Errors on prefixed verbal forms: Effects of root type and number of prefixed related forms

Cristina Burani, Alessandro Laudanna & Antonella Cermele

This study investigated the representation of prefixed verbal forms in the mental lexicon, with particular reference to the output phonological lexicon. A free recall experiment in which prefix substitution errors were elicited was carried out. The effects of the following variables were evaluated: (i) root type (whether free, e.g., It.: *formare* in *preformare* or bound, e.g., It.: *ludere* in *preludere*), (ii) number of prefixed words sharing the same root. It was found that prefixed words with many other prefixed forms sharing the same root give rise to more prefix substitution errors than prefixed words with few prefixed related forms, regardless of the root type involved in the error. However, prefixed words with bound root were overall recalled better as whole forms than prefixed words with free root. It is argued that both types of prefixed derivatives (with free and bound root) are represented in the lexicon as morphologically related to the other words including the same root. It is also suggested that the principles of morphological organization and activation may differ in part according to the type of root involved.*

1. *Introduction.*

Experimental research has provided evidence for the presence of morphological relationships in the reader's/speaker's mental lexicon, between prefixed words and their base words, and among prefixed words sharing the same base. Different proposals have been but forward about the representaton of morphological relationships, sometimes taking into consideration the types of morphemes which may be included in a word (see below, for a review). The present study, as well as the study by Chialant & Burani (1992 this issue), investigate the morphological organization of prefixed words in the mental lexicon by evaluating the role of two factors in the processing and representation of Italian prefixed verbs, namely the root's boundedness and the number of prefixed words in the language sharing a given root (whether free or bound). In this study, the factors

* The authors would like to thank Anna Maria Thornton for her helpful comments on an earlier version of the manuscript.

that where investigated concern (formal and distributional) characteristics of prefixed words' root morphemes. In other studies, some characteristics of prefixes (Laudanna *et al.* 1992), and of both prefixes and roots (Chialant & Burani 1992 this issue) were taken into account. Investigation of derivational suffixes along the same line of research has recently started (Burani & Thornton 1992, see also, for more general considerations, Frauenfelder & Schreunder 1991).

Before discussing the hypoteses, the content and the functional component (the phonological lexicon involved in single-word retrieval) addressed in the present study, we briefly review current evidence on the processing of affixed derived words, with main reference to prefixed words.

2. *Processing and representation of derived words.*

The experimental investigations of derived words (as well as investigations of inflected words) have tried to provide an answer to the following questions. Are polymorphemic words represented in the mental lexicon as whole forms, or are they represented in decomposed form, with separate lexical entries for the root and the affixes? If they are represented as undecomposed whole forms, are there morphological links in the lexicon among word representations which share some morpheme? Are there differences in morphological processing and/or organization according to the kinds of roots and affixes involved? Within derivational affixes, which are the processing and representational differences between suffixes and prefixes? Which is the relation between the representation of a word's structural characteristics and that of the word's semantics? Which are the mechanisms through which the representation of morphological relationships is activated and retrieved in the course of access to the lexicon?

Many authors have provided evidence in favor of a «decompositional» hyphotesis for derived words, or for a view in which affixed derived words, although not decomposed in the lexicon, are connected to their bases and possibly to other derived words with the same base. Evidence for such views comes mainly from tasks such as the (visual or auditory) lexical decision task on polymorphemic stimuli, by which it is assumed that the (orthographic or phonological) input lexicon is tapped. On he basis of a large body of data it is generally assumed that morphological relationships are represented in the lexicon for suffixed words whose roots do not show much orthographic/phonological variation with respect to the bases from which they derive, which have a low frequency in the language, and whose suffixes are frequently used (Bradley 1979, Stanners *et al.* 1979, Fowler *et al.* 1985, Burani & Caramazza 1987, Burani & Laudanna 1988, Cole' *et al.* 1989, Beauvillain & Segui 1992, Burani & Laudanna 1992, in press). However, evidence for morphological relationships in the lexicon among derived forms

and their bases or roots exists also for derivatives which are not phonologically transparent (Fowler *et al.* 1985, Napps 1989, Tyler *et al.* in press) or even not semantically transparent with respect to their bases (Emmorey 1989, Tyler *et al.* in press, Bentin & Feldman 1990).

As for prefixed words, part of the evidence from both the visual and the auditory domain is in favor of the decompositional hypothesis (e.g., Taft & Forster 1975, Taft *et al.* 1986), part is not (e.g., Rubin *et al.* 1979, Tyler, *et al.* 1988, Cole' *et al.* 1989, Beauvillain & Segui 1992). Differences between prefixed and suffixed derived words have been in many occasions stated. However, they were not systematically investigated for their consequences on processing and mental representation. Moreover, with the exception of some recent studies (Laudanna *et al.* 1992), differences within prefixes were not taken into account.

Few experimental studies have addressed these issues from the side of word production. Some studies have dealt with the experimental elicitation of morphological errors in English, and mainly concerned inflectional phenomena (see Lapointe & Dell 1988, for a review, and see also Burani 1992a, 1992b this issue). With reference to derivatives, some studies focused on the complex relationships existing between phonological and morphological factors in the retrieval of English suffixed derived words (MacKay 1978). This sparse evidence is in favor of a morphological organization of the «phonological output lexicon». Other evidence comes from the analysys of morphological speech errors and from the performance of patients with acquired disturbances of language; this evidence is briefly reviewed in the following of the paper with reference to the question under investigation (for further discussion of morphological errors in normal and disturbed language, see Burani in press b).

In our research we started from the consideration that there are reasons, both theoretical and empirical, for not considering prefixed words as a homogenous class. On the contrary, they seem to constitute quite a heterogeneous set. This observation holds for affixed derived words in general, but suits prefixed words particularly. Thus it seems inappropriate to collect experimental evidence on the processing of affixed derived words (wheter suffixed or prefixed) as they were two main classes of words, with no distinctions inside. The hypothesis of a lexical organization of affixed derived words on the basis of morphological principles should be assessed with reference to the differences within (types of) derived words.

Many factors can affect the probability that a morphological relationship becomes established in the mental lexicon, or that a possible morpheme acts as a unit of processing and/or representation. There can be both linguistic (e.g. affix productivity) and empirical or distributional dimensions (e.g. word or morpheme frequency) affecting this probability, and there can be interactions between factors of the two types. The attention payed to the role of these factors in the processing and mental representation of

polymorphemic words implies that a role is assigned to the characteristics of a given language in constraining or even imprinting the functioning of the processing system and the form of storage and representation of lexical entries (for further discussion of these issues, see Burani in press a, Burani & Laudanna in press, Laudanna *et al.* 1992).

3. *Bound and free roots.*

In this paper, the issue of the representation of prefixed words is addressed with reference to a specific question, namely: how are prefixed words with bound roots processed and represented? The hypothesis is that morphological relationships can exist in the lexicon among prefixed derivatives also when they involve a bound root, that is a root which cannot occur alone as a words, but which constitutes a word only if combined with a derivational affix. The data that will be reported, both from other studies and from the present one, converge in indicating that prefixed derivatives with bound roots are morphologically organized in the lexicon, in a way possibly not different from derivatives with free roots. In determining morphological relatedness among derivatives with bound roots, however, a distributional aspect, namely the number of word forms sharing a given bound root, might play some role.

Prefixes may apply to a free-standing root (e.g. in English: *replay*, *unaware*; in Italian: *riportare*, *incosciente*) or to a bound root (e.g. in English: *– gress* in *ingress*, *progress*, *regress*;—*trieve* in *retrieve*; in Italian:—*plicare* in *esplicare*, *applicare*, *implicare*, *replicare*, *complicare*, *supplicare*;—*sipare* in *dissipare* (for a discussion of bound roots, see e.g. Selkirk 1982: 98).

According to traditional morphology (Nida 1949, Marchand 1969, Dardano 1978), only prefixed words with free rots are polymorphemic. By contrast, prefixed words with bound roots, although etymologically derived, are not considered to be polymorphemic for the following reasons. First, they do not contain in a proper sense a root morpheme, that is a root corresponding to a base form which can appear, in absence of a prefix, in other words of the language. Second, the meaning of the prefixed word is not obtainable by combination of the root's and the prefix's meanings. Furthermore, different prefixed words sharing the same (bound) root may not have a common core of meaning. Usually, prefixed words constituting a "family" with the same bound root tend to differ more, in meaning, than prefixed words sharing the same free-standing root.

It must be acknowledged that some Italian prefixed words with the same bound root may have some common core of meaning, although this is not always necessarily the case. For cultivated people, a common core of meaning in prefixed words with bound roots can be identified by relying on etymological knowledge, but it seems quite implausible that awareness of

etymological factors plays a role in "on-line" language comprehension and production.

However, the speakers' mental lexicon may represent some relatedness among prefixed words although they include a bound root, by virtue of other factors which will be discussed. Two kinds of considerations converge towards this hypothesis: both linguistic observations, following Aronoff (1976), and empirical data coming from various domains.

Aronoff (1976) argued that the definition of morpheme as "the minimal meaningful element" must be adjusted to include morphemes which have no constant meaning (like the latinate stems contained in the English words *remit*, *commit*, *transmit*, *submit*, *permit*, *admit*, in which the bound stem *-mit*, does not have a constant meaning). Aronoff pointed out that although words of this type do not share a similar meaning, they undergo the same phonological rule which is morphologically conditioned, thus giving rise to *remission*, *commission*, *transmission* and so on. Thus Aronoff proposed to broaden the definition of morpheme: a morpheme would be a phonetic string which can be connected arbitrarily to a linguistic entity outside that string—either to a constant meaning or to a morphophonemic rule. According to Aronoff, what is essential about a morpheme is not that it has meaning, "...but rather merely that we are able to recognize it." (Aronoff 1976: 15).

Aronoff's view points to the possibility that morphological relationships among words are represented in the lexicon on the basis of other factors than meaning of the morphemic segments. However, it is not obvious that the principle providing morphological relatedness among lexical entries is a morphophonological *rule*. Other factors related to the distribution and frequency of lexical and sub-lexical units in the language might prove relevant in affecting the possibility that a given phonetic string becomes a morphemic units in the mental lexicon.

4. *Processing and representation of prefixed words with bound (and free) roots.*

4.1. *Evidence from word recognition.*

How are prefixed words with bound roots represented in the lexicon and processed? Some studies on the processing of printed words indicate that prefixed words with bound roots are not processed differently from those with free roots. A first set of results come from lexical decision experiments, in which subjects are asked to decide as quickly as possible whether a given string of letters corresponds to a real word or is not a word.

Stanners *et al.* (1979) used the paradigm called "morphemic repetition priming", which involves presenting at various lags, prior to the target word, a morphologically related prime word which should facilitate access to the target word. Facilitation should occur when prime and target share parts

of the representation in the lexicon. The authors found facilitation effects on lexical decisions to prefixed words with bound roots by primes including the same root. Furthermore, the facilitation effect was not different in size from the facilitation produced by prefixed word primes with free rots on prefixed word targets sharing the same free root.

In other lexical decision esperiments, Bergman *et al.* (1988) found longer decision times and higher error rates for pseudo-prefixed words (like *religion*) than for truly prefixed words. Truly prefixed words with bound roots did not behave differently from truly prefixed words with free roots.

Using a different experimental methodology, Lima (1987) monitored eye-movements on prefixed and pseudo-prefixed words, and found longer fixations on pseudo-prefixed than on prefix words. The latter included both words with free roots and words with bound roots.

Some authors have thus suggested analogous principles of processing/representation for both types of prefixed words: morphological relationships would exist in the mental lexicon also for prefixed words with bound roots. According to Taft & Forster (1975), access to a prefixed word always implies that the prefixed and the root are partitioned, and the root accesses a lexical representation even when it is a bound morpheme. Stanners *et al.* (1979b) suggest that a representation of the prefixed word as a whole is simultaneously activated along with the representation of its root, even when the root is a bound morpheme, and the combination of information from these two sources is required for the complete processing of the word.

These considerations concern processing and representation of printed words, but some results have been obtained also for auditorily presented stimuli. Emmorey (1989) has addressed the issue of the representation of morphological relations among prefixed words with bound roots in a study of auditory lexical decision in which the priming paradigm was employed. In her study, both prime and target were presented auditorily and subjects had to decide whether the stimulus was a word or a non-word. Emmorey (1989) found that the recognition of a target prefixed word with bound root (e.g. *inject*) was facilitated by the previous presentation of a prime prefixed word with the same root, although not associated for meaning to the target word (e.g. *object*). The facilitation did not seem to be due to phonological similarity between prime and target words, since pairs of words which were only phonologically similar, but did not share a morpheme (e.g. *balloon-saloon*, *salute-pollute*) did not show facilitation. From these results Emmorey argued that morphological relationships are represented in the lexicon even when they are purely structural, namely in absence of relations of meaning.[1]

[1] In two other experiments, Emmorey (1989) found some phonological priming for morphologically unrelated word pairs which shared the final syllables. It might therefore be argued, as suggested by Tyler *et al.* (in press), that intramodality priming induced phonological low-level effects. This might attenuate Emmorey's conclusions.

4.2. *Evidence from language disturbances.*

Derivational errors are common in some forms of fluent aphasias, in which patients occasionally create neologisms formed by a root and an inappropriate derivational affix, or even by a non-existing base combined with a real derivational affix (Panzeri *et al.* 1990, Panzeri & Job in press). In the described cases, some neologisms involve prefixes, mainly productive ones. Other evidence is available in studies of disturbances of reading. Dyslexic patients who produce morphological errors in reading aloud have been shown to produce more prefix substitution errors on words which are (phonologically and) semantically transparent with respect to their bases (Cosslett 1988, Kay 1988, Badecker & Caramazza 1991). There is only a study (Kay 1988), to our knowledge, in which boundedness of the prefixed word's stem was taken into account. In this study, two patients showed a tendency, although not significant, to make more morphological reading errors which preserved the bases of semantically transparent words (e.g., *the untruth* → *truth*) than the bases of semantically opaque free-stem forms (*the report* → *port*), or of forms with bound stems (*the reject* → *the object*).

4.3. *Evidence from speech errors.*

A source of evidence for the organization of the phonological output lexicon is the analysis of errors produced by speakers in their spontaneous speech (Garrett 1975; 1982, Stemberger 1985 a and b, del Viso *et al.* 1987; for Italian, see Magno Caldognetto *et al.* 1987; Magno Caldognetto & Tonelli 1989, Chialant 1987-88, 1988). The speech errors which are relevant to the issue under discussion are morphological errors involving prefixes (for a more detailed discussion of these speech errors, see Burani in press b). Prefixes may be involved in contextual errors, such as affix shifts and root exchanges (with stranding of the affixes), which originate from the sentence context by movement of morphemes. Examples are (1) and 2), drawn from Garrett (1975) (the displaced morphemes are capitalized; the intended targets are indicated by T):

(1) He made a lot of money in TELEPHONing STALLS
T: installing telephones

(2) I had inSTAYed TENDing
T: intended staying

Emmorey's findings could rather be interpreted as effects of syllabic priming. This would suggest a role of syllables as representational units, an hypothesis currently debated. However, morphological effects do not seem to be reducible to syllabic effects, as supported by two types of considerations. First, morphological priming is consistently found under a lot of experimental conditions. Second, the amount of priming produced by morphologically related primes is consistently very large if compared to other types of priming effects. This is true also of Emmorey's results: while the size of syllabic priming effects varied between 74 and 77 msecs, the amplitude of morphological priming caused by a prime sharing the bound stem with the target was 143 msecs.

However, the majority of errors on derivational suffixes or prefixes are non-contextual (e.g. Garrett 1982, Stemberger, 1985a, del Viso *et al.* 1987). This means that when a prefix is substituted or added, it is often selected from the entire class of prefixes, with no apparent source in the sentence context. Thus errors on derivational affixes seem to reflect principles of lexical organization and retrieval independently of the affix's assignment to a phrasal site.

Examples of non-contextual errors are the following (from Stemberger 1985a):

(3) She' s so EXquisitive
T: inquisitive

(4) See, my pants are easier to UNDERdo
T: undo

(5) positively or negatively REmarked as
T: marked as

To our knowledge, the types of morphemes involved in prefix errors, and specifically the distinction between errors involving either free or bound roots, have not been systematically analyzed. However, in English corpora, sparse prefix errors involve bound roots, while apparently the largest proportion involves free roots. Errors involving bound roots should be, intuitively, prefix-substitution errors. Examples are the following (from Fromkin 1973, and Stemberger 1985a, respectively):

(6) CONsistent rules
T: persistent rules

(7) INstruct
T: destruct.

However, Stemberger (1985a) reports a surprising case of prefix-deletion error in which the "bare" bound root was produced:

(8) They weren't -geal-
T: congealing

In a corpus of Spanish speech errors (del Viso *et al.* 1987), prefix-substitution errors involving bound roots definitely occur. Some examples follow:

(9) INsistencia
T: asistencia

(10) REsiste
T: persiste

(11) SUBjetivos
T: objetivos

(12) IMplico
T: explico

(13) DEstructoras
T: constructoras

(14) TRANSferencias
T: interferencias

In the corpus of Italian speech errors collected by Chialant (1987-88, 1988), prefix errors occur in analogous proportion to other languages. The errors mainly involve free roots (examples (15) and (16)), but some involve also bound roots (in the example (17) a free root and a bound root mutually exchange leaving their prefixes stranded):

(15) scrivere
T: riscrivere

(16) Sfavorevole
T: favorevole

(17) ho trasCRITTO e riDOTTO l'intero brano
T: ho tradotto e riscritto l'intero brano

In conclusion, in current speech errors' corpora, errors involving prefixed bound roots do occur along with errors involving prefixed free roots. This suggests that prefixed words are subject to decomposition even when they include a bound root, or that a bound root can act as a morphemic unit around which affixed derivatives are represented in interconnected way.

5. *The present research.*

From the review of existing evidence on processing and representation of prefixed words, there are indications that words with bound roots can be morphologically related in the lexicon, in a way possibly not different from prefixed words with free rots. Furthermore, this lexical organization might hold not only for the (orthographical and phonological) input lexicons, but also for the output phonological lexicon which is involved in production tasks. However, the issue seems worth of further investigation.

As far as the phonological output lexicon is concerned, the evidence drawn from speech errors does not allow to take into consideration other factors which might affect the establishment of a morphological relationship in the lexicon among prefixed words and, hence, the probability that a prefix substitution error occurs (see also, for further considerations on the limitations intrinsic to the speech errors' methodology, Burani 1992a) this issue; Burani in press (b)). This aspect might be particularly important for words with the same bound root, since in natural communication, speakers may choose words which are frequently used in the language, with the

consequence that prefixed words with free roots might have a greater chance to be involved in an error than prefixed words with bound roots, the former tending to be more frequent in the language than the latter. (These and the following considerations do not rely on published counts, but are derived from a close inspection of dictionaries and counts of frequency for Italian). Moreover, a morphological error might occur more likely on words with a greater number of morphological "relatives" acting as competitors of the target form, and prefixed words with free roots seem more likely to have many morphological relatives if compared to prefixed words with bound roots. For these reasons it seemed worth comparing words with free and bound roots in a controlled situation in which these biases were put under control.

6. *Experiment.*

What wight affect the probability that a speaker/reader posits some relations among prefixed words sharing a bound root could be the fact that s/he encounters the same bound root in many different word-types in the language. To say it differently, the hypothesis can be entertained that, in order for a bound root to act as a unit of representation in the mental lexicon, it needs to be realized in many different word-types (in combination with different affixes) in the language. This dimension should not in principle affect, or should not affect at the same extent, the probability of establishing lexical morphological relationships among prefixed words with free roots, or between each of these derived words and their (free) root, standing the considerations reported above (for further discussion of the role of distributional factors in lexical representation and processing, see also Burani in press a), Burani & Laudanna 1992).

The use of an experimental methodology for eliciting morphological errors enables to investigate systematically the effects of the variables hyphotesized to play a role in lexical processing and representation. The methodology adopted in Burani (1992b this issue), in Chialant & Burani (1992 this issue), and discussed in Burani (1992a this issue) was used in the present experiment to investigate the role of formal and distributional factors in the retrieval of prefixed words for spoken production. The task used for inducing morphological errors was oral free-recall of lists of words presented auditorily. The lists of words submitted to the subjects included only prefixed words. This list composition allowed a set-induction technique by which, if recall errors occur, they should respect the word's morphological composition, thus consisting for the most part in the substitution of the prefix or the root of the target words. The underlying assumption is that, if prefix substitution errors do not occur randomly but they are distributed differently according to different types of prefixed words and their

distribution is not reducible to the distribution of other phonological errors not involving morphemically defined strings of phonemes, this might indicate that different types of prefixed derivatives are represented in partially different ways in the lexicon.

6.1. *Method.*

6.1.1. *Materials and design.* In the experiment two factors, namely root type (whether free or bound) and number of prefixed words which share the same root, were investigated. Four sets of prefixed Italian words were selected. The four experimental groups differed for root type and number of prefixed words constituting a morphological family (examples for each group are given in the Appendix). The first group (FR-LN) included prefixed words with free roots (FR) and low number (LN) of prefixed words in the family. More precisely, for each prefixed word there was only one other prefixed word in the language (one lemma) with the same root. The second group (BR-LN) was constituted by prefixed words (lemmata) in the family (two members for each family). The third group (FR-HN) included prefixed words with free roots and high number (HN) of prefixed words in the morphological family. The number of prefixed words constituting a family varied from four to seven, with a mean of five members. The fourth group (BR-HN) was composed by prefixed words with bound roots and high number of prefixed words in the family (a mean of five members).

All the prefixed words were verbs in the infinitive form. The four experimental groups were accurately matched for the following aspects which can affect memory performance: length of prefixed words and their degree of "imageability" or concreteness; frequency of the target prefixed words and cumulative frequency of all the prefixed words sharing the same root; types of prefixes involved. Length was calculated in syllables. Prefixed words with free roots were selected among those whose base verbs were low-frequency, in order to match as much as possible the cumulative frequency of morphological families in the groups with free and bound roots. Since all the selected prefixed words except three (having very low frequency) did not even occur in the frequency count for Italian (Bortolini *et al.* 1971), they were submitted to eighteen subjects for subjective ratings of frequency, in order to assess their relative frequency and to balance words frequency across experimental groups. The prefixed words which were included as targets in the experimental lists had the lowest frequency within their morphological family, i.e. within the family constituted by all the prefixed words with the same root. The prefixes occurring in the experimental derivatives were among the most frequent and productive in Italian (see Iacobini 1992). The two latter factors (low frequency of derivatives and high frequency and/or productivity of prefixes involved) were intended to maximize the possibility of inducing prefix substitution errors (for the role

of target frequency in affecting speech errors, see Dell 1990; for the tendency shown by productive affixes to be particularly involved in morphological errors, see Chialant 1987-88, Cosslett 1988, Panzeri *et al.* 1990, Badecker & Caramazza 1991; for additional evidence on the role of affix productivity in affecting performance, see also Badecker *et al.* 1990, Burani & Thornton 1992).

There were fourteen prefixed words in each group. From the four groups, four experimental lists were constructed. In each list, there were one fourth of words from each group, randomly mixed. Four random orders for each list were created.

Experimental lists were balanced for length, frequency and types of prefixes inlcuded. Within each list, relations of meaning and/or sound among words were avoided.

6.1.2. *Procedure.* Each subject was administered all the prefixed words of the different groups mixed in the four lists. The four lists were presented in different random orders. The experimenter read aloud one list of prefixed words, at the rate of about one word every three seconds. After an interfering task following each list (some simple written arithmetic operations lasting at least twenty seconds), the subject had to recall orally as many words of the list as possible. Subjects were required to recall the words in the same exact form as they were heard, although independently of the order of presentation. The subject was not given any deadline, and s/he stopped when s/he was not able to recall any more words. The experimenter scored all the words produced by the subject. Each experimental session lasted about fifteen minutes.

6.1.3. *Subjects.* Seventy subjects, students at the University of Rome, participated in the experiment and were paid for their participation.

6.1.4. *Predictions.* Given the accurate balancing of the various factors which affect the probability of producing an error, any difference in the distribution of prefix-substitution errors in the four experimental categories should originate from differences in the composition of prefixed words or of their morphological families. If prefixed words with bound roots are represented (not differently from words with free roots) in morphologically decomposed form, or as whole forms but interconnected through morphological relations, they should give rise to an analogous number of prefix substitution errors as words with free roots. If, on the contrary, prefixed words sharing the same bound root are not related or are more weakly related in the lexicon than prefixed words sharing the same free root, prefixed words with bound roots should show fewer prefix substitution errors than words with free roots.

An alternative prediction is that, within the class of prefixed words with

bound roots, only those whose morphological family is constituted by many members (BR-HN) give rise to as many morphological errors as those found with prefixed words with free roots and the same number of prefixed realtives (FR-HN), while prefixed words with bound roots and only one other prefixed word in their family (BR-LN) might produce no errors or far fewer morphological errors than prefixed words with free roots and the same low number of prefixed relatives (FR-LN). This possible outcome would point to the role of empirical distributional factors in affecting lexical representation, by showing that bound roots act as units of processing and representation only when they occur in many words of the language.

6.2. *Results.*

The subjects' correct recalls, omissions (i.e. items not recalled) and errors were analyzed. Subjects recalled about one third of the items in the experimental list, either in their correct forms or making an error related to the target. Thus the total percentage of items omitted was 66% across all subjects. Of the items retrieved, 71.4% were recalled in their correct form. This is a stable percentage in all the experiments in which this methodology was adopted, and in which experimental lists had approximately the same number of stimuly of analogous length (Burani 1992b), Exp. 2, this issue, Chialant & Burani 1992 this issue). The distribution of correct recalls is analyzed below.

The items retrieved not in their correct form consisted for the most part in prefix substitution errors (10.9% of the total of recalls), and in so-called "phonological" errors, i.e. errors differing from the target word for one or more phonemes in various parts of the word, independently of its morphological structure (e.g. *erigere* → *redigere*; *conculcare* → *occultare*). Errors consisting in possible root substitutions were classified among phonological errors (e.g. *commisurare* → *commissionare*). Phonological errors were 10.2% of the total of subjects' recalls. There were also a few errors (1.2%) which were related to the target for meaning (e.g. *erigere* → *edificare*), or for both meaning and sound (1.3%) (e.g. *rigettare* → *rigurgitare*). A small percentage (0.9%) consisted in the recall of the target's base verb, or in prefix additions. Some errors (4.1%) were considered to be unrelated to any target.

Some items exceeding two standard deviations above the mean of either correct recalls or prefix substitution and phonological errors were excluded from the analyses. There were two items excluded in each experimental category. A first analysis took into account prefix substitution (morphological) errors, and showed that they were distributed differently in the four groups of word-types. Results are shown in Table 1. The analysis of variance included two factors: root-type (FR vs BR), and number of prefixed morphological relatives (LN vs HN). The results showed a

significant effect of the factor "number of prefixed morphological relatives" (Min F'(1,94) = 3.88, p < .06), with derivatives with a higher number of prefixed morphological relatives giving rise to more prefix substitution errors than derivatives with less prefixed morphological relatives. However, neither the factor "root-type", nor the interaction between the two factors were significant (by subjects, F(1,69) = 1.55, n.s.; F(1,69) = 2.59, n.s., respectively; by items, F < 1 for both analyses).

Table 1. *Percentage of prefix substitution (morphological) errors in each experimental category (FR-LN: free root, low number of prefixed relatives; FR-HN: free root, high number of prefixed relatives; BR-LN: bound root, low number of prefixed relatives; BR-HN: bound root, high number of prefixed relatives).*
Percentages are calculated on the total number of items to be recalled in each category.

	LN	HN
FR	1.4	4.6
BR	1.5	2.8

The analysis of the distribution of phonological errors aimed at assessing whether morphological errors were genuinely "morphological", and not merely phoneme substitutions, deletions and additions. The assumption underlying the analysis was the following. It might be the case that for some reason some word-types elicit more phonological errors. Thus some of these errors might result in apparently morphological errors, although coming from a phonological source. If this were the case, phonological errors too should be distributed not randomly in the four groups and their distribution might parallel the observed distribution of morphological errors. If, on the contrary, phonological and morphological errors come from different sources, their distribution might be different.

The analysis was performed on the percentages of errors which differed from the target word for one or more phonemes independently of morphological structure (phonological errors were defined as errors preserving at least 50% of the phonemes of the target word). The percentages of phonological errors (calculated on the total number of items to be recalled in each category) are shown in Table 2. The two-way analysis of variance showed that they were distributed not significantly differently according either to root-type or to number of prefixed morphological relatives. However, there was interaction between the two factors (by subjects, F (1,69) = 5.72, p < .02; by items, F (1,48) = 5.42, p < .05).

Table 2. *Percentage of phonological errors in each experimental category (FR-LN: free root, low number of prefixed relatives; FR-HN: free root, high number of prefixed relatives; BR-LN: bound root, low number of prefixed relatives; BR-HN: bound root, high number of prefixed relatives).*
Percentages are calculated on the total number of items to be recalled in each category.

	LN	HN
FR	2.3	3.4
BR	4.8	2.6

These analyses show that the four classes of derived words were analogously subject to phonological errors. By contrast, they elicited prefix substitution errors in different degrees. Thus prefix substitution errors can be taken more confidently as true morphological errors. In order to control further for the "genuinity" of morphological errors, their percentages were calculated, for each group, on the total number of (presumed) morphological errors and phonological errors, namely on the total of errors which, having a resemblance in sound with the target-word, could in principle arise from a phonological source. The results, that are shown in Table 3, were in accordance with the first analysis on prefix substitution errors: there were significantly higher percentages of morphological errors on the total number of morphological and phonological errors (by subjects, F(1,69) = 18.37, p < .001) in the two groups with a high number of prefixed words in the morphological family than in the two groups whose morphological families included only two prefixed members. Again, the percentages of morphological errors did not differ along the dimension "root type" (F < 1). Similarly, there was no interaction between the two factors (F < 1).

Table 3. *Percentage of morphological errors calculated on the total number of morphological + phonological errors in each experimental group (FR-LN: free root, low number of prefixed relatives; FR-HN: free root, high number of prefixed relatives; BR-LN: bound root, low number of prefixed relatives; BR-HN: bound root, high number of prefixed relatives).*

	LN	HN
FR	34	59
BR	27	57

An unexpected result was found analyzing correct recalls, that is the percentages of items, in each category, which were recalled in the exact form in which they were heard. The percentages of correct recalls (calculated on the total number of items to be recalled in each category) are shown in Table 4. They were significantly higher for words with bound roots than for words with free roots (min F' $(1,104) = 4.95$, $p < .05$). By contrast, correct recalls did not differ according to the number of prefixed morphological relatives (by subjects, $F(1,69) = 1.04$, n.s.; by items, $F < 1$). No interaction between the two factors was found ($F < 1$ by both subjects and items). In synthesis, the probability of recalling a word in its correct whole form was function of root type, with prefixed words with bound roots being more subject to be recalled correctly as whole forms.

Table 4. *Percentage of correct recalls in each experimental category (FR-LN: free root, low number of prefixed relatives; FR-HN: free root, high number of prefixed relatives; BR-LN: bound root, low number of prefixed relatives; BR-HN: bound root, high number of prefixed relatives). Percentages are calculated on the total number of items to be recalled in each category.*

	LN	HN
FR	20	19
BR	29	26

7. *Discussion.*

These results show that when words are accurately controlled for the factors affecting the probability of inducing a morphological error, analogous patterns of morphological errors occur on both prefixed words with free roots and prefixed words with bound roots. This suggests that in the speaker's lexicon both types of prefixed words are represented as morphologically related to the other words sharing the same root. The effect of the number of prefixed words included in a morphological family (with more prefix substitution errors on words with a larger number of prefixed morphological relatives) is not in itself particularly surprising, since words with more morphological relatives have a larger set of alternatives that can be activated when the target is for some reason not available. What is more interesting is that this effect was analogous for prefixed words with free root *and* for words with bound root. Also the fact that no interaction was found between the effect of the number of prefixed relatives and the second factor, namely root type, does not speak in favor of different representation modalities for the two types of prefixed derivatives.

However, possible differences between the two types of prefixed derived words are suggested by the different pattern of correct recalls (which is quite stable having being exactly replicated with other sets of prefixed verbal forms by Chialant & Burani 1992 this issue). This pattern of results (more correct recalls on words with bound roots than on words with free roots) seems connected to the presence, in the morphological organization of words with free roots (but not in the family of words with bound roots), of the unprefixed base word-form. This word-form, although activated by the input word and available to the speaker for retrieval, cannot be produced because of the experimental list's composition, which requires the production of a prefixed word. At the same time, it can be assumed that, for a number of reasons, the lexical entry corresponding to the base form tends to have a higher activation level in the mental lexicon than its derived forms. Thus it can constitute a strong "competitor" for the retrieval of the target derivative, with the conseguence of inhibiting the derivative's production.

An asymmetry in the representation or availability of the base form with respect to its derivatives is suggested for instance by Bybee (1985, 1988). According to Bybee, the base form's representation has greater "lexical strength" than its derived forms. This imbalance implies a dependency relation of the more complex form (the derivative) on the simpler one (the base). A derived word is lexically represented in terms of its base form, while the opposite does not hold. To put it differently, the derived forms, being the weaker forms (in that they are less frequent and more complex than the base), are learned and stored in the lexicon in relation to stronger forms, namely their bases (which, by contrast, are the more frequent, morphologically simpler forms, thus acting as the bases for innovation).

This might indicate that the retrieval of a derived word from the lexicon is sensitive to the composition of the word's morphological family. While the lexical representation of morphological families of derived words with free rots includes a form (the base form) which has a special status and acts as "attractor" of the other forms, no such asymmetry is present in the morphological families constituted by derived words with bound roots. In the lexical representation of morphological families of the latter type, there is no form (corresponding to an existing word) with a special status in terms of "basicness" or structural simplicity, able to work as attractor and strong competitor of other forms. This organization should advantage, in a task like the one we employed, the retrieval of a derived word with bound root in comparison to derived words with free roots (for further discussion of this issue, see Burani in press a).

On the basis of these results only, it is not possible to go further in the interpretation. At the moment, these data suggest that prefixed derivatives with both free and bound roots are morphologically organized in the output mental lexicon. Moreover, the data indicate both analogies and differences in the lexical representation of prefixed words of the two types. However, like most data on morphological effects, our results are

still compatible with two main types of representational hypotheses. Specifically, the data seem to be explained by both a "decompositional" account, in which it is assumed that lexical entries for morphologically complex words are represented in morphologically decomposed form with roots connected to the affixes they can be combined with (Laudanna & Burani 1985, Burani & Caramazza 1987, Caramazza *et al.* 1988, Tyler *et al.* in press), and by an alternative account in which morphologically related words are represented in the lexicon as whole forms but interconnected along morphological links (Lukatela *et al.* 1980, Fowler *et al.* 1985, Stemberger 1985a, 1985b).

The decompositional hypothesis, if adopted for both types of derived words, would assume that, like free roots, bound roots too are represented in the lexicon as independent entries. If, by contrast, the hypothesis of whole-word interconnected representations is adopted for both types of words, it should take into consideration the presence of the unprefixed base form within the set of lexical entries sharing a free root. Thus the lexical entry corresponding to the base word would probably be assigned a central position in which it would function as a "nucleus" around which the derived forms would cluster uniformly, in a way analogous to "satellites" lexical entries postulated by some authors (Lukatela *et al.* 1980).

Different solutions for each type of derived words are also conceivable. For instance, prefixed words with free roots might be morphologically decomposed while prefixed words with bound roots might be represented as whole structurally interconnected forms. In this hypothesis, the pattern of correct recalls we found in the experiment, with words with bound roots being recalled better as whole words than words with free root, might originate from the fact that the former are represented and consequently retrieved as whole forms, while the latter have to be produced compositionally by combining the root with the appropriate prefix. In the course of the compositional process of the latter forms, the lexical entry corresponding to the (unprefixed) root might compete with the retrieval of the morphologically complex form, by virtue of its higher activation level.

All these representational variants have to be further specified with reference to processing modalities. At the same time, additional detailed empirical evidence needs to be collected. By closer examination of both theoretical models and empirical evidence we will hopefully gain a better understanding of representation and processing of morphologically complex words.

Address of the Authors:
Istituto di Psicologia del C.N.R.
Viale Marx, 15
00137 Roma
e-mail: BURANI@IRMKANT.bitnet

Appendix

Examples of prefixed verb forms in the four experimental groups:
(a) FR-LN: prefixed words with free roots and a low number of prefixed words in the morphological family.
(b) BR-LN: prefixed words with bound roots and a low number of prefixed words in the morphological family.
(c) FR-HN: prefixed words with free roots and a high number of prefixed words in the morphological family.
(d) BR-HN: prefixed words with bound roots and a high number of prefixed words in the morphological family.
(The approximate English translation is given in parentheses).

FR-LN		*BR-LN*	
Target	Prefixed members in the family	Target	Prefixed members in the family
RIMORDERE (to prick)	DEMORDERE (to leave off)	DISTRICARE (to disentangle)	INTRICARE (to entangle)
RIGONFIARE (to inflate again)	SGONFIARE (to deflate)	ERIGERE (to erect)	DIRIGERE (to direct)
PERLUSTRARE (to reconnoitre)	ILLUSTRARE (to illustrate)	DEBELLARE (to defeat)	RIBELLARE (to incite to revolt)
ERODERE (to erode)	CORRODERE (to corrode)	PERCUOTERE (to strike, to beat)	SCUOTERE (to shake)

FR-HN		*BR-HN*	
Target	Prefixed members in the family	Target	Prefixed members in the family
INCENTRARE (to centre)	DECENTRARE (to decentralize)	ECCEPIRE (to object, to except)	RECEPIRE (to take into)
	ACCENTRARE (to centralize)		CONCEPIRE (to conceive)
	CONCENTRARE (to concentrate)		PERCEPIRE (to perceive)
PREFORMARE (to preform)	DEFORMARE (to deform)	ADDURRE (to adduce)	DEDURRE (to deduce)
	RIFORMARE (to reform)		RIDURRE (to reduce)
	CONFORMARE (to conform)		CONDURRE (to lead, to guide)
	INFORMARE (to inform)		INDURRE (to induce)
	TRASFORMARE (to transform)		TRADURRE (to translate)
	SFORMARE (to pull out of shape)		PRODURRE (to produce)

References

Altmann, G. T. M. & R. Shillcock, eds. (in press), *Cognitive Models of Speech Processing: the Sperlonga Meeting II*, Hove, Lawrence Erlbaum Associates.

Aronoff, M. (1976), *Word Formation in Generative Grammar*, Cambridge, MA, MIT Press.

Aronoff, M. & M. L. Kean, eds. (1979), *Juncture*, Cambridge, MA, MIT press.

Badecker, W. & Caramazza, A. (1991), "Morphological composition in the lexical output system", *Cognitive Neuropsychology* 8: 335-367.

Badecker, W., Hillis, A. & Caramazza, A. (1990), "Lexical morphology and its role in the writing process: evidence from a case of acquired dysgraphia", *Cognition* 35: 205-243.

Beauvillain, C. & Segui, J. (1992), "Representation and processing of morphological information", in Frost & Katz (1992: 377-388).

Bentin, S. & Feldman, L. B. (1990), "The contribution of morphological and semantic relatedness to repetition priming at short and long lags: evidence from Hebrew", *Quarterly Journal of Experimental Psychology* 42A: 693-711.

Bergman, M. W., Hudson, P. T. W. & Eling, P. A. T. M. (1988), "How simple complex words can be: morpological processing and word representations", *Quarterly Journal of Experimental Psychology* 40A: 41-72.

Booij, G. E. & J. van Marle, eds. (1990), *Yearbook of Morphology*, Dordrecht, Foris.

Bortolini, U., Tagliavini, C. & Zampolli, A. (1971), *Lessico di frequenza della lingua italiana contemporanea*, Milano, Garzanti.

Bower, G. H., ed. (1975), *The Psychology of Learning and Motivation vol. 9*, London, Academic.

Bradley, D. (1979), "Lexical representation of derivational relation", in Aronoff & Kean (1979: 37-55).

Burani, C. (1992a), "Experimentally induced morphological errors: Implications for the morphological organization of the mental lexicon", *Rivista di Linguistica*, this issue.

Burani, C. (1992b), "Patterns of inflectional errors with reference to the Italian adjectival system", *Rivista di Linguistica*, this issue.

Burani, C. (in press a), "What determines morphological relatedness in the lexicon?", in Altmann & Shillcock (in press).

Burani, C. (in press b), "The lexical representation of prefixed words: data from production tasks", *Acta Linguistica Hungarica*.

Burani, C. & Caramazza, A. (1987), "Representation and processing of derived words", *Language and Cognitive Processes* 2: 217-227.

Burani, C. & Laudanna, A. (1988), "Relazioni morfologiche tra forme derivate e forme verbali", *Giornale Italiano di Psicologia* 15: 625-640.

Burani, C. & Laudanna, A. (1992), "Units of representation for derived words in the lexicon", in Frost & Katz (1992: 361-376).

Burani, C. & Laudanna, A. (in press), "L'elaborazione della informazione morfologica in soggetti adulti", in Laudanna & Burani (in press).

Burani, C. & Thornton, A. M. (1992), "Productivity of derivational suffixes as a factor in the processing of derived words", paper presented at the Workshop on "Psycholinguistic Approaches to the Lexical Representation of Morphological Structure", Fifth International Morphology Meeting, Krems (Austria), 6-7 July 1992.

Bybee, J. L. (1985), *Morphology: a Study of the Relation between Meaning and Form*, Amsterdam, Benjamins.

Bybee, J. L. (1988), "Morphology as lexical organization", in Hammond & Noonan (1988: 119-142).

Caramazza, A., Laudanna, A. & Romani, C. (1988), "Lexical access and inflectional morphology", *Cognition* 28: 297-332.

Carlson, G. N. & Tanenhaus, M. K. T. eds (1988), *Linguistic Structure in Language Processing*, Boston, Kluwer.

Chialant, D. (1987-1988), "Un'analisi di errori morfologici di produzione spontanea", *Annali della Facoltà di Lettere e Filosofia dell'Università di Perugia* 25: 183-203.

Chialant, D. (1988), "Gli errori morfologici nella produzione linguistica: un'indagine sulla struttura del lessico mentale", tesi di laurea, Perugia University.

Chialant, D. & Burani, C. (1992), "Errors on prefixed verbal forms: Effects of root type and prefix type", *Rivista di Linguistica*, this issue.

Cole', P., Beauvillain, C. & Segui, J. (1989), "On the representation and processing of prefixed and suffixed derived words: a differential frequency effect", *Journal of Memory and Language* 28: 1-13.

Cosslett, B. (1988), "Morphological processing and reading", paper presented at the Sixth European Workshop on Cognitive Neuropsychology, Bressanone (Italy), 24-29 January 1988.

Dardano, M. (1978), *La formazione delle parole nell'Italiano di oggi*, Roma, Bulzoni.

Dell, G. S. (1990), "Effects of frequency and vocabulary type on phonological speech errors", *Language and Cognitive Processes* 5: 313-349.

Ellis, A. W., ed. (1982), *Normality and Pathology in Cognitive Functions*, London, Academic.

Ellis, A. W., ed. (1985), *Progress in the Psychology of Language 1*, London, Lawrence Erlbaum Associates.

Emmorey, K. D. (1989), "Auditory morphological priming in the lexicon", *Language and Cognitive Processes* 4: 73-92.

Fowler, C.A., Napps, S. E. & Feldman, L. B. (1985), "Relations among regularly and irregularly morphologically related words in the lexicon as revealed by repetition priming", *Memory & Cognition* 13: 241-255.

Frauenfelder, U. H. & Schroeder, R. (1991), "Constraining psycholinguistic models of morphological processing and representation: the role of productivity", in Booij & van Marle (1991: 165-184).

Fromkin, V. A. (1973), *Speech errors as linguistic evidence*, The Hague, Mouton.

Frost, R. & L. Katz, eds. (1992), *Orthography, Phonology, Morphology and Meaning*, Amsterdam, Elsevier.

Garrett, M. (1975), "The analysis of sentence production", in Bower (1975: 133-177).

Garrett, M. (1982), "Production of spech: observations from normal and pathological language use", in Ellis (1982: 19-76).

Hammond, M. & M. Noonan, eds. (1988), *Theoretical Morphology*, San Diego, Academic.

Iacobini, C. (1992), *La prefissazione nell'italiano contemporaneo*, unpublished Ph. D. Thesis, Roma, Università degli Studi "La Sapienza".

Kay, J. (1988), "On the origin of morphological errors in two cases of acquired dyslexia", *Linguistics* 26: 669-697.

Lapointe, S. G. & Dell, G. S. (1988), "A synthesis of some recent work in sentence production," in Carlson & Tanenhaus (1988: 107-156).

Laudanna, A. & Burani, C. (1985), "Address mechanisms to decomposed lexical entries", *Linguistics* 23: 775-792.

Laudanna, A. & C. Burani, eds. (in press), *Il Lessico: processi e rappresentazioni*, Roma, La Nuova Italia scientifica.

Laudanna, A., Burani, C. & Cermele, A. (1992), "What makes a prefix a processing unit?", ms. submitted for publication.

Lima, S. D. (1987), "Morphological analysis in sentence reading", *Journal of Memory and Language* 26: 84-99.

Lukatela, G., Gligorijević, B. & Kostič, A. (1980), "Representation of inflected nouns in the internal lexicon", *Memory & Cognition* 8: 415-423.

MacKay, D. G. (1978), "Derivational rules and the internal lexicon", *Journal of Verbal Learning and Verbal Behavior* 17: 61-71.

Magno Caldognetto, E., Tonelli, L. & Pinton, A. (1987), "I morfemi radicali nella produzione della parola", *Acta Phoniatrica Latina* 9: 373-380.

Magno Caldognetto, E. & Tonelli, L. (1989), "Gli errori di parola → I paroli di errora. L'organizzazione della morfologia nell'esecuzione linguistica", *Quaderni del Dipartimento di Linguistica e Letterature comparate*, Istituto Universitario di Bergamo, 5: 267-276.

Marchand, H. (1969), *The Categories and Types of Present-Day English Word Formation*, Munich, Beck.

Napps, S. E. (1989), "Morphemic relationships in the lexicon: are they distinct from semantic and formal relationships?", *Memory & Cognition* 17: 729-739.

Nespoulous, J.-L. & P. Villiard, eds. (1991), *Morphology, Phonology, and Aphasia*, New York, Springer.

Nida, E. A. (1949), *Morphology*, Ann Arbor, University of Michigan Press.

Panzeri, M. & Job, R. (in press), "Evidenza neuropsicologica per un modello dell'elaborazione dell'informazione morfologica", in Laudanna & Burani (in press).

Panzeri, M., Semenza, C., Ferreri, T. & Butterworth, B. (1991), "Free use of derivational morphology in an Italian Jargonaphasic", in Nespoulous & Villiard (1991: 72-94).

Rubin, G. R., Becker, C. A. & Freeman, R. H. (1979), "Morphological structure and its effect on visual word recognition", *Journal of Verbal Learning and Verbal Behavior* 18: 757-767.

Selkirk, E. O. (1982), *The Syntax of Words*, Cambridge, MA, MIT Press.

Stanners, R. F., Neiser, J. J., Hernon, W. P. & Hall, R. (1979a), "Memory representation for morphologically realted words", *Journal of Verbal Learning and Verbal Behavior* 18: 399-412.

Stanners, R. F., Neiser, J. J. & Painton, S. (1979b), "Memory representation for prefixed words", *Journal of Verbal Learning and Verbal Behavior* 18: 733-743.

Stemberger, J. P. (1985a), *The Lexicon in a Model of Language Production*, New York, Garland.

Stemberger, J. P. (1985b), "An interactive activation model of language production", in Ellis (1985: 143-186).

Taft, M. & Forster, K. I. (1975), "Lexical storage and retrieval of prefixed words", *Journal of Verbal Learning and Verbal Behavior* 14: 638-647.

Taft, M., Hambly, G. & Kinoshita, S. (1986), "Visual and auditory word recognition of prefixed words", *The Quarterly Journal of Experimental Psychology*, 38A: 351-366.

Tyler, L. K., Marslen-Wilson, W., Rentoul, J. & Hanney, P. (1988), "Continuous and discontinuous access in spoken word recognition: the role of derivational prefixes", *Journal of Memory and Language* 27: 368-381.

Tyler, L. K., Marslen-Wilson, W. & Waksler, R. (in press), "The representation and access of derived words", in Altmann & Shillcock (in press).

del Viso, S., Igoa, J. M. & Garcia-Albea, J. E. (1987), "Corpus of spontaneous slips of the tongue in Spanish", ms, Universidad de Oviedo.