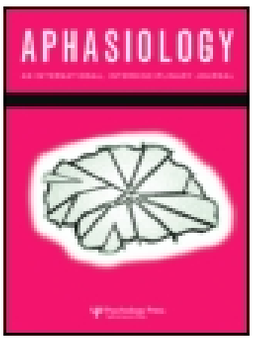

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Patterns of dissociation in comprehension and production of nouns and verbs

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Theoretical analysis and experimental evidence converge in support of a model of the lexicon which assumes that lexical information is represented in a number of independent lexical components. This distributed model of the lexical system assumes that there are independent input and output lexical components which, in turn, consist of independent orthographic and phonological lexical components. The input lexicons are connected to the output lexicons through a lexical-semantic component (see Caramazza, 1988, for review and discussion).

The proposed architecture of the lexical system assumes that the input and output lexical components are modality specific and that the semantics of lexical entries are represented in a central lexical component. A crucial issue to be addressed in an architecture of the proposed type concerns how each lexical component is organized and the kind of information that is represented in each component. An important source of evidence for constraining claims concerning the organization of different components of the lexical system comes to us from the analysis of patterns of lexical processing dysfunction in brain-damaged patients. Thus, for example, Goodglass, Klein, Carey, and Jones' (1966) demonstration that lexical deficits may be category-specific provides an important constraint on the possible forms of organization of lexical information. More recent reports have further documented a number of category-specific deficits for various semantic categories (Hart, Berndt and Caramazza 1985, Warrington and McCarthy 1983, 1987, Warrington and Shallice 1984). The fact that semantic categories can be damaged selectively may be taken as evidence for the view that the lexical-semantic component is organized by semantic categories. Analogously, category-specific deficits for grammatical word classes (e.g. selective deficit of nouns) would provide evidence in favour of the hypothesis that some or other component of the lexical system is organized by grammatical classes (Caramazza, 1988). This latter issue forms the focus of the present report.

Miceli, Silveri, Villa and Caramazza (1984), see also Baxter and Warrington (1985) have shown that the ability to produce verbs may be dissociated from the ability to produce nouns in aphasic patients. These authors found that there are aphasic patients who present with greater difficulties in naming actions (verbs) than naming objects (nouns). They also found patients with the reverse pattern of impairment, greater difficulty naming objects than actions. These results were interpreted as support for the view that the lexicon is organized by form class (i.e. verb, noun, etc.) and that different subcomponents of the lexicon may be selectively damaged.

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That the lexicon should be organized by form class is demanded by current accounts of language processing (e.g. Garrett 1980). Form class information is crucially needed for morphological and syntactic processing and therefore must be explicitly indicated in the lexicon in order for us to normally understand or produce sentences. What is not clear is whether such information is only represented in a central master lexicon (Forster 1978), used both for comprehension and for production, or whether form class information is duplicated in different subsystems of a distributed lexicon which distinguishes between input and output subcomponents for orthographic and phonological components of the lexical system. On this latter account form class information could be selectively damaged in comprehension or production. That is, we should observe differential patterns of dissociations in the ability to process words of different form class in comprehension and production. For example, we might find patients who are impaired in producing verbs or nouns but not in comprehending them or patients who are selectively impaired in either comprehending or producing words of a particular grammatical class (McCarthy and Warrington 1985). In this paper we report differential patterns of dissociations in comprehension and production of verbs and nouns in several aphasic patients.

Materials and methods

Object naming test and Action naming test

Two naming tests were constructed to evaluate patients' ability to orally produce the names of objects and actions: the Object naming test, consisting of forty-eight stimuli (mean root length: 4·9 letters; mean root frequency: 155/million), and the Action naming test, consisting of thirty-six stimuli (mean root length: 4·6 letters; mean root frequency: 168/million. Black-and-white line drawings were used as stimuli.

The two tests were administered to twenty normal subjects in order to obtain baseline, normal performance measures. The stimulus pictures were presented without time limits. Subjects were instructed to respond with one (and only one) word—the name of the presented object (a noun) or action (a verb). The twenty subjects produced on the average 47·2 (98·2%) correct responses to the Object naming test (range: 45–48; standard deviation: 0·95) and 34·7 (96·1%) correct responses to the Action naming test (range: 32–36; standard deviation: 1·22).

Object comprehension test and Action comprehension test

In order to test comprehension of nouns (objects) and verbs (actions), two spoken, word-to-picture matching tests were prepared.

Stimuli, either a noun (Object comprehension test) or a verb (Action comprehension test), were presented auditorily. Subjects were asked to indicate comprehension of the spoken word stimuli by choosing the appropriate picture from an array of three, portraying the correct response, a semantically related object/action and an unrelated object/action.

In the Object comprehension test, the semantically-related objects in the picture response triad were close associates (e.g. piano–trumpet; hand–foot; etc.). In the Action comprehension test, the two related actions were either related antonymously (e.g. to pull–to push; to laugh–to cry; etc.) or associatively (to walk–to run; to knock–to ring; etc.). In preparing the stimuli for this latter test, care was taken to use

only animate agents and inanimate themes, whenever themes had to be portrayed in the stimulus picture. For each test, fifty word stimuli were chosen, matched for root length (nouns: 4·8; verbs: 4·7) and for root frequency (nouns: 153/million; verb: 152/million).

The two comprehension tests were administered to twenty normal subjects (the same subjects to whom the naming tests had previously been administered). The comprehension tests proved to be very easy. Only two incorrect responses were produced, one on the Object comprehension test and one (made by a different subject) on the Action comprehension test.

Additional tests

A speech sample was obtained for each of the patients included in the present research. The qualitative measures of spontaneous speech reported in table 2 were derived from these speech samples. The patients were administered other tests in order to obtain a general assessment of their language and cognitive processing ability. The results of these tests are also reported in table 2. In addition to the standardized shortened version of the Token test (DeRenzi and Faglioni 1978) and Raven's progressive coloured matrices, the following tests were administered:

Phoneme discrimination test. This test requires the patient to discriminate, in a same-different paradigm, meaningless CCVC syllables (/prIn/, /trIn/, /krIn/, /brIn/, /drIn/, /grIn/).

Auditory and visual comprehension of single words. The patient is shown an array of three semantically-related pictures and is required to point to the picture corresponding to an auditorily or to a visually presented word.

Auditory sentence comprehension. This test requires matching an auditorily-presented stimulus sentence to a picture. Semantically reversible sentences were used. The following sentence types were included: simple declaratives or embedded sentences, in the active and in the passive voice, and locative sentences or sentences expressing temporal relations of the type before/after. The correct picture was presented among syntactic, morphological or semantic foils.

Patients

The two naming tests and the two comprehension tests were administered to twenty-five patients displaying a wide range of language disturbances, and among whom were some of the aphasic subjects described in Miceli *et al.* 1984. In this report we will focus on the naming and single-word comprehension performance of seven of the original twenty-five who showed category specific dissociations (FDP, CS, FS and AM, AA, SF and AE). Relevant background information for the patients included in this study is reported in table 1. Other relevant information about the language and cognitive processing abilities of the patients is displayed in table 2. The first three measures in this latter table concern qualitative indices of language production performance. A plus sign indicates the presence of obvious phoneme substitutions, word-finding difficulty, or grammatical disorder in spontaneous production. In this table are also reported quantitative indices of speech perception, single-word and sentence comprehension, and reasoning ability.

From the results reported in table 2, it can be seen that patients FDP, CS, FS and AM present with agrammatic speech, whereas the main pathological feature of

Table 1. Patient information.

	Age	Years of schooling	Etiology	Lesion site	Interval
FDP	53	13	CVA	T–P	3 yrs
CS	70	13	CVA	Rt. F–T	3 yrs
FS	60	17	CVA	F–T	8 yrs
AM	53	8	CVA	F–T–P	4 yrs
AA	31	13	Herpes enceph.	bilat. T	7 yrs
SF	40	13	lobectomy	T	8 yrs
AE	47	8	CVA	Left T Right F	1 yr

T = Temporal; P = Parietal; F = Frontal; Rt. = Right

patients AA, SF and AE is the occurrence of anomias. Furthermore, patients CS and FS show poor discrimination of phonemes: patients AA and AE and, to a lesser degree, CS, have difficulties in comprehending words in isolation, as assessed by a multiple-choice test; patients FDP, CS, FS, AM and AE have difficulties understanding reversible sentences in a multiple-choice paradigm.

Results

Results relevant to the issues raised in the present research are summarized in tables 3, 4 and 5.

Dissociation between verb and noun naming abilities

Since the focus of this research is on patients' ability to produce words belonging to different grammatical classes, the presence of dysarthric or phonemic distortion was ignored when scoring aphasic patients' performance. Inspection of the results displayed in table 3 shows that patients FDP, CS, FS and AM fared worse in naming actions than in naming objects (mean percent correct: action naming test = 53·5%; object naming test = 84·9%). The opposite pattern of results was obtained for patients AA, SF and AE, who named correctly 70·0% of the actions but only 47·9% of the objects. Inspection of table 3 also shows that a very high percentage of the incorrect responses produced by patients FDP, CS, FS and AM when trying to name actions are nouns (40·3%). That is, as in our previous report (Miceli *et al.* 1984), those patients who have difficulty naming verbs have a tendency to nominalize the expected action name. By contrast, patients who have difficulty naming nouns are more likely to make omission errors on the object naming task. This distribution of error types replicates that reported in our earlier study.

Dissociation between verb naming and verb comprehension abilities

Inspection of table 4 shows that for the seven patients under consideration, comprehension and naming abilities are not correlated. Thus, consider the naming and word comprehension performance of patient FDP versus that of FS, and of patient CS versus that of AM. The two pairs of patients show comparable performance in action naming (78·0% *vs* 75·0%, and 36·1% *vs* 25·0%, respectively), but they produce very different percentages of errors in comprehension of action words (16% *vs* 0%, in both instances).

Table 2. Information about patients' language and cognitive processing abilities.

	Spontaneous speech			Comprehension data (number of errors)					
	Phoneme subst.	Word finding difficulty	Grammatical disorder	Phoneme discrim.	Single word comprehension Auditory	Visual	Sentence comprehension	Token test	Progressive matrices
FDP	+	+	+	3/60	2/40	1/40	23/58	21/36	2/36
CS	−	+	+	8/180	11/80	2/60	63/118	25/36	14/36
FS	+	+/−	+	38/180	7/40	1/20	43/118	15/36	14/36
AM	+	+	+	1/60	2/40	1/40	19/58	22/36	11/36
AA	−	+	−	1/120	10/40	8/20	1/50	15/36	8/36
SF	−	+	−	0/120	0/40	0/20	0/50	2/36	5/36
AE	−	+	−	1/180	13/80	5/60	36/118	24/36	14/36

Table 3. Incidence and distribution of errors in naming objects (N=48) and actions (N=36).

	Object Naming Test				Action Naming Test			
	Total Incorrect Responses	Incorrect Noun Resp. (1)	Incorrect Verb Resp. (2)	Other Incorrect Resp. (3)	Total Incorrect Responses	Incorrect Noun Resp. (1)	Incorrect Verb Resp. (2)	Other Incorrect Resp. (3)
FDP	2 (4·2)	2 (100)	—	—	8 (22·0)	3 (37·5)	3 (37·5)	2 (25·0)
CS	8 (16·7)	8 (100)	—	—	23 (63·1)	13 (56·5)	7 (30·4)	3 (13·0)
FS	4 (8·3)	3 (75·0)	—	1 (25·0)	9 (25·0)	5 (55·6)	3 (33·3)	1 (11·1)
AM	15 (31·2)	4 (26·7)	—	11 (73·3)	27 (75·0)	6 (22·2)	3 (11·1)	18 (66·7)
AA	26 (54·2)	16 (61·5)	1 (3·8)	9 (34·6)	13 (26·1)	1 (7·7)	9 (53·8)	5 (38·5)
SF	15 (31·2)	5 (33·3)	1 (6·7)	9 (60·0)	5 (13·9)	—	4 (80·0)	1 (20·0)
AE	34 (70·8)	13 (38·2)	—	21 (61·8)	18 (50·0)	1 (5·6)	13 (72·2)	4 (22·2)

(1) This category also includes incorrect multi-word responses containing a full noun and an empty verb (e.g. climbing → he's on the stairs).
(2) This category also includes incorrect multi-word responses containing a full verb and an empty noun (e.g. horse → I rode one of those).
(3) This category includes anomias, multi-word responses containing both a full noun and a full verb, neologisms, unrelated verbal paraphrasias.
(4) Percentages are in parentheses.

Table 4. Performance obtained on the object naming test and on the action naming test, expressed as numbers of incorrect responses.

	Object naming	Action naming	Object comprehension	Action comprehension
FDP	2/48 (4·2)	18/36 (22·0)	0/50 (0)	8/50 (16·0)
CS	8/48 (16·7)	23/36 (63·9)	1/50 (2·0)	8/50 (16·0)
FS	4/48 (8·3)	9/36 (25·0)	0/50 (0)	0/50 (0)
AM	15/48 (31·2)	27/36 (75·0)	1/50 (2·0)	1/50 (2·0)
AA	26/48 (54·2)	13/36 (26·1)	6/50 (12·0)	0/50 (0)
SF	15/48 (31·2)	5/36 (13·9)	0/50 (0)	0/50 (0)
AE	34/48 (70·8)	18/36 (50·0)	6/50 (12·0)	7/50 (14·0)

(Percentages are in parentheses.)

Table 5. Scores obtained by the three patients who showed a dissociation of noun and verb comprehension.

		First session		Second session		Overall	
Patient	Test	Errors	p	Errors	p	Errors	p
	Nouns	0/50		0/50		0/100	
FDP			<0·002		<0·021		<0·001
	Verbs	8/50		5/50		13/100	
	Nouns	1/50		0/50		1/100	
CS			<0·013		<0·006		<0·001
	Verbs	8/50		7/50		15/100	
	Nouns	6/50		5/50		11/100	
AA			<0·013		<0·089		<0·003
	Verbs	0/50		1/50		1/100	

Dissociation between comprehension of nouns and verbs

The primary focus of this investigation concerns the dissociation of noun and verb comprehension ability. As is apparent from table 4, there are patients (FS, AM, SF and AE) who, independently of the form of their naming production deficit, either are normal in single-word comprehension of nouns and verbs (FS, AM and SF) or are equally impaired for these word classes (AE). However, some patients (FDP, GS and AA) appear to be selectively impaired in the comprehension of nouns or verbs: Patients FDP and CS display normal ability to understand nouns but are impaired in the comprehension of verbs (Fischer's exact probability test: Case FDP $P < 0{\cdot}002$; Case CS, $P < 0{\cdot}013$); patient AA exhibits the opposite dissociation: his comprehension of verbs is normal, but his comprehension of nouns is impaired (Fischer's exact probability test: $P < 0{\cdot}013$).

The tasks used to evaluate our patient's ability to comprehend object *vs* action names has low performance ceilings so that few errors were made by our patients. We readministered this task in order to evaluate the reliability of the reported results. The three patients who showed a dissociation in their ability to understand nouns *vs*. verbs (FDP, CS and AA) were tested again on the same comprehension test, approximately nine months later.

The observed dissociation between comprehension of nouns and of verbs was demonstrated again. As in the first session, FDP and CS were selectively impaired in comprehending verbs (Fischer's exact probability test: Case FDP, $P < 0{\cdot}021$; Case

CS, $P < 0{\cdot}006$), and AA again demonstrated a greater impairment in noun (as opposed to verb) comprehension (this time, however, the observed value fell just short of statistical significance: Fischer's exact probability test $P < 0{\cdot}089$). If patients' performance is collapsed across the two test sessions, highly reliable statistical differences are obtained for performance levels for noun versus verb comprehension (Case FDP $P < 0{\cdot}001$; Case CS $P < 0{\cdot}001$; Case AA $P < 0{\cdot}003$).

Discussion

The reported results confirm our earlier report (Miceli *et al.* 1984) showing that the production of single verbs or nouns may be differentially impaired in different aphasic patients. This result is interesting in its own right as it demonstrates that one dimension of lexical organization is the grammatical class of words. More important for our present purposes is the fact that a similar organizational principle is indicated for the input lexicon and that the input and output lexicons are functionally autonomous. Thus, our results demonstrate that the ability to comprehend nouns and verbs may be selectively damaged. Furthermore, these latter dissociations were found to be independent of the nature of damage observed in word production—the presence of a specific form of impairment in naming did not predict whether or not a similar impairment was found in comprehension of nouns or verbs. This latter statement should be tempered somewhat. Our results show that if there is a dissociation in word comprehension for nouns and verbs then a similar dissociation obtains in word production. However, we also found that a dissociation in word production for nouns and verbs is not necessarily associated with a similar deficit in word comprehension. On the whole, then, we are justified in concluding that naming and word comprehension disorders for nouns and verbs are dissociable.

The implications of these results for the functional architecture of the lexical system are straightforward: not only is it the case that the lexicon is organized by grammatical class but this organizational principle is duplicated for input and output subcomponents of the lexical system (see Caramazza 1988, for discussion). A functional architecture of the lexical system of the form proposed here has considerable *prima facie* plausibility. After all, we want the relevant lexical distinctions to be represented at just those levels where they would serve a useful purpose. In the present case we want form class information to be represented both in the input and output components of the lexicon so that it may be exploited in sentence comprehension (input) and sentence production (output).

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