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The Construct Validity of the *Limb Apraxia Test* (LAT): Implications for the Distinction Between Types of Limb Apraxia

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The *Limb Apraxia Test* (LAT) (Duffy, 1974) was developed to meet the need for a comprehensive test of limb apraxia in aphasic individuals. Citing data from several studies that have used the LAT, Duffy and Duffy (1989, 1990) have claimed that it is a reliable and valid test of limb apractic *behavior.* The issue addressed in the present investigation is whether the LAT is a valid test for discriminating ideomotor from ideational apractic *processes.*

The term *limb apraxia* refers to an "impairment of movement control which cannot be explained on the basis of disruptions to afferent and/or efferent sensory-motor systems, poor or absent comprehension of the task in hand, intellectual deficit, inadequate attention or poor co-operation" (Miller, 1986, p. 1). Generally, the term is used to refer not only to the observable impaired motor behaviors but also to two neuropsychological processes construed to be responsible for these behaviors. These two underlying causal constructs are called *ideational apraxia* (IA) and *ideomotor apraxia* (IMA). The existence of these two types of limb apractic processes has been generally accepted since they were conceived by Hugo Liepmann (1900, 1905) in the early 1900s.

DEFINITIONS OF IDEATIONAL APRAXIA (IA) AND IDEOMOTOR APRAXIA (IMA)

Liepmann's model—and most other current models—posits two stages of motor performance: the *idea* of a purposeful act and its *programmed* *execution*. Liepmann hypothesized that the idea, which he called a "space-time" memory, is aroused in the posterior cortex and transmitted to a frontal area that programs the idea for execution by selected neuromuscular systems. Impairment at either of these two stages produces different symptoms or types of limb apraxia. IA results from damage to the idea in the posterior cortex (or disruption of transmission from it); IMA, from damage to programming in the frontal cortex. Some clinicians and researchers (Kleist, Sittig, & Zangwill, cited in DeRenzi, 1985, p. 47), however, hold that there is only a single causal process responsible for limb apractic behaviors and that IA is simply a more severe form of IMA.

TESTING FOR LIMB APRAXIA

In a comprehensive review of the issues involved in testing limb apraxia, DeRenzi (1985) cites three features that must be considered in any valid test of limb apractic behaviors and their causal processes or types (i.e., IA and IMA). These three features are

1. the types or classes of movements elicited;
2. the modalities used to elicit a response; and
3. the types of error responses.

Types of Movement

According to DeRenzi, a test of limb apraxia should comprise classes of movements that are sensitive to (a) different levels of severity of limb apraxia and (b) differences in IA and IMA. He classifies movements by (a) their *psychological purposes* (to communicate, to manipulate objects, and meaningless movements) and (b) their *physical features* or *shapes* (i.e., whether the movement is sequenced, segmented, simple, complex, or involves the manipulation of objects).

Modality of Elicitation

When selecting the modality of elicitation (e.g., imitation, pictures, verbal command), DeRenzi strongly recommends imitation because it

1. allows the testing of aphasic subjects with comprehension deficits;
2. results in more reliable scoring; and

3. makes possible the inclusion of movements in the "meaningless" class, which do not lend themselves to elicitation in any other modality.

For these and other reasons, imitation was chosen as the sole mode of elicitation in the LAT. When imitation is used, however, the "communicative" classes (pantomime and intransitive gestures) of movements are necessarily eliminated; although a subject can imitate a movement that simulates the shape of a communicative act, there is no assurance that any imitated motor act is meaningful or communicative to the subject.

On the other hand, using a modality other than imitation (such as verbal command) also has significant disadvantages. Using a nonimitative modality

1. eliminates the meaningless class of movements;
2. risks confounding by aphasic verbal comprehension problems; and
3. confounds motor dysfunction with aphasic symbolic or propositional deficits in communicating meaning.

Even though the use of imitation eliminates communicative classes of movements such as pantomime, there still remain important differences in the shapes of the movements; that is, test task movements can be sequential or segmented, they can be relatively simple or complex, and they can involve manipulated objects or not.

To ensure an adequate sample of classes of movement, the LAT was specifically designed to retain these six shapes (i.e., movement features): Sequenced, Segmented, Simple, Complex, Object, No Object. These six shapes were counterbalanced as three binary feature combinations in the eight subtests of the LAT as shown in Table 1.

The presence of these binary features not only may measure degrees of severity of limb apraxia but also may discriminate IA from IMA. For example, IA (often associated with complex actions) can be contrasted with IMA (often associated with more simple movements). From this standpoint, the Complex subtests of the LAT (3, 4, 7, and 8) may be more sensitive to IA, whereas the Simple subtests (1, 2, 5, and 6) may be more sensitive to IMA. Similarly, the Object subtests (2, 4, 6, and 8) may be more sensitive to IMA. Alternatively, if IA is a consequence of memory, attention, or sequencing ability, as some definitions suggest, the Sequenced subtests (1, 2, 3, and 4) may be more sensitive to IA than are the Segmented subtests (5, 6, 7, and 8).

Table 1. Binary Features and the Eight Subtests of the Limb Apraxia Test (LAT)

	Features		
LAT subtest	*Sequenced (+)/ Segmented (–)*	*Complex (+)/ Simple (–)*	*Object (+)/ No Object (–)*
1	+	–	–
2	+	–	+
3	+	+	–
4	+	+	+
5	–	–	–
6	–	–	+
7	–	+	–
8	–	+	+

LAT Scoring

DeRenzi suggests that distinctions between IA and IMA can be made not only by including various classes of movements but also on the basis of the types of observed response errors. For example, IMA is reportedly characterized by clumsiness and distortion of movements, whereas IA presents itself as omissions, sequencing errors, mislocations, perplexity, and inappropriate object use. To capture these error types and others, the LAT was designed with a comprehensive scoring system capable of quantifying the types of errors that reportedly distinguish IA and IMA. It uses a 21-point, multidimensional, PICA-like scoring scale. (See Duffy & Duffy, 1990, for a detailed description of LAT scoring.)

Therefore, the LAT, even though using only the imitative elicitation modality, may claim to be a valid measure of the constructs of IA and IMA based both on the variety of shapes of the movements it includes and on its method of scoring.

PRESENT INVESTIGATION

The present investigation reviews evidence for the construct validity of the LAT as a test that distinguishes between IMA and IA. Put another way, we investigated whether the data generated by the LAT can support the existence of more than a single construct underlying limb apractic behaviors.

METHOD

Subjects

The LAT has been administered to 77 left-hemisphere-damaged (LHD) aphasic subjects. Fifty-three of the 77 subjects were classified as limb apractic because their overall mean LAT score fell below all 30 non-neurologically impaired control subjects and 2.58 *SDs* below the controls' overall mean LAT score. These groups of subjects have been described in detail by Duffy and Duffy (1989). The present investigation is concerned with only the 53 LHD aphasic subjects classified as limb apractic and whether they can be discriminated into subgroups evidencing IA or IMA.

RESULTS

Intercorrelations Among LAT Subtests

To obtain evidence of the presence of the constructs of IA and IMA, the intercorrelations among the eight LAT subtests were obtained. This initial analysis is consistent with the recommendation of the American Psychological Association's (APA, 1985) guidelines for the construction of psychological tests: "When several scores are obtained from a single test, each purporting to measure a distinct construct, the intercorrelations among the scores . . . should be reported. . . . Relationships among test scores provide important information regarding the distinctiveness of the constructs being measured" (p. 15). The intercorrelations for the 53 LHD apractic subjects are presented in Table 2, which shows moderate to strong

Table 2. Pearson Product Moment Correlation Matrix for Eight LAT Subtests

LAT subtest	*1*	*2*	*3*	*4*	*5*	*6*	*7*
2	.67						
3	.69	.53					
4	.64	.52	.81				
5	.70	.64	.76	.80			
6	.51	.81	.47	.50	.68		
7	.62	.63	.75	.76	.78	.68	
8	.43	.47	.77	.78	.65	.52	.76

Note: All coefficients are significant ($p < .05$).

intercorrelations among all pairs of subtests. They range from .43 to .81, with a median of .64, and all are significant ($p < .05$).

These findings do not support the assertion that more than one construct is being measured by the 8 subtests of the LAT.

Cronbach's Alpha

The impression of unidimensionality for the eight subtests is supported by Cronbach's alpha (SPSS, 1988). This coefficient is an index of the internal consistency or reliability of the LAT. In a sense, it treats each LAT subtest as an observer of limb apractic behavior and measures the degree to which the eight subtests are observing the same behavior. The high alpha of .94 indicates that the eight subtests, despite the differences in the shapes of the movements being sampled, are uniformly sensitive to only a single underlying construct.

Factor Analysis

The impression of a single construct underlying performance on the eight LAT subtests was further investigated using a principal components factor analysis (SPSS, 1988). The analysis resulted in the extraction of only one factor with an eigenvalue greater than 1 (which accounts for 70% of the variance in LAT performance). The additional results presented in Table 3 strongly support the assertion that there is only a single factor underlying performance on the LAT.

1. The eight subtests load on a single factor, and the factor loadings for each subtest are high, ranging from .76 to .90.
2. The factor score coefficient matrix shows that each subtest contributes almost identical proportions to the factor being measured (varying slightly between 14% and 16%).
3. The communalities are high for each of the eight subtests. (Communalities are the proportion of variance in the LAT score that each subtest has with all of the other seven subtests.)

In summary, the results of the factor analysis demonstrate that only a single factor was extracted accounting for a major portion of the variance in overall test performance, that all LAT subtests load strongly on the same factor, that each subtest contributes equally to the factor being measured, and that each subtest is strongly related to what is being measured by all the other subtests.

Table 3. Factor Analysis of Eight LAT Subtests

Factor Loadings	
	Factor 1
Subtest 5	.90
Subtest 7	.90
Subtest 4	.87
Subtest 3	.87
Subtest 8	.81
Subtest 1	.78
Subtest 2	.78
Subtest 6	.76
Factor Score Coefficient Matrix	
	Factor 1
Subtest 1	.14
Subtest 2	.14
Subtest 3	.16
Subtest 4	.16
Subtest 5	.16
Subtest 6	.14
Subtest 7	.16
Subtest 8	.16
Communalities	
Subtest 1	.61
Subtest 2	.61
Subtest 3	.76
Subtest 4	.77
Subtest 5	.81
Subtest 6	.58
Subtest 7	.81
Subtest 8	.66

Binary Features Correlational Analyses

Further analysis of the number of factors underlying LAT performance was undertaken by factor analyzing each dichotomous pair of the three binary features represented in the LAT (Sequenced-Segmented; Simple-Complex; Object-No Object). Prior to the actual factor analysis, a composite factor score for each set of four subtests was obtained to represent the construct being measured by those four subtests. For example, a factor score was obtained for the Sequenced subtests (1, 2, 3, and 4) and the

Table 4. Binary Factor Correlational Analyses

Binary Features	*LAT Subtests*	*Pearson* r	r²	*1–r²*
Sequenced	(1,2,3,4)	.97	.94	.08
Segmented	(5,6,7,8)	.96	.92	.06
Simple	(1,2,5,6)	.93	.87	.13
Complex	(3,4,7,8)	.95	.90	.10
Object	(2,4,6,8)	.96	.92	.04
No Object	(1,3,5,7)	.98	.96	.08

Segmented subtests (5, 6, 7, and 8) (SPSS, 1988). The results of this analysis are presented in Table 4. The steps in the analysis are illustrated for the Sequenced-Segmented binary features:

Step 1: The Sequenced factor score was correlated with the overall LAT score. The r was .97.

Step 2: The r was squared to obtain a measure of the amount of the variance (i.e., the information) in the overall LAT score that is accounted for by the four Sequenced subtests (1, 2, 3, 4). The r^2 for the Sequenced subtest was (a very large) .94.

Step 3: The next step was to examine the amount of variance (i.e., information) *not* explained by the four Sequenced subtests, that is, by the Segmented subtests (5, 6, 7, and 8). This was obtained by the formula $1 - r^2$. For the Sequenced factor this result was .06. This means that very little (6%) of the variance in LAT not already accounted for by the Sequenced factor was accounted for by the Segmented or some other factor. These steps were then repeated for the Segmented factor score (Subtests 5, 6, 7, and 8). Table 4 shows that the results are virtually identical: The r between the Segmented factor score and the overall LAT score was .96; the r^2 was .92; and $1 - r^2$ was .08. Thus, only 8% of variance in LAT was explained by some construct(s) other than Segmented, which means that it is accounting for the same construct as the Sequenced factor score.

Together, these two analyses indicate that whatever construct is being measured by the Sequenced subtests is also being measured equally by the Segmented subtests. The results are strong evidence that only a single construct underlies performance on the Sequenced and Segmented features of the LAT.

These same analyses were done for the other two pair of binary features, and the results for all three binary features are presented in Table 4. The results for the Simple-Complex and the Object-No Object binary features are virtually identical to those of the Sequenced-Segmented binary feature. For each of the three pairs of features, the $1 - r^2$ proportions are small and of similar magnitude, and the conclusions are the same: There is very strong evidence that only one construct is being measured, despite the dichotomous differences in the classes of movement that are represented in the subtests themselves.

Summary

The results of the correlational and factor analyses used in this investigation consistently support the conclusion that the LAT measures only a single underlying construct. The construct validity for the LAT as a test that detects and discriminates IA and IMA was not supported.

DISCUSSION AND CONCLUSIONS

Ventry and Schiavetti (1980), offer the following observation: "The construct validity of a test or measure is borne out if measurements agree with the theoretical prediction, but if the prediction is not verified, it may be the result of an invalid measure, *or* an incorrect theory, *or* both" (p. 90). Applying this statement to the present investigation leads to two possible conclusions about the LAT and limb apraxia. First, the LAT may lack construct validity for detecting distinctions between valid constructs of IA and IMA. The alternative possibility is that the LAT does not detect traditional types of limb apraxia because such types do not exist; that is, the theory about the distinction between IA and IMA is incorrect.

Further Research

Although acceptance of the theory that limb apraxia can be differentiated into two (or more) distinct processes or types has been long-standing, the empirical basis for this theory is surprisingly narrow. Much of the support for it is based on individual case studies. Direct investigations regarding the "modality" effect and "movement type" effect for distinguishing between IA and IMA in a LHD aphasic population are essential to determine whether IA and IMA are qualitatively distinct constructs and clinically discernible types of limb apractic processes in patients with aphasia. One such investigation has been reported by Belanger, Duffy, and Coelho (1992). Consistent with the present investigation, they failed to support the presence of more than a single factor underlying limb apractic behaviors.

The results of the present investigation encourage additional investigations of the validity of the traditional view that IA and IMA are distinct and independent processes.

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