Errors on prefixed verbal forms: Effects of root type and prefix type

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The effects of two variables on the induction of prefix substition errors in a free-recall task were evaluated. The variables were (i) root type (whether free or bound, see also Burani *et al.* 1992 this issue), (ii) prefix type (whether unmodifying or modifying). By "unmodifying" prefix it was meant a prefix (e.g., It.: *pre-*, *s-*) which does not produce, when combined with a root, any phonological process (as assimilation) at the morphological boundary. By contrast, "modifying" prefixes (e.g., It.: *a-*, *con-*) may induce, when combined with a root, some phonological accommodation of the prefix to the root. Results show that prefix substitution errors did not vary according to both root and prefix type. However, prefixed words with bound roots were better recalled as whole forms than prefixed words with free roots. These results suggest both analogies and differences in the morphological organization of prefixed words of the two types within the mental lexicon.*

1. *Introduction.*

The issue of processing and representation of derived words in the mental lexicon has in the last years been taken into increasing consideration. Experimental effort has been devoted to assessing whether affixed derived words are processed and represented as morphologically related to their base forms and to the other derived words sharing the same base, or as independent lexical entries. The hypothesis of morphological relatedness among lexical entries has taken two main versions. The first assumes that polymorphemic words are processed and stored in morphologically decomposes form i.e. as affix plus base (Taft & Forster 1975, Caramazza *et al.* 1988, Caramazza *et al.* in press; Tyler *et al.* in press). A second version posits that polymorphemic words are processed and represented as whole-words, but not independently from each other. According to this latter hypothesis, whole-word lexical entries which are morphologically related

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would be interconnected through morphological links (Lukatela *et al.* 1980, Fowler *et al.* 1985). More detailed reviews of experimental findings in this area of research are presented in Burani (in press a); Burani *et al.* (1992 this issue).

Different tasks, involving either recognition or production of printed and spoken words have been investigated. By contrast, differences between suffixed and prefixed derived words, or differences within sets of suffixed and prefixed derivatives, have not systematically been taken into consideration.

However, many properties of affixed derived words may affect their morphological processing and lexical organization (for a discussion of this issue, see Frauenfelder & Schroeder 1991, Burani in press a); Burani & Laudanna 1992). It can be supposed that the more a derivative's morphemic constituents are available as units of processing and representation, the more the derivative is subject to morphological decomposition (or to be processed and represented as morphologically related to other forms). Thus the effects of root types and affix types involved in a derivative, as well as the effects of root's and affix's combination, should be investigated.

In the present paper, the interaction of two properties of morphemes, namely the root's property of being either free or bound, and the prefix's property of determining phonological accommodation when combined with the (free or bound) root, is taken into account. For the role in processing and representation of free and bound roots, the reader is referred to Burani *et al.* (1992 this issue), in which the issue is widely discussed both from a theoretical and an experimental point of view. Here we wish only to remind that prefixes can attach either to a free-standing root (e.g. Eng.: *re-write*; It. *ri-scrivere*) or to a root that cannot appear alone (e.g. Eng.: *-ceive*: *re-ceive*, *con-ceive*; It.: *-durre*: *con-durre*, *ri-durre*). While prefixed words with free roots are usually considered to be polymorphemic, the status of prefixed words with bound roots is controversial (See Nida 1949, Aronoff 1976, for different positions; see also Burani *et al.* 1992 this issue, for further discussion). Although etymologically derived, these words do not contain a root morpheme in the proper sense, as their root cannot appear in isolation and it does not convey an invariant meaning. However, the speaker's mental lexicon may represent some degree of relatedness among prefixed words sharing the same (bound) root, by virtue of other formal and distributional aspects, as discussed in Burani *et al.* (1992 this issue).

The second factor (i.e. phonological modification consequent to affix's and root's combination), which has not been considered in Burani *et al.* (1992 this issue), is discussed in more detail in the present paper.

The paper is organized as follows. First, a review of experimental evidence concerning the role in lexical processing and representation of phonological/orthographical transparency of a derived word with respect to its base is presented. Although the present research deals with the morpho/phonological organization of the mental lexicon involved in the

retrieval of spoken words, the review will take into account processing and representation of printed words as well, which have been more thoroughly investigated. Then hypotheses formulated within linguistics, specifically within lexical phonology, for which the interaction of phonological and morphological aspects is crucial, are discussed. The hypotheses underlying the present research are subsequently discussed. Finally, our experimental research is presented and its outcomes discussed.

2. *Phonological/orthographical transparency of derived words.*

2.1. *Experimental investigations.*

One of the properties of derived words possibly affecting their processing and representation is their degree of phonological (and/or orthographical) transparency with respect to the base, namely the degree to which a root is modified when it accommodates an affix. This formal transparency, as well as the transparency of meaning between a derivative and its morphological constituents, should affect the probability that the derived word is processed and represented with reference to its morphological constituency.

The role of phonological/orthographical transparency has been experimentally investigated with reference to suffixed derivatives. To our knowledge, no study investigating this dimension has taken into account prefixed words. A first set of results comes from experiments involving printed stimuli. Using a visual lexical decision task, in which subjects have to decide as quickly as possible whether a printed stimulus is a real word or is not a word, Bradley (1979) found evidence for activation of the base root in phonologically transparent English suffixed derivatives, but not in phonologically more opaque ones. Bradley showed root-frequency effects, with quicker lexical decisions to derived words having more frequent base roots, for derivatives which preserve the phonological characteristics of the base word, namely derivatives suffixed by *-er*, *ment-* and *ness-*. By contrast, no frequency effects were found for derivatives suffixed by *-ion*, in which the suffix affects the root morpheme's phonology (e.g. *prevention* from *prevent*), sometimes stress placement (e.g. *discrimination* from *discriminate*), and very often root morpheme's spelling (e.g. *division* from *divide*).

Both Burani & Caramazza (1987) and Colé *et al.* (1989) replicated the root-frequency effect with Italian and French suffixed derivatives, respectively, which did not differ orthographically, and for Italian also phonologically, from their base roots. The derived words were medium-low frequency, and had mostly productive suffixes.

Other evidence for a role of phonological/orthographical transparency in lexical access to printed derived words comes from studies in which the

"morphemic repetition priming" paradigm was adopted. In this paradigm, prior to the presentation of a target word, and at various lags (usually of 8-12 intervening items), a prime word morphologically related to the target is presented. Lexical decision to the target word is facilitated by the previous presentation of the word morphologically related to it. Some authors (Stanners *et al.* 1979) have shown that facilitation on a base word is larger when the prime derived word is phonologically and orthographically transparent with respect to its base (e.g. *appearance* → *appear*), than when it shows some degree of formal modification (e.g. *destruction* → *destroy*). However, subsequent studies found that when episodic factors were minimized, a base form was primed as effectively by an affixed form which did not preserve the spelling, or the spelling and pronunciation of the base, as by an affixed form which preserved both spelling and pronunciation (Fowler *et al.* 1985, Napps 1989). Fowler *et al.* (1985, Exp. 4b) replicated this finding with auditory primes and targets.

With reference to Italian, Burani & Laudanna (1988) found morphemic repetition priming effects on printed derivatives of the same type studied by Burani & Caramazza (1987). In Burani & Laudanna's (1988) study, the facilitation effect induced by a transparent suffixed derived word on a target inflected verbal form having the same root of the prime was not different in size from the effect obtained by an inflected verbal prime sharing the root with the inflected verbal target (e.g., the derivative *osservazione* primed the verbal form *osserviamo* in the same way as the inflected verbal form *osservavate* primed *osserviamo*). This finding was replicated when prime and target were presented contiguously (i.e., with no intervening stimuli) by Laudanna *et al.* (1992).

It has been amply demonstrated that morphological effects cannot be reduced to orthographical/phonological effects, or to a combination of effects (and relations) of form and meaning (Emmorey 1989, Napps 1989, Bentin & Feldman 1990; see also, for a review, Burani & Laudanna in press). However, it can be argued that intra-modality morphemic priming effects benefit of residual lower-level orthographical/phonological similarities among words which might be confounded with effects arising within a more central component, namely the mental lexicon. Thus some authors (Tyler *et al.* in press) have adopted the cross-modal priming paradigm, in which the prime word is presented auditorily and the target word visually. According to the authors, this methodology allows to interpret facilitation effects between morphologically related words as genuinely lexical effects not arising with the contribution of lower-level relations of bound and/or orthographic form. Tyler *et al.* (in press) found facilitation effects by a suffixed derived word on its base word also when the derivatives was not phonologically transparent with respect to its base (e.g., *judge* primed *judicial* as well as *passionate* primed *passion*). However, the priming effect occurred only when the derivative was semantically transparent with respect to its base.

2.2. *Data from patients with acquired disturbances of language.*

Studies of brain damaged patients present findings relevant to the issue of the relation between morphological and phonological processing. A number of patients have been reported (see Badecker *et al.* 1990, Badecker & Caramazza 1987, 1991, Kay 1988, Miceli & Caramazza 1988; see also, for a review, Panzeri & Job in press) who present deficits that affect the processing of morphological aspects of words and that cannot be reduced to a phonological and/or semantic impairment.

For example, Badecker *et al.* (1990), found that affix productivity and semantic transparency play a role in the production of errors by a brain damaged patient. Words like *darkness*, which are constituted by semantically transparent and productive suffixes, were found to be subject to root and affix substitutions significantly more often than words like *active*, which are constituted by semantically opaque and non productive suffixes. The same result is obtained by Badecker & Caramazza (1991) in the case of another patient. The patient's errors were substitutions or insertions of productive affixes of the language which resulted in illegal combinations of morphemes, such as *poorest* → *poorless* (other cases are discussed in Burani *et al.* 1992 this issue).

These cases speak in favor of an independent role of morphological factors in the processing of words. However, no case has been reported who presents a pure morphological deficit. On the contrary, morphological impairments have been reported as occurring in association with either a semantic or a phonological impairment.

In synthesis, from the review of the literature on the role of phonological transparency on processing and representation of polymorphemic derived words, the following considerations can be drawn. On the one hand, morphological relationships seem to be autonomous and not reducible to phonological and/or orthographic relationships. On the other hand, there is evidence that derived words which are phonologically and/or orthographically transparent with respect to their bases may be more strictly related than words which are less transparent.

3. *Linguistic theory.*

The issue under discussion is obviously relevant to a linguistic theory which investigates the relationships existing between the phonological and the morphological lexical components.

As previously mentioned, no case of brain damaged patients has been reported where a pure morphological impairment occurs in isolation. Morphological impairments consistently occur in association with some other type of deficit. Relevant to the present discussion are the cases which present

an association between morphological and phonological deficits (e.g. Miceli & Caramazza 1988). This association might reflect an interdependency between morphological and phonological aspects of word processing, as proposed by recent morphological theories (Mohanan 1986).

Different aspects of the meaning of a word are expressed through different portions of the phonological string that composes the word. Conceptual aspects of the meaning of a word (for example, the characteristics of the object or concept that the word refers to) are usually expressed by the radical part of the lexical form (e.g. Eng.: *cat*; It.: *gatt-*, 'cat'), whereas morpho-syntactic aspects are usually expressed by the affixal parts of the lexical form (e.g. Eng.: *-s* "plural"; It.: *-o*; *-i* "singular, masculine" and "plural, masculine" respectively). Distinct morphological functions can be expressed by different phonological modification of the lexical form. In this sense the morphological aspects of a lexical form are expressed by features of its phonological representation.

Furthermore, a phonological modification of a root or of an affix at the morphological boundary can be triggered by a specific morphological context. For example, in English (see Mohanan 1986) phonological processes take place in the process of derivation by affixation of the prefix *in-* or the suffix *-ity*, but do not take place in the process of derivation by affixation of the prefix *un-* or the suffix *-ness*. We can exemplify this point with the case of the process of assimilation of /n/ to a subsequent sonorant segment.[1] This process takes place in the context of *in-* but not in that of *un-*:

	*illegal/*inlegal*	*irreligious/*inreligious*
but	**ullawful/unlawful*	**urreasonable/unreasonable*

Because of the morphological selectivity of phonological rules such as the one presented above, it can be argued that morphological and phonological processes interact in a systematic way. As for English, it has been suggested (Mohanan 1986) that distinct morphological processes (such as inflection, derivation and compounding) are correlated with distinct phonological processes and that a specific order in the application of these processes needs to be assumed in order to explain the sequence of phonological modifications that occur in the phonological string.

The lexical components dedicated to morphological processing would then be characterized by an interaction between morphological and phonological processes of word formation. This hypothesis would account for the observed association between morphological and phonological impairments (see also, for considerations drawn from data on speech errors, Chialant 1988).

[1] The process of assimilation is a phonetic process by which a segment influences the articulation of another, adjacent segment, such that the two segments become more or completely similar: e.g., It.: *in + legale → illegale* (total assimilation); *in + porre → imporre* (partial assimilation).

The specific way in which such linguistic distinctions should be incorporated into a model of lexical processing remains to be defined. Regardless of how this problem is ultimately solved, the question remains of which phonological processes are more strictly related to morphological processes. Current linguistic theories suggest that these phonological processes can be selectively impaired whenever the correspondent morphological process is disrupted, and that a biunivocal correlation exists between phonological processes and morphological aspects of word formation. In this sense, different degrees of morphological segmentability and/or productivity can be correlated to different degrees of phonological transparency of the morphological boundaries.[2]

4. *The present research.*

The present experiment was designed to evaluate the morphological aspects of the phonological output lexicon involved in language production, by exploiting a single-word retrieval task. The same methodology adopted in Burani (1992b this issue), and in Burani *et al.* (1992 this issue), was used in the present research. The leader is referred to the cited papers, as well as to Burani (1992 a) this issue) for a discussion of the methodology.

In the present research, special attention is given to Italian prefixed verbs. The following two factors were investigated: (a) root type, i.e. whether lexical forms with free vs. bound roots are differently processed, and (b) prefix type, i.e. whether the presence vs. the absence of phonological modification of the last segment of the prefix and/or of the first segment of the root has an influence on the processing of a lexical form.

From a theoretical point of view, any phonological modification that applies after a morphological process constitutes a further step in the derivational process. Parsing of the lexical form into its morphological constituents implies that a process of recovery of the underlying form of the prefix and of the root be carried out first. Furthermore, a phonologically modified prefix will not be any longer directly identifiable and its surface form will depend on the nature of the first segment of the following root. In this sense a tighter link is established between the prefix and its root by the phonological process. Therefore, the presence of a modifying prefix might play a role similar to that of the presence of a bound root, i.e. it should make the lexical form more resistant to parsing into constituents.

[2] By transparency of morphological boundaries we mean the degree of transparency that can be observed in the phonetic output that results from a morphological process, i.e. after the application of a (derivational or inflectional) rule to a given base form. Non-transparent lexical forms are called "opaque". A lexical form such as *sent-ire → sent-iro'* is defined as transparent, whereas a lexical form such as *ven-ire → verro'* is defined as opaque. The concept of transparency in morphology has been extensively investigated in the work of W. U. Dressler (e.g. 1987), who proposed a "scale of morphotactic transparency" with eight degrees of decreasing transparency.

It can be argued then that the more transparent a lexical form is, the more likely it is that it will undergo parsing into constituents and the more likely a morphological error will occur in its processing. Conversely, the more opaque a lexical form is, the more likely it is that it will be preserved and processed as a whole and the less likely a morphological error will occur in its processing.

5. *Experiment.*

In the experiment, it was investigated whether prefixed words of the two types (with free and bound roots respectively) were likely to produce prefix substitution errors in different degrees according to the types of prefixes (whether unmodifying or modifying) involved. For "unmodifying" prefix is meant a prefix (e.g. It.: *pro-*, *pre-*, *de-*, *s-*) which does not produce, when combined with a root, any phonological process (as assimilation) at the morphological boundary. By contrast, "modifying" prefixes (e.g. It.: *a-*, *con-*, *in-*, *sub-*) may induce, when combined with a root, some phonological modification in the prefix and/or the root at the morphological boundary. It might be argued that prefixed words which include a prefix in its phonologically modified form show a higher degree of cohesion between the prefix and the root than prefixed words with an unmodifying prefix. To say it differently, it might be claimed that prefixed words with some phonological accommodation of the prefix at the morphemic boundary are more likely to be "lexicalized" as whole forms, thus being susceptible to induce fewer prefix substitution errors, and to be better preserved as whole forms, than prefixed words with unmodifying prefixes.

The goal of the experiment was to induce morphological errors of prefix substitution in the course of retrieval of single words. We expected the highest percentage of prefix substitution errors to be produced on lexical forms that have a free root and a prefix that does not present any phonological modification. By contrast, lexical forms with a bound root and/or modified prefix should be the best preserved as whole words.

5.1. *Method.*

5.1.1. *Materials and design.* In the experiment two factors, namely root type (whether free or bound) and prefix type (unmodifying or modifying), were investigated. Four sets of Italian prefixed words were selected (examples are given in the Appendix): (1) lexical forms with a free root and an unmodifying prefix, i.e. a prefix which is not subject to phonological modification at the morphemic boundary (FR-UP); (2) lexical forms with a free root and a modifying prefix, namely a prefix in its modified form with respect to its basic form (FR-MP); (3) lexical forms with a bound root

and an unmodifying prefix (BR-UP); (4) lexical forms with a bound root and a modifying prefix (BR-MP).

Lexical prefixed forms were classified as falling into any given experimental category according to the following criteria:[3]

i) a lexical form belongs to the free-root category if its root can occur in isolation as a lexical form in the language; e.g. *incorrere* ('to run into') whose root occurs in *correre* ('to run');

ii) a lexical form belongs to the bound-root category if it falls in one of the two following cases: (a) it is either a circumfixed form (eg. *abbellire*, 'to make beautiful', which comes from the adjective *bello*, 'beautiful') (for a discussion of circumfixed, or parasynthetic derivatives, see Reinheimer-Rîpeanu 1974, Dardano 1978, Crocco Galèas & Iacobini in press); (b) or it is a form whose root cannot stand alone anymore although the word is etymologically derived (e.g. *preludere*, 'to prelude', which includes **ludere*) (Selkirk 1982, Burani *et al.* 1992 this issue);

iii) a prefixed lexical form belongs to the unmodifying-prefix category if it shows no phonological modification at the morphological boundary (e.g. *pre-dire*, 'to foretell'; *pre-ludere*, 'to prelude');

iv) a prefixed form belongs to the modified-prefix category if it presents any of the following phonological modifications at the morphological boundary: (a) assimilation (e.g. *con* + *legare* → *collegare*, 'to bound'); (b) partial assimilation (e.g. *con* + *porre* → *comporre*, 'to compose'); (c) phonotactic reduplication (e.g. *a* + *bello* → *abbellire*, 'to make beautiful'; *fra* + *porre* → *frapporre*, 'to interpose').[4].

All the prefixed words were verbs in the infinitive form. The four experimental groups were matched for various aspects. Length of prefixed words, calculated in number of syllables, and their degree of "imageability" or concreteness, were analogous in each group. There was the same number of prefix-types in each group. Prefixes included in each experimental group had the same mean length calculated in phonemes. Across lists, prefixes were matched for the number of word-types including that prefix (relying on Zingarelli 1987), and for the mean cumulative frequency of words

[3] A lexical form is considered to be prefixed whenever it is etymologically prefixed. However, forms which can be ambiguous have been excluded, such as forms whose root presents an etymologically unrelated homophonic root (e.g. *ac*-costare ← *a* + *costa* vs *costare*) or unrelated homophonic forms (e.g. *scordare* ← *ricordare* vs *scordare* ← *accordare*). Only monosyllabic prefixes been taken into consideration. Polysyllabic prefixes might have a higher tendency to occur in isolation, thus favouring our hypothesis.

[4] Other types of phonological modifications at the morphological boundary can be observed in Italian. An example is the process of consonant deletion (e.g., Lat.: *ex* + *vapor* → It.: *evaporare*). In the present experiment we have taken into account only those processes which result in a phonological modification of the surface form of the prefix and/or of the root that can be regarded as part of a productive process of affixation.

including the prefix (Bortolini *et al.* 1971). Prefixes were also controlled, as much as possible, for a quantitative dimension which was shown to affect the availability of a prefix as a processing unit (Burani & Laudanna 1992, Laudanna *et al.* 1992), namely the proportion of real prefixes to pseudoprefixes with identical orthographic structure in Italian word-types.

Across lists, prefixed words had an analogous mean number of prefixed relatives sharing the same root, either free or bound (for the effect of this factor, see Burani *et al.* 1992, this issue). The number of prefixed morphological relatives for each target word was between one and four. Prefixed verbs were selected in a medium-low frequency range going from 0 to 15 out of 500.000 occurrences (Bortolini *et al.* 1971). Root frequency of prefixed words with free roots was as low as possible, in order to match the cumulative frequency of morphological families in the groups with free and bound roots. Given the very low frequency of target words, they were submitted to a group of subjects for ratings of subjective frequency, in order to better balance frequency across the four experimental groups. The prefixed morphological relatives too were submitted to subjects for frequency ratings. The prefixed words to be included as targets in the experimental lists had the lowest frequency within their morphological family, i.e. within the family of all the prefixed words sharing the same root. The lower frequency of the target derivative was intended to maximize the possibility of inducing prefix-substitution errors (for the role of target frequency in affecting speech errors, see Dell 1990). The morphological prefixed relatives were also matched across groups for prefix-type, frequency and for all the other relevant factors. In the two groups with bound roots, the number of circumfixed forms was the same.

In synthesis, the four experimental groups were matched for the following aspects: mean word length; mean prefix length; number of prefix-types; number of word-types and cumulative frequency of words with a given prefix; mean root frequency; mean word frequency; mean number of prefixed morphological relatives; number of circumfixed forms in each group with bound roots. Also the prefixed morphological relatives in each group were matched for all the relevant factors. These controls were made to ensure the same probability of prefix-substitution errors in each group, and to guarantee that, if some error occurs, it does not arise from some uncontrolled factor in the experimental sets of words, but it derives from differences in the prefixed words' phonological/morphological representations.

The final experimental groups included eight prefixed words in each group, for a total of thirty-two experimental forms. Thirteen filler prefixed verbs were also included in the experimental lists in order to balance the number of prefix-types presented to the subjects, and to include in the lists some prefix-types which did not occur among target words, but occurred among the targets' morphological relatives. This should give analogous

chances of being retrieved to all types of prefixed morphological relatives. Fillers were matched to experimental words for frequency and for the other relevant factors.

The thirty-two experimental words and the thirteen fillers, randomly mixed, were divided into three experimental lists, each constituted of fifteen items. In the set of prefixed words constituting each list, there was approximately the same number of prefixes of each type, and the same number of free and bound roots. Lists were also balanced for length and frequency of items. Within each list, relations of meaning and/or sound among words were avoided. There were different random orders for each list.

5.1.2. *Procedure.* Each subject was administered all the prefixed words of the different experimental groups mixed in the three lists. The three lists were submitted to subjects in different random orders and in different orders of presentation. 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 arithmetic operations lasting at least twenty seconds), the subject's task was 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. After the recall of the first list, the procedure was repeated for the other two lists. Each experimental session lasted about ten minutes.

5.1.3. *Subjects.* Forty-five subjects, students at Pisa University, participated in the experiment.

5.2. *Results.*

The subjects' correct recalls, omissions (i.e., items not recalled) and errors were analyzed. Subjects recalled about one half 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 54% across all subjects.

Three items which gave rise to either correct recalls or prefix substitution errors exceeding two standard deviations above the mean were excluded from the analyses (one item was excluded in each of the following categories: FR-UP; FR-MP; BR-MP). Of the remaning items, 69.8% were recalled in their correct form. This percentage is similar in all the experiments in which this methodology has been used and in which experimental lists had approximately the same number and length of stimuli (Burani 1992 b) this issue, Exp. 2; Burani *et al.* 1992 this issue). The distribution of correct recalls is analyzed below.

The items not retrieved in their correct form consisted in prefix substitution errors (7.6% of total recalls), and in "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., *deridere* → *dirigere*). Errors consisting in possible root substitutions were classified as phonological errors (e.g., *imbucare* → *imbiancare*). Phonological errors were 6.3% of subjects' total recalls. There were also a few errors (3.0%) which were related to the target for meaning (e.g., *sommergere* → *allagare*), or for both meaning and sound (0.8%) (e.g., *avviluppare* → *avvolgere*). Some errors (12.5%) were classified as unrelated to any target.

A first analysis took into account prefix substitution (morphological) errors. The analyses of variance included two factors: root-type (FR vs BR) and prefix-type (UP vs MP). The results, which are presented in Table 1, showed a significant effect of root-type (by subjects, $F(1,176) = 7.70$, $p < .01$; by items, $F(1,25) = 5.2$, $p. < .01$), with derivatives with bound root giving rise to more prefix substitution errors than derivatives with free root. However, the "prefix-type" factor did not affect performance ($F < 1$ by both subjects and items).

Analogously, there was no interaction between the two factors (by subjects, $F(1,176) = 3.12$, n.s.; by items, $F < 1$).

Table 1. *Percentage of prefix substitution (morphological) errors in each experimental category (FR-UP: free root, unmodifying prefix; FR-MP: free root, modified prefix; BR-UP: bound root, unmodifying prefix; BR-MP: bound root, modified prefix)*
Percentages are calculated on the total number of items to be recalled in each category.

	UP	MP
FR	2.2	1.6
BR	4.7	5.4

Given the unexpected effect of root type, which was at variance with the absence of an effect in the experiment by Burani *et al.* (1992 this issue), it was particularly relevant to control for the distribution of phonological errors in the different categories. The analysis of the distribution of "phonological errors", i.e. errors differing from the target by one or more phonemes independently of morphological structure, aimed at ascertaining whether some experimental category included words which for some uncontrolled reason were proner to elicit more word errors phonologically related to the target. This should allow to assess whether seeming

morphological errors really come from a morphological source, and are not merely phoneme substitutions, deletions or additions which casually result in the substitution of the prefix.

In what follows, we will make clear the logic of this type of analysis, as well as that of a further analysis which is reported below and which compares the distribution of morphological errors in the four categories on the total number of errors (phonological plus presumed morphological) related to the target for "formal" aspects. If apparent morphological errors only reflect phonological similarity with the target word, they should distribute in the four categories not differently from phonological errors. To say it differently, if phonological errors do not occur randomly on the four categories, but their distribution parallels that of morphological errors, it may be suspected that apparently morphological errors, instead of resulting from morphological organization, come from the same source as phonological errors. If, on the contrary, morphological errors are distributed differently from phonological ones, the former can be taken with more confidence as reflecting principles of lexical relatedness other than phonological similarity.

As in Burani *et al.* (1992 this issue), the analysis was performed on the percentages of errors which differed from the target word for one or more phonemes independently of morphological structure. To be considered phonologically related to the target, errors had to preserve at least 50% of the phonemes of the target word. The percentages of phonological errors (calculated on total items to be recalled in each category) are shown in Table 2. Although the χ^2 test did not show significantly different distributions (χ^2 (1) = .782, p. = .38), it is apparent that words with bound root and bound prefix tend to elicit more phonological errors, as well as morphological errors.

Table 2. *Percentage of phonological errors in each experimental category (FR-UP: free root, unmodifying prefix; FR-MP: free root, modified prefix; BR-UP: bound root, unmodifying prefix; BR-MP: bound root, modified prefix).*
Prcentages are calculated on the total number of items to be recalled in each category.

	UP	MP
FR	2.9	2.2
BR	2.5	4.1

Thus when the percentages of morphological errors were calculated, for each experimental group, on the total number of morphological errors and phonological errors, i.e. on the total instances of errors having a resemblance in sound with the target word, their overall distribution (see Table 3) did not result significantly different (χ^2 (1) = .090, p = .69). Specifically, neither the prefix-type factor nor the root-type factor resulted significant (χ^2 (1) = .24, p = .62; χ^2 (1) = 3.11, p = .07, respectively). This last result seems to correct and undermine the preceding one (which evidentiated more morphological errors on prefixed words with bound root), suggesting that the selected words with bound root might have been proner, for some uncontrolled reason, to elicit more "formal" errors overall, thus possibly confounding phonological and morphological errors.

Table 3. *Percentage of morphological errors calculated on the total number of morphological + phonological errors in each experimental group (FR-UP: free root, unmodifying prefix; FR-MP: free root, modified prefix; BR-UP: bound root, unmodifying prefix; BR-MP: bound root, modified prefix)*

	UP	MP
FR	44	42
BR	65	57

Table 4. *Percentage of correct recalls in each experimental category (FR-UP: free root, unmodifying prefix; FR-MP: free root, modified prefix; BR-UP: bound root, unmodifying prefix; BR-MP: bound root, modified prefix). Percentages are calculated on the total number of items to be recalled in each category.*

	UP	MP
FR	23.5	20.6
BR	42.5	41.3

The analysis of correct recalls (i.e., the percentages of items, in each category, which were recalled in the exact form in which they were heard) showed the same result obtained by Burani *et al.* (1992 this issue). Results are shown in Table 4. The percentages of correct recalls (calculated on the total number of items to be recalled in each category) were significantly higher for words with bound roots than for words with free roots (min F' (1,43) = 17.77, $p < .001$). By contrast, correct recalls did not differ according to prefix type (by subjects, $F(1,176) = 3.57$, n.s.; by items, $F < 1$). Furthermore, there was no interaction between the two factors ($F < 1$ by both subjects and items). In synthesis, the probability of retrieving an item in its correct form was function of root type, with prefixed words with bound roots being more subject to be recalled correctly as whole forms.

6. *Discussion.*

These results show analogous rates of prefix substitution errors on both prefixed words with free roots and prefixed words with bound roots, thus confirming the findings by Burani *et al.* (1992 this issue). The apparent bias found in the first analysis, towards having more prefix substitution errors on words with bound roots than on words with free roots, was corrected in the following analyses which took into account the distribution of phonological errors, i.e. errors originating from a phonological source: prefixed words with bound roots were shown to induce overall more phonological errors as well, thus indicating a possible word selection bias. When morphological errors were ricalculated in terms of the percentage of presumed morphological errors on the total number of both morphological and phonological errors (i.e. on the total number of errors originating from form similarity), the distribution of morphological errors did not differ significantly according to root type any more.

The distribution of prefix substitution errors did not differ along the second dimension, namely the presence of a phonologically unmodified vs. modified prefix, either. Thus no support was given to the hypothesis of different representational modalities related to prefixed words of the two types. Specifically, the hypothesis by which prefixed words with phonologically modified prefix would show a higher degree of lexical cohesion between prefix and root or a higher degree of lexicalization did not find support in the data. Prefixed words in which the prefix phonologically accommodates to the root thus obscuring the morphemic boundary were not subject to fewer morphemic substitution errors in the course of word retrieval, than prefixed words including phonologically unmodified prefixed (i.e. words phonologically transparent with respect to their morphological constituency). This dimension of formal transparency, although presumably relevant at other, more peripheral, stages of word

production, does not seem to play a role in lexical representation and in the process of lexical selection.

Thus the interpretation suggested by Burani *et al.* (1992 this issue), according to which both prefixed words with free roots and prefixed words with bound roots should be represented as morphologically related to the other words sharing the same root, should be extended to prefixed words with different types of prefixes. Both prefixed words with unmodified prefixes and prefixed words with phonologically modified prefixes (independently of root type) should be related in the same degree to the other words constituting their morphological family.

However, a difference between prefixed words with free roots on the one hand, and prefixed words with bound roots on the other, was found in the pattern of correct recalls. As in Burani *et al.* (1992 this issue), more correct recalls of prefixed whole word-forms were found on prefixed words with bound roots. The pattern of correct recalls exactly paralleled that found in the previous study, thus giving additional support to the account proposed in Burani *et al.* (1992 this issue). Burani *et al.* pointed out that this finding should be connected to the presence, in the morphological organization of derived words with free roots, but not in that of derived words with bound roots, of the unprefixed base word-form. This form, because of its higher activation level in the lexicon originating from a number of asymmetries in its lexical representation with respect to its derived forms (Bybee 1985, 1988), would act as a strong competitor for the retrieval of the target derivative. This would cause inhibition on the derivative's retrieval.

In other words, the retrieval of a derived word from the lexicon would be sensitive to the composition of the word's morphological family. In the lexical representation of morphological families including derived forms with bound roots, there is no word-form with a special status in terms of "basicness" or structural simplicity (as, on the contrary, it is the case for derived words with free roots). Thus in the morphological organization of derivatives with bound roots there is no word-form which acts as attractor and strong competitor for other forms (see also Burani in press). This organization should advantage, in the task we employed, the retrieval (as a whole form) of a prefixed word with bound root in comparison to a prefixed word with free root.

As discussed in Burani *et al.* (1992 this issue), data of this type are not sufficiently constraining if they are taken in isolation, that is they are compatible with different theoretical accounts. Specifically, these results seem to be compatible also with a framework in which it is assumed that, instead of being represented as whole-forms interconnected through morphological links, morphologically complex words are represented in morphologically decomposed way, as roots plus affixes (Laudanna & Burani 1985, Tyler *et al.* in press). The data are also compatible with a model in

which it is assumed that prefixed words with free roots are morphologically decomposed within the lexicon, while prefixed words with bound roots are represented as whole structurally interconnected forms. According to this hypothesis, the pattern of correct recalls that we have found both in the present study and in the study by Burani *et al.* (1992 this issue), with words with bound roots being recalled better as whole forms than words with free roots, might receive the following interpretation.

While prefixed words with bound roots are represented and consequently retrieved as whole forms, prefixed words with free roots should be retrieved compositionally, by combining the root's representation with the appropriate prefix. In the course of this compositional process, the lexical entry corresponding to the (unprefixed) free root might thus compete, by virtue of its higher activation level, with the retrieval of the prefixed, morphologically complex form, thus causing its inhibition.

In order to opt for one of a number of available hypotheses, further evidence is needed, and models of lexical access for production should be further developed. At the moment, our results suggest that prefixed derivatives with both free and bound roots and both phonologically unmodified and modified prefixes, are morphologically organized in the output mental lexicon. Furthermore, present data, as well as data by Burani *et al.* (1992 this issue) suggest both analogies and differences in the lexical representation of prefixed words with free and bound roots.

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Appendix

Examples of prefixed verb forms in the four experimental groups:
(a) FR-UP: prefixed words with free root and unmodifying prefix.
(b) FR-MP: prefixed words with free root and modified prefix.
(c) BR-UP: prefixed words with bound root and unmodifying prefix.
(d) BR-MP: prefixed words with bound root and modified prefix.
(The approximate English translation is given in parentheses).

FR-UP		*FR-MP*	
PRELEVARE	(to pick up)	COMPARARE	(to compare)
DECADERE	(to decade)	ASSEGNARE	(to assign)
BR-UP		*BR-MP*	
PRELUDERE	(TO PRELUDE)	SUPPLICARE	(to implore)
DERIVARE	(to derive)	ANNETTERE	(to annex)

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