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An Investigation of Limb Apraxia Regarding the Validity of Current Assessment Procedures

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Limb apraxia has been recognized as a distinct manifestation of brain damage since the early 1900s. It is usually defined as a disturbance in the performance of skilled, purposeful motor movements that cannot be attributed to impairments of strength, sensation, coordination, verbal comprehension, or general intelligence (Duffy & Duffy, 1989; Rothi, Ochipa, Leadon, & Meher, 1989). Skilled intentional movements involving either limb are compromised despite the presence of normal reflexes, power, tone, and mobility, as well as seemingly adequate comprehension of the eliciting verbal request. Beyond this general definition, however, there is little agreement. A consensus has yet to emerge regarding observed symptoms, the neuropsychological processes producing the symptoms, or the brain structures involved.

This lack of consensus is reflected in current approaches to clinical assessment. For the most part, the clinical assessment of limb apraxia has been highly subjective and variable. It is currently based on a set of logical distinctions regarding *movement type* (e.g., transitive pantomimes vs. intransitive gestures or meaningful movements vs. nonmeaningful movements) and *eliciting modality* (verbal, visual, and imitative) that have seldom been subjected to rigorous empirical investigation (DeRenzi, 1985). Indeed, even the traditional division of limb apraxia into types—ideational versus ideomotor—has been based on *a priori* distinctions defined by the assessment procedures employed. Ideomotor apraxia (IMA) is usually assessed by observing the production of transitive pantomimes and intransitive gestures elicited in response to verbal commands or imitation (Heilman, Rothi, & Valenstein, 1982; Helm-Estabrooks, 1990). Ideational apraxia (IA), however, is presumed by most investigators necessarily to involve the manipulation of single or multiple objects (DeRenzi & Lucchelli, 1988; Ochipa, Rothi, & Heilman, 1989; Poeck & Lehmkuhl, 1980). In any case, there have been few attempts in the past to verify empirically the validity of this distinction (Duffy & Duffy, 1989).

This state of affairs is unfortunate, for limb apraxia has emerged as a critical issue in the assessment and clinical management of aphasic patients. Helm-Estabrooks and Albert (1991) have written that an early apraxia assessment is crucially important in evaluating aphasic individuals; otherwise, they claim, results of language and cognitive testing may be misleading, because most aphasic examinations require the individual to produce purposeful movement. Furthermore, limb apraxia is the most frequently cited reason for aphasic patients' frequent failure to use nonverbal gestures for communicative purposes (Duffy & Duffy, 1989). Nevertheless, despite its clinical and theoretical significance, the assessment of limb apraxia has been based on distinctions yet to be empirically validated.

PURPOSE OF THE INVESTIGATION

The present investigation was designed to assess the validity of distinctions reported in the literature as important to the assessment IMA and its differentiation from IA. Multiple task comparisons across a group of aphasic subjects were used to make this assessment. The investigation addressed the following specific issues and questions:

1. *The validity of the modality effect:* Does the assessment of IMA through production of transitive pantomimes vary according to the modality used to elicit the response (verbal instructions, visual presentation, or imitation)?

2. *The validity of movement type distinctions:* Do transitive pantomimes versus intransitive gestures or meaningful movements versus nonmeaningful movements represent distinct classes of praxis that may be differentially affected by brain damage?

3. *The validity of types of limb apraxia:* Do the behavioral deficits traditionally associated with IA and IMA reflect different neuropsychological processes, or do they simply reflect a continuum of severity?

METHOD

Subjects

The subjects in this investigation were 20 left-hemisphere-damaged aphasic adults (15 males, 5 females). The mean age of the subjects was 63 years, with a standard deviation of 13.5 and a range of 24 years to 85 years. Mean educational level was 13.5 years, with a standard deviation of 3.53 and a range of 8 years to 19 years. Time post onset averaged 28 months, with a standard deviation of 37.4 and a range from 1 month to 13.5 years. Severity of aphasia, as measured by the overall percentile on the *Porch Index of Communicative Ability* (PICA) (Porch, 1981), ranged from the 12th to the 87th percentile, with the mean occurring at the 53rd. Half of the subjects were above the 50th percentile and half were below. Handedness of the aphasic subjects and hand used in the study were not reported.

The Fluency Rating scale from the *Western Aphasia Battery* (WAB) (Kertesz, 1982) was used to classify subjects as fluent or nonfluent. On this basis, 14 subjects were classified as nonfluent, and 6 were classified as fluent.

Comparison With Neurologically Normal Controls

Ten neurologically normal (NN) subjects were also included in the investigation for comparison purposes. Six of the NN subjects were males, and four were females. All were right-handed by self-report with no previous histories of neurologic or psychiatric illness. The mean age of the NN subjects was 67 years, with a standard deviation of 13.2 and a range of 45 to 82 years. Mean educational level was 12 years, with a standard deviation of of 3.4 and a range of 8 to 17 years.

T-tests indicated that the age and the educational levels of the aphasic and NN subjects did not differ significantly (age: $t = -.90$, $df = 28$, $p = .38$; education: $t = 1.03$, $df = 28$, $p = .31$).

Procedures

Subjects were administered the following experimental tasks:

1. *The Multiple Object Test (MOT):* Given the necessary objects, subjects were asked to (a) light a candle, (b) open a bottle and pour out its contents, (c) prepare a cup of coffee, (d) pretend to smoke a cigarette, (e) begin to paint a picture, (f) pound a nail into a block of wood, and (g) beat an egg. Tasks of this type are generally accepted as valid elicitation measures of IA (DeRenzi, 1985; Poeck & Lehmkuhl, 1980). A modification of a scoring procedure reported by DeRenzi and Lucchelli (1988) was employed to assess performance on the MOT. Each subject's score was the total number of errors made across the seven individual test items. Possible error types included mislocation errors, misuse errors, sequencing errors, and perplexity errors.

2. *Three transitive pantomime tasks (TP-VIS, TP-VER, TP-IM):* The three transitive pantomime tasks were identical except for the modality used to

elicit the response: TP-VIS was visual; TP-VER was verbal; and TP-IM was imitative. Test items for the transitive pantomime tasks consisted of pantomiming the function of 15 common objects. For the transitive pantomime tasks, as well as for all subsequent tasks, subject performances were judged using a multidimensional scoring procedure adapted from that employed on the PICA.

3. *Two intransitive gestural tasks (IG-IM and IG-C):* The first intransitive gestural task was imitative; the second involved eliciting the target gestures using verbal commands. Test items for the intransitive gestural tasks consisted of eight well-known symbolic gestures such as waving good-bye and making the victory sign.

4. *A single measure of the ability to imitate nonmeaningful movements (IM-NMM):* This measure consisted of the first subtest of the *Limb Apraxia Test* (LAT) (Duffy & Duffy, 1989).

Tasks 2 through 4 are generally accepted measures of IMA (Heilman et al., 1982; Helm-Estabrooks, 1990; Wang, 1990). All scoring was done on the basis of videotapes made at the time of task administration.

Reliability

Intraexaminer reliability coefficients were obtained for all measures and ranged from .93 to .99. Interexaminer reliability coefficients were not reported. Test-retest reliability coefficients for 10 aphasic subjects ranged from .81 to .97.

RESULTS

Comparison of Aphasic and NN Subjects

Table 1 presents the results of a series of *t*-tests between performances of aphasic and NN subjects on all experimental tasks. The results demonstrate that the aphasic subjects performed significantly less well than the NN subjects on six of the seven tasks. Only on the intransitive gestures–imitation (IG-IM) task were the mean performances of the aphasic and NN subjects *not* significantly different ($p = .05$).

The Modality Effect

The hypothesis that the aphasic subjects' production of transitive pantomimes might vary depending on the eliciting modality was not sup-

Table 1. Comparison Between Aphasic and Neurologically Normal (NN) Subjects' Mean Performances on Experimental Tasks

Value	*Tasks*						
	MOT	*TP-VIS*	*TP-VER*	*TP-IM*	*IG-IM*	*IG-C*	*IM-NMM*
Mean							
Aphasics	3.2	10.6	10.4	10.4	13.6	11.7	12.4
NN	0.5	13.5	13.7	14.0	14.4	14.4	13.8
SD							
Aphasics	3.4	2.7	2.6	2.6	1.6	2.8	1.7
NN	0.7	0.8	0.8	0.8	0.7	0.6	0.5
t	3.42*	−4.40*	−5.09*	−5.81*	−1.88	−4.15*	−3.37*

Note: The mean MOT score is the total number of errors recorded on this measure averaged across subjects. All other means are mean PICA scores. MOT = multiple object test; TP-VIS = transitive pantomimes–visual modality; TP-VER = transitive pantomimes–verbal modality; TP-IM = transitive pantomimes–imitation modality; IG-IM = intransitive gestures–imitation; IG-C = intransitive gestures on command; IM-NMM = imitation of nonmeaningful movements.
*$p < .01$.

Table 2. Aphasic Subjects' Means, Standard Deviations, and Ranges for Each of the Transitive Pantomime Tasks

Values	*Tasks*		
	TP-VIS	*TP-VER*	*TP-IM*
Mean	10.6[a]	10.4[a]	10.4[a]
SD	2.7	2.6	2.6
Range	4.7–14.4	5.5–14.6	6.3–14.5

Note: TP-VIS = transitive pantomimes–visual modality; TP-VER = transitive pantomimes–verbal modality; TP-IM = transitive pantomimes–imitation modality.
[a]F—not significant ($p > .05$)

ported. As indicated in Table 2, mean scores across the three transitive pantomime tasks (TP-VIS, TP-VER, and TP-IM) were nearly identical (10.6, 10.6, and 10.4, respectively). Standard deviations and ranges were also comparable. Moreover, examination of the Pearson *r* correlation coefficients among the variables indicated extremely strong intercorrelations. The correlation between TP-VIS and TP-VER was .92; between TP-VIS and TP-IM, .92; and between TP-VER and TP-IM, .91. Finally, Cronbach's alpha, a measure of internal consistency, was .98 when the three measures were analyzed as a single 45-item scale.

These findings support the assertion that, for a randomly selected group of aphasic subjects, the modality effect does not exist. The aphasic subjects performed similarly when asked to produce transitive pantomimes regardless of whether the corresponding object was shown, verbal instructions were given, or subjects were asked to imitate the target movements of the examiner. It therefore appears that when transitive pantomimes are used as a measure of IMA, similar results will be obtained irrespective of the eliciting modality.

Type of Movement Distinctions

Because there were no differences in mean performance on each of the three transitive pantomime tasks, a new variable was created to represent transitive pantomime performance. This new variable, TP-3, is a composite variable created by averaging scores across the three transitive pantomime tasks.

Table 3 shows the means, standard deviations, and ranges for the variables TP-3, IG-IM (intransitive gestures–imitation), IG-C (intransitive gestures on command), and IM-NMM (imitation of nonmeaningful movements). Each of these variables was employed as a measure of IMA. With one exception, pairwise multiple *t*-tests indicated that the mean scores among the four variables were significantly different from each other at the .05 level (adjusted for Type I error). The exception was the difference between IG-C and IM-NMM.

Table 4 presents the correlation coefficients (Pearson *r*) among the four IMA variables. The data indicate strong correlations among all four variables: Four of the six correlation coefficients are above .72, and both remaining coefficients are above .60.

Table 3. Aphasic Subjects' Means, Standard Deviations, and Ranges for Measures of IMA (Ideomotor Apraxia)

	Measures			
Values	*TP-3*	*IG-IM*	*IG-C*	*IM-NMM*
Mean[a]	10.5_a	13.6_b	11.7_c	12.4_c
SD	2.6	1.6	2.8	1.7
Range	5.7–14.5	8.5–15.0	7.0–14.7	8.9–14.9

Note: TP-3 = transitive pantomimes; IG-IM = intransitive gestures–imitation; IG-C = intransitive gestures on command; IM-NMM = imitation of nonmeaningful movements.

[a]Means with different subscripts are significantly different at the .05 level.

Table 4. Pearson r Correlation Coefficients Among Measures of IMA (Ideomotor Apraxia)

Measures	*TP-3*	*IG-IM*	*IG-C*
IG-IM	.73*		
IG-C	.87*	.77*	
IM-NMM	.73*	.62*	.66*

Note: TP-3 = transitive pantomimes; IG-IM = intransitive gestures–imitation; IG-C = intransitive gestures on command; IM-NMM = imitation of nonmeaningful movements.
*$p < .01$.

Table 5. Results of Factor Analysis of IMA (Ideomotor Apraxia) Variables

Variables	*Factor 1*
TP-3	.934
IG-C	.924
IG-IM	.813
IM-NMM	.750

Note: TP-3 = transitive pantomimes; IG-C = intransitive gestures on command; IG-IM = intransitive gestures–imitation; IM-NMM = imitation of nonmeaningful movements.

Table 5 displays the results of a factor analysis of the four IMA variables; principle factors was used as the method of extraction (Dixon, Brown, Engelman, & Jennrich, 1990). Only a single factor was extracted. By itself, this single factor, which had an eigenvalue of 2.95, explained 98% of the common variance attributable to all four IMA variables.

These findings suggest that movement-type distinctions reported in the literature regarding IMA assessment are *not* representative of distinct classes of praxis. Although different types of movements appear to involve different degrees of difficulty (i.e., overall mean scores for the IMA tasks were, with one exception, significantly different from one other), factor analysis yielded only a single underlying factor. Indeed, it is worth noting that performances across the different movement types (transitive pantomimes, intransitive gestures, and nonmeaningful limb movements) were so strongly correlated that multicollinearity was detected when an attempt was made to examine the relationships among the IMA variables through multiple regression (Belanger, 1992).

Types of Limb Apractic Processes: Ideomotor (IMA) and Ideational (IA)

Tasks involving the manipulation of multiple objects and simple acts not involving the manipulation of real objects (i.e., transitive pantomimes, intransitive gestures, and nonmeaningful limb movements) were used to assess the traditional distinction between ideational and ideomotor limb apraxia. Table 6 displays the results of a factor analysis (Principle factors; Dixon et al., 1990) using MOT (the investigation's measure of IA) and three of the four IMA variables. (Intransitive gestures–imitation was not included in the analysis to preserve the five-to-one ratio between subjects and variables that Tabachnick and Fidell, 1989, suggest is necessary for reliable factor analysis. This variable was excluded because, of the four IMA tasks, it was the only one on which mean performances between aphasic and NN subjects were not significantly different.) As Table 6 indicates, only a single underlying factor was extracted; by itself, it explained 98% of the shared variance among the variables.

A single composite score was also obtained for all the IMA variables. This score was generated by factor analysis (see Table 5) and served to represent IMA performance. The correlation between this score and MOT performance was .83 ($p < .01$).

These findings support the assertion that measures of IA and IMA are best viewed as reflecting a single underlying disorder along a continuum of severity. If IA and IMA were distinct disorders representing unique underlying neuropsychological impairments, more than one factor should have been generated through a factor analysis of the IA and IMA variables.

SUMMARY AND CONCLUSIONS

Current procedures in the diagnosis and assessment of limb apraxia typically reflect the assumption that important distinctions in elicited performance can be obtained by using tests that (a) differ in the modality of elicitation, (b) differ in the type of movement, and (c) reflect two distinct and independent impaired neuropsychological processes traditionally identified as ideomotor and ideational apraxia. A group of 20 left-hemisphere-damaged aphasic adults underwent a battery of tests of limb movements, and the results were analyzed to determine whether the assumption of differences in motor performance related to these three factors is valid and whether any differences in performance across tasks can be accounted for by two or more independent underlying casual factors.

Table 6. Results of Factor Analysis of IA (Ideational Apraxia) and IMA (Ideomotor Apraxia) Variables

Variables	*Factor 1*
IG-C	.932
TP-3	.931
MOT	.871
IM-NMM	.746

Note: IG-C = intransitive gestures on command; TP-3 = transitive pantomimes; MOT = multiple object test; IM-NMM = imitation of nonmeaningful movements.

Modality Effect

Does the production of transitive pantomimes differ with the modality used (verbal, visual, or imitation) to elicit the response? The three mean scores for transitive pantomimes (TP-VER, TP-VIS, TP-IM) were not significantly different from one another. The assertion of a modality effect on pantomime performance thus is not supported.

Type of Movement Distinctions

Does motor performance differ across different classes of movement (transitive pantomimes, intransitive gestures, and nonmeaningful limb movements)? Statistically significant differences were obtained between tasks that differed in the classes of movement used. There was a modality difference for intransitive gestures elicited by imitation (IG-IM) and by verbal command (IG-C); performance on both intransitive gestures tests (IG-IM, IG-C) differed significantly from a measure of transitive pantomime (TP-3) performance; and nonmeaningful imitated movements (IM-NMM) differed significantly from transitive pantomimes (TP-3) and imitated intransitive gestures (IG-IM). The only performances that did not differ significantly were intransitive gestures elicited by verbal command (IG-C) and nonmeaningful movements (IM-NMM).

Our results, therefore, support the assertion that motor performance differs with the class of movement that is being tested. Such differences in the accuracy of performance should not, however, be interpreted as reflecting distinct or different types of limb apractic processes. The strong correlations obtained between all four movement types and the extraction of only a single factor from a factor analysis of the four types of movement support the assertion that the differences across tests reflect different levels of task difficulty rather than distinct types of underlying practic processes.

Types of Limb Apractic Processes: Ideomotor (IMA) and Ideational (IA)

Do the two types of apractic behaviors commonly identified as IA and IMA reflect different and independent impaired neuropsychological processes? A multiple object manipulation test (MOT) was used as a test of IA, and a composite single object pantomime score (TP-3), an intransitive gesture test (IT-C), and an imitative test of nonmeaningful movements (IM-NMM) were used as measures of IMA. The relationship between the IA and IMA measures was examined using correlational and factor analyses. Only a single factor was extracted from the IA and three IMA measures. A very high correlation coefficient (.83) was also obtained between the measure of IA (MOT) and a composite factor score representing the four IMA tasks (TP-3, IG-C, IG-IM, IM-NMM). These results fail to support the assertion that differences in performance on IMA and IA tests reflect deficits in different and distinct underlying neuropsychological processes. Our results are similar to those of Duffy, Duffy, and Watt (1994) in failing to confirm the independence of IA and IMA processes. The results of our study support the need for additional investigations to examine the validity of distinctions that have generally been believed to exist among types of limb apraxia.

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