Noun-verb dissociation in aphasia: the role of imageability and functional locus of the lesion.

Davide Crepaldi[1*], Silvia Aggujaro[1], Lisa Saskia Arduino[2,3], Giusy Zonca[4], Graziella Ghirardi[5], Maria Grazia Inzaghi[6], Mariarosa Colombo[7], Gennaro Chierchia[1], Claudio Luzzatti[1]

[1] Department of Psychology, University of Milano Bicocca

[2] Department of Psychology, University of Urbino

[3] Institute of Psychology, ICST-CNR, Roma

[4] S. Maugeri Foundation, Montescano Medical Center, Pavia

[5] Rehabilitation Unit, G. Salvini Hospital, Passirana, Milano

[6] Rehabilitation Unit, Villa Beretta Hospital, Costamasnaga, Lecco

[7] Rehabilitation Unit, Legnano General Hospital

*CORRESPONDING AUTHOR: Davide Crepaldi. Department of Psychology, University of Milano Bicocca. Piazza dell'Ateneo Nuovo 1, 20126 Milano, Italy. Tel: ++39 02-6448 6775. Fax: ++39 02-6448 6706. E-mail: davide.crepaldi@unimib.it

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ABSTRACT

Aphasic patients occasionally manifest a dissociated naming ability between objects and actions: this phenomenon has been interpreted as evidence of a separate organization for nouns and verbs in the mental lexicon. Nevertheless, Bird, Howard and Franklin (2000) suggested that the damage underlying noun-verb dissociation affects the corresponding *semantic* concepts and not the *lexical* representation of words; moreover they claimed that many dissociations reported in literature are caused merely by a strong imageability effect (Bird, Howard and Franklin, 2000; 2003). In fact, most authors used a picture naming task to assess patients' naming ability and, due to the fact that this test involves the use of pictures to represent actions and objects, nouns were frequently more imageable than verbs (Luzzatti at al., 2002). In order to overcome this drawback, we devised a new task -Nouns and Verbs Retrieval in a Sentence Context (*NVR-SC*)- in which nouns and verbs have the same imageability rate. Patients' performance on this task is compared with that obtained by the same patients on a standard picture naming task. Of the sixteen aphasic patients with a selective verb deficit, as revealed by the picture naming task, two continued to show dissociation in the NVR-SC task, while fourteen did not. The data indicate that at least some patients have an imageability-independent lexical deficit for verbs. The functional locus/i of the damage is also considered, with particular reference to the *lemma/lexeme* dichotomy suggested by Levelt et al., (1999).

KEYWORDS: Lexical retrieval; Noun-verb dissociation; Imageability; Grammatical class; Argument structure; Anomia.

1. Introduction

Since the late sixties, it has been widely accepted that cognitive models must explain pathological behaviour, as the latter is thought to reflect a normal cognitive system with specific modules partially or totally injured by cerebral damage.

In this perspective, neuropsychological evidence is a crucial test for models based on data from normal subjects and is an important source of information about the human cognitive system; remarkable progress in understanding the mental organization of language has been made thanks to this methodology.

Specific deficits of single linguistic processing abilities (e.g. phonological, lexical or syntactic) have been observed, revealing the functional independence of the mental linguistic modules.

Lexical deficits may be even more selective: in particular, patients have been observed who suffered from a dissociated noun or verb impairment in tasks eliciting lexical retrieval (Miceli, Silveri, Villla & Caramazza, 1984; McCarthy & Warrington, 1985; Zingeser & Berndt, 1988; Caramazza & Hillis, 1991; Thompson, Shapiro, Li & Schendel, 1994).

According to Caramazza and colleagues (Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Rapp & Caramazza, 2002), dissociated impairments may be caused by damage which selectively affects verbs or nouns at a late lexical stage (phonological or orthographical output lexicons). This conclusion is drawn from the fact that a noun-verb dissociation may appear in some linguistic tasks, but not in others: for instance, patient SJD suffered from verb impairment only in written naming and spelling to dictation, but not in oral naming and in reading; on the contrary, patient HW suffered from verb impairment in a spoken naming task, but not in the written version of the same task (Caramazza & Hillis, 1991). An even more striking pattern emerged in patient EBA (Hillis & Caramazza, 1995): this patient performed better on verbs than nouns in spoken production, and on nouns than verbs in written comprehension. This dissociation between written and spoken output and between production and comprehension has been accounted for by hypothesizing a multiple representation of grammatical classes (i.e. noun vs verb) in all four lexicons (orthographic and phonological input and output lexicons).

The interpretation of these findings offered by Caramazza and colleagues is arguably uneconomic. Why does the cognitive system need to represent information four times that might just as effectively be represented once? After all, we always use the same knowledge when we carry out syntactic processing, irrespective of whether we are speaking, understanding, reading or writing. In fact, several models of lexical access hypothesize unitary lexical-syntactic storage. Levelt and coworkers (Levelt, 1989; Levelt, Roelofs & Meyer, 1999) proposed a lexicon model based on a first layer of representations storing/activating grammatical and conceptual information *(the lemma level)* and on a second more peripheral level where the phonological word form is represented *(the lexeme level)*.

Shapiro and colleagues (Shapiro, Shelton & Caramazza, 2000; Shapiro, Pascual-Leone, Mottaghy, Gangitano & Caramazza, 2001; Shapiro & Caramazza, 2003) have suggested that selective damage of word forms is not the only cause of noun-verb dissociation. They observed some patients who were selectively impaired either in producing the third person of a verb (and of non-words used as verbs) or the plural form of a noun (and of non-words used as nouns). They concluded that these patients had a selective "deficit in retrieving or manipulating syntactic features" of nouns or verbs (Shapiro et al., 2000). However, while these findings are *per se* very interesting, they do not directly account for noun-verb dissociation. The selective impairment of number features (which are generally held to be significant on nouns) versus person features (significant on verbs), or possibly of the corresponding rule ("inflect for number" versus "inflect for person") might in principle leave the corresponding lexical categories unaffected. It is conceivable, in other words, that a deficit might affect a morpheme (or a morphological rule) without impacting the lexical/syntactic category typically associated with that morpheme. It is also unclear how the deficit identified by Shapiro et al. could explain the difficulty encountered on the picture naming task, in which the relevant morphemes are apparently not called upon.

The existence of a lexical-syntactic representation of grammatical class has been claimed by Rita Berndt and coworkers (Berndt, Mitchum, Haendiges & Sandson, 1997a; 1997b; Berndt, Haendiges, Burton & Mitchum, 2002). They tested ten aphasic patients using several tasks involving isolated words or sentences and deduced that the deficit causing noun-verb dissociation would concern a lexical device, either at an orthographic-phonological modality-specific level (i.e. the *lexeme level* in Levelt's model) or at a unitary lexical-syntactic device (i.e. the *lemma level* in Levelt's model). This claim is based on three major outcomes of the study. A qualitative error analysis brought to light a great number of semantic errors in some patients and an absence of such errors in others; some patients showed an important word frequency effect, while the imageability effect was significant in others; some patients had considerable deficits both in the production of well-structured sentences and in the comprehension of reversible sentences (two deficits typically related to lemma damage), while others did not. Taken as a whole, these results seem to indicate two different breakdown loci, with some patients having a lemma deficit, and others a lexeme deficit.

Bird and colleagues (Bird, Howard & Franklin, 2000; Bird, Howard & Franklin, 2001; Bird, Howard & Franklin, 2002) on the other hand argued that noun-verb dissociation might be a semantic, rather than lexical phenomenon. Moreover, they suggested that many dissociations might be generated by an increased level of sensibility in aphasic patients to a number of semantic differences and imageability in particular. In fact, since nouns refer to concrete objects, they usually have a higher imageability rate than verbs and tests used to assess noun-verb dissociation were frequently not matched for this variable. Furthermore, many studies showed imageability to be an important predictor of patients' ability to retrieve words (e.g. Luzzatti et al., 2002; Berndt et al., 2002; Bates et al., 2001).

In spite of Bird et al.'s interesting attempt, strong evidence has emerged in recent studies to support the position that imageability is not necessarily the main cause of grammatical class effects (Rapp and Caramazza, 2002) and, even when arguably a causal relation exists, it does not suffice to explain the entire noun-verb dissociation phenomenon (Berndt et al., 2002; Luzzatti et al., 2002); however, these findings, though very consistent, do not yet appear to be conclusive (Berndt et al., 2002).

As it is well known, predominant noun impairment is also attested (Berndt et al., 1997; Luzzatti et al., 2002a, 2002b). This phenomenon cannot be explained in terms of imageability, since verbs are systematically less imaginable than nouns. At the same time, the idea that verb impairment may be caused (*in toto* or in part) by an increased imageability effect remains plausible.

According to Bird and co-workers, even patients who continue to manifest dissociation after balancing for imageability are not suffering from a lexical deficit. Their naming impairment would be the result of selective damage to either their sensory or functional semantic features. Since verbs mainly denote actions and action concepts are mainly defined by functional properties, selective damage to functional knowledge may result in verb impairment. Analogously, selective damage to sensory knowledge will result in verb superiority, given that nouns frequently denote concrete objects and that concrete objects are defined above all by their sensory properties. This interpretation, appealing though it may seem, has some drawbacks. The assumption that object concepts are mostly defined by sensory features and action concepts by functional features is rather vague: it lacks a precise definition of the terms “*sensory”* and “*functional”* and a clear-cut experimental basis (Farah & McClelland, 1991; Caramazza & Shelton, 1998). Moreover, Bird’s explanation predicts that verb impairment should co-occur with a better performance on natural objects rather than on artificial objects and, symmetrically, noun impairment should co-occur with a better performance on artificial objects rather than on natural objects. However, this prediction is not fully verified empirically (but see Bird et al., 2000 a,b).

Finally, noun-verb dissociation has been explained as a consequence of syntactic damage (Saffran, Schwartz & Marin, 1980; Friedmann, 2000). An early account considered selective verb deficits to be a more general aspect of agrammatic morphosyntactic impairment (Saffran, Schwartz & Marin, 1980), while a more recent account specifies the syntactic hypothesis in greater detail

(Friedmann, 2000). Verb deficits would result from a pathological pruning of the syntactic tree: in the presence of such damage, verbs cannot move to the relevant functional categories and be inflected. Syntactic explanations share two major drawbacks: they do not account for verb-superiority nor do they supply a reason why non-agrammatic patients may suffer from selective verb damage.

Many other aspects of noun-verb dissociation, and in particular the role of argument structure underlying verb lexical entries, have been discussed in literature (Jonkers and Bastiaanse, 1997; Kim and Thompson, 2000, 2004; Thompson, 2003). However, the functional account of word-class effect - and its interaction with imageability- still seems to be poorly understood. If the noun-verb dissociation occurs as a consequence of unmatched imageability rates instead of as an effect of lexical or syntactic damage, the major neurolinguistic evidence that grammatical classes are mental entities and not only purely theoretical constructs would no longer be valid. If, on the other hand, new findings were to demonstrate that noun-verb dissociation does not merely follow from an imageability effect and that grammatical classes are represented somewhere in the cognitive system, then it would be important to understand at which psycholinguistic level/levels this happens.

In conclusion, there is still little consensus on noun-verb dissociation; in particular, the functional locus/i of the lesion causing the dissociation and the role of the imageability effect have still to be clarified. This study aims at providing a contribution to the recent debate on these two topics, based on experimental data. More specifically, the following questions will be addressed: (i) Does imageability play a role in determining predominant verb impairments? (ii) If so, is the imageability effect the unique cause of this dissociation? (iii) If additional damage occurs somewhere in the linguistic system, at which level of processing does it take place?

In addressing these questions, the present study describes a task in which grammatical class effects are disentangled from imageability effects (i.e. nouns and verbs are matched for imageability). In this task, the target word is not triggered by a picture, but by morphologically and semantically related words belonging to the opposite grammatical class: for instance, *esplodere* (to explode) is triggered by *esplosione* (explosion). This task is similar to that used by Shapiro and colleagues (Shapiro et al., 2000, 2001; Shapiro & Caramazza, 2003), exploiting English inflectional morphology: however, the English plural and third person singular inflection –s is completely regular and allows the lexical retrieval to be by-passed by using sub-word level inflectional rules. Our targets on the contrary entertain a derivational relationship with the stimulus. Since several suffixes can in principle enter the derivational process (though only one yields the correct output), we can be sure that patients will not be able to fall back on a sub-lexical strategy to solve the task, but will have to retrieve the appropriate lexical entry.

2. Materials and Methods

A group of aphasic brain-damaged patients with predominant verb impairment on a picture naming task were tested for lexical retrieval using a task in which nouns and verbs had to be retrieved in a sentence context (NVR-SC task). The participants were asked to generate a noun (e.g. *explosion*) from a lexically and morphologically related verb *(to explode)* and, vice versa, a verb from its nominal counterpart. As previously explained, nouns and verbs elicited through a picture naming task cannot be appropriately matched for imageability, since verbs usually have an average low imageability rate and pictures of nouns with comparable imageability do not unambiguously elicit a target noun. The NVR-SC task, on the contrary, allows matching of nouns and verbs for imageability and thus the imageability effect can be ruled out. Moreover, this task permits the testing of performance in a sentence context, where syntactic or lexical-syntactic damage is more likely to emerge than in a task involving the retrieval of single words, as is usually the case in a picture naming test.

Subjects

Sixteen mild-to-moderate Italian aphasic patients participated in the study, all of whom showed predominant verb impairment on a picture naming task; all patients gave their informed consent prior to their inclusion in the study. Mean age and mean education were 49 and 9 years respectively. Type and severity of aphasia were assessed by means of the Italian version of the Aachener Aphasia Test (AAT: Luzzatti, Willmes, & De Bleser, 1996). Five patients suffered from fluent aphasia: three were classified as suffering from anomic aphasia and two from Wernicke's aphasia. Seven patients suffered from non-fluent aphasia; six patients presented agrammatic speech output and the remaining patient the symptoms of non-fluent aphasia without classical telegraphic speech. Two patients were diagnosed with symptoms of residual (fluent) aphasia, and two patients had a language disorder which could not be classified into any of the major aphasic syndromes.

A group of eleven control subjects (matched with the aphasic patients for age and education) participated in the study. A further four groups of control subjects were tested in order to obtain *imageability* and *picture typicality* ratings for the picture naming task, and *imageability* and *age of acquisition* ratings for the NVR-SC task.

Task 1: Picture naming of objects and actions

Materials. A picture naming task with 50 objects (25 natural and 25 artificial) and 50 actions was used to detect predominant impairment on naming verbs. Pictures of verbs were taken from an initial set of 123 line drawings, while objects were selected from another set of 266 drawings from the PD/DPSS database (Lotto, Dell'Acqua & Job, 2001). The general criterion adopted for including an item in the task was name agreement ≥ 85% in a sample of normal undergraduate students (n=84 for nouns; n=37 for verbs). In other words, all items included in the task were named with the same word by at least 85% of the control subjects; further responses given by at least 5% of the controls were accepted as an alternative correct answer when produced by the aphasic patients.

Procedures. Pictures eliciting nouns and verbs were presented in separate sessions in randomised order. Verbs could be produced either in nonfinite form (for instance, *camminare,* to walk) or in finite form (for instance, *cammina,* he is walking). Self-repairs and latencies which lasted longer than three seconds, were scored as errors; phonological errors in which the target word was clearly recognizable (for instance, **pavolo*, *pable, for *tavolo*, table) were scored as correct responses.

Lexical-semantic variables. The major lexical-semantic variables which have been found to influence lexical retrieval (i.e. oral word frequency, imageability, age of acquisition and word length) were included in the experimental design. Oral word frequency was computed as stem frequency, i.e. considering the total frequency of all inflected forms corresponding to a single citation form. Picture typicality was also considered: 23 control subjects were asked to score each item using a 7-point scale according to how closely each drawing represented a prototypical exemplar of the object/action underlying the target noun/verb. A rating of 1 indicated very low typicality and a rate of 7 the highest typicality. A 7-point scale was also used to collect imageability ratings: control subjects were asked to score each word according to the ease with which it evoked a mental image. A similar procedure was used to collect the age of acquisition ratings: 20 subjects were asked to score each word on a 9-point scale where 1 corresponded to acquisition within the second year of life, 2 within the third year of life and so on until 9 (13 years of age or later). Self-report by adult subjects has been repeatedly demonstrated to be an important predictor of word retrieval performance both on aphasic patients (Rocheford & Williams, 1962; Hirsh & Ellis, 1994) and normal subjects (Bates, Burani, D'Amico & Barca, 2001).

Table 1 summarizes the mean values for oral word frequency, imageability, word length, age of acquisition and typicality.

No differences emerged for oral word frequency, age of acquisition and typicality. As usual, nouns and verbs could not be matched for imageability (nouns are more imageable than verbs). Furthermore, due to their bisyllabic infinitive inflectional endings, verbs are longer than nouns.

TABLE 1 ABOUT HERE

Task 2: Noun and Verb Retrieval in a Sentence Context

In order to examine patients' ability in naming objects and actions an imageability-balanced task was developed.

Materials. 45 pairs of sentences denoting the same event, using either a noun or the corresponding verb, were chosen.

E.g. (a) A Maria piace *conversare*

Mary likes to *converse*

(b) A Maria piace la *conversazione*

Mary likes the *conversation*

Two different conditions were employed for each pair of sentences: in the N-to-V condition, the first sentence contained a noun, and the verb of the second sentence was substituted with a gap; in the V-to-N condition, the first sentence contained a verb, and the noun of the second sentence was substituted with a gap. Thus, the NVR-SC task was composed of 90 trials, 45 of which triggering a verb, 45 a noun.

The trials were given following an ABBA paradigm. Twenty-three pairs of sentences were administered to elicit a verb, followed by the remaining 22 to elicit a noun. After an interval of 30 minutes, the first 23 pairs of sentences were administered to elicit a noun, followed by the remaining 22 to elicit a verb. Prior to each set, the examiner gave three examples in which s/he repeated the instructions until the participants could unequivocally demonstrate that they had fully understood the task.

As already mentioned, there is a morphological relationship between the stimulus and the target word; thus it could be argued that the patients might have solved the task using derivational sub-word level rules and not retrieving lexical entries. However, the unpredictability of the Italian derivational system excludes a possible sub-lexical strategy in this task.

In Italian it is not possible to produce uninflected nouns or uninflected verbs; in the NVR-SC task all relevant nouns and verbs were given and elicited in their morphological base form, i.e. the infinitival form for verbs and the singular form for nouns.

Procedures. The patient was seated in front of a PC monitor. A sample trial appeared on the screen together with a picture representing the event denoted by the two sentences; as already described, there was a gap in the second sentence in correspondence of the critical noun/verb. The examiner read aloud the two sentences reinforcing the gap by prosodic intonation. If the patient was unable to solve the task, the examiner repeated the instructions, helped the patient to answer and, as a last resort, gave him the solution. After three examples, the examiner started with the experimental trials. No further aids or feedbacks were given to the patient during the experiment. The instructions and the examples were re-administered before each section. Self-repairs and latencies longer than three seconds were scored as errors; phonological errors in which the target word was clearly recognizable (for instance, **appluso*, *appluse, for *applauso*, applause) were scored as correct responses. Wrong inflected forms of the correct lexical entry (for instance, *esploso*, exploded, for *esplodere*, to explode) were also scored as correct responses, unless the grammatical class of the answer was ambiguous (as is the case of some Italian nouns that are homophonous with the past participle or with the present tense of the corresponding verb; for instance *raccolto* is both a noun, meaning “harvest”, and the past participle of the verb *raccogliere*, meaning “collected”).

Lexical-semantic variables. Target nouns and verbs were perfectly matched for imageability (measured in a sample of 21 normal subjects along a seven-point scale) and length (number of letters; see Table 2). Verbs had a mean stem frequency that was moderately higher than that of nouns (Oral word frequency: De Mauro. Mancini, Vedovelli & Voghera, 1993). The mean imageability of the verbs in the NVR-SC task is almost identical to that of the verbs in the picture naming task (see Table 3). On the contrary, the nouns in the NVR-SC task were less imageable than those used in the picture naming task.

TABLE 2 ABOUT HERE

TABLE 3 ABOUT HERE

All nouns entertained a derivational relationship with the corresponding verb. In a first class of items, nouns were derived from the corresponding verb by the addition of a deverbal suffix such as *–zione* (e.g. *conversare,* to converse, and *la conversazione,* the conversation). In a second class of items, nouns were phonologically identical to the past participle of the corresponding verb (e.g. *caduta,* fallen, and *la caduta*, the fall). In a third class, nouns were phonologically identical to the first person of the present tense of the corresponding verb (e.g. *io salto, (lit.)* I jump, and *il salto,* the jump).

Statistical methods

Logistic regression analysis (LRA: Mc Cullagh & Nelder, 1983) was applied to the profiles obtained by each patient in both tasks, making it possible to study the effects of variables that might have influenced the naming performance, and to disentangle the effects of variables that are usually associated, as is the case for imageability and grammatical class. The units were the stimuli of the naming tasks, and the dependent variable for each stimulus was dichotomous (passed or failed). Candidate variables for the model were both categorical (verbs versus nouns) and continuous (word frequency, word length, imageability and age of acquisition). A *univariate* LRA was first used to assess independently the role of each single variable; a *multivariate* LRA was carried out on those patients who showed a significant effect of one (or more) of the concomitant variables.

3. Results

Group analysis. A three-way ANOVA was conducted with a mixed design: Task (picture naming versus NVR-SC) and Grammatical Class (nouns versus verbs) were the within subjects variable and Group (control subjects versus aphasic patients) was the between subjects variable.

The results indicate a significant effect of Group [$F(1,25) = 56.1$, $p<.001$], Task [$F(1,25) = 4.38$, $p<.05$] and Grammatical Class [$F(1,25) = 33.11$, $p<.001$]; moreover, the analysis reveals an interaction between Group and Grammatical Class [$F(1,25) = 23.93$, $p<.001$] and between Task and Grammatical Class [$F(1,25) = 37.82$, $p<.001$]. Given the significant effect of Group and the ceiling performance obtained by control subjects, an additional ANOVA with repeated measures was conducted using the data of the aphasic group only. This analysis showed a non-significant difference between the two tasks [$F(1,15) = 0.89$, n.s.], a significant effect of Grammatical Class [$F(1,15) = 42.91$; $p<.001$] and an interaction effect between Task and Grammatical Class [$F(1,15) = 41.1$, $p<.001$]. The Tukey post-hoc test indicates a significant grammatical class effect in the picture naming task (nouns: 73% of correct answers versus verbs: 35%; $p<.001$), but not in the NVR-SC task (nouns: 58% versus verbs: 56%; $p = .92$); moreover, aphasic patients name actions in the NVR-SC task better than in the picture naming task (56% versus 35%; $p<.001$), whereas, when naming objects, their performance in the picture naming task is better than in the NVR-SC task (73% versus 58%; $p = .002$; Fig. 1).

FIGURE 1 ABOUT HERE

Multiple single-case analysis: picture naming task. Table 4 summarizes the results of the univariate LRA. Imageability emerges as a significant predictor of the performance of all patients. Only one subject showed a word frequency effect, whereas age of acquisition and word length were significant in twelve and eight patients respectively. The multivariate logistic regression analysis indicates that grammatical class is the unique significant predictor in three patients, but it never reaches significance in the remaining thirteen patients (see Table 5); imageability emerges as a reliable predictor in nine of these thirteen patients, being the unique significant variable in four cases. No patients show both grammatical class and imageability effect.

TABLE 4 ABOUT HERE

TABLE 5 ABOUT HERE

Multiple single-case analysis: NVR-SC task. Two of the verb-impaired patients maintained a predominant verb deficit in the NVR-SC task (see Table 6); one patient (No 11) continued to retrieve nouns better than verbs, but the difference only approaches significance both in the Chi-square test and in the univariate logistic regression analysis. In ten patients, the difference between nouns and verbs was clearly no longer significant; in three patients, a paradoxical dissociation (V>N) emerged.

Of the thirteen patients whose grammatical class effect on the picture naming task was no longer significant after the introduction of the concomitant variables in the logistic regression, two had a noun-superiority also in the NVR-SC task. Furthermore, none of the three verb-impaired patients whose grammatical class effect in the picture naming task remained significant after the introduction of the concomitant variables in the statistical analysis had a selective verb deficit in the NVR-SC task.

TABLE 6 ABOUT HERE

Univariate logistic regression analysis indicates that, in the NVR-SC task, only one patient had an imageability effect, and none of the patients had either a frequency or a length effect; when all possible predictors (grammatical class, imageability, word frequency and length) were considered together in the multivariate LRA, grammatical class was significant in six patients, whereas imageability was significant in one patient and word frequency in another patient.

Error analysis. The errors produced by the patients in the NVR-SC task were classified into two main groups on the basis of the patients' ability or inability to accomplish the required change of grammatical class (V-to-N or N-to-V). Lexical substitutions and morphological errors were then individuated in both of these groups. Examples of error with the appropriate switch of grammatical class are *bomba*, bomb, instead of *esplosione*, explosion (lexical error) and **calcol(a)–mento*, *calcul(ate)–ment, instead of *calcol–o*, calcul–ation (morphological error). Examples of error without the appropriate switch of grammatical class are *palla*, ball, instead of *lanciare*, to throw (lexical error) and *salv–atore*, sav–iour, instead of *salv–are*, to save (morphological error). Latencies longer than three seconds, failures to respond, circumlocutions, perseverations and errors that could not be unambiguously classified were included in a separate group (*other errors*).

TABLE 7 ABOUT HERE

Table 7 reports the error distribution of each single patient. Overall, lexical errors are few (14%) and equally distributed in the V-to-N (13% of total errors) and N-to-V condition (14% of total errors; see Fig. 2), whereas morphological errors are much more frequent in the former than in the latter condition (23% and 6% respectively; see Fig. 2); this distribution remains unvaried also when only the errors in which the requested shift of grammatical class was accomplished are taken into consideration. Broca's patients produced more morphological errors than fluent patients (21% and 9% respectively); however, even in this group, morphological errors are as frequent as lexical errors in the N-to-V condition (see Fig. 3). Quite similar results emerge when patients are grouped according to the type of dissociation: N<V patients have the highest proportion of morphological errors (39% versus 9% and 7%), but the difference between morphological and lexical errors is much smaller in the N-to-V condition (see Fig. 3).

FIGURE 2 and 3 ABOUT HERE
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4. Discussion

4.1 Does Imageability contribute in creating noun-superiority?

The univariate LRA on the patients' performance in the picture naming task clearly indicates that most verb-impaired patients have an important imageability effect. This finding has already been reported in other studies (Bird et al., 2000; Luzzatti et al., 2002). On the contrary, the imageability effect appears only occasionally in patients with predominant noun impairment (Luzzatti et al., 2002).

In general, the co-occurrence of predominant verb impairment and imageability effect seems to be fairly constant, but what does it reveal about verb impairment?

FIGURE 4 ABOUT HERE

A mere co-occurrence of phenomena is in itself not sufficient to explain the relationship between the phenomena. If variables A and B correlate, several possible explanations may be explored: A may cause B or B may cause A; or again, a third variable C may cause both A and B (Fig. 4). In this case, a strong imageability effect may certainly determine verb impairment. Nouns in picture naming tasks are usually more imageable than verbs, and most aphasic patients find highly imageable items easier to name. This may explain why objects are easier to name than actions.

With regards to the third hypothesis, it is not easy to conceive a single functional damage that might be the direct cause of both imageability and grammatical class effects. However, there are two possible explanations of the co-occurrence of these two phenomena that follow the model represented in Fig. 4iii.

Rephrasing Coltheart's account of deep dyslexia (1987, 2000; Coltheart et al., 1987), the association of imageability effect and verb impairment may be explained with a "Right Hemisphere Hypothesis" (RHH). Noun-superiority does not result from selective impairment of the lexical representations of verbs in the left hemisphere; in fact, a different naming system located in the right hemisphere may emerge after full left hemisphere lexical damage. Since right hemisphere lexical knowledge is limited to high-frequency concrete nouns (Coltheart, 1987, 2000; Coltheart et al., 1987; Zaidel, 1991), the association between imageability effect and verb impairment is straightforwardly accounted for. This hypothesis, however, cannot account for the opposite dissociation, in which nouns are more severely impaired.

An alternative explanation of the relationship between predominant verb impairment and imageability effect is outlined by Luzzatti and Chierchia (2002). They hypothesise that noun-superiority is caused by a lexical damage specific to verbs. Since argument structure is the core of the verb representation, its impairment will probably be part of the verb damage. The authors argue that aphasic patients will try to build up a compensatory strategy to their verb impairment which is likely to rely on a visual representation of the action: patients have to reconstruct the thematic grid of the action, a type of knowledge that can be easily deduced from visual representation (at least, in a significant number of cases). In this perspective, the effectiveness of the compensatory strategy is increased as a function of the accessibility of the visual representation (i.e. to what extent the action is imageable).

To sum up, three alternatives have emerged: (i) noun-superiority is a consequence of the imageability effect and of the imageability mismatch between nouns and verbs in picture naming tasks (Bird et al., 2000, 2001); (ii) both phenomena depend on the emergence of the limited right hemisphere lexical abilities; (iii) both phenomena are caused (one directly, the other by means of a compensatory strategy) by damage involving the verb argument structure.

FIGURE 5 ABOUT HERE

4.2 Is imageability the unique cause of noun-superiority?

As far as the imageability account is concerned, a straight causal relationship between imageability and verb impairment does not exclude that other factors, wholly independent of imageability, may contribute to determining predominant verb impairment.

A multivariate logistic regression analysis was used to detect possible additional causal factors; in this analysis the grammatical class was disentangled from the concomitant variables, and, in particular, from imageability. In thirteen of the sixteen patients grammatical class ceased to be significant as the concomitant variables were introduced into the model. In these patients the difference in performance between naming objects and actions would therefore seem to depend on the effect of the concomitant variables. In the remaining three patients, however, grammatical class remained significant also in the multivariate model. These findings indicate the presence, at least in some patients, of an imageability-independent damage specific to verbs at some level of linguistic processing.

It must be said that the multivariate LRA does not completely solve the problem of disentangling the effects of the possible interacting causes. A new experimental condition has been created to break the causal chain linking the imageability effect, the overall higher imageability rates of nouns, and noun-superiority. The NVR-SC task bypasses the major limit of picture naming tasks (i.e. they cannot elicit abstract nouns) and triggers the production of nouns and verbs perfectly balanced in imageability. It is worthy of note that, in this task, two of the sixteen patients with verb impairment in the picture naming task do maintain the noun-superiority effect. This result, together with that obtained with the multivariate LRA, clearly indicates that imageability may account for verb impairment in *some, but not all dissociated patients*; in the remaining patients, there is rather clear evidence of additional damage which is the direct cause of the observed noun-superiority.

There is a further reason why the imageability matching of nouns and verbs in the NVR-SC task cannot account alone for the lower rate of verb-impaired patients. Two different devices were used to disentangle verb impairment from the imageability effect: the multivariate LRA and the NVR-SC task. However, the results of the two procedures display some *prima facie* inconsistencies: none of the three patients whose grammatical class effect remained significant after multivariate LRA shows verb impairment also in the NVR-SC task. And, surprisingly, two of the patients whose grammatical class effect turned out to be non-significant in the multivariate LRA displayed verb impairment in the NVR-SC task.

4.3. Investigating the additional verb-specific damage

The nouns in the NVR-SC task were less imageable than those in the picture naming task, while the verbs used in the two tasks had an almost identical imageability rating. If imageability were the unique cause of the lack of noun-superiority observed in some patients on the NVR-SC task, their performance on nouns should be better in the picture naming than in the NVR-SC task, while there should be no difference for verbs. However, the results indicate a better retrieval of nouns in the picture naming task, and of verbs in the NVR-SC task. This outcome cannot be explained in terms of imageability, and must be accounted for by the additional factor hypothesised above.

The NVR-SC task permitted us to factor out the role of imageability, but matching in imageability is not the only difference with respect to the picture naming tasks. In the NVR-SC task patients were required to retrieve words in a sentence context and to spell out the target word after listening to the corresponding noun or verb. It is probable that these different conditions have influenced the outcome.

Three mechanisms could in principle account for the different performance on verbs in the two tasks, but, as we shall see, only one fits the data satisfactorily.

First, patients might have derived the target word by applying sub-word level derivational rules. If this were the case, the task would not test lexical retrieval and this could explain the inconsistent performance on nouns – and respectively on verbs – across tasks. However the Italian morphological system is opaque for the derivational suffixes used to generate a noun from a verb, and vice versa, a verb from a noun. Therefore, such a sub-word level morphological strategy would not help the patients to carry out the task. Instead, the use of a morphological strategy should then necessarily result in a high rate of morphological errors. However, morphological errors only constitute 14% of the total errors, and they are much more frequent in the V-to-N than in the N-to-V condition. Very similar results emerged when only the two groups of patients having the highest rate of morphological errors, i.e. Broca's and N<V patients, were considered. In both of these groups, morphological errors are less frequent than non-morphological errors. Furthermore, Broca's patients produced many more morphological errors in the V-to-N condition than in the N-to-V condition.

Second, the NVR-SC task could prime verb retrieval since patients were provided with a lexical entry morphologically related to the target (i.e. the corresponding noun or verb); it is well known that the activation of a lexical entry spreads over semantically and morphologically related nodes making them more easily retrievable. However, this explanation for the better performance on verbs on the NVR-SC task would also require noun retrieval to be easier on the symmetrical condition of the same task, but the data show that noun retrieval in the NVR-SC task is lower than in the picture naming task. It could be argued that the decrease in imageability hid the effect of the spreading activation, however it is unlikely that the decrease in imageability would be responsible for a 15% decline in correct responses, particularly in the presence of an opposite priming effect.

The third explanation assumes that verb impairment involves the argument structure. In this case the additional damage accounts for the predominant impairment in retrieving verbs, given that the argument structure is a much more crucial aspect of verb representation than of noun representation; it would therefore be reasonable to suggest that the sentence frame into which patients are required to insert the appropriate verb itself provides its argument structure and therefore facilitates retrieval of the verbs. This hypothesis also fits with the absence of a similar advantage when retrieving nouns. In fact, even if the sentence frame were to provide the patients with the correct argument structure, this would not significantly improve noun retrieval, as the argument structure is much less essential for the lexical retrieval of nouns than for the lexical retrieval of verbs.

Altogether, it seems that the improvement in verb retrieval observed in the NVR-SC task can be satisfactorily accounted for by only one hypothesis, which is based on the assumption that verb-specific damage involves the argument structure or some aspects of the lexical representation interfacing the word form with the syntactic system. Referring to Levelt et al.'s model (1999), verb impairment seems to occur at the *lemma* level, i.e. a central lexical level, shared by input and output procedures and directly linked to information such as argument structure, diacritic parameters, lexical category and other lexical-syntactic information.

4.4 A right hemisphere effect or a syntactic deficit?

As a consequence of this line of reasoning, the alternatives given in Fig. 5 may be reduced to two and can become more explicit (Fig. 6).

According to hypothesis (i), extensive damage to the left hemisphere language areas let emerge right hemisphere lexical abilities. However, since these abilities are limited to high-frequency concrete nouns, a predominant verb impairment would emerge.

FIGURE 6 ABOUT HERE

The second hypothesis suggests that damage to the argument structure would cause predominant verb impairment, since the argument structure is the core of verb representation (Fig. 6,ii). This same deficit also causes the imageability effect by means of a compensatory strategy which, it seems reasonable to maintain, might enable a reconstruction of the argument structure through a mental image of the action (and hence the more imageable the action, the easier it would be to retrieve the associated canonical argument structure – see Luzzatti & Chierchia, 2002). Finally, since nouns are generally more imageable than verbs, the imageability effect makes nouns easier to retrieve than verbs.

There are no clear reasons to discard either of these two explanations and for the present it seems reasonable to hypothesise that both situations (i) and (ii) may occur; this is in accordance with findings regarding the lesion sites underlying predominant verb impairment (Luzzatti, Zonca, Pistarini, Taricco, Abelli & Frustaci, 2002). Such evidence indicates that two types of lesion are associated with predominant verb impairment: extensive perisylvian left damage (which would cause the right linguistic abilities to emerge) or a more limited posterior-temporal and inferior-parietal lesion (which would underlie a lexical-syntactic deficit to the argument structure).

5. Conclusion

The results which emerge from this study provide new evidence of a strong association between disproportionate verb impairment and imageability effect (Bates et al., 2001; Berndt et al., 2002; Luzzatti et al., 2002).

We have argued that this association may reflect a causal relationship: since nouns are generally more imageable than verbs (at least in standard picture naming tasks), imageability causes predominant verb impairment.

However, it must be hypothesized that an additional, imageability-independent damage can make nouns easier to retrieve for some patients than verbs. This is indicated (i) by the fact that some patients presented a predominant verb impairment also in an imageability-matched task, such as the NVR-SC task, and (ii) by the outcome of the multivariate LRA, where grammatical class effect was evaluated after being disentangled from the effect of some concomitant variables and, in particular, from the imageability effect.

Moreover, the presence of additional damage predominantly involving verb lexical representations becomes evident in the group analysis: in fact, insofar as the imageability effect is concerned, the better performance on verbs in the NVR-SC task than in the picture naming task cannot be accounted for. Indeed, we have argued that these findings can only be explained by locating additional damage at *lexical-syntactic level*, i.e. the verb argument structure.

It is also possible that the co-occurrence of imageability and verb impairment arises from extensive damage to the left hemisphere language areas. This would induce the emergence of right hemisphere lexical abilities, which are limited to high-frequency, concrete nouns (Zaidel, 1990; Coltheart, 2000). Therefore, imageability effect and noun-superiority are expected to co-occur.

We suggest, considering also the site of lesions causing predominant verb impairments (Luzzatti et al., 2002,b), that both accounts may be valid, possibly in interaction with each other.

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Tables

Table 1. Lexical-semantic variables for nouns and verbs in the *picture naming task*.
*Oral word frequency is taken from a corpus of 500.000 words (see De Mauro et al., 1993).

Variable	*Verbs (n=50)*	*Nouns (n=50)*	*t Test*	*p*
Oral word frequency*	13,82 ± 21,22	8,48 ± 15,69	1,45	n.s.
Imageability	4,58 ± 0,77	6,01 ± 0,39	-11,84	<*.01*
Length	8,08 ± 1,41	7,08 ± 1,77	3,17	<*.01*
Age of acquisition	3,76 ± 1,14	3,40 ± 1,03	1,66	n.s.
Picture typicality	5,63 ± 0,80	5,81 ± 0,94	1,29	n.s.

Table 2. Lexical-semantic variables for nouns and verbs in the *NVR-SC task*.
*Oral word frequency is taken from a corpus of 500.00 words (see De Mauro et al., 1993)

	Verbs (n=45)	*Nouns (n=45)*	*t Test*	*p*
Oral word frequency*	36,53 ± 77,66	11,02 ± 15,28	-2,16	<*.05*
Imageability	4,52 ± 0,68	4,30 ± 0,92	-1,28	n.s.
Length (number of letters)	8,06 ± 1,54	7,71 ± 2,41	0,24	n.s.

Table 3. Imageability ratings of nouns and verbs: comparison across tasks**.**

	Picture naming task	*NVR-SC task*	*t Test*	*p*
Verbs	4,58 ± 0,77	4,52 ± 0,68	0,37	n.s.
Nouns	6,01 ± 0,39	4,30 ± 0,92	11,74	<.001

Table 4. Performance of the patients on the picture naming task and results of the univariate logistic regression analysis. Empty cells indicate non significant effects.

						Univariate logistic regression analysis											
		N-V				Imageability			Word frequency			Word length			Age of acquisition		
N°	Aph	%N	%V	chi^2	p	Beta	chi^2	p	Beta	chi^2	p	Beta	chi^2	p	Beta	chi^2	p
1	A	84	44	15,49	<.001	1,38	21,27	<.001				-0,49	11,03	.001	-0,58	6,84	<.01
2	NC	78	28	25,09	<.001	1,18	16,09	<.001				-0,29	5,07	<.05			
3	RAS	82	46	14,06	<.001	0,99	14,26	<.001									
4	NC	78	32	21,37	<.001	1,04	15,2	<.001							-0,46	5,37	<.05
5	RAS	78	58	4,6	<.05	0,77	9,51	<.005									
6	A	86	48	6,59	.01	0,9	12,32	<.001				-0,381	7,26	<.01	-0,54	6,68	.01
7	B+	82	46	12,5	<.001	1,14	17,17	<.001							-0,54	6,84	<.01
8	B+	60	16	18,72	<.001	2,02	20,93	<.001				-0,50	10,99	.001	-0,93	14,32	<.001
9	B-	46	4	21,33	<.001	1,97	14,4	<.001				-0,52	9,44	<.005	-0,56	5,26	<.05
10	A	88	38	24,7	<.001	0,84	11,36	.001				-0,29	4,73	<.05	-0,39	3,88	<.05
11	B+	64	36	7,62	<.01	0,93	12,84	<.001							-0,54	6,98	<.01
12	B+	84	44	15,68	<.001	1,33	20,50	<.001									
13	W	70	32	14,45	<.001	1,57	22,79	<.001				-0,29	5,06	<.05	-0,99	16,92	<.001
14	W	26	8	5,74	.01	0,99	5,94	.01	0,04	9,12	<.005				-0,80	6,67	.001
15	B+	70	42	7,95	<.005	0,84	11,26	.001				-0,65	16,10	<.001	-0,39	4,06	<.05
16	B+	96	40	32,97	<.001	1,96	27,37	<.001							-0,42	4,33	<.05

Legend: Aph = aphasia type; A = anomic aphasia; NC = non-classifiable aphasia; B+ = Broca's aphasia with telegraphic speech; B- = Broca's aphasia without telegraphic speech; RAS = residual aphasic symptoms; %N = percentage of correct responses with nouns; %V = percentage of correct responses with verbs; Im = imageability; Freq = word frequency; AoA = age of acquisition.

Table 5. Performance of the patients on the picture naming task and results of the multivariate logistic regression analysis. Empty cells indicate non significant effects.

						Multivariate logistic regression analysis														
		N-V				N-V			Imageability			Word frequency			Word length			Age of acquisition		
N°	Aph	%N	%V	chi^2	p	Beta	chi^2	p	Beta	chi^2	p	Beta	chi^2	p	Beta	chi^2	p	Beta	chi^2	p
1	A	84	44	15,49	<.001				1,24	6,30	.01				-0,39	5,47	.01			
2	NC	78	28	25,09	<.001				1,00	4,46	<.05									
3	RAS	82	46	14,06	<.001															
4	NC	78	32	21,37	<.001	1,85	6,29	.01												
5	RAS	78	58	4,6	<.05				0,97	4,61	<.05									
6	A	86	48	6,59	.01	1,69	4,99	<.05												
7	B+	82	46	12,5	<.001				1,00	4,61	<.05	0,05	4,86	<.05						
8	B+	60	16	18,72	<.001				1,55	6,45	.01				-0,38	4,42	<.05	-0,71	4,83	<.05
9	B-	46	4	21,33	<.001															
10	A	88	38	24,7	<.001	2,7	11,84	<.001												
11	B+	64	36	7,62	<.01															
12	B+	84	44	15,68	<.001				1,27	6,91	<.01									
13	W	70	32	14,45	<.001				1,50	7,63	<.01							-0,64	4,48	<.05
14	W	26	8	5,74	.01							0,05	7,40	<.01						
15	B+	70	42	7,95	<.005										-0,57	11,35	<.001			
16	B+	96	40	32,97	<.001				1,37	7,07	<.01									

Legend: Aph = aphasia type; A = anomic aphasia; NC = non-classifiable aphasia; B+ = Broca's aphasia with telegraphic speech; B- = Broca's aphasia without telegraphic speech; RAS = residual aphasic symptoms; %N = percentage of correct responses with nouns; %V = percentage of correct responses with verbs; Im = imageability; Freq = word frequency; AoA = age of acquisition.

Table 6. Comparison between patients' performance on the picture naming task and in the NVR-SC task. The results of the uni- and multivariate logistic regression analysis about imageability are also reported.

	PICTURE NAMING TASK						NVR-SC TASK				
			Univariate analysis		Multivariate analysis				Univariate analysis		
	Results		Im		N-V		Results		N-V		
N°	%N	%V	chi^2	p	chi^2	p	%N	%V	chi2	p	Diss
2	78	28	16,09	<.001			82	27	28,00	<.001	N>V
9	46	4	14,40	<.001			53	27	6,67	<.01	N>V
11	64	36	12,84	<.001			56	36			N=V
3	82	46	14,26	<.001			76	78			N=V
4	78	32	15,20	<.001	6,29	.01	29	42			N=V
5	78	58	9,51	<.005			91	80			N=V
6	86	48	12,32	<.001	4,99	<.05	64	76			N=V
7	82	46	17,17	<.001			84	87			N=V
10	88	38	11,36	.001	11,84	<.001	53	47			N=V
12	84	44	20,50	<.001			73	69			N=V
13	70	32	22,79	<.001			44	27			N=V
14	26	8	5,94	.01			31	31			N=V
16	94	40	27,37	<.001			64	60			N=V
1	84	44	21,27	<.001			60	89	9,87	<.005	V>N
8	60	16	20,93	<.001			15	38	5,68	<.05	V>N
15	70	42	11,27	.001			60	82	5,41	<.05	V>N

Legend: N° = patient's number; %N = percentage of correct responses with nouns; %V = percentage of correct responses with verbs; Im = imageability; N-V+Im = statistics associated with the grammatical class factor when imageability is introduced in the statistical model; Wald = Wald value; Diss = type of dissociation.

Table 7: Qualitative analysis of the errors made by the patients in the NVR-SC task: single patients' distribution.

						Error type				
						Appropriate switch of grammatical class		No switch of grammatical class		Other
N°	Aph	Diss		N° of errors	Prop. of errors	Lexical #	Morphological ^	Lexical @	Morphological §	
2	NC	N>V	N	8	0,28	0,00	0,13	0,00	0,13	0,74
			V	31	0,69	0,13	0,00	0,06	0,00	0,81
			T	39	0,43	0,10	0,03	0,05	0,03	0,79
9	B-	N>V	N	21	0,47	0,05	0,14	0,00	0,00	0,81
			V	32	0,71	0,03	0,03	0,00	0,00	0,94
			T	53	0,59	0,04	0,08	0,00	0,00	0,88
3	RAS	N=V	N	11	0,24	0,09	0,18	0,00	0,18	0,55
			V	9	0,20	0,00	0,11	0,00	0,00	0,89
			T	20	0,22	0,05	0,15	0,00	0,10	0,70
4	NC	N=V	N	32	0,71	0,28	0,06	0,06	0,00	0,60
			V	24	0,53	0,29	0,00	0,08	0,04	0,59
			T	56	0,62	0,29	0,04	0,07	0,02	0,58
5	RAS	N=V	N	4	0,09	0,00	0,00	0,00	0,25	0,75
			V	9	0,20	0,00	0,00	0,00	0,00	1,00
			T	13	0,14	0,00	0,00	0,00	0,08	0,92
6	A	N=V	N	18	0,40	0,00	0,11	0,17	0,17	0,55
			V	11	0,24	0,18	0,00	0,00	0,00	0,82
			T	29	0,32	0,07	0,07	0,10	0,10	0,66
7	B+	N=V	N	7	0,16	0,00	0,57	0,00	0,00	0,43
			V	6	0,13	0,00	0,00	0,00	0,00	1,00
			T	13	0,14	0,00	0,31	0,00	0,00	0,69
10	A	N=V	N	21	0,47	0,14	0,20	0,05	0,00	0,61
			V	24	0,53	0,38	0,00	0,08	0,00	0,54
			T	45	0,50	0,27	0,08	0,07	0,00	0,58
11	B+	N=V	N	20	0,44	0,15	0,00	0,05	0,15	0,65
			V	28	0,62	0,25	0,00	0,00	0,00	0,75
			T	48	0,53	0,21	0,00	0,02	0,06	0,71
12	B+	N=V	N	12	0,27	0,00	0,17	0,00	0,00	0,83
			V	14	0,31	0,00	0,07	0,00	0,00	0,93
			T	26	0,29	0,00	0,12	0,00	0,00	0,88
13	W	N=V	N	25	0,56	0,12	0,04	0,00	0,00	0,84
			V	32	0,71	0,00	0,00	0,03	0,06	0,91
			T	57	0,63	0,05	0,02	0,02	0,04	0,87
14	W	N=V	N	31	0,69	0,03	0,03	0,03	0,03	0,88
			V	32	0,71	0,03	0,03	0,00	0,03	0,91
			T	63	0,70	0,03	0,03	0,02	0,03	0,89
16	B+	N=V	N	16	0,36	0,13	0,19	0,00	0,00	0,68
			V	18	0,40	0,00	0,00	0,06	0,00	0,94
			T	34	0,38	0,06	0,09	0,03	0,00	0,82
1	A	N<V	N	18	0,40	0,44	0,17	0,06	0,00	0,33
			V	5	0,11	0,60	0,00	0,00	0,00	0,40
			T	23	0,26	0,48	0,13	0,04	0,00	0,35
8	B+	N<V	N	38	0,84	0,00	0,16	0,00	0,47	0,37
			V	25	0,56	0,00	0,28	0,04	0,08	0,60
			T	63	0,70	0,00	0,21	0,02	0,32	0,45
15	B+	N<V	N	17	0,38	0,00	0,35	0,00	0,00	0,65
			V	8	0,18	0,00	0,00	0,00	0,00	1,00
			T	25	0,28	0,00	0,24	0,00	0,00	0,76
TOTAL			N	299	0,42	0,09	0,16	0,03	0,09	0,64
			V	308	0,43	0,12	0,03	0,02	0,01	0,81
			T	607	0,42	0,10	0,10	0,03	0,05	0,72

(Table 7 : follows.)

Legend: Diss = type of dissociation; Aph = aphasia type; A = anomic aphasia; NC = non-classifiable aphasia; B+ = Broca's aphasia with telegraphic speech; B- = Broca's aphasia without telegraphic speech; RAS = residual aphasic symptoms; N = nouns; V = verbs; T = nouns and verbs (total)0,

Examples of errors:

\# Lexical error with the appropriate switch of GC

It: Nella savana si sentì il ruggito del leone
Eng (lit): In the savannah it has been heard the roar of the lion

It: Nella savana si sentì *ringhiare* il leone
Eng (lit): In the savannah it has been heard *snarling* the lion

^ Morphological error with the appropriate switch of GC

It: Il maestro chiede di calcolare la media
Eng (lit): The teacher asks to calculate the average

It: Il maestro chiede il **calcol-amento* della media
Eng (lit): The teacher asks for the **calculate-ment* of the average

@ Lexical error without the appropriate switch of GC

It: I soldati videro esplodere la bomba
Eng (lit): The soldiers saw exploding the bomb

It: *I soldati videro *scoppiare* della bomba
Eng (lit): The soldiers saw the *bursting* of the bomb

§ Morphological error without the appropriate switch of GC

It: Ho visto il salvataggio del bambino
Eng (lit): I saw the rescue of the child

It: *Ho visto *salv-atore* il bambino
Eng (lit): I saw *sav-er* the child

Captions for figures

Fig. 1. Patients' performances on the *picture naming task* (dashed line) and the *NVR-SC task* (full line): comparison.

Fig. 2. Distribution of lexical and morhpological errors in the two conditions of the NVR-SC task: white columns represents the V-to-N condition, whereas grey columns represents the N-to-V condition**.**

Fig. 3. Percentage of lexical (white columns) and morphological (grey columns) errors made in the NVR-SC task by the Broca's and N<V patients: comparison across conditions.

Fig. 4. There are at least three explanations of the co-occurrence of two phenomena: A causes B; B causes A; a third phenomenon, C, causes both A and B.

Fig. 5. Possible explanations of the co-occurrence of imageability and noun-superiority.

Fig. 6. Two possible general explanations of the phenomenon of noun-superiority. An arrow has been added in scheme (ii) from "Verb deficit at a lexical-syntactic level" to "Imageability effect" as suggested by Luzzatti and Chierchia (2002) .

Appendix A. Complete list of the stimuli in the picture naming task and their normative values.

Num	Rand Ord	Item		GC	Im	WF	Length	AoA
1	50	accarezzare	*to caress*	V	5,63	0	11	2,65
2	29	affogare	*to drown*	V	4,32	1	8	4,30
3	22	affondare	*to sink*	V	3,89	2	9	5,05
4	27	annaffiare	*to water*	V	4,89	0	10	4,05
5	8	arrestare	*to arrest*	V	4,00	9	9	5,10
6	37	atterrare	*to land*	V	3,89	1	9	5,85
7	13	baciare	*to kiss*	V	5,53	1	7	2,50
8	26	brillare	*to shine*	V	3,58	1	8	4,80
9	11	bussare	*to knock*	V	5,42	0	7	3,40
10	1	cadere	*to fall*	V	4,32	62	6	1,75
11	33	camminare	*to walk*	V	5,84	18	9	2,11
12	24	crescere	*to grow*	V	2,68	44	8	3,20
13	19	decollare	*to take off*	V	4,42	1	9	6,00
14	34	dimagrire	*to lose weight*	V	2,89	9	9	5,90
15	44	fiorire	*to bloom*	V	3,63	0	7	3,55
16	46	fischiare	*to hiss*	V	4,53	3	9	3,75
17	17	fotografare	*to photograph*	V	5,05	8	11	4,45
18	10	gonfiare	*to swell*	V	4,42	7	8	3,95
19	36	guidare	*to guide/drive*	V	5,58	14	7	4,60
20	7	imbucare	*to post*	V	3,95	6	8	5,70
21	31	lanciare	*to launch*	V	4,53	22	8	3,16
22	48	leccare	*to lick*	V	4,37	0	7	2,85
23	28	legare	*to tie*	V	4,47	40	6	3,55
24	41	marciare	*to march*	V	4,32	4	8	5,45
25	3	mordere	*to bite*	V	5,06	0	7	2,60
26	14	nuotare	*to swim*	V	5,95	0	7	3,85
27	5	pattinare	*to skate*	V	5,21	0	9	4,50
28	18	pelare	*to peel*	V	3,95	0	6	4,95
29	35	piangere	*to cry*	V	5,05	24	8	1,80
30	12	pregare	*to pray*	V	5,89	41	7	4,50
31	23	raccogliere	*to collect*	V	4,16	39	11	3,90
32	42	ridere	*to laugh*	V	5,58	41	6	2,26
33	16	ruggire	*to roar*	V	3,39	0	7	4,15
34	9	salire	*to go up*	V	4,21	35	6	2,85
35	15	salutare	*to greet*	V	5,42	111	8	1,80
36	20	sanguinare	*to bleed*	V	4,53	1	10	4,10
37	2	sbadigliare	*to yawn*	V	5,74	1	11	3,50
38	47	scendere	*to descend*	V	4,16	44	8	2,55
39	25	sciare	*to ski*	V	5,53	0	6	4,40
40	45	scivolare	*to slip*	V	4,53	14	9	2,85
41	32	scoppiare	*to burst*	V	3,79	9	9	3,75
42	38	scuotere	*to shake*	V	3,74	0	8	5,45
43	21	soffiare	*to blow*	V	5,32	9	8	2,35

(Appendix A: follows)

Num	Rand Ord	Item		GC	Im	WF	Length	AoA
44	49	sollevare	*to raise*	V	4,26	3	9	4,40
45	40	sparare	*to shoot*	V	4,26	9	7	4,20
46	4	spingere	*to push*	V	4,22	13	8	3,15
47	43	starnutire	*to sneeze*	V	4,84	0	10	2,90
48	39	tagliare	*to cut*	V	5,00	39	8	2,95
49	30	versare	*to pour*	V	4,95	22	7	3,95
50	6	volare	*to fly*	V	4,37	17	6	2,85
51	2	ananas	*pineapple*	N	6,42	1	6	4,47
52	1	antenna	*aerial*	N	5,00	56	7	5,0
53	29	arpa	*harp*	N	5,53	2	4	5,73
54	18	banana	*banana*	N	6,26	0	6	2,33
55	7	bottiglia	*bottle*	N	6,58	11	9	1,87
56	32	camion	*truck*	N	6,00	12	6	3,1
57	13	cammello	*camel*	N	5,68	0	8	3,93
58	25	candela	*candle*	N	6,53	0	7	2,73
59	46	cane	*dog*	N	6,16	59	4	1,87
60	17	canguro	*kangaroo*	N	5,63	0	7	3,86
61	48	carota	*carrot*	N	6,21	4	6	2,93
62	44	cavallo	*horse*	N	6,16	43	7	2,60
63	19	chiesa	*church*	N	6,21	34	6	2,86
64	43	chitarra	*guitar*	N	6,47	3	8	4,26
65	27	ciliegia	*cherry*	N	6,53	0	8	2,93
66	41	clessidra	*hourglass*	N	5,95	0	9	6,13
67	6	coltello	*knife*	N	6,47	2	8	2,33
68	35	cravatta	*necktie*	N	6,26	2	8	3,93
69	40	cucchiaio	*spoon*	N	6,53	7	9	2,00
70	22	divano	*sofa*	N	6,47	36	6	2,5
71	3	elefante	*elephant*	N	6,21	1	8	2,67
72	9	elicottero	*helicopter*	N	5,79	1	10	4,0
73	14	fionda	*sling*	N	5,21	0	6	4,40
74	26	fisarmonica	*accordion*	N	5,32	0	11	4,80
75	30	fragola	*strawberry*	N	6,53	0	7	2,53
76	8	fungo	*mushroom*	N	6,00	6	5	2,93
77	16	giacca	*jacket*	N	6,11	9	6	3,33
78	12	giraffa	*giraffe*	N	5,74	0	7	2,87
79	45	guanto	*glove*	N	6,32	0	6	2,93
80	36	gufo	*owl*	N	5,47	0	4	4,06
81	33	imbuto	*funnel*	N	5,95	0	6	3,80
82	23	ippopotamo	*hippopotamus*	N	5,68	1	10	4,00
83	34	maiale	*pig*	N	5,95	15	6	2,53
84	37	manette	*handcuffs*	N	5,79	0	7	5,1
85	50	pappagallo	*parrot*	N	5,79	4	10	3,53
86	10	pavone	*peacock*	N	5,32	1	6	4,47
87	4	pecora	*sheep*	N	5,95	3	6	2,80
88	49	peperone	*capsicum*	N	5,95	6	8	4,33
89	31	pinguino	*penguin*	N	5,74	1	8	3,27
90	20	pipa	*pipe*	N	5,89	1	4	3,60

(Appendix A: follows)

Num	Rand Ord	Item		GC	Im	WF	Length	AoA
91	42	piramide	*pyramid*	N	6,11	4	8	4,73
92	15	pomodoro	*tomato*	N	6,47	7	8	2,66
93	21	rinoceronte	*rhinoceros*	N	5,58	0	11	4,60
94	38	scarpa	*shoe*	N	6,16	17	6	2,1
95	28	scoiattolo	*squirrel*	N	5,68	0	10	2,93
96	5	stivale	*boot*	N	5,84	3	7	3,53
97	47	tavolo	*table*	N	6,37	59	6	2,07
98	11	trattore	*tractor*	N	5,79	2	8	3,00
99	24	zebra	*zebra*	N	5,79	0	5	3,60
100	39	zucca	*pumpkin*	N	5,53	5	5	4,80

Legend: Rand Ord = randomised order; GC = grammatical class; Im = imageability; WF = word frequency; AoA = age of acquisition.

Appendix B: complete list of the stimuli entering the NVR-SC task and their normative values.

Num	Rand ord	Item		GC	WF	Length	Im
1	81	abbracciare	*to embrace*	V	17	11	4,95
2	36	abbraccio	*embrace*	N	15	9	5,95
3	10	applaudire	*to applaud*	V	2	10	5,10
4	55	applauso	*applause*	N	10	8	4,86
5	15	arrestare	*to arrest*	V	9	9	3,95
6	60	arresto	*arrest*	N	0	7	3,00
7	9	baciare	*to kiss*	V	1	7	6,10
8	54	bacio	*kiss*	N	61	5	5,95
9	83	ballare	*to dance*	V	17	7	4,90
10	38	ballo	*dance*	N	5	5	5,76
11	76	bombardare	*to bomb*	V	0	10	4,00
12	31	bombardamento	*bombardment*	N	3	13	4,48
13	2	cadere	*to fall*	V	62	6	4,57
14	47	caduta	*fall*	N	5	6	4,00
15	18	calcolare	*to calculate*	V	11	9	4,33
16	63	calcolo	*calculation*	N	32	7	2,52
17	82	camminare	*to walk*	V	18	9	5,10
18	37	camminata	*walk*	N	0	9	4,48
19	87	cantare	*to sing*	V	11	7	4,48
20	42	canto	*song*	N	10	5	4,67
21	7	conversare	*to converse*	V	1	10	4,52
22	52	conversazione	*conversation*	N	10	13	4,14
23	13	correre	*to run*	V	29	7	5,33
24	58	corsa	*run*	N	8	5	4,24
25	78	costruire	*to build*	V	39	9	3,90
26	33	costruzione	*construction*	N	34	11	3,86
27	4	crollare	*to collapse*	V	8	8	4,24
28	49	crollo	*collapse*	N	2	6	4,19
29	22	esplodere	*to explode*	V	7	9	4,52
30	67	esplosione	*explosion*	N	3	10	5,00
31	79	evadere	*to escape*	V	0	7	3,19
32	34	evasione	*escape*	N	4	8	3,05
33	11	giurare	*to swear*	V	22	7	3,24
34	56	giuramento	*oath*	N	8	10	2,81
35	8	interrogare	*to examine*	V	15	11	4,67
36	53	interrogazione	*interrogation*	N	12	15	4,38
37	72	lanciare	*to throw*	V	22	8	4,33
38	27	lancio	*throw*	N	0	6	3,81
39	21	leggere	*to read*	V	263	7	4,81
40	66	lettura	*reading*	N	64	7	3,40
41	90	massaggiare	*to massage*	V	0	11	4,62
42	45	massaggio	*massage*	N	0	9	5,14
43	14	mordere	*to bite*	V	0	7	4,95
44	59	morso	*bite*	N	5	5	4,10

(Appendix B: follows)

Num	Rand ord	Item		GC	WF	Length	Im
45	85	nascere	*to be born*	V	94	7	3,62
46	41	nascita	*birth*	N	34	7	5,29
47	71	nevicare	*to snow*	V	4	8	5,70
48	26	neve/nevicata	*snow*	N	14	6	6,24
49	20	partire	*to leave*	V	207	7	4,24
50	65	partenza	*departure*	N	15	8	3,24
51	6	pattinare	*to skate*	V	0	9	5,33
52	51	pattinaggio	*skating*	N	0	11	4,48
53	86	piangere	*to cry*	V	24	8	4,43
54	40	pianto	*crying*	N	1	6	4,71
55	74	piovere	*to rain*	V	10	7	5,29
56	29	pioggia	*rain*	N	25	7	6,19
57	88	potare	*to prune*	V	7	6	3,67
58	43	potatura	*pruning*	N	0	8	3,76
59	16	pregare	*to pray*	V	41	7	4,57
60	61	preghiera	*prayer*	N	12	9	3,14
61	73	raccogliere	*to harvest*	V	39	11	4,05
62	28	raccolta	*harvest*	N	19	8	3,00
63	1	radere	*to shave*	V	3	6	4,52
64	46	rasatura	*shaving*	N	0	8	3,76
65	5	ridere	*to laugh*	V	41	6	5,52
66	50	risata	*laugh*	N	4	6	4,33
67	12	ruggire	*to roar*	V	0	7	4,24
68	57	ruggito	*roar*	N	0	7	4,19
69	17	saltare	*to jump*	V	22	7	4,48
70	62	salto	*jump*	N	11	5	4,05
71	89	salutare	*to greet*	V	111	8	5,14
72	44	saluto	*greeting*	N	41	6	4,62
73	77	salvare	*to save*	V	22	7	2,57
74	32	salvataggio	*rescue*	N	0	11	4,19
75	70	sbadigliare	*to yawn*	V	1	11	5,19
76	25	sbadiglio	*yawn*	N	0	9	5,29
77	84	scoppiare	*to burst*	V	9	9	4,10
78	39	scoppio	*burst*	N	4	7	4,24
79	19	scrivere	*to write*	V	420	8	5,05
80	64	scrittura	*writing*	N	11	9	4,14
81	23	soffiare	*to puff*	V	9	8	4,24
82	68	soffio	*puff*	N	0	6	2,90
83	3	sparare	*to shoot*	V	9	7	4,90
84	48	sparo	*shot*	N	0	5	4,05
85	75	starnutire	*to sneeze*	V	0	10	5,05
86	30	starnuto	*sneeze*	N	0	8	5,38
87	80	ululare	*to howl*	V	0	7	4,00
88	35	ululato	*howl*	N	1	7	4,19
89	69	volare	*to fly*	V	17	6	4,10
90	24	volo	*flight*	N	13	4	4,76

Legend: Rand Ord = randomised order; GC = grammatical class; WF = word frequency; Im = imageability.