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Morpho-lexical Representations in Naming

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In two naming experiments, it was shown that response times for morphologically structured pseudowords are faster than those for orthographically matched controls. These results are consistent with those obtained in lexical decision tasks with morphologically structured pseudowords. The implications of these results for models of lexical processing are considered. In particular, it is argued that the results reported provide support for compositional models of lexical knowledge.

INTRODUCTION

Considerable research effort has been expended in the attempt to clarify the role played by the morphological structure of printed words in visual lexical access (see, e.g. Taft, 1991, ch. 5, for a review; see also papers in Feldman, 1995). Two issues have been addressed: (1) whether or not morphologically complex words are represented in morphologically decomposed form with independent, although interconnected, representations for roots or stems and affixes; and (2) whether lexical access is based on graphemic access representations corresponding to whole words, or whether it requires parsing of the stimulus word into its constituent morphemes. Here we will be concerned with the first of these issues; we will present evidence in favour of the morphological composition hypothesis of lexical knowledge.

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The contrasting theoretical proposals about the role of morphology in the representation of lexical knowledge may be summarised as follows. On the one hand, non-compositional models adopt the view that lexical representations consist of whole words, which are organised in the lexicon into classes of morphologically related entries, possibly clustered under a common tag or under the unmarked form (e.g. Butterworth, 1983; Lukatela, Gligorijevic, Kostic, & Turvey, 1980; Segui & Zubizarreta, 1985). On the other hand, compositional models assume that the basic units of lexical knowledge are morphemes (stem or roots and combinable affixes; e.g. Caramazza, Laudanna, & Romani, 1988; Frauenfelder & Schreuder, 1991; Marslen-Wilson, Tyler, Weksler, & Older, 1994; Stemberger & MacWhinney, 1988; Taft & Forster, 1975). The latter models can be further distinguished on the basis of the assumptions they make about the format of orthographic access representations—that is, the assumptions they make about the representations used in addressing stored lexical forms. Two hypotheses have been advanced: one is that morphemic access representations are the only units of access to the lexicon (Taft & Forster, 1975); the other is that lexical representations may be addressed through the activation of word as well as morpheme access units (Caramazza et al., 1988; Frauenfelder & Schreuder, 1991; Marslen Wilson et al., 1994).[1]

Although much of the research concerned with morphological processing has used words as stimuli, a substantial proportion has used pseudowords. The results with word stimuli have generally been consistent with the morphological composition hypothesis. However, they have not been particularly problematic for non-compositional theories. Thus, for example, although the results on repetition priming with morphologically complex words (e.g. Fowler, Napps, & Feldman, 1985; Murrell & Morton, 1974; Stanners, Neiser, Hernon, & Hall, 1979) and the results on stem frequency (e.g. Burani, Salmaso, & Caramazza, 1984; Colé, Beauvillain, & Segui, 1989; Taft, 1979) have typically been cited as support for compositional theories, they can more or less easily be accommodated within non-compositional theories (see, for example, Henderson, 1985).

The research that has used pseudowords as stimuli poses a greater challenge to non-compositional theories. The results showing effects of morphological structure in processing pseudowords, when orthographic factors are strictly controlled, would seem to support compositional over non-compositional models of lexical representation. Thus, for example, Taft and Forster (1975) found that in a lexical decision task, subjects are slower in

[1] A completely different view is that morphology plays no role in lexical representation or processing. On this view, the putative morphological effects documented in the literature could equally well be explained by such factors as frequency of orthographic patterns and, more generally, by the orthographic redundancy implicit in the distribution of letter sequences in written language (e.g. Seidenberg, 1987; but see Rapp, 1992, for a rebuttal of this view).

rejecting pseudoword stimuli that are composed of inappropriately combined morphemes (e.g. DEJUVENATE) than they are in rejecting orthographically matched pseudowords that do not contain morphological structure (e.g. DELIGION). Similarly, Caramazza et al. (1988) found that pseudowords composed of a verbal stem and an inflectional suffix that is appropriate for a different verb type are harder to reject than control pseudowords matched for degree of similarity to words by the *N*-count measure (Coltheart, Davelaar, Jonasson, & Besner, 1977). Thus, for example, the pseudoword DORMEVO, which may be parsed into the stem DORM- (the stem-morpheme of the verb DORMIRE, "to sleep", third conjugation) and the verbal suffix -EVO (first-person singular, past-tense suffix for verbs of the second conjugation), is more difficult to reject as a word than a pseudoword such as DECRELO, which does not have morphological structure. The crucial observation in these experiments is that, in lexical decision tasks, pseudowords are harder to reject as words if they contain morphological structure than if they do not have such structure. This type of result is problematic for non-compositional theories because these theories can only appeal to sub-morphemic, orthographic factors or whole-word factors to explain the effects of morphological structure in lexical decision experiments with pseudowords. And, since neither of the two factors could be appealed to in order to explain the results with pseudowords—orthographic structure could not distinguish between morphologically composed and non-morphologically structured pseudowords, and lexical factors are obviously irrelevant in this case—the results undermine non-compositional theories of lexical representation.

A number of theories of lexical processing that postulate morphological composition have been proposed. Here we briefly discuss how the Augmented Addressed Morphology (AAM) model (Caramazza, Miceli, Silveri, & Laudanna, 1985; Caramazza et al., 1988; but see also Frauenfelder & Schreuder, 1991; Marslen-Wilson et al., 1994, for similar models) can account for the lexical decision data with pseudowords.

The AAM model assumes that the mechanism of lexical access contains both whole-word units (for known words) and morphemic access units which are activated in parallel when a letter string is presented. The access unit(s) which reach a preset threshold first will make available, in turn, a morphologically decomposed lexical representation, with the stem represented independently of its inflectional affix. The model also assumes that the activation of a whole-word access representation is faster than the activation of the corresponding morphemic access units. This assumption is motivated by the observation that the activation of morphemic access units involves a process not required in the activation of whole-word access units; namely, the former but not the latter case involves parsing the orthographic input into appropriate access units. This extra process will, by hypothesis, disfavour lexical access through morphemic access units relative to whole-word units.[2]

When a pseudoword is presented to a subject, the only access units activated are orthographically similar words and/or morphemes, since, by definition, there is no whole-word access unit corresponding to that orthographic string. If we compare morphologically decomposable (e.g. DORMEVO) and morphologically non-decomposable (e.g. DECRELO) pseudowords matched for similarity to known words, the crucial difference between them is that the former (but not the latter) will activate the morpheme access units (DORM- and -EVO in our example) which will reach threshold and address corresponding representations in the orthographic lexicon. Since the representations DORM- and -EVO activated in the lexical system cannot be combined to form a word, the stimulus will be classified as a pseudoword at the level of the system (the orthographic input lexicon) at which the information about grammatical features and requirements for combinability of morphemes is specified. Thus the successful activation of the two morphemes in the orthographic lexicon is expected to interfere with the correct rejection response. No such interference is expected in the case of morphologically non-decomposable pseudowords, since they fail to activate any access units and thus can be rejected at the earliest level of analysis. And, finally, some interference is expected to occur in the case of pseudowords with partial morphological structure. These are stimuli such as DONACA, which contains a legal stem (DON-, first conjugation, "to donate") but not a legal suffix (-ACA), or DEDIVA, which contains a verbal suffix (-IVA) but not a legal stem (DED-). The expectation of decision interference for these stimuli is motivated by the fact that they are hypothesised to successfully activate one morpheme access unit each—the stem (DON-) or the suffix (-IVA) in the two examples cited here. These stimuli can be rejected prior to the activation of a full lexical pattern but after the possible rejection due to the failure to activate any access unit. Thus in the AAM model, lexical decision latencies are related to the amount of morphological information detected by the access system (in addition, of course, to whatever whole-word activation has taken place in the system). The data from lexical decision experiments with "morphologically structured" pseudowords are consistent with expectations derived from the AAM model. However, the role of such data to inform theories of lexical representation and access has been challenged.

[2] The issue of whether whole-word or morphemic access units reach threshold first (and determine lexical access) is not nearly as simple as presented here. Word and stem frequency (as well as other factors; e.g. semantic and/or formal transparency, cohort size) also play a role in determining which access unit reaches threshold first. Thus, for example, it could be that low-frequency words with high-frequency stems are usually accessed through morphemic and not whole-word access units (see Frauenfelder & Schreuder, 1992; Schreuder & Baayen, 1995).

It has been claimed that data from pseudoword processing do not allow inferences to the mechanisms engaged in processing real words (Henderson, 1986), and that the lexical decision paradigm is not the best procedure to assess lexical access because this task implicates post-access strategic processes (Balota & Chumbley, 1984; Seidenberg, 1987). We find neither of these challenges convincing. The claim that data from pseudoword processing cannot be used to inform models of lexical processing has been asserted without detailed justification. The claim could be correct, of course, but in the absence of compelling justification we have no more reason for accepting it than the many other possible claims one could make about other types of tasks typically used to inform theories of cognitive processing. For example, one could argue that phoneme or word monitoring tasks cannot be used to inform theories of lexical access, or that visual search tasks cannot be used to inform theories of visual attention, or that naming tasks cannot be used to inform theories of lexical processing, and so on.[3] As to the claim that post-lexical strategic processes may contaminate the lexical decision data, we have no difficulty accepting the observation that lexical decision performance does not directly reflect access processes. But we are not particularly disturbed by the observation either; after all, it is unlikely that any task directly reveals the functioning of a hypothesised component of processing. For our present purposes, the issue is whether or not the lexical decision data can be used to constrain claims about the structure of lexical representations even if post-access factors contribute to the overall variation in performance obtained with different types of stimuli. Since there is no simple way to decide this issue, we have chosen to deflect the criticism by extending the investigation to other experimental paradigms which are supposedly not open to the criticisms that have been levelled against the lexical decision task (see, for example, Balota & Chumbley, 1984). In the research reported here, we used a pseudoword naming task to investigate the verbal inflectional system of Italian. These experiments were intended to complement the lexical decision experiments with similar stimuli reported in Caramazza et al. (1988, experiments 1 and 2). The use of a different paradigm was not the only reason for carrying out the two naming experiments reported here; they were also carried out to test more specific hypotheses about the structure of lexical representations as revealed in interaction with different experimental tasks.

The effect of morphological structure in lexical decision experiments with pseudowords is to make the decision to reject these stimuli as words more difficult. However, the effects of such structure in naming pseudowords is likely to be facilitatory. This expectation is based on the assumption that pronunciation of morphologically structured pseudowords involves the

[3] Caramazza et al. (1988) provide a more detailed rebuttal to this challenge.

combination of pre-assembled morphemic representations, whereas pronunciation of control pseudowords does not benefit from the availability of pre-assembled phonological representations. This is certainly the expectation derived from the AAM model.

Consider the contrast between morphologically decomposable and non-decomposable pseudowords. The AAM model assumes that each orthographic string is processed in parallel by the lexical access procedures (whole-word access procedure and morpheme access procedure) as well as the non-lexical conversion procedures from orthography to phonology (Coltheart et al., 1977). Both morphologically decomposable and morphologically non-decomposable pseudowords fail to activate whole-word access representations, but they can both be processed successfully by the non-lexical, orthography-to-phonology conversion procedure. Hence, by hypothesis, the only structural factor that might contribute to a difference in their processing is that in those cases where the parsing process of the orthographic string is successful, the morphologically decomposable pseudowords may be processed by the morpheme access procedure, thereby gaining access to morphemic representations in the lexicon.[4] In such cases, the letter string may be read by relying on mechanisms different from those engaged in reading morphologically non-decomposable pseudowords. More precisely, while morphologically decomposable pseudowords may be read by means of access to lexically based phonological representations, morphologically non-decomposable pseudowords, which cannot access the lexicon, may only be read through the non-lexical procedure by converting sub-morphemic orthographic segments (letters and/or letter clusters) into phonological segments. For these reasons, morphologically decomposable pseudowords are expected to be named faster than morphologically non-decomposable pseudowords. These expectations were tested in Experiment 1.

EXPERIMENT 1

Experiment 1 was designed to determine whether morphological structure affects latencies in naming pseudowords. For this purpose, we compared naming latencies for morphologically decomposable pseudowords consisting of a verbal stem plus verbal suffix (e.g. DORMEVO), and morphologically non-decomposable pseudowords (e.g. DECRELO).

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[4] This claim requires that we assume that the phonological output lexicon also represents lexical information in morphologically decomposed form. The evidence from our results is not conclusive in this regard; nevertheless, it is consistent with the pattern of speech errors in normal speakers (e.g. Garrett, 1982; Stemberger, 1985) and the pattern of omissions and substitutions of inflectional affixes in aphasic patients (see Caramazza, 1988, for a review).

Method

Stimuli. Three hundred stimuli were used in this experiment. The stimuli were composed of 200 words and 100 pseudowords, 40 of which were experimental items divided into two sets of 20 items each (the experimental stimuli are reported in Appendix 1). Set 1 consisted of morphologically decomposable pseudowords (DORMEVO); set 2 consisted of morphologically non-decomposable pseudowords (DECRELO). The mean length and mean *N*-count—that is, the number of full word forms that can be derived from a pseudoword by changing one letter at a time in each position (Coltheart et al., 1977)—were identical for the pseudowords in each experimental set: 6.85 and 1.4, respectively. To ensure that the regularity of the orthographic patterning was balanced, the natural logarithm of the mean bigram frequency was calculated for both experimental sets, based on a corpus of 1.5 million occurrences (Istituto di Linguistica Computazionale del CNR di Pisa, 1989): the values were 10.87 for set 1 and 10.8 for set 2. The 60 filler pseudowords were obtained by changing one or two letters, approximately equally in the initial, medial and final part of 15 adjectives, 15 verbs and 30 nouns, whose length varied between 4 and 9 letters. Of the 200 words, 20 were high-frequency verb forms (mean form frequency: 72.6/500,000) and 20 were low-frequency verb forms (mean form frequency: 1.4/500,000). No stem appeared more than once in the stimulus set. The mean word length in these two sets of stimuli was 6.7 and 6.5, respectively. These stimuli were included in the experiment to determine whether the task was sufficiently sensitive to reveal effects of word frequency on response time. The remaining 160 filler words were 90 nouns, 50 adjectives and 20 verbs, which varied between 4 and 9 letters in length.

Procedure. A naming task was used in which subjects were instructed to pronounce as rapidly as possible the letter sequence displayed in upper-case letters in the centre of a screen.

Participants. Twenty-one participants completed the experiment. They were chosen from a pool of university students and they were tested individually in a single session lasting about 35 min. All participants were native speakers of Italian and were paid for their participation in the experiment.

Results and Discussion

The mean response times and percentage errors for the two experimental conditions are shown in Table 1. The morphologically decomposable pseudowords were read 25 msec faster and induced about 2% fewer errors than morphologically non-decomposable pseudowords. One-way analyses

TABLE 1
Experiment 1: Mean Response Time (RT) and Error Performance

	DORMEVO (+*Stem*,+*Suff*)	*DECRELO* (−*Stem*,−*Suff*)
RT (msec)	582	607
Errors (%)	9.5	11.4

of variance by subjects and by items on both response times and errors were performed and showed a significant difference for response times [by subjects: $F(1,40) = 15.86$, $P < 0.001$; by items: $F(1,38) = 4.35$, $P < 0.05$; min $F(1,71) = 3.42$, $P = 0.07$] but not for errors ($F < 1$ both by subjects and by items). Furthermore, response times for high-frequency words were 23 msec faster than for low-frequency words (525 *vs* 548 msec). One-way ANOVA by subjects was highly significant [$F(1,40) = 25.6$, $P < 0.001$], whereas one-way ANOVA by items only approached significance [$F(1,38) = 3.55$, $P = 0.06$].

These results have interesting implications for models of reading and lexical representation in Italian. The fact that subjects named high-frequency words faster than low-frequency words, even though Italian has a segmentally shallow orthography, is consistent with the view that under normal circumstances, oral reading in Italian is lexically mediated (Miceli & Caramazza, 1993; Tabossi & Laghi, 1992).[5,6] It is important to emphasise that even though Italian orthography is segmentally transparent, the correct pronunciation of words requires access to word-specific knowledge because word stress is assigned lexically. Thus, for example, consider the following word pairs: *sparito* (disappeared) *vs spirito* (spirit) and *tavolo* (table) *vs tesoro* (treasure). For both word pairs, the first word receives stress on the first syllable, whereas the second member of each pair receives stress on the second syllable. Indeed, the correct placement of stress for most words in Italian (unlike English) cannot be determined by just their syllable (or consonant/vowel) structure—it is lexically determined.

Of particular interest here is the relative naming speeds for pseudowords of different "morphological structure". The fact that naming latencies for

[5] Tabossi and Laghi (1992) showed that, in Italian, which has a segmentally transparent orthography, the naming task may differentially exploit the lexical route depending on factors such as nonword density in the list.

[6] Although the word frequency effect in a naming task has been simulated in models that do not explicitly represent lexical representations (see Seidenberg & McClelland, 1989), it remains to be seen whether the entire set of results on both words and pseudowords which are explained by appealing to a dual-route model can have an equally coherent explanation within a completely different architecture.

morphologically decomposable pseudowords were speeded up relative to morphologically non-decomposable pseudowords is explicable by assuming that the former stimuli are pronounced by accessing morpheme-sized units in the lexical system. This interpretation is consistent with the results obtained in lexical decision experiments with the same stimuli (although in the latter case, morphological structure leads to slower reactions times; Caramazza et al., 1988). In other words, the results reported may be taken as support for the morphological composition hypothesis of lexical representation.

EXPERIMENT 2

Experiment 2 was designed to replicate the results obtained in Experiment 1 and to extend our investigation to pseudowords with partial morphological structure—that is, pseudowords in which only one morphemic unit can be extracted from the stimulus input (e.g. CANTOVI and CANZEVI, which only contain the stem CANT- and the suffix -EVI, respectively). Performance with this type of pseudoword has already been examined in the context of the lexical decision task (Caramazza et al., 1988, experiments 1 and 2), where it was shown that reaction times and/or error rates were intermediate between the two extreme categories of fully decomposable and non-decomposable pseudowords. It was not obvious, however, what expectations we would have for naming latencies for the partially morphologically decomposable stimuli. That is, it is not immediately obvious whether partial morphological structure should lead to intermediate effects as in the lexical decision task, or whether it should have a pattern in line with the fully decomposable or non-decomposable stimuli. To answer this question requires making assumptions about the way in which the pronunciation system deals with incompletely parsable orthographic strings. The results of this experiment can help guide hypotheses about this poorly understood issue.

Method

Stimuli. The list included 280 words and 140 pseudowords, arranged in two different random orders. Of the 140 pseudowords, 80 were experimental stimuli: 20 each for the four experimental conditions (the experimental stimuli are reported in Appendix 2). Two subsets of entirely new stimuli were structured like those used in Experiment 1. One set consisted of (fully) morphologically decomposable pseudowords (e.g. pseudowords like DURIVA, formed with the stem DUR-, first conjugation, “to last”, and the verbal suffix -IVA, third conjugation, past-tense, third-person singular); the other set consisted of morphologically non-decomposable pseudowords in which neither a legal stem nor a legal suffix could be recovered, although they contained attested beginnings and endings of Italian words (e.g. the pseudoword DELISO composed of the beginning of DELITTO, "crime", and the ending of DECISO, "decided"). The other two subsets of stimuli each had partial morphological structure, but neither was fully decomposable into a stem + suffix sequence. More precisely, one set consisted of 20 pseudowords (e.g. DONACA) which contained a legal stem (DON-, first conjugation, "to donate"), but did not have a legal suffix (-ACA), although the ending was an attested word ending in Italian (e.g. MONACA, "nun"). The other set included pseudowords (e.g. DEDIVA) which contained a verbal suffix (-IVA) but did not have a legal stem, although, once again, the beginning was an attested word beginning in Italian (e.g. DEDICA, "dedication").

The experimental items respected the following additional constraints:

1. The mean length of the pseudowords in each experimental condition was identical, i.e. 6.65 letters.
2. The mean stem frequencies of the words from which the pseudowords of the first two sets were derived were almost identical (98.6 and 97.8).
3. The verbal suffixes contained in the first and third sets were the same and had the same distribution.
4. The mean *N*-count value for the four experimental sets was the same, i.e. 1.6 words.
5. The distribution of *N*-count values was similar across the four experimental conditions.
6. The number of words embedded in pseudowords was approximately the same in the four sets: set 1, $n = 19$; set 2, $n = 20$; set 3, $n = 18$; set 4, $n = 20$.[7]
7. The mean bigram frequencies for the four experimental sets, calculated on a logarithmic scale and based on a corpus of 1.5 million occurrences (Istituto di Linguistica Computazionale del CNR di Pisa, 1989), were as follows: set 1, $\bar{x} = 10.79$; set 2, $\bar{x} = 10.87$; set 3, $\bar{x} = 10.81$; set 4, $\bar{x} = 10.82$.
8. The trigram frequencies of the non-suffix endings in sets 2 and 4 were kept as similar as possible to the frequencies of suffixes included in sets 1 and 3: their natural logarithmic values, calculated on the basis of the same corpus cited above, were 7.4 and 7.9 respectively, corre-

[7] Given the internal structure of the stimuli, which are characterised by the presence (sets 1 and 2) versus absence (sets 3 and 4) of a real stem in the leftmost side of the string, embedded words were mostly at the beginning of the pseudowords in sets 1 and 2 (11 and 15 times, respectively), while they were mostly at the end of the pseudowords in sets 3 and 4 (12 and 13 times, respectively). However, it is not clear how and to what extent this asymmetry might influence the pattern of results in a pseudoword naming task.

sponding to an absolute frequency of 1096 and 1850 per million respectively.

9. The syllabic structure of the experimental pseudowords was not matched in a one-to-one fashion, but number and types of syllabic structure were balanced for the four conditions across the list.
10. The four experimental categories were perfectly matched for the presence of the same initial phoneme (and grapheme).

The 60 filler pseudowords were obtained by changing one or two letters approximately equally often in the initial, medial and final parts of 15 adjectives, 15 verbs and 30 nouns, whose length varied between four and nine letters. Of the 280 words, 40 were selected for the control of the frequency effect and subdivided in two sets of 20 high-frequency verbal forms (mean form frequency 70.1/500,000) and 20 low-frequency verbal forms (mean form frequency 1.4/500,000). These two sets of stimuli also had the same mean length (i.e. 6.65 letters). The remaining 240 words comprised 74 adjectives, 118 nouns and 68 verbs. No stem was used more than once in the whole stimulus list. The total pool of 420 items was presented to all the subjects.

Procedure. The general procedure was the same as that in Experiment 1, except for the following: the test blocks were expanded to six blocks of 70 items each, for a total of 420 trials.

Participants. Twenty-one participants completed the experiment. They were all native speakers of Italian and were paid for their participation.

Results and Discussion

The mean reaction times and percentage errors for the experimental pseudowords are shown in Table 2. Analyses of variance, by subjects and by items, performed on both reaction times and error data, revealed the following pattern of results. A significant effect of stimulus type for reaction times was obtained in the analysis by subjects [$F(3,80) = 4.01$, $P = 0.01$] and only a marginal effect in the analysis by items [$F(3,76) = 2.38$, $P = 0.08$]. A significant effect of experimental conditions was also obtained for the error data in the analyses by subjects [$F(3,80) = 5.13$, $P < 0.005$] and by items [$F(3,76) = 3.24$, $P < 0.03$]. Min F was not significant [min $F(3,155) = 1.99$, $P = 0.14$]. Additional comparisons based on Duncan's test were carried out to detail the pattern of single comparisons between morphologically decomposable pseudowords and the other pseudoword categories. Morphologically decomposable pseudowords (+Stem,+Suff) were faster

TABLE 2
Experiment 2: Mean Response Times (RT) and Error Performance

	DURIVA (+*Stem*,+*Suff*)	*DONACA* (+*Stem*,−*Suff*)	*DEDIVA* (−*Stem*,+*Suff*)	*DELISO* (−*Stem*,−*Suff*)
RT (msec)	571	591	588	588
Errors (%)	10.5	16.7	16.4	17.1

and induced fewer errors than partially decomposable (+Stem,−Suff or −Stem,+Suff) and non-decomposable (−Stem,−Suff) pseudowords, which, in turn, did not differ from each other. The results of these comparisons revealed significant differences for both reaction times [+S+S *vs* +S−S: $t(k = 4) = 3.83$, $P < 0.02$; +S+S *vs* −S+S: $t(k = 3) = 3.4$, $P < 0.03$; +S+S *vs* −S−S: $t(k = 2) = 3.31$, $P < 0.03$] and errors [+S+S *vs* +S−S: $t(k = 3) = 3.91$, $P < 0.01$; +S+S *vs* −S+S: $t(k = 2) = 3.79$, $P < 0.01$; +S+S *vs* −S−S: $t(k = 4) = 4.23$, $P < 0.01$]. The overall pattern of the reaction time and error results with pseudowords paint a consistent picture: fully decomposable pseudowords are advantaged in naming relative to the other three types of pseudowords.

To ensure that the pattern of results was not critically affected by the orthographic frequencies of the suffixal and/or non-suffixal endings employed, a *post-hoc* product–moment correlation between trigram frequency of nonword endings and naming times was calculated for each experimental set. The correlation was close to zero in all experimental sets, ranging from +0.1 (in set 3) to −0.1 (in sets 1 and 4).

In Experiment 2, as in Experiment 1, we again obtained a frequency effect for words: high-frequency words were responded to 25 msec faster than low-frequency words (508 *vs* 533 msec). This effect was significant both by subjects [$F(1,40) = 19.6$, $P < 0.001$] and by items [$F(1,38) = 4.6$, $P < 0.05$]. Min *F* approached significance [min $F(1,75) = 3.74$, $P < 0.06$].

The results of this experiment replicate those in Experiment 1 for stimuli with fully decomposable morphological structure and no morphological structure; that is, morphologically decomposable pseudowords were named faster than orthographically matched non-decomposable pseudowords. The results for pseudowords with partial morphological structure, which were pronounced no faster than pseudowords with no morphological structure, suggest that partial morphological structure is not sufficient to implicate the lexical system in pronouncing pseudowords. Consistent with this interpretation, we found a negative correlation (although statistically non-significant) between reaction times and stem frequency in the +Stem,+Suff category ($r = -0.28$); that is, the more frequent the stem, the quicker the naming times. The same tendency did not hold for the +Stem,−Suff category ($r = +0.11$). Thus the results of this experiment lend further support to the morphological composition theories of lexical representation, and they are suggestive with regard to the manner in which words and pseudowords varying in degree of morphological structure might be pronounced. We discuss these two issues in greater detail below.

GENERAL DISCUSSION

Lexical decision experiments with words and pseudowords have long been one of the mainstays of theories of lexical processing and representation. However, research based on this paradigm has often been challenged on the grounds that the task strongly implicates post-access decisional strategies and that, therefore, the data thus obtained cannot be taken to directly reflect lexical access processes. Leaving aside whether or not these criticisms are justified, we can turn to other experimental paradigms in the effort to provide converging evidence for theories of lexical processing. Thus the principal objective of the research reported here was to determine whether the effects of morphological structure in lexical decision tasks with pseudowords could be extended to the naming paradigm. The results of Experiments 1 and 2 clearly indicate that morphological structure is a strong determinant of performance in naming pseudowords, just as has been reported for the lexical decision paradigm: The better performance in naming morphologically decomposable pseudowords relative to performance in naming both morphologically non-decomposable and partially decomposable pseudowords provides further evidence in favour of the view that morphemes constitute the basic units of lexical representation. Indeed, it is difficult to imagine how non-compositional theories of lexical representation could accommodate the effects of morphological structure in pseudowords in both naming and lexical decision experiments, not to speak of the results of lexical decision, recognition and naming experiments with words, which have invariably shown clear effects of morphological structure (e.g. Bentin & Feldman, 1990; Laudanna, Badecker, & Caramazza, 1989, 1992; Marslen-Wilson et al., 1994; Murrell & Morton, 1974; Stanners et al., 1979; Taft, 1979).

The results reported here constitute a clear challenge to non-compositional theories of lexical processing. However, it is not obvious that extant compositional models can accommodate the full pattern of results either. The crucial results concern the effects of different types of morphological structure in pseudowords in the lexical decision and naming tasks. In the lexical decision task, the pattern of response times (and errors) took the following form (Caramazza, et al., 1988): fully morphologically decomposable pseudowords (+Stem,+Suff) were rejected more slowly than pseudowords with only partial morphological structure (+Stem,−Suff; −Stem,+Suff), which, in turn, were rejected more slowly than pseudowords with no morphological structure (−Stem,−Suff). In the naming task, the pattern of response times (and errors) took the following form: fully morphologically decomposable pseudowords were faster than partially morphologically decomposable pseudowords, which did not differ from morphologically non-decomposable pseudowords. Here we will briefly discuss how the AAM model (Caramazza et al., 1988; but see also Frauenfelder & Schreuder, 1991; Marslen-Wilson et al., 1994, for similar models) can account for the contrasting patterns of results in the lexical decision and naming tasks.

In the Introduction, we argued that in lexical decision tasks the effect of morphological structure in pseudowords is to slow down rejection times. We also argued that in the AAM model, the magnitude of this effect is proportional to the degree of morphological structure in the stimulus—the more word-like the stimulus, the greater the effect. In the present context, this translates into a larger effect for fully morphologically decomposable pseudowords than for partially decomposable pseudowords and non-decomposable pseudowords (controlling for orthographic similarity of the pseudowords by *N*-count). This expectation is based on the assumption that the more opportunities there are for activating lexical representations, the more difficult the decision to reject the stimulus as a nonword. As already noted, these expectations are consistent with the results reported by Caramazza et al. (1988). However, in the naming task, unlike the lexical decision task, partial morphological structure in pseudowords does not lead to intermediate effects between fully decomposable and non-decomposable pseudowords, but seems to have no effect at all. How do we account for this discrepancy between tasks on the effects of partial morphological structure? The discrepancy follows naturally from plausible assumptions about differences between the lexical decision and the naming tasks.

The demands of the naming task are different from those of the lexical decision task. These differences have implications for the pattern of results that might be expected in naming pseudowords with different types of morphological structure. In the lexical decision task, the similarity of the stimulus to stored lexical representations is a sufficient condition for obtaining a reaction time effect. The task does not require that the stimulus be fully decomposable for it to activate stored lexical representations. However, in the naming task, the activation of stored representations is not a sufficient condition for obtaining an effect in naming latencies. The reason is that lexical representations must not merely be activated, they must also be selected in the orthographic lexicon for subsequent selection of semantic and phonological forms for production. And, if we were to make the plausible assumption that selection of morphemic forms only occurs if the stimulus is fully decomposable, then we have the conditions for the observed differences in naming times. The plausibility of this assumption derives from the fact that there must be well-defined conditions for "deciding" which route will be engaged in the pronunciation of a letter string. The proposal here is that the lexical route is engaged just in case the stimulus is fully parsable into morphemes. This assumption ensures that the stimulus meets the minimal conditions for lexical status. In other words, since no stimulus that is not (at least) exhaustively parsable into morphemes can be a word of the language, we could use this condition to determine which pronunciation procedure to use for any given stimulus.

On the reasoning developed here, the benefit of morphological structure in naming fully decomposable pseudowords does not carry over to pseudowords with partial morphological structure. Since in the naming task subjects are required to produce a response that corresponds to the whole input, the task may be successfully performed only in those cases where the letter string is entirely parsed and read through one pathway. Thus while morphologically decomposable pseudowords may be read by addressing morphologically decomposed lexical representations, pseudowords with partial or no morphological structure (e.g. DONACA, DEDIVA, DELISO) can only be read by assembling a pronunciation through sub-morphemic orthography-to-phonology conversion. This restriction on the use of the lexical route allows us to explain the differences in naming times for pseudowords with different degrees of "morphological structure".

In conclusion, the results we have reviewed do not appear to be easily accommodated within models of lexical processing which assume that lexical representations correspond to whole words. It is not obvious how these models could explain results (from both lexical decision and naming) which apparently depend on the manipulation of the internal morphological structure in pseudowords, which, by definition, are not stored in the lexicon. By contrast, the results reported here do seem to find a natural explanation in the context of those models of lexical processing and representation that postulate morphologically defined access units as well as morphologically decomposed lexical representations.

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APPENDIX 1

Experimental pseudowords in each category: Experiment 1

Category 1 (+*Stem,*+*Aff*)	*Category 2* (−*Stem,*−*Aff*)
BASTIVI	BALCOVI
USEVI	UTELI
ANDERE	ANCURA
GRIDERE	GRALIDA
RESTUTO	REFLESO
VIVITE	VEVETA
MANDETE	MASTILE
CANTEVI	CUNDELA
COLPUTI	CATRAVE
CERCUTO	CITRAME
FINUTI	FALUNE
FERMIVO	FERGIDA
DORMEVO	DECRELO
INDICUTA	IMPORALE
MENTAVA	MONSOLE
SCRIVATE	STRIVULE
ORDINERE	ORBIRALE
PARTUTI	PEGRETA
ENTRERE	ESPRIDO
TIRUTO	TEGOME

APPENDIX 2

Experimental pseudowords in each category: Experiment 2

Category 1 (+*Stem*,+*Aff*)	*Category 2* (+*Stem*,−*Aff*)	*Category 3* (−*Stem*,+*Aff*)	*Category 4* (−*Stem*,−*Aff*)
BADUTO	BASASE	BANUTO	BAMONI
CADITO	CALASE	CUDITO	COPACE
CEDAVI	CITASO	CINAVI	CEMICE
CONTERE	CANTOVA	CANDERE	CANZANE
DURIVA	DONACA	DEDIVA	DELISO
ELEVUTA	ESIGICO	EMERUTA	EPITERI
EVITEVA	ESITEMI	EVIGEVA	ESILIPI
FERMIVO	FONDENO	FORSIVO	FARTACO
GIRUTA	GELAFE	GINUTA	GENALI
GIURITO	GIOCURE	GIUNITO	GIAVIDA
IMPEDATI	IMPARAPA	INSADATE	INDUFESE
LIBERETE	LAVOROVI	LUPINETE	LEMINUDO
MANDETE	MANCIDO	MENDETE	MANTISE
MOSTRIRE	MERITETO	MILTRIRE	MINTRARI
NOTEVI	NEGASI	NACEVI	NAPIDO
ODIERE	OLIOTE	OFIERE	ONIANI
PENSITI	PUNGETA	PENCITI	PINDOLO
RUBEVI	RECAFI	RACEVI	RUMIDI
SPARERE	SPERURE	SPAMERE	SPAMOLA
UDEVA	USILI	ULEVA	URIDE