A test, called the Functional Test, that evaluates the integrated function of the total upper extremity of an adult hemiparetic patient has been developed. It was used with 82 patients admitted to Rancho Los Amigos Hospital for stroke rehabilitation, together with a battery of six objective test measures. Sequential testing by two examiners demonstrated that the test had interrater reliability. The Functional Test score accounted for 87 percent of the variation in the scores achieved by the patients on the six separate objective measures. This tool integrates the information from these objective assessments and appears to be a valid measure of functional use of the hemiparetic upper extremity. The test can be administered in approximately 30 minutes, can be used in different treatment settings, and provides an accurate and immediate assessment of upper extremity capabilities.

Improvement in ability to perform purposeful tasks is the goal of all rehabilitation programs. The assessment of this improvement is too often indirect and many times subjectively derived from observations of performance. Upper extremity function requires variable and versatile interaction of multiple joints. This makes an objective assessment difficult. Few tests or objective measurements of total upper extremity function of the hemiparetic patient have been reported in the literature. Some evaluate the hand while ignoring proximal function (1, 2), others are less specific, including such activities as speech and ambulation skills (3-5), reasoning capacity, and social interaction (6). A cohesive evaluation of a hemiparetic patient’s ability to use the upper extremity for purposeful tasks has not been specifically addressed, although there are tests of the total somatosensory picture of the arm and hand (7, 8). In addition, most of these tests have not been evaluated for their reliability and validity (1, 3-8). Even though range of motion (passive and active), strength, motor control, and sensation can be tested objectively, the manner in which these components interrelate in performance of functional tasks has not been documented.

Attempts to document this relationship resulted in the development in 1964 of the first Upper Extremity Functional Use Test (9). This test consisted of 40 activities divided into 5 categories based on the upper extremity recovery stages of an adult following a cerebrovascular accident (CVA) (9, 10). The activities were sequenced in order of difficulty within each category depending on the degree of bilaterality required, and ranged from weighting down paper while writing to bilateral typing. The purpose of the test was to assess spontaneous use of the impaired upper extremity.

After use of the test in a pilot program, several problems were identified. First, there were too many test items, making the test impractical for a busy clinician to use. Second, more than half the 40 test activities were “too easy” for the patients; these activities could easily be accomplished with one hand. Third, the order of presenting the activities was not right. Many patients could perform activities in the more difficult categories and yet not succeed in some activities in the easier categories. The opportunity to develop a new test arose when a research
project for the stroke service at Rancho Los Amigos Hospital required an objective measure of total upper extremity function. The purpose of this paper is to report a study that determined the validity of the new Functional Test and to discuss the implications for the test's use in clinical practice.

Method
Subjects. Eighty-two hemiparetic consenting adult patients who were admitted consecutively for rehabilitation following onset of CVA to the Stroke Service at Rancho Los Amigos Hospital were included in the study. Only patients with bilateral dysfunction of the upper extremities were disqualified from the study.

Measurements. (A) The Functional Test: The purpose of the Functional Test is to evaluate the hemiparetic patient's motor capability for function. The Functional Test consists of 17 graded activities, 8 of which came from the upper Extremity Functional Use Test. The activities are arranged in seven levels by degree of difficulty (Figure 1). The tasks range from resisted contralateral muscle contractions intended to elicit associated reactions such as elbow or shoulder flexion in the impaired arm, to tasks requiring a high degree of upper extremity coordination and finger dexterity such as using the impaired arm to put a light bulb into a socket held at shoulder height. The Test measures specific motor abilities or combinations of abilities required to perform each task. Grading is on a pass-fail basis. After level 1, each task is timed, with the exception of associated reactions and patients who do not successfully complete an activity within the prescribed period (3 minutes) are failed on that activity. All tasks were standardized for equipment and patient positioning so that a highly experienced therapist would assess a patient's capability much the same as a less experienced therapist. A representative task from the Test illustrates the grading and structure (Figure 2). Loss of visual acuity and perceptual difficulties are routinely compensated for by verbal and visual cues from the examiner.

To determine interexaminer reliability of the Functional Test before the study, two therapists tested ten patients within a 2-day time period. It was found that all scores for the Functional Test were within one item of each other.

Figure 1
Functional test for the hemiplegic/paretic upper extremity

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>TASK</th>
<th>GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Patient is unable to complete higher-level tasks</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A. Associated reaction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Hand into lap</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. Shoulder abduction</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>D. Hold a pouch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E. Stabilize a pillow</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F. Stabilize a jar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G. Stabilize a package</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H. Wringing a rag</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I. Hold a pan lid</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>J. Hook and zip a zipper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K. Fold a sheet</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>L. Blocks and box</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M. Box on shelf</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N. Coin in coin gauge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O. Cat's cradle</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>P. Light bulb</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q. Remove rubber band</td>
<td></td>
</tr>
</tbody>
</table>

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These instructions from the Test protocol for task G illustrate the procedure for administering and grading this task. Similar instructions for each task are contained in the test manual.

**Level 4**

**Task G: Stabilize a Package**

(a) Place wrapping paper on the table with a 5 x 5 x 1-inch wood "package" centered on it.

(b) Show the patient how the "package" is to be wrapped.

Normal procedure: fold left side over right and secure with tape; fold in first bottom edge and secure with tape; repeat for opposite end.

(c) Place three 2-inch tape pieces on the edge of the table on the patient's good side.

(d) The patient must actively place his or her involved arm on the table and actively stabilize the package and paper while the uninvolved hand manipulates the paper and applies the tape.

(e) Record the time required to complete the task.

**Key Actions:**

**Table Top Placement Abilities**

**Grade:**

+ If the patient actively places the involved arm on the table and adequately stabilizes the package and paper while the good hand manipulates the paper and tape.

- If the paretic hand is unable to stabilize adequately for the package to be wrapped and taped securely.

- If the paretic hand interferes with wrapping the package (i.e., pushing the package away).

- If the patient uses the uninvolved hand to move the paretic hand to various holding postures.

for any individual patient. The reliability coefficient between the testers was 0.976, which was significant at the \( p < .001 \) level.

**(B) Objective Test Battery.** The objective test battery used in the study consisted of: 1. active selective extension of the elbow, wrist, and metacarpal (MP) joint of the index finger; 2. active shoulder flexion and abduction; 3. isometric wrist extension torque; 4. two-point discrimination on the palmar distal phalanx of the index finger; 5. proprioception of the index finger, wrist, and elbow; and 6. assessment of spasticity in the finger, wrist, and elbow flexors. These measurements were used because they could be assessed in a somewhat objective manner, are commonly used within the clinic, and the motions or activities measured contribute to function in the upper extremity.

**Procedures.** All testing was done on the first Friday following the patient's admission to the Stroke Service. The testing process involved four examiners, each responsible for one or more of the objective evaluations or for the Functional Test. For purposes of this study three examiners were used to administer the battery of objective tests, with patients rotating through each test station as examiners became available. The examiner responsible for administering the Functional Test was not involved in, or aware of, the grading on the objective test battery.

Active selective extension of the index finger, wrist, and elbow was measured by using electrical goniometers at the appropriate joint (12, 13). The examiner could hold the numeric display of the joint angle by depressing a foot switch. In this manner, the examiner was free to palpate muscles around the adjacent joints and freeze the numeric display when synergistic motion was first palpated. The accuracy of the goniometric equipment is ±1 degree (14). The selective range of motion measurement is repeatable to within 5 degrees when the goniometer is removed and replaced for test. Shoulder flexion and abduction were measured with a hand goniometer in the traditional manner, whereas adjacent joints were visually assessed for active muscle contraction.

Isometric wrist extension was measured with the hand and forearm pronated in a stabilizing orthosis equipped with strain gauge tensiometers. The wrist was positioned in neutral flexion and extension. When the patient extended the wrist, a numeric display recorded the maximum force produced. The accuracy of the device was ±0.5 pounds (14).

Two-point discrimination was tested with an aesthesiometer specifically engineered to assure equal pressure on both points (13). Therapist and patient positioning assured no sensory contact except for the aesthesiometer. Patients were tested with three pairs of stimuli at each of three discriminative levels. When all six responses were correct at the most coarse discriminative level of 9 mm separation, the patient was advanced to the intermediate separation of 6 mm. The final discriminative level was 4 mm of separation. The patient's discrimina-
tive level was determined when all six stimuli were identified correctly. A grade of greater than 9 mm was assigned if the patient was unable to identify correctly the first six stimuli.

Proprioception of the index finger and wrist was tested by using a specially designed Lucite guide (Figure 3). Successive arcs of 10 degrees each were marked from either side of a neutral position, yielding a total of a 100-degree arc. The patient’s hand or finger was aligned with the central mark, and motions to either side of neutral were carried out in the usual style of proprioception testing. The test was initiated with three motions of 10 degrees each from neutral, the direction being determined by a random numbers table. The arc of the motion was increased from 10 to 20 degrees if any of the three responses were incorrect. This procedure continued until three responses were correct, at which point four additional position changes were evaluated. If all seven responses were correct, the patient was assigned that total arc as the proprioception grade. Thus the best possible score was a 20-degree arc, 10 degrees either side of neutral. Elbow proprioception could not be done by using the guide because of technical difficulties, and was therefore tested in the traditional manner. Proprioception was graded at the elbow as intact, minimally, moderately, severely impaired, or absent.

Spasticity was evaluated by manually giving a quick stretch to the designated joint. A slight catch during the quick stretch was graded minimal spasticity. When a noticeable increase in force was needed to range the joint quickly, or if clonus occurred, the spasticity was graded moderate. When muscle tone prevented the examiner from quickly moving the joint, spasticity was graded severe.

Data Analysis. Spearman’s rank correlation was used to determine the interexaminer reliability of the Functional Test. The number of patients attempting and successfully completing each task on the Functional Test was evaluated to determine whether the ranking of items was appropriate. A multiple regression analysis was done to evaluate the patients performance on the Functional Test as compared to their composite scores on the objective test battery. In addition, a stepwise regression was done to determine which of the six objective tests of the battery was primarily responsible for the variation in the Functional Test scores.
Distribution of patients attempting and successfully completing each task. With only two exceptions, the number of patients succeeding in each task decreased as the difficulty of the task increased, indicating the activities are appropriately ranked.

### Results

During assessment with the Functional Test, the 82 subjects were evaluated on a total of 704 activities. Patients who were unable to perform one task adequately could successfully complete the next higher-level task only 2 percent of the time. At no time did a patient fail at two or more tasks and successfully complete a subsequent higher-level activity. No one activity was demonstrably more difficult or easy based on the number of patients who were discontinued from further testing (Figure 4).

Although 82 patients were evaluated, some patients were unable to comprehend or cooperate with testing, and this resulted in missing data. Only data from those patients who completed all six tests within the objective battery plus the Functional Test were included in all regression analysis (N = 52).

Evaluation of the data by the multiple regression analysis demonstrated that the composite scores from the test battery accounted for 86 percent of the Functional Test score ($p < .001$). Thus the Functional Test provided a measure comparable to that achieved when the battery of objective tests was given. The Functional Test required one examiner a maximum of 30 minutes to administer. A minimum of 30 minutes and often as much as 90 minutes were still required to complete the test series for any given patient.

The stepwise regression analysis demonstrated that four tests from the objective battery accounted for a total of 87 percent of the variation in the Functional Test scores. These four tests were selective wrist extension, voluntary wrist extension torque, shoulder range of motion, and the combined proprioception score for the finger, wrist, and elbow.

The remaining variation in the Functional Test scores, unexplained by the multiple or stepwise regressions, may have resulted from the patients' perceptual or visual acuity deficits that were incompletely compensated for by the verbal and visual cues. In addition, the patients' cognitive level and subsequent ability to cooperate with the testing procedure were complicating factors. No attempt was made to evaluate these factors.

### Discussion

The Functional Upper Extremity Test was designed to assess upper extremity functional deficits of the hemiparetic patient population. Although range of motion, strength, and sensation can each be semi-objectively measured, they fail to accurately predict individually total upper extremity capability. Therefore the Functional Test cannot be compared with any single objective measure to determine its validity. The Test is valid in the sense that it integrates information from several "objective" measures of upper extremity ability into a single "functional" score. Although this study used the Test only for initial assessment, we use the Functional Test routinely throughout the patient's rehabilitation treatment program to document progress. We find it an effective evaluation tool because evaluation of a patient's progress on an integrated treatment program requires more than individual measurement of the components of function. Also, this 30-minute assessment provides an index of functional gains that can be used to report progress toward treatment goals. The Functional Test has been found to be reliable since more than one therapist can administer the test and grade the patient with equivalent scores. In addition, through clinical use, we have found that the test can be administered by the same therapist.
several times with comparable grades given.

A weakness of the Functional Test is that it does not provide specific information about why a patient has failed a task. Thus, several patients may all fail the same task for different reasons: one because of sensory loss, another because of lack of muscle strength, and a third because of inadequate selective motor control. Although the Functional Test provides an overview of motor capabilities of the hemiparetic upper extremity, specific treatment goals must be determined by assessment of the components of function, namely, motor control, strength, and sensory awareness.

Patients who have had a CVA that results in hemiparesis frequently demonstrate cognitive and perceptual deficits that interfere with performance of abstract tasks. The concrete characteristics of the Test items lend themselves to successful completion by this patient group. In addition, the Test is useful in many different grades given. A brief time required for testing allows for immediate implementation of general treatment programs. Although these factors are necessary in the inpatient rehabilitation setting, the ability to reassess patients accurately and demonstrate functional improvement is critical in any treatment setting. Patients performing at a low level of function require only a brief testing period because of their inability to complete a large number of the tasks. Patients with good functional capability can rapidly complete the lower level of the Test. As they near their maximal functional level, more time is required for each task. A time limit for completion of each task ensures practical, functional performance, yet the maximum time to administer the test has never exceeded 30 minutes.

Conclusion
The Functional Test evaluates the integrated function of the total upper extremity of an adult hemiparetic patient and has been shown to be both valid and reliable. It enables an objective, integrated measurement of patient progress. It is a practical and time-saving clinical tool for assessing outcome of total upper extremity treatment programs. Because the Test uniquely evaluates the extremity as a whole, it is directly related to a patient's ability to perform specific functional tasks. Each task is related to a host of activities encountered in the functional world.

Acknowledgments
Our thanks to Laural Benton, PT, and Sherrel Shelton, PT, who assisted in testing. This study was supported in part by the Veterans Administration, contract V101 (134) P545.

Resources
The complexity of the test materials and length of the precise instructions preclude their inclusion in this paper. Detailed Functional Test instructions and equipment list are available from: The Professional Staff Association, Rancho Los Amigos Hospital, 7601 E. Imperial Highway, Downey, CA 90242.

Please address reprint requests to: Lucinda L. Baker, PT, Neuro-muscular Engineering—Bonita Hall, Rancho Los Amigos Rehabilitation Engineering Center, 7601 E. Imperial Highway, Downey, CA 90242.

REFERENCES