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Assessing daily use of the hemiparetic arm after stroke

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Abstract—*Background:* Data from monkeys with deafferented forelimbs and humans after stroke indicate that tests of the motor capacity of impaired extremities can overestimate their spontaneous use. Before the Motor Activity Log (MAL) was developed, no instruments assessed spontaneous use of a hemiparetic arm outside the treatment setting. *Objective:* To study the MAL's reliability and validity for assessing real-world quality of movement (QOM scale) and amount of use (AOU scale) of the hemiparetic arm in stroke survivors. *Methods:* Participants in a multisite clinical trial completed a 30-item MAL before and after treatment (n = 106) or an equivalent no-treatment period (n = 116). Participants also completed the Stroke Impact Scale (SIS) and wore accelerometers that monitored arm movement for three consecutive days outside the laboratory. All were 3 to 12 months post-stroke and had mild to moderate paresis of an upper extremity. *Results:* After an item analysis, two MAL tasks were eliminated. Revised participant MAL QOM scores were reliable (r = 0.82). Validity was also supported. During the first observation period, the correlation between QOM and SIS Hand Function scale scores was 0.72. The corresponding correlation for QOM and accelerometry values was 0.52. Participant QOM and AOU scores were highly correlated (r = 0.92). *Conclusions:* The participant Motor Activity Log is reliable and valid in individuals with subacute stroke. It might be employed to assess the real-world effects of upper extremity neurorehabilitation and detect deficits in spontaneous use of the hemiparetic arm in daily life.

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Commonly used measures of upper-extremity function after neurologic injuries assess motor capacity.[1,2] Measures of functional independence in the home[3] capture important aspects of rehabilitation outcome but cannot assess changes in real-world hemiparetic (i.e., more-impaired) arm function, as changes in scores on functional independence tests could result from improvements in more-impaired arm function, compensatory strategies, or both.[4] To evaluate actual use of the more-impaired arm outside of the treatment setting, our laboratory developed a structured interview named the Motor Activity Log (MAL).[4,5]

The importance of measuring spontaneous, real-world use of an extremity separately when assessing treatment outcomes is supported by the differential effects of constraint-induced movement therapy (CIMT)[5,6] on more-impaired arm use in daily life and more-impaired arm motor ability, as measured by laboratory-based motor performance tests.[7] Studies of the motor status of stroke[8,9] and traumatic brain injury survivors[10] have also found differences between what patients can do with their more-impaired arm and how much they actually use it. The effects of neurorehabilitation on real-world more-impaired arm use are largely unexamined and deficits in more-impaired arm use after neurologic injury may be underdiagnosed.[7] In this paper, we assess a method for evaluating more-impaired arm use, i.e., the 30-item MAL. We present item, content, reliability, and validity analyses of this instrument from a large, nationwide sample with subacute stroke.[11]

Additional material related to this article can be found on the *Neurology* Web site. Go to www.neurology.org and scroll down the Table of Contents for the October 10 issue to find the title link for this article.

Methods. *Participants.* Participants were individuals with subacute stroke (i.e., 3 to 12 months post-stroke) with mild to moderate motor impairment of their hemiparetic arm. All were enrolled in the Extremity Constraint-Induced Therapy Evaluation (EXCITE) trial (N = 229)[11] and had completed the baseline assessment (n = 222). The EXCITE trial is a single-blind, multisite, randomized clinical trial of CIMT,[5,6] which is an upper-extremity physical rehabilitation method based on behavioral neuroscience studies of deafferented monkeys.[12] Minimum motor criteria[11] for participants were ability to actively extend the wrist, the metacarpophalangeal and interphalangeal joints of the thumb, and of any two other digits of 10 degrees. In addition, all participants had to possess 45 degrees of active shoulder flexion and abduction and 20 degrees of active elbow extension and were required to show deficits in more-impaired arm use (average MAL score <2.5). Presence of a single stroke was determined by medical examination and history. All trial participants were randomized to either immediate or delayed treatment.[11] Immediate-treatment participants received 10 consecutive workdays of CIMT immediately

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Table 1 *Demographic, stroke-related, mobility, and impaired-arm characteristics of participants*

Characteristic	Immediate treatment, n = 106	Delayed treatment, n = 116	All participants, n = 222
Demographic			
Age, y (mean ± SD)	61.0 ± 13.5	63.3 ± 12.6	62.2 ± 13.0
Education, y (mean ± SD)	14.4 ± 3.5	14.0 ± 2.8	14.2 ± 3.2
Female, no. (%)	37 (35)	43 (37)	80 (36)
Race, no. (%)			
European American	71 (67)	86 (74)	157 (71)
African American	28 (26)	23 (20)	51 (23)
Other	7 (7)	7 (6)	14 (6)
Stroke related			
Paresis of right side, no. (%)	48 (45)	54 (47)	102 (46)
Concordance of paretic and dominant side, no. (%)	56 (53)	56 (48)	112 (51)
Type of stroke, no. (%)			
Ischemic	97 (92)	98 (84)	195 (88)
Hemorrhage	9 (9)	18 (16)	27 (12)
Real-world mobility			
SIS Mobility scale, points (mean ± SD)	73.3 ± 18.5	70.9 ± 18.8	72.0 ± 18.7
Duration of unimpaired-arm movement, % (mean ± SD)*	21.7 ± 9.4	22.5 ± 11.2	22.1 ± 10.3
Real-world impaired-arm function			
Motor Activity Log, points (mean ± SD)			
Patient QOM scale	1.5 ± 0.9	1.5 ± 0.9	1.5 ± 0.9
Patient AOU scale	1.4 ± 0.9	1.5 ± 1.0	1.4 ± 1.0
Caregiver QOM scale	1.1 ± 0.9	1.0 ± 0.9	1.1 ± 0.9
Caregiver AOU scale	1.1 ± 0.8	1.0 ± 0.9	1.1 ± 0.9
SIS Hand Function scale, points (mean ± SD)	30.4 ± 23.3	30.7 ± 23.3	30.3 ± 23.3
Ratio of impaired-to-unimpaired arm movement (mean ± SD)	0.56 ± 0.15	0.57 ± 0.17	0.56 ± 0.16
Impaired-arm Motor AbilityLevel of function, no. (%)†			
Higher	83 (78)	94 (81)	177 (80)
Lower	23 (22)	22 (19)	45 (20)

There were no significant differences between immediate- and delayed-treatment participants.

* The duration of less-impaired-arm movement as a percentage of the accelerometry recording period is reported; this parameter in calculated by dividing the number of epochs in the less-impaired arm accelerometer record with above-threshold values by the total number of epochs.[14]

† Based on active range of motion of the hemiparetic hand, participants were divided into higher (20 degrees wrist extension, 10 degrees metacarpophalangeal and interphalangeal joint extension at all digits) and lower (10 degrees wrist extension, 10 degrees metacarpophalangeal and interphalangeal joint extension at two digits and thumb) functioning subgroups.[6]

QOM = Quality of Movement; AOU = amount of use; SIS = Stroke Impact Scale Version 2.

after baseline testing. Over this period, delayed-treatment participants engaged in their usual activities, including any physical rehabilitation that might be part of customary care. They received CIMT 1 year later. Recruitment, randomization, and treatment procedures on the EXCITE trial are described in detail elsewhere.[11] Table 1 summarizes the participants' characteristics.

Measures. The MAL-30 is a structured interview during which patients are asked to rate how well (Quality of Movement [QOM] scale)[4] and how much (amount of use [AOU] scale)[4] their more-impaired arm was used to accomplish each of 30 activities of daily living (see table E-1 on the *Neurology* Web site at www.neurology.org). When available, the MAL is also administered independently to an informant who is usually a participant's primary caregiver. Both MAL scales are anchored at six points (0 = never used, 5 = same as pre-stroke), and participants may select scores halfway between the anchors.[4] Scale totals are the mean of the item scores. The original version of the MAL had 14 items.[4,5] Subsequently, 16 items were added and four were replaced to include activities of daily living (ADL) that might be accomplished by individuals with greater impairment of their hemiparetic arm than participants in early CIMT studies[5,6] possessed. Interview procedures were also more tightly codified[7]; current interview procedures are specified in the MAL testing manual.[13] Procedures on the EXCITE trial differed from previous studies[4,5,7] in that the MAL was only administered before and after treatment; in the previous studies, alternate halves were completed on each treatment day. In addition, interviewers did not probe changes in participants' responses, i.e., they did not ask whether scores that were different from those on the previous interview date represented an actual change in use.[4]

Accelerometers (Manufacturing Technologies Inc., Fort Walton Beach, FL), which are sensors that monitor movement, and the

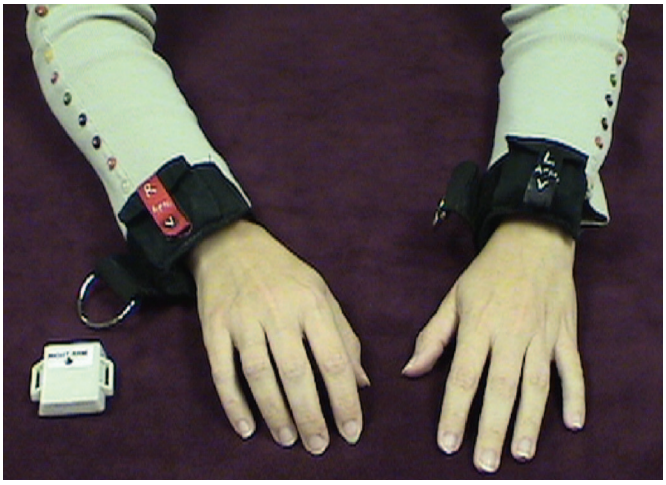

Figure. The accelerometers were placed in snug pouches sewn onto cloth and elastic bands, and one monitor was strapped onto each wrist. Participants wore the monitors for 3 days during all waking hours, except when they were in contact with water. The accelerometers (see unit next to right hand) contain a single piezoelectric crystal mounted in such a way that the monitors are sensitive to movement in two directions. The charge produced by the piezoelectric crystal when it is subject to acceleration is sampled at 10 Hz and integrated over a user-specified epoch. The integrated value, called a raw count, represents a rough index of the amount of movement by the object to which the accelerometer is attached. For example, lifting a can from a table to a shelf produces roughly 20 raw counts/second from a wrist-mounted accelerometer. The recording epoch in this study was 2 seconds; recording capacity for these wireless, self-contained monitors was approximately 72 hours.

Stroke Impact Scale (SIS) Version 2.0 Hand Function scale were used to obtain convergent measures of more-impaired arm function outside the laboratory. Accelerometers were worn on both forearms (figure) because a single unit on the more impaired arm might cue use of that extremity and thereby confound the measurement of treatment outcome.[14] Additionally, previous studies[14,15] suggest that the ratio of more-impaired to less impaired arm recordings controls adequately for variations in overall levels of physical activity (e.g., ambulation), whereas more-impaired arm recordings alone do not correct for such variations. The accelerometry methods and the reliability and validity of the ratio described above are presented in detail elsewhere.[14-16] The SIS is considered a reliable and valid self-report instrument.[17] It contains eight subscales, four of which assess different aspects of physical function and one subscale each that assesses cognitive problems, mood disorders, communication difficulties, and social participation. On the SIS Hand Function scale, participants rate their ability to use their more-impaired arm in their daily environment with a 5-point scale (1 = could not do at all; 5 = not difficult at all).

Two indices of overall physical activity, the SIS Mobility scale and recordings from the accelerometer worn on the less-impaired arm, were selected to test the discriminant validity of the MAL. The Mobility scale assesses participants' perceptions of their ability to move about in their daily environment. Using unimpaired-arm unit recordings as an index of overall physical activity is supported by studies showing that recordings from wrist-worn accelerometers are correlated with energy expenditure[18] and diary measures[19] of real-world, overall physical activity in healthy individuals.

Procedure. Immediate-treatment group participants and, if available, a caregiver or family member were asked to complete MALs in the laboratory before and after (tests 1 and 2) CIMT. The delayed-treatment group completed MALs on two occasions separated by approximately 14 days during which they did not receive CIMT. Participants also completed the SIS and wore accelerometers for 3 days outside the laboratory. When completing MALs, respondents were asked to report on their arm use over a 3-day period. Testing was conducted by trained, blinded project members, whose compliance with trial procedures was periodically checked by reviewing video of their performance.[11]

Data analysis. Item and content analyses of the MAL were conducted prior to evaluating its reliability and validity. Construct validity of the MAL was evaluated using a multitrait-multimethod approach.[20] In this approach, a measure is considered valid when it is more strongly correlated with measures tapping similar underlying constructs (i.e., convergent instruments; table 2) than with measures tapping other constructs (i.e., divergent instruments; table 2), irrespective of the measurement technique used. Multitrait-multimethod validation is a more robust approach than many other validation strategies because

Table 2 *Pearson correlations between the MAL scales and other measures of real-world arm function (convergent instruments) and measures of real-world mobility (divergent instruments; n = 222)*

	Convergent instruments (type)		Divergent instruments (type)	
MAL scales	Accelerometry ratio* (physical)	SIS Hand Function Scale (self-report)	Less-impaired arm accelerometer recordings† (physical)	SIS Mobility scale (self-report)
Participant				
QOM	0.52‡	0.72‡	0.14	0.14
AOU	0.47‡	0.68‡	0.14	0.14
Caregiver				
QOM	0.61‡	0.40‡	0.23§	0.07
AOU	0.57‡	0.35‡	0.25§	0.10

* The ratio of the duration of more- to less-impaired arm movement is reported.
† The duration of less-impaired-arm movement as a percentage of the recording period is reported. It is calculated by dividing the number of epochs in the less-impaired arm accelerometer record with above-threshold values by the total number of epochs. Each epoch was 2 seconds.[14]
‡ $p < 0.01$.
§ $p < 0.001$.

MAL = Motor Activity Log; SIS = Stroke Impact Scale Version 2; QOM = quality of movement; AOU = amount of use.

both convergent and discriminant validity are considered and the contribution of shared method variance (e.g., using two self-report instruments) to validation coefficients can be evaluated.[20] In this study, test 1 MAL-30 scores (self-report) from all participants were correlated with two similar measures of real-world arm function: the SIS Hand Function scale (self-report instrument) and ratio of more-impaired to less-impaired arm accelerometer recordings (physical measure). Test 1 MAL-30 scores were also correlated with two measures of overall real-world physical activity: the SIS Mobility scale (self-report instrument) and less-impaired arm accelerometer recordings (physical measure). Stability of the MAL was evaluated by paired t tests of test 1 and 2 scores in the delayed-treatment group. Test-retest reliability was evaluated by type 3,1 intraclass correlations (ICCs)[21] between test 1 and 2 scores in the same group. Because the MAL scales were highly correlated (see Results section), α values were corrected for inflation of family-wise error using the Bonferroni procedure. Correlations were characterized as weak ($r = 0.1$), moderate ($r = 0.3$), and strong ($r = 0.5$) following the convention in the meta-analysis literature.[22]

Results. *Item analysis.* We evaluated items using several traditional approaches, including examination of item-total correlations, reliability, and frequency with which the item was deemed not applicable at test 1 (i.e., proportion of missing data; table E-1). Two items had a higher or equal proportion of missing data than the a priori cutoff of 20%: write on paper (48%) and put make-up/shaving cream on face (20%). Write on paper was not applicable to many because most participants who had paresis of their nondominant side had never used their more-impaired hand for writing prior to the stroke. It appeared that put make-up/shaving cream on face was not applicable to large numbers because many men after stroke switch to an electric razor, which does not require shaving cream. This item, in addition, had lower item-total correlations and reliability coefficients than others. Consequently, these items were dropped for all subjects when calculating test scores. All of the remaining items were completed by >80% of participants. Furthermore, 92% of these items had item-total correlations >0.5, whereas 89% had reliability coefficients above this threshold (table E-1). Internal consistency of the revised test was high; Cronbach's α was 0.94 for both the QOM and AOU scales.

Item-total correlations and reliability coefficients for the caregiver MAL were largely similar to those for the patient MAL (table E-1). Not surprisingly, there was a larger number of items with >20% missing data for the caregiver MAL[5] than for the patient MAL.[2] Except for write on paper, they were virtually all ADL that are typically performed in private (e.g., brush teeth, comb hair). Because we thought it was desirable for patients and caregivers to report on identical items, we only removed the same two items from the caregiver MAL that were dropped from the patient MAL. In addition, the proportion of missing data for the other three items with >20% missing data were not excessive (range 21 to 33%). Internal consistency of the revised test was high; Cronbach's α was 0.95 for both the QOM and AOU scales. Table E-2 summarizes the content analysis of the test.

Reliability and validity of revised test. Construct validity of the revised patient MAL was supported. Correlations between the patient MAL QOM and AOU test scores and other measures of more-impaired arm function (Hand Function scale, accelerometry ratio) were strong, whereas correlations between the patient MAL scales and measures of overall physical activity (Community Mobility scale, less-impaired arm accelerometer recordings) were weak (table 2). Not surprisingly, the correlation of the patient MAL scales with the other subjective measure of more-impaired arm function (Hand Function scale) was somewhat stronger than with the objective measure (table 2). The correlation between the QOM and AOU scores was 0.92 ($p < 0.001$). Patient MAL QOM and AOU test scores from delayed-treatment participants were reliable (QOM: ICC = 0.82; AOU: ICC = 0.79). However, the stability of their scores was questionable; there was a trend toward an increase from test 1 to 2 (QOM: 0.3 ± 0.5, $p = 0.02$; AOU: 0.3 ± 0.6, $p = 0.04$).

Construct validity of the caregiver MAL QOM and AOU scales was also supported. Correlations between the caregiver MAL scales and Hand Function scale and accelerometry ratio were moderate to strong, whereas correlations between the caregiver MAL scales and Community Mobility scale and less-impaired arm accelerometer recordings were weak (table 2). Interestingly, the correlations between the caregiver-MAL scales and Hand Function scale were substantially weaker than corresponding correlations for the patient MAL scales, suggesting that common method variance (i.e., both the patient MAL and Hand Function scale are self-reports) contributed to the very strong correlations observed between the patient MAL scales and Hand Function scale ($r > 0.68$). The correlation between participant and caregiver forms of the revised MAL was 0.59 ($p < 0.001$) for each of the scales. Delayed treatment group caregiver MAL QOM and AOU test scores were less reliable (QOM: ICC = 0.72; AOU: ICC = 0.66) than patient MAL test scores. The stability of the caregiver scores was also questionable; there was a trend toward an increase from test 1 to 2 (QOM: 0.4 ± 0.7, $p = 0.02$; AOU: 0.4 ± 0.7, $p = 0.05$). Validity and reliability coefficients for the original (30-item) and revised (28-item) versions of both the patient and caregiver MAL were similar.

Discussion. Two guidelines were used when the MAL items were chosen: each item had to be encountered commonly and the items together had to cover a comprehensive range of activities. The item analysis indicates that the first guideline was applied successfully. Excluding the two items that were dropped, the ADL on the test were encountered by an average of 94% of participants. This is important because comparing scores across participants or time would be problematic if in each instance participants report on markedly different subsets of items. The content analysis (table E-2) suggests that the second guideline was also applied successfully. The MAL-28 items encompass both basic[23] (63%) and instrumental[23] ADL (41%) from multiple spheres (e.g., eating, dressing, and housework). Furthermore, approximately two-thirds of items require finger movement, whereas one-third do not and, according to how able-bodied individuals use their upper extremities, approximately half of the items are unimanual, one-fourth bimanual, and one-fourth either. The wide array of ADL increases confidence that differences in MAL-28 test scores reflect differences in upper extremity use generally rather than on a narrow set of

tasks. Notably, despite this broad range, the adequate internal consistency coefficients and relatively uniform item-total correlation values for the MAL-28 suggest that the items retained all measure a single construct (i.e., that scores for the various types of ADL typically move together).

The analysis of the MAL-28 test scores suggests that the patient QOM and AOU scales are reliable and have convergent and discriminant validity. Patient scales were strongly correlated with other measures of real-world more-impaired arm function and weakly correlated with measures of overall physical activity (table 2). The data also indicate that the caregiver scales are valid but less reliable than the patient scales. Caregiver reliability may have been reduced because they only observed selected slices of patient behavior on each occasion (i.e., tests 1 and 2) that were not representative of patients' arm use in general.

Post hoc analyses of the effect of side of paresis on MAL scores suggest that on average patients with paresis of their prestroke dominant arm detect deficits in use of the more-impaired arm, relative to prestroke, that are no different from those with paresis of their prestroke nondominant arm. For example, the mean QOM score before treatment for patients with paresis of their dominant arm was 1.4 ± 0.8. For those with paresis of their nondominant arm, the mean QOM score was 1.6 ± 1.0, which was not significantly different. In addition, the reliability and validity of the patient MAL did not vary substantially with side of paresis except for convergent validity between the MAL and accelerometry ratio. Although the correlation between the MAL and accelerometry ratio was significant in both patients with paresis of the dominant and nondominant arm, it was stronger in patients with paresis of their dominant arm (QOM: $r = 0.59$; AOU: $r = 0.56$) than in others (QOM: $r = 0.34$; AOU: $r = 0.28$). This post hoc finding is supported by a study of more-impaired arm use during 15-minute videotaped periods of spontaneous activity in 16 individuals with chronic stroke (i.e., >1 year post-stroke) who wore accelerometers that monitored their arm movements (G. Uswatte, unpublished data, February 2006). Amount of more-impaired arm use was evaluated in 2-second intervals from the videotape by trained observers using a reliable scale.[24] The correlation between more-impaired arm use and the accelerometry ratio for individuals with paresis of their dominant arm was 0.73. For those with paresis of their nondominant arm, the corresponding correlation was only 0.43. Together, these findings suggest that movement of the more-impaired arm after stroke is more frequently connected with the performance of functional activities when hemiparesis affects the upper extremity that was dominant pre-stroke than otherwise.

Our results are mostly consistent with a recent study of the 14-item MAL in individuals with chronic, mild to moderate arm motor impairment after stroke that found the patient QOM scale was a reliable and valid measure of real-world arm use.[4] However, the MAL-14 study found that the MAL was stable over a 2-week placebo control period, whereas this study found that its stability was questionable. Possible reasons delayed-treatment participants showed increases in scores from test 1 to test 2 are that some participants might have experienced spontaneous recovery because their strokes were subacute or gains in more-impaired arm use after usual and customary care. An alternate explanation is that the first administration of the MAL primed participants to remember when they used the more-impaired arm. In any case, the increases were small; they were less than the minimal clinically important difference (i.e., <0.5 points)[4,25] on the MAL. Another divergent finding was that the patient AOU scale in the MAL-14 study was found to be less reliable than the patient QOM scale. Reliability of the patient AOU scale may have been adequate in this study because of the larger number of items on the MAL-28 than the MAL-14. Regardless, both studies suggest the AOU scale might be dropped because the QOM and AOU scales are highly correlated with each other (MAL-28, $r = 0.92$, MAL-14, $r = 0.8$) and have similar associations with the convergent measures used in each study. Whether the MAL-28 is a better test than the relatively brief MAL-14 cannot be evaluated directly with data from this study because only eight of the MAL-14 items are on the MAL-28.

A limitation of this study was that we did not examine correlations between pre- and posttreatment changes on the MAL and other measures. The reason was that the authors were kept blind to EXCITE trial outcomes until all delayed-treatment subjects received CIMT. The MAL-14 study,[4] however, suggests that the MAL is a valid and responsive measure of treatment outcome. van der Lee and colleagues,[25] in an article on the Dutch MAL, raise concerns about its validity for measuring treatment outcome because they found weak correlations between changes on the MAL and a measure of more-impaired arm motor capacity and a single-item, unvalidated patient rating scale of more-impaired arm function. Problems with this validation method that challenge the conclusions of van der Lee et al. have been discussed previously.[4]

As noted, the severity of motor impairment, under certain conditions, is not a reliable indicator of amount of more-impaired extremity use in daily life. One explanation of how such a dissociation occurs is learned nonuse, which is based on research using a deafferented monkey model (reviewed by Taub[26]). This research program showed that monkeys do not use a forelimb from which somatic sensation has been abolished surgically because of the contingencies of reinforcement that prevail soon after deafferentation. Although dorsal rhizotomy leaves the motor neurons controlling the deafferented limb intact, these motor neurons remain in a state of re-

duced excitability for several weeks to months after surgery. Therefore, when the monkeys attempt to pick up a food object or support themselves using their deafferented limb during this period, they are unable to coordinate movements of that limb and fail. These failures constitute punishments that suppress attempts to use the deafferented forelimb. Meanwhile, the animals are able to operate in their environment successfully using their other limbs and are thereby rewarded for this compensatory pattern of behavior. When the motor neurons spontaneously return to a state of sufficient excitability and the animals recover the ability to control movements of their deafferented limb, the monkeys continue to avoid using the deafferented limb because of their learning history in the immediate postinjury period. Without an intervention to countercondition the suppression of deafferented forelimb use, a permanent dissociation prevails between motor ability of the deafferented extremity, which is not normal but sufficient for an animal to manipulate objects and support its weight, and how much it used spontaneously. Learned nonuse is also thought to occur in humans after neurologic or other injuries that result in an initial severe loss of function, attempts to use the impaired function during this initial period that are punished, attempts to use compensatory strategies that are reinforced, and a subsequent gradual recovery of function.[7,12]

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Table (E)T-1 *Item Characteristics of the Patient (n = 222) and Caregiver (n = 185) Forms of the MAL*

		Patient MAL					Caregiver MAL				
			QOM Scale		AOU Scale			QOM Scale		AOU Scale	
Item	Description	Not applicable*	Item–total correlation†	Test–retest reliability‡	Item–total correlation	Test–retest reliability	Not applicable	Item–total correlation	Test–retest reliability	Item–total correlation	Test–retest reliability
1	Turn on a light with a light switch	1%	.64	.54	.60	.56	12%	.57	.41	.54	.46
2	Open drawer	2%	.66	.53	.60	.55	17%	.69	.61	.65	.72
3	Remove an item of clothing from drawer	2%	.60	.55	.67	.52	20%	.83	.61	.77	.63
4	Pick up phone	3%	.62	.64	.61	.65	9%	.64	.49	.55	.59
5	Wipe off a kitchen counter or other surface	7%	.49	.40	.55	.47	16%	.57	.38	.52	.42
6	Get out of a car	4%	.51	.45	.61	.51	7%	.56	.51	.48	.56
7	Open refrigerator	2%	.56	.50	.54	.57	9%	.62	.60	.62	.53
8	Open a door by turning a door knob	3%	.66	.64	.67	.64	9%	.71	.58	.68	.71

9	Use a TV remote control	8%	.58	.57	.54	.52	11%	.66	.51	.55	.57
10	Wash your hands	0	.62	.72	.53	.64	15%	.71	.67	.66	.46
11	Turning water on/off with knob/lever on faucet	1%	.70	.51	.70	.54	18%	.76	.64	.74	.57
12	Dry your hands	0	.65	.76	.54	.63	14%	.79	.72	.65	.53
13	Put on your socks	4%	.63	.65	.64	.68	12%	.56	.67	.54	.69
14	Take off your socks	3%	.61	.51	.63	.65	17%	.69	.59	.66	.59
15	Put on your shoes	2%	.62	.54	.54	.56	9%	.69	.63	.59	.61
16	Take off your shoes	14%	.57	.57	.61	.55	21%	.70	.59	.71	.66
17	Get up from a chair with arm rests	4%	.61	.60	.59	.58	12%	.72	.61	.69	.58
18	Pull chair away from table before sitting down	5%	.66	.53	.70	.50	13%	.78	.55	.79	.61

19	Pull chair toward table after sitting down	7%	.64	.63	.62	.62	18%	.80	.42	.72	.42
20	Pick up a glass, bottle, drinking cup, or can	1%	.70	.57	.67	.54	2%	.70	.56	.67	.38
21	Brush your teeth	18%	.60	.46	.64	.44	34%	.57	.33	.57	.35
22	Put on makeup base, lotion, or shaving cream on face	20%	.46	.29	.51	.27	25%	.56	.26	.42	.29
23	Use a key to unlock a door	16%	.56	.59	.55	.49	20%	.61	.44	.63	.34
24	Write on paper	48%	.65	.65	.49	.61	52%	.65	.58	.65	.53
25	Carry an object in your hand	1%	.58	.53	.61	.47	3%	.68	.51	.64	.57
26	Use a fork or spoon for eating	6%	.56	.67	.55	.61	8%	.60	.69	.60	.67
27	Comb your hair	15%	.40	.46	.38	.46	21%	.66	.46	.70	.32
28	Pick up a cup by a	8%	.64	.51	.61	.49	13%	.78	.61	.76	.46

	handle										
29	Button a shirt	10%	.47	.60	.37	.55	17%	.58	.65	.55	.70
30	Eat half a sandwich or finger foods	4%	.67	.68	.66	.62	5%	.77	.67	.74	.65

*Scoring of the MAL on the EXCITE trial differed from previous studies.[1, 2, 5] In addition to dropping items if they were impossible when calculating the test score (e.g., comb hair for a bald person), items were dropped if they had not been encountered during the period reported on or were not conducted with the more-impaired arm prior to stroke (e.g., write on paper for an individual with paresis of the non-dominant side). In the previous studies,[1, 2, 5] the last two types of responses were given a value of 0. The reasons that items with these types of responses were dropped instead on the EXCITE trial were that giving a value of 0 was thought to bias the test against individuals who did not encounter particular items or had paresis of the non-dominant side.

†For each item, the Pearson correlation between it and sum of the other items is reported.

‡Test-retest reliability was assessed by Type 3,1 intraclass correlations[22] between Test 1 and 2 scores in the Delayed-treatment group.

MAL = Motor Activity Log; QOM = Quality of Movement; AOU = Amount of Use.

Table (E)T-2 *Types of Upper-extremity Activities on the Motor Activity Log (MAL)*

			Type of Activity		
Item	Description	Sphere*	Basic or Instrumental†	Uni- or Bimanual‡	Finger Movement Required§
1	Turn on a light with a light switch	Manipulating environment	Instrumental	Unimanual	No
2	Open drawer	Manipulating environment	Instrumental	Uni/Bimanual	Yes/No
3	Remove an item of clothing from drawer	Dressing	Basic	Uni/Bimanual	Yes/No
4	Pick up phone	Communicating	Instrumental	Unimanual	Yes
5	Wipe off a kitchen counter or other surface	Housework	Instrumental	Unimanual	No
6	Get out of a car	Transferring	Instrumental	Uni/Bimanual	No
7	Open refrigerator	Housework	Instrumental	Unimanual	Yes
8	Open a door by turning a door knob	Manipulating environment	Instrumental	Unimanual	Yes
9	Use a TV remote control	Manipulating environment	Instrumental	Unimanual	Yes
10	Wash your hands	Grooming	Basic	Bimanual	No
11	Turning water on/off with knob/lever on faucet	Manipulating environment	Instrumental	Unimanual	Yes/No
12	Dry your hands	Grooming	Basic	Bimanual	No
13	Put on your socks	Dressing	Basic	Bimanual	Yes
14	Take off your socks	Dressing	Basic	Uni/Bimanual	Yes
15	Put on your shoes	Dressing	Basic	Bimanual	Yes
16	Take off your shoes	Dressing	Basic	Uni/Bimanual	Yes

17	Get up from a chair with arm rests	Transferring	Basic	Bimanual	No
18	Pull chair away from table before sitting down	Transferring	Basic	Uni/Bimanual	No
19	Pull chair toward table after sitting down	Transferring	Basic	Bimanual	Yes
20	Pick up a glass, bottle, drinking cup, or can	Eating	Basic	Unimanual	Yes
21	Brush your teeth	Grooming	Basic	Unimanual	Yes
22	Put on makeup base, lotion, or shaving cream on face	Grooming	Basic	Uni/Bimanual	Yes
23	Use a key to unlock a door	Manipulating environment	Instrumental	Unimanual	Yes
24	Write on paper	Communicating	Instrumental	Unimanual	Yes
25	Carry an object in your hand	Manipulating Environment	Instrumental	Unimanual	Yes
26	Use a fork or spoon for eating	Eating	Basic	Unimanual	Yes
27	Comb your hair	Grooming	Basic	Unimanual	Yes
28	Pick up a cup by a handle	Eating	Basic	Unimanual	Yes
29	Button a shirt	Dressing	Basic	Bimanual	Yes
30	Eat half a sandwich or finger foods	Eating	Basic	Unimanual	Yes

Note. The content analysis was carried out by a panel consisting of a physical therapist, occupational therapist, behavioral neuroscientist, and rehabilitation psychologist, all of whom had extensive experience in upper-extremity rehabilitation research. The initial categorization of items was conducted independently; any differences were resolved by consensus. When classification of

an item into one category or another (e.g., uni- or bimanual) depended on the qualities of the specific object being manipulated (e.g, a narrow drawer with one handle versus a wide drawer with two handles), both categories were listed (e.g., uni/bimanual).

[*]Items were divided into spheres of activity based on a description of activities of daily living (ADL) provided by the National Center for Health Statistics;[24] items that did not fall into one of the spheres listed by the National Center for Health Statistics were put in the category "Manipulating environment".

[†]Items were classified as basic and instrumental ADL according to the definitions given by the National Center for Health Statistics.[24]

[‡]Items were deemed uni- or bimanual depending on how they are performed typically by individuals without impairment of the upper-extremities. As noted, the MAL was not administered during treatment on the EXCITE Trial. On studies in which the MAL was administered daily during therapy,[1, 2, 5] virtually all items were carried out unimanually during the treatment period as the less-impaired arm was prevented from being used by a restraint device for up to 90% of waking hours.

[§]Items were classified as requiring finger movement if the activity called for objects to be manipulated by the hand and fingers to be successfully accomplished.