < .01).

^a Control.

^b Right damage.

^c Left damage.

^d Bilateral damage.

unequivocal evidence of cerebral involvement. It is also true that the nonneurological group consisted of "off the street" individuals rather than the hospital populations usually studied (Halstead, 1947; Reitan, 1955; Vega & Parsons, 1967). These facts may have

Table 2
Numbers of Subjects in the Right- and Left-Damaged Groups Classified According to the Lateralizing Implications of Their Performance

Test and group	Hemisphere implicated			χ^2
	Right	Left	Neither	
Dynamometer				
Right damaged	12	1	12	16.88**
Left damaged	3	13	9	
Tapping				
Right damaged	10	6	9	6.01*
Left damaged	3	7	15	
Tactual Performance				
Right damaged	9	3	13	6.39*
Left damaged	2	7	16	

* *p* < .05.

** *p* < .001.

served to accentuate the general differences between the groups, but they did not give the Tapping Test or the Tactual Performance Test any noticeable edge in discriminant ability over the dynamometer. This was particularly surprising in view of the extreme simplicity of the dynamometer. An incidental observation was that when performances by the preferred hand alone were considered, control subjects outperformed their matched brain-damaged subjects 91% of the time with the dynamometer, 82% of the time with the Tapping Test, and 84% of the time with the Tactual Performance Test. Thus, it appears that the dynamometer does effectively discriminate between normal and brain-damaged adults when consideration is made either on a subject-by-subject or on a group-by-group basis.

The discriminability of the dynamometer may in part relate to the age of the person to whom it is administered. It is of interest to note that Reitan (1974) showed only minimal discrimination between normal and brain-damaged young children with the dynamometer, but Boll (1974) showed better discrim-

inability consistent with that obtained with older children. The reasons for this are not clear, although it is possible that the test is most useful when a brain insult occurs well after the development of cerebral dominance.

The relatively good lateralization of lesions by the dynamometer was somewhat surprising. Admittedly, the criterion of 1 standard deviation above or below the control mean is arbitrary. Furthermore, it leads to findings that are, if anything, conservative in implicating one cerebral hemisphere or the other. For example, the performance by the control group with the left hand on the Tapping Test was approximately .93 that of the performance on the right hand. The standard deviation was .09, so that any score from .84 through 1.02 was considered within normal limits, whereas scores less than .84 implicated the right cerebral hemisphere and scores greater than 1.02 implicated the left cerebral hemisphere. If one assumes that a person's right (preferred) hand averages 50 on the Tapping Test, an identical performance by the left hand would fall in the range of normal limits, whereas clinical interpretation would definitely suggest that the right hand was slow. Furthermore, the score with the left hand would have to be 41 or less in order to implicate the right cerebral hemisphere, whereas in clinical practice scores of 42 or 43 would certainly raise the question of slowness with respect to the left hand. With the procedure being somewhat conservative, it is not surprising to discover that 42% to 58% of the people evaluated in the lateralization analysis (Table 2) had performances that implicated neither cerebral hemisphere on each test. However, the conservative and arbitrary nature of the procedure would not appear to favor any particular test and is not likely to account for the fact that when decisions were made, they were correct in 86% of the cases for the dynamometer and in 65% and 76% of the cases for the Tapping Test and the Tactual Performance Test, respectively.

The question can be raised as to whether or not a cutoff score should be established for the dynamometer in the same fashion that it has been established for the Halstead measures. This appears unwise, because (a) the

number of subjects in the present study is too small to constitute an adequate standardization sample, (b) there are obvious sex differences that would require separate norms, (c) certain vocational and avocational activities of individuals may affect scores on this test, and (d) the accuracy of the Smedley dynamometers depends on a spring that may become weakened with use and lead to error in measurement. Therefore, no effort has been made to establish a cutoff score.

Overall, the hand dynamometer both discriminates between normal and brain-damaged persons and lateralized lesions as well as do existing measures. It appears to be a promising neuropsychological measure that warrants both clinical use and further formal evaluation, especially in consideration of the brief administration time required vis-à-vis the other two neuropsychological measures (Tactual Performance Test, Tapping Test) conventionally used in the Halstead-Reitan battery.

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Received December 19, 1977 ■