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Words and Morphemes as Units for Lexical Access

Pascale Colé

University of Nice–Sophia Antipolis, Nice, France

Juan Segui

Laboratory of Experimental Psychology, CNRS René Descartes University, Paris, France

and

Marcus Taft

School of Psychology, University of New South Wales, Sydney, Australia

The representation of morphological information in memory was investigated in three experiments using French monomorphemic words that can stand as the base of derivationally related words (e.g., the word PLUME forms the base of the words PLUMER, PLUMAGE, PLUMIER, . . .). The results of Experiment 1 yielded no effect of the Cumulative Frequency of all forms sharing the base morpheme. Experiments 2a and 2b showed an effect of Morphemic Frequency (the frequency of only the derived forms), but only when Word Frequency was less frequent than Morphemic Frequency. In Experiment 3, an effect of Word Frequency was observed only when Word Frequency was more frequent than Morphemic Frequency. The results are explained in terms of independent representations for the free word form and the form used as the base of the other members of the morphological family.

The role of morphology in visual word recognition has been studied extensively during the past decade, and two main hypotheses have been put forward: the ''full listing hypothesis'' and the ''meaningful subform hypothesis.'' The first of these considers the lexicon as a store of full forms operating in such a way that lexical representations corresponding to these full word forms are accessed by a direct mapping of the word's letters (Butterworth, 1983; Manelis & Tharp, 1977). The latter hypothesis considers that a word form is decomposed and looked up under some meaningful subpart so that morphological structure implicit in the string of letters composing the word form, is detected and used as the basis of access to the lexicon (Taft & Forster, 1975).

Among the recognition models that assume that morphologically complex words are represented at some level of the processing system in a decomposed form, it is necessary to distinguish those that postulate that access to the lexicon implies the existence of an obligatory morphological decomposition procedure and those which propose that lexical representations can be accessed on the basis of either a whole word access unit or a morphemic access unit.

The most representative model of the first type is the decomposition model of Taft and Forster (1975). According to the original formulation of this model, the stem constitutes the lexical entry of affixed words. In order to recognize a morphologically complex word,

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Request for reprints should be addressed to Pascale Colé at Université de Nice–Sophia Antipolis, Faculté des Lettres, 98 bd E. Herriot, B.P. 209, 06204 Nice Cédex 3, France.

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the affix component must be stripped off for lexical access to be successful. In other words, an obligatory morphological parsing precedes access to the morphologically decomposed lexical representation (Taft & Forster, 1975; Taft, 1979, 1981, 1984). In more recent formulations of the decomposition model (e.g., Taft, 1991, 1994; Taft & Zhu, 1995), morphemes are represented as units within a hierarchical activation system and are activated whenever congruent orthographic information is contained within the letter-string. Activation within the morpheme units is then passed on to units representing the whole polymorphemic word. In this way, a polymorphemic word is not actively decomposed prior to lexical access, yet that word is always accessed via activation of its morphemes. Thus there is obligatory decomposition, but it is achieved passively.

In contrast, the activation model developed by Caramazza, Laudanna, and Romani (1988), the ‘‘Augmented Addressed Morphology Model’’ (AAM), assumes that the stimulus word activates both the whole word form and the morphemic access units. An important assumption of this model is that the activation of a whole word form representation proceeds more rapidly than the activation of its morphemes for known words. However, both whole-form and morpheme access mechanisms address morphologically decomposed entries in the orthographic input lexicon. So, these entries are always activated independently of the employed access mechanism.

Both of these ‘‘morphological’’ models make the crucial assumption that the representations of affixed words are organized around the representation of the base morpheme which composes them. Interestingly, this assumption is shared by some non-decompositional models that consider, first, that the members of a morphological family (a morphological family is defined by all affixed words that share the same base) are strongly related and, second, that the common base morpheme constitutes the ‘‘head’’ of the family (Segui & Zubizarreta, 1985, Colé, Beauvillain, & Segui, 1989). Thus, morphological information is encoded through the relationship shared by the members of the family and each derived form constitutes a lexical entry of its own but it is not an isolated one.

Most of the experiments designed to test the relative validity of these theoretical models were conducted using derivationally or inflectionally complex words (e.g., Feldman, 1991; Feldman & Fowler, 1987; Fowler, Napps, & Feldman, 1985; Grainger, Colé, & Segui, 1991; Henderson, Wallis, & Knight, 1984; Lima, 1987; Marslen-Wilson, Tyler, Waksler, & Older, 1994; Stanners, Neiser, Hernon, & Hall, 1979; Stanners, Neiser, & Painton, 1979; Taft, Hambly, & Kinoshita, 1986). In these experiments, the role of specific parameters related to the morphemic components or to the whole word form were manipulated.

One important finding has been the demonstration that the recognition time of polymorphemic words depends not only on their surface frequency (the frequency of the presented word form) but also on their cumulative frequency, corresponding to the sum of the frequencies of all affixed forms that share the same stem (including the frequency of the stem itself, if it is a free lexical item). Thus, the recognition time of words having the same surface frequency has been shown to vary as a function of their cumulative frequency, with higher cumulative frequency generally leading to faster recognition (Taft, 1979; Colé et al., 1989; Bradley, 1979; Burani & Caramazza, 1987; Andrews, 1986; Holmes & O’Reagan, 1992). This result indicates that in order to predict the recognition time of a morphologically complex word, one must take into consideration not only its own frequency but also the frequency of all other words sharing with it the same base morpheme or stem. This is predicted by the obligatory decomposition model since higher frequency morphemic access units will be processed more quickly than lower frequency ones, and the frequency of a morpheme unit will be determined by the frequency of all those words that are accessed via that unit (i.e., cumulative frequency). In the AAM model, even though words are typically accessed via their whole word representation, the frequency of this representation is said to be influenced by the frequency of all the other words which share the same stem morpheme (i.e., cumulative frequency) because the representation of the stem feeds back to this whole word representation.

If either of these positions is true, it follows that cumulative frequency should not only have an impact on the recognition of polymorphemic words, but also on the recognition of monomorphemic stems, if they are free lexical items in their own right (i.e., if they are words). In fact, Taft (1979) demonstrated this to be the case in relation to inflections. For example, it was easier to recognize SHOE than FORK even though they have the same surface frequency, because the higher frequency of the inflectional variations of SHOE (i.e., SHOES compared to FORKS) leads to a higher cumulative frequency.

Now, the decompositional hypothesis was proposed for both inflectionally and derivationally complex words, so this means that the recognition of a monomorphemic stem should also be affected by the frequency of all polymorphemic words derivationally related to that stem. Finding an effect of inflectionally related forms is possibly less surprising than finding the same thing with derivationally related forms since it is generally considered that two words that differ only in their inflectional affixes represent two versions of the same word, whereas two derivationally related words are generally considered to be two different words.[1] As Feldman (1994) has pointed out, inflectional and derivational processes can be distinguished according to syntactic and semantic properties. More precisely, inflectional forms, unlike derivational ones, do not often change the syntactic class of the base morpheme which composes them and their meaning can be derived more often from both the meaning of the base and affix morphemes. The purpose of experiments reported here was to establish whether the recognition of monomorphemic words, which can stand as the stem of a morphological family is influenced by the cumulative frequency of words derivationally related to it.

[1] In fact, studies in French are currently forced to make this assumption since the only available frequency listing, Trésor de la Langue Française, presents word frequencies collapsed across inflected forms.

EXPERIMENT 1

In the first experiment, the stimuli were French monomorphemic words matched on their surface frequency, but varying on their cumulative frequency, calculated as the total frequency of all derivationally related words. If, as is generally assumed, the base morpheme used as a free form and the base morpheme of the other family members share the same representation, one would predict that recognition times for the base word will be controlled by the ‘‘cumulative frequency’’ of all the elements of its morphological family (including itself). As an example, the recognition of the French lexical item PLUME (feather) should be related not only to the frequency of PLUME itself (and to the frequency of its inflectionally related words such as PLUMER which means ‘‘to pluck’’) but to the frequencies of the morphologically related words PLUMEAU (feather duster), PLUMAGE (plumage), and so on.

Method

Design and stimuli. Ten pairs of words that could stand as base morphemes were selected. Both the items of the pairs were matched as closely as possible on surface frequency, but differed on cumulative frequency (high Cumulative Frequency or low Cumulative Frequency). As an example, in French, the words TAILLE (cutting, waist) and CIRE (wax) are of the same surface frequency, but the former has a higher cumulative frequency than the latter as a result of the higher frequency of TAILLER (to cut), TAILLEUR (tailor), etc., than CIRER (to wax), CIREUR (polisher), etc. The average surface frequencies for words with low cumulative frequency was 132 (*SD* = 89) occurrences per million according to the Trésor de la Langue Française (1971), and for words with high cumulative frequency it was 146 (*SD* = 115). The average cumulative frequencies were respectively 237 (*SD* = 220) and 418 (*SD* = 368) occurrences per million.

Members of each pair were matched as closely as possible on length and grammatical class and were between 3 and 6 letters long. Mean length for High Cumulative Frequency items was 4.9 letters (*SD* = 0.9) and it was 4.7 (*SD* = 1.1) for Low Cumulative Frequency items. Length did not differ significantly across these two conditions ($t(18) = .886$, $p > .10$). These stimuli (listed in the Appendix) were also matched for average positional bigram frequency according to a computerized lexical data base for French (Brulex) developed by Content, Mousty, and Radeau (1990). The mean bigram frequency (only logarithmic values are available) was 2.93 (*SD* = 0.3) for High Cumulative Frequency items and 2.73 (*SD* = 0.4) for Low Cumulative Frequency items ($t(18) = 1.132$, $p > .10$). The two stimulus sets were also matched on neighborhood density *N* ($t(18) = .60$, $p > .10$) as defined by Coltheart, Davelar, Jonasson, and Besner (1977) and on number of higher frequency neighbors ($t(18) = 1.068$, $p > .10$). For the High Cumulative Frequency items the mean *N* value was 4.1 (*SD* = 2.2) and the mean number of higher neighbors was 1.6 (*SD* = 1.3). These values for Low Cumulative Frequency items were respectively 4.8 (*SD* = 2.6) and 1 (*SD* = 1). Each subject saw all the 20 test-words inserted among 20 other words and 40 pseudo-words. The pseudo-words were between 4 and 6 letters long and were constructed by changing 1 or 2 letters within words so that they were orthographically and phonologically legal.

Procedure. The task was ‘‘lexical decision.’’ Each trial began with the presentation of a fixation cross at the center of the display screen of a personal computer for 250 ms followed by a 50-ms blank screen. An item was then presented (in lowercase) until subjects responded. They had to quickly press one key if the stimulus was a word (with their preferred hand) and another if it was a pseudoword. The next trial followed after a 500-ms delay. Stimulus presentation was randomized, with a different order for each subject. The experiment began with 20 practice trials.

Subjects. The 20 volunteer subjects who participated in this experiment were undergraduates of the University of Nice–Sophia Antipolis and were native French speakers. All had normal or corrected-to-normal vision.

Results and Discussion

Average lexical decision latencies were 619 ms for High Cumulative Frequency words and 576 ms for Low Cumulative Frequency words. The error rates were 2% for High Cumulative Frequency and 1% for Low Cumulative Frequency. Analysis of variance showed the 43-ms difference to be significant only in the subject analysis ($F_1(1,19) = 5.11$, $p < .05$; $F_2 < 1$). The error analysis showed no significant effect (both F_1 and $F_2 < 1$).

Surprisingly, the trend in this experiment was toward a negative effect of cumulative frequency: words with higher cumulative frequency were responded to significantly more slowly (in the subject analysis) than words with lower cumulative frequency. Thus, it is apparent that the recognition of a monomorphemic word is not enhanced by the existence of relatively common derivationally related words, unlike the situation with inflectionally related words, and in fact their existence, if anything, is inhibitory.

There is, in fact, a previous result in the literature showing an inhibitory effect on monomorphemic stimuli where there is a higher frequency polymorphemic word which contains the stimulus as its stem. Taft and Forster (1975) found that lexical decision times to words like VENT which are the bound stems of other higher frequency prefixed words (e.g., INVENT, PREVENT) were longer than those to words like COIN which do not exist as bound stems. When the free form was more frequent than the bound form (e.g., CARD is more common than DISCARD), there was no such effect. This result was explained by Taft and Forster in terms of their search model, where there is an access file listing morphemes in order of frequency. The bound form of #VENT[2] will be accessed prior to the free form of VENT and, since a correct lexical decision response must be based on access of a free form, response times will be delayed; but this is not so when the free form is accessed prior to the bound form, as in the case of #CARD. It is also possible to explain this result in terms of the hierarchical activation model (Taft, 1994) using similar logic. If the morphemic unit representing the bound form is activated more strongly than the word unit representing the free form, lexical decisions will be delayed. However, it is important to note that the relationship between VENT and PREVENT is rather different to that between TAILLE and TAILLER. In the former case, the meaning of the free form is not to be found within the meaning of the bound form and therefore there is reason to suppose that they are independently represented and likely to compete with each other. On the other hand, the meaning of TAILLE# in TAILLER is clearly related to the meaning of the free form TAILLE. Words of this kind that were used in the experiment were generally the most frequent member of the morphological family. Moreover, because the same orthographic form (TAILLE) possesses two types of status, one as a free lexical item and the other as the base morpheme of a morphological family, one might also hypothesize that two types of representation, word or morpheme, could be assessed during the visual recognition of this form. In order to explain the negative effect of cumulative frequency on the recognition of these words, one could suggest that the morphemic unit representing TAILLE# (i.e., the unit used in accessing TAILLER, TAILLEUR, etc.) is activated more strongly than the word unit for TAILLE, leading to a delay in the response. What is relevant to the response is therefore the frequency of the morphemic form relative to the free form rather than the absolute frequency of the morphemic form (that is cumulative frequency). Morphemic form refers to the stem status of the monomorphemic word and this can be described in terms of a *morphemic frequency* corresponding to the cumulative frequency of all derived words sharing this stem morpheme (excluding the frequency as a free lexical item). Since it was absolute cumulative frequency that was manipulated in Experiment 1 rather than the relative frequency of the morphemic form to the free form, the lack of generalizability across items might be explained. That is, while these two measures of frequency would be correlated, it does not follow that high cumulative frequency necessarily means that the morpheme form is of higher frequency than the free form or vice versa for low cumulative frequency items. This suggests that it is the *relationship between the two kinds of frequencies* that may have influenced the recognition of words used in this experiment. In fact, a detailed examination of the experimental material showed that for words having a high cumulative frequency, 5 of 10 words had a frequency of the morphemic form higher than the frequency of the free form and 5 words had a frequency of the morphemic form equal to the frequency of the free form. In contrast, with words having a low cumulative frequency, 9 of 10 had the frequency of the free form superior to the one corresponding to the morphemic form and only one word had a frequency of the morphemic form equal to the frequency of the free form. However, post-hoc analysis including this factor was impossible to conduct because of mismatch in the frequency of the free form

[2] For purposes of clarity, #VENT will note the bound stem of VENT and VENT (alone) will note the free form. In the same vein, for the kind of words used in the experiments, TAILLE# will note the base morpheme and TAILLE (alone) the free form.

and the morphemic form. Therefore, in the following experiments the relationship between word and morphemic forms of the same orthographic form was systematically examined by manipulating the relative frequency of the morphemic form to the free form.

EXPERIMENTS 2A AND 2B

On the basis of the previous proposal, when a monomorphemic word which can stand as a stem morpheme is the most common member of its morphological family, it should be the case that access to this word is determined by its surface or *Word Frequency* (this term seems preferable because it refers more evidently to the word status of such a word). On the other hand, when such a monomorphemic word is a relatively unusual version of the morphemic base, access to this word may essentially be affected by the frequency of its morpheme base. We will call this *Morphemic Frequency*, defined as the cumulative frequency of all its derivationally related words (but not including the frequency of the free standing word form).

In Experiments 2A and 2B, this was tested by looking at the effect of variations in Morphemic Frequency for monomorphemic words of two types: either the presented word was uncommon compared to its affixed forms (so that its Word Frequency was inferior to its Morphemic Frequency) or the affixed forms were uncommon compared to the free-form of the word (so that its Word Frequency was superior to its Morphemic Frequency). The manipulation of Morphemic Frequency was achieved by holding constant the frequency of the presented word form (Word Frequency) and varying the frequency of the morpheme form (Morphemic Frequency), that is the frequency of the form of the word that is only ever used in combination with affixes.

In one set, Word Frequency was less than Morphemic Frequency (Word Frequency < Morphemic Frequency), but Morphemic Frequency could be either high or low. For example, in Experiment 2A, VOL (flight, theft) and GÊNE (embarrassment) have a similar Word Frequency (38 and 31 per million, respectively), while their affixed versions are more frequent (a Morphemic Frequency of 93 per million and a Morphemic Frequency of 48, respectively). The prediction for such Word Frequency < Morphemic Frequency words is that there will be an advantage for the ‘‘high’’ Morphemic Frequency words over the ‘‘low’’ Morphemic Frequency words because access will be controlled by morphemic frequency.

In the second set of words, Word Frequency was greater than Morphemic Frequency (Word Frequency > Morphemic Frequency), but again Morphemic Frequency could be high or low. To take an example of Experiment 2A, the words MONSTRE (monster) and POISSON (fish) are approximately matched on Word Frequency (a Word Frequency of 38 and 36 per million respectively), while the morphemic form found in the affixed words MONSTRUEUX or MONSTRUEUSE is less frequent than the Word Frequency (a Morphemic Frequency of 28) and that found in POISSONNIER, POISSONNERIE, POISSONNEUX, etc., is less frequent again (a Morphemic Frequency of only 2). It is predicted that for such Word Frequency > Morphemic Frequency words there will be no effect of the Morphemic Frequency manipulation because access to these words depends essentially on their Word Frequency. The prediction for the experiment is therefore that there will be an interaction between the Word/Morphemic Frequency relationship and Morphemic Frequency, with Word Frequency < Morphemic Frequency words showing a larger advantage of high Morphemic Frequency over low Morphemic Frequency than will Word Frequency > Morphemic Frequency words.

The set of predictions described above was tested using both a lexical decision task (Experiment 2A) and a naming task (Experiment 2B). Lexical decision and naming tasks have been used extensively to study word recognition. However, reservations have been expressed about the lexical decision task because it involves additional decisional processes as

TABLE 1

CHARACTERISTICS OF ITEMS USED IN EXPERIMENT 2A

	Word Frequency > Morphemic Frequency				Word Frequency < Morphemic Frequency			
	High Morphemic Frequency		Low Morphemic Frequency		High Morphemic Frequency		Low Morphemic Frequency	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word Frequency	60.7	27	61.4	28.8	49.2	68.1	48.7	68.5
Morphemic Frequency	35.8	16.7	8.8	6.1	111.1	78.8	74.6	71.1
N	2.7	2.6	2.7	2.05	2.3	2.9	3.1	2.7
Mean No. of higher neighbors	0.4	0.6	0.7	0.6	0.7	0.6	0.7	0.7
M bigram frequencies	2.6	0.5	2.7	0.5	2.7	0.3	2.7	0.3
Letter length	5.1	1.2	5.2	1.2	5.8	1.7	5.7	1.3

Note. N, No. of orthographic word neighbors.

well as word recognition processes (e.g., see Balota, 1990, and Balota and Chumbley, 1984). However, there are also reservations related to the use of naming task, so several researchers have suggested that the best strategy in word recognition studies is to obtain converging evidence from both tasks (Balota & Chumbley, 1984; Andrews, 1989).

EXPERIMENT 2A

Method

Design and stimuli. Twenty pairs of words matched as closely as possible on word frequency, length, bigram frequency, neighborhood characteristics (density and number of higher neighbors) and grammatical class, but with different morphemic frequencies (high or low) were selected. Ten pairs were composed of words with word frequencies higher than morphemic frequencies (i.e., Word Frequency > Morphemic Frequency items) and 10 others composed of words with word frequencies lower than morphemic frequencies (i.e., Word Frequency < Morphemic Frequency items). Thus, two factors, namely Morphemic Frequency (high or low) and the Word/Morphemic Frequency Relationship were manipulated. The 10 pairs composed of Word Frequency > Morphemic Frequency words were matched as closely as possible on word frequency to 10 pairs of Word Frequency < Morphemic Frequency words according to the Trésor de la Langue Française (1971). Table 1 shows means and standard deviations of word and morphemic frequencies, length, bigram frequency, and neighborhood characteristics of the stimuli used in the experiment. The full set of items is given in the Appendix. Words in the Word Frequency > Morphemic Frequency pairs did not differ in bigram frequency ($t(18) = .223$, $p > .10$), N value ($t = 0$), the number of higher frequency neighbors ($t(18) = 1.029$, $p > .10$), letter length ($t(18) = .172$, $p > .10$), or in word frequency ($t(18) = .053$, $p > .10$). This was also the case for words of the Word Frequency < Morphemic Frequency pairs (respectively, $t(18) = .36$, $p > .10$; $t(18) = .598$, $p > .10$; $t = 0$; $t(18) = .137$, $p > .10$; and $t(18) = .0155$).

Eighty filler items (20 words and 60 pseudo-words) were inserted in the experimental list for the purposes of the lexical deci-

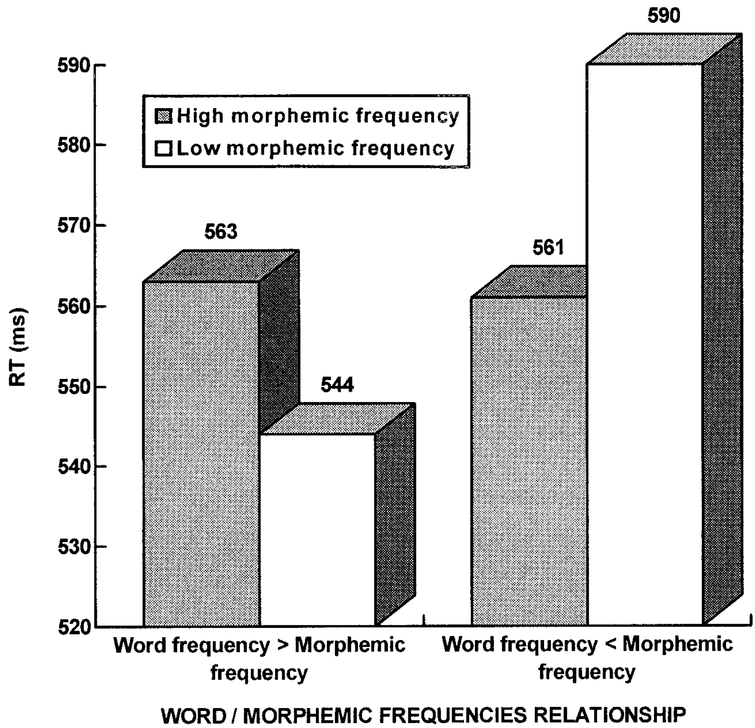

FIG. 1. Mean lexical decision times (ms) as a function of Morphemic Frequency and Word/Morphemic Frequencies Relationship of test-words in Experiment 2A.

sion task. The pseudo-words were constructed in the same manner as in Experiment 1 and were between 4 and 6 letters long.

Procedure. The procedure was the same as in Experiment 1.

Subjects. Forty-seven third-year psychology students at the University of Nice–Sophia Antipolis who had not participated in Experiment 1, served as subjects for course credit. All were native French speakers.

Results and Discussion

The results are presented in Fig. 1.

Analysis of variance showed no significant effect of overall Morphemic Frequency in either the subject or item analyses ($F_1(1,46) = 1.99$; $F_2 < 1$). In contrast, the effect of the Word/Morphemic Frequency relationship was significant in both the subject and item analyses ($F_1(1,46) = 32.09$, $p < .001$; $F_2(1,36) = 4.13$, $p < .05$). Of central interest, though, was the interaction between this factor and the Word/Morphemic Frequency Relationship factor which proved to be significant ($F_1(1,46) = 37.91$, $p < .001$; $F_2(1,36) = 5.42$, $p < .025$). The direction of this interaction was as predicted: a Morphemic Frequency effect was found for the Word Frequency < Morphemic Frequency words ($F_1(1,46) = 36.08$, $p < .001$; $F_2(1,18) = 3.66$, $p < .07$), while a significantly negative effect of Morphemic Frequency was observed for Word Frequency > Morphemic Frequency words in the subject analysis ($F_1(1,46) = 10.84$, $p < .0025$) but not the item analysis ($F_2(1,18) = 1.794$, $p > .10$).

The analysis of the error rates showed that these did not vary significantly across the experimental conditions. For the Word Frequency > Morphemic Frequency words, error rates were 2.9 and 1.5% for high and low Morphemic Frequency, respectively, while for

Word Frequency < Morphemic Frequency words they were 2.1 and 1.9%.

The data obtained in this experiment counter the view that all members of a (derivational) morphological family are accessed via a representation of their base morpheme. If they were, recognition of any member of the family, including the monomorphemic base word, would be affected by cumulative frequency. More precisely, the hypothesis that morphologically simple words corresponding to the base morpheme of affixed (derived) words can either be accessed as a free lexical morpheme or as the base morpheme of a morphological family has been tested through the manipulation of the Word/Morphemic Frequency Relationship and the Morphemic Frequency of such words. It has been demonstrated that reaction times to such words with a Morphemic Frequency superior to its Word Frequency are influenced by Morphemic Frequency, suggesting access as the base morpheme of a morphological family. On the other hand, reaction times to words with a Morphemic Frequency inferior to its Word Frequency are not sensitive to the manipulation of Morphemic Frequency, suggesting no access as a morphological element. However, these results need to be replicated first with a naming task, and this was the purpose of Experiment 2B, to confirm that the observed results are localized in the word recognition stage rather than in the decision stage. In the former case, effects of Morphemic Frequency might be observed.

EXPERIMENT 2B

Method

Stimuli and design. As in Experiment 2A, 16 pairs of monomorphemic words that could be base morphemes of a morphological family varying on morphemic frequency were selected but because of severe constraints on the selection of materials it was not possible to match these on word frequency. Eight pairs were composed of Word Frequency > Morphemic Frequency words and 8 pairs of Word Frequency < Morphemic Frequency words. Again, two factors were manipulated, namely the Word/Morphemic Frequency Relationship and Morphemic Frequency. Table 2 gives the word and morphemic frequencies, the neighborhood characteristics, bigram frequency, and length of the stimuli. As can be seen, bigram frequency did not differ significantly in the Word Frequency > Morphemic Frequency condition ($t(14) = .875$) and in the Word Frequency < Morphemic Frequency ($t = 0$), nor did the N value ($t(14) = .240$ and $t(14) = .474$, respectively), the number of higher frequency neighbors ($t(14) = .608$ and $t(14) = .832$, respectively), the letter length ($t(14) = .392$ and $t(14) = .546$, respectively), or the word frequency ($t(14) = .216$ and $t(14) = .119$, respectively).

For the purpose of the naming task, pairs of words (given in the Appendix) were matched as closely as possible on length, number of syllables, initial phoneme, and grammatical class. They were between 3 and 8 letters long. Moreover, these items were mostly bi-directionally consistent (spelling to phonology and phonology to spelling) according to Véronis (1986) and to Ziegler, Jacobs and Stone (1996). The exception items were ‘‘essai,’’ ‘‘balai,’’ ‘‘discret,’’ ‘‘voisin,’’ and ‘‘flot,’’ which are composed of endings that are bi-directionally inconsistent. The practice and experimental lists consisted of words between 4 and 10 letters long and they contained from one to three syllables.

Procedure. As in Experiment 1, items were presented in isolation on the center of the display screen of a personal computer. At the beginning of a trial, a fixation cross was presented for 250 ms. The screen then went blank for 50 ms, at the end of which the item appeared in lowercase. Subjects were then instructed to name the item as rapidly and as accurately as possible. The computer recorded the naming times measured from the item onset to the triggering of the voice key by the subject’s response (via a Sennheiser MD211N microphone). The experimenter sat in the same room as the subject in order to check

TABLE 2

CHARACTERISTICS OF ITEMS USED IN EXPERIMENT 2B

	Word Frequency > Morphemic Frequency				Word Frequency < Morphemic Frequency			
	High Morphemic Frequency		Low Morphemic Frequency		High Morphemic Frequency		Low Morphemic Frequency	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word Frequency	78.1	44	73.3	37.8	29.3	13.5	28.4	14
Morphemic Frequency	38	31.3	15.9	20.6	114.4	47.3	47.9	19.2
N	1.8	2.0	1.6	1.9	2.8	3.1	2.1	2.8
Mean No. of higher neighbors	0.1	0.3	0.2	0.4	0.7	0.9	0.4	0.7
M bigram frequencies	2.6	0.4	2.8	0.4	2.7	0.2	2.7	0.3
Letter length	5.9	1.3	5.6	1.1	5.9	1.6	5.5	0.7

Note. N, No. of orthographic word neighbors.

and note the responses of the subject. The next trial followed after a 2-s delay. Item presentation was randomized with a different order for each subject.

Subjects. Thirty third-year psychology students at the René Descartes University served as subjects. They were all native French speakers and none had participated in the prior experiments.

Results and Discussion

Mean naming latencies are presented in Fig. 2. Latencies longer than 1500 ms were excluded (less than 4% of the data). F values are reported by subjects (F_1) and by items (F_2).

Analysis of variance showed a significant effect of Morphemic Frequency in the subject analysis ($F(1,29) = 3.74$, $p = .06$; $F_2 < 1$). This was also the case for the Word/Morphemic Frequency Relationship ($F(1,29) = 8.75$, $p < .01$; $F_2 < 1$). However, the interaction between these two factors failed to achieve significance in either the subject or the item analysis ($F(1,29) = 2.06$, $p > .10$; $F_2 < 1$). However, planned comparisons showed a significant Morphemic Frequency effect for Word Frequency < Morphemic Frequency words only ($t(29) = 2.18$, $p < .05$) and no effect for Frequency > Morphemic Frequency words ($t < 1$). Because the error rates were consistently low (2%), no ANOVA was conducted on the error rates.

We see, then, that a significant effect of Morphemic Frequency was replicated with a naming task, suggesting that this effect is not idiosyncratic to lexical decision and it influences the recognition of the words used in the two experiments. As in Experiment 2A, we observed a significant effect of Morphemic Frequency only for words with a Morphemic Frequency higher than their Word Frequency which again suggests access via the morphological representation of such words. So the fact that having a high Morphemic Frequency is not advantageous to the recognition of a word when the likelihood of competition with other words is low (Word Frequency > Morphemic Frequency) implies that the free word form and the morphemic form are represented independently (in the same way that the word VENT and the morphemic form #VENT are assumed to be represented). Moreover, the negative effect of Morphemic Frequency observed with such words in the lexical decision task of Experiment 2A suggests that it might have occurred at the decision stage. However,

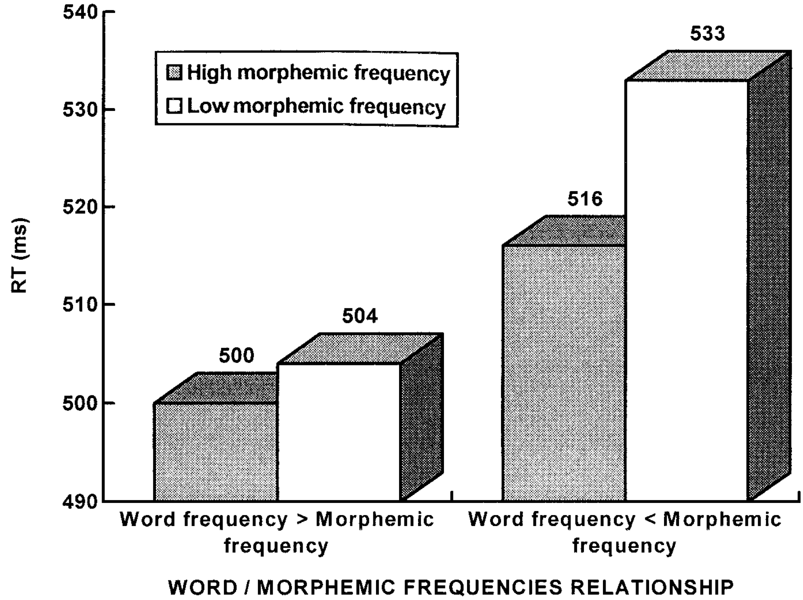

FIG. 2. Mean word naming times (ms) as a function of Morphemic Frequency and Word/Morphemic Frequencies Relationship of test-words in Experiment 2B.

further assumptions need to be made in order to explain the complete pattern of results. One possibility that is worth considering is that when Word Frequency is greater than Morphemic Frequency the response can be made purely on the word representation with no influence from the morphemic representation (and hence no significant effect of Morpheme Frequency), while when Morphemic Frequency is greater than Word Frequency it is the morphemic representation that is activated first (and hence there is a significant effect of Morphemic Frequency).

Before attempting to analyze how this could be theoretically instantiated, a further experiment will be presented which tests an essential corollary of it. In particular, when it is the word representation that is activated first, there should be a significant effect of the frequency of that word (i.e., an effect of Word Frequency for Word Frequency $>$ Morphemic Frequency words), whereas when it is the morphemic representation that is activated first, there should be no effect of Word Frequency. Thus, the normally ubiquitous Word Frequency effect (see Taft, 1991) should be absent for Word Frequency $<$ Morphemic Frequency words. Experiment 3 examines this prediction.

EXPERIMENT 3

Method

Design and stimuli. Twenty pairs of words matched as closely as possible on morphemic frequency, length, neighborhood characteristics, bigram frequency and grammatical class, but with different word frequencies (high or low) were selected. Ten pairs of Word Frequency $>$ Morphemic Frequency words and 10 pairs of Word Frequency $<$ Morphemic Frequency words were constructed. The factors manipulated were therefore the Word/Morphemic Frequency relationship and Word Frequency. Table 3 gives the means and standard deviations of word and morphemic frequencies, bigram frequency, length, and neighborhood characteristics of the stimuli (the full set is given in the Appendix). For the Word Frequency $>$ Morphemic Frequency pairs, words did not differ in bigram frequency

TABLE 3

CHARACTERISTICS OF ITEMS USED IN EXPERIMENT 3

	Word Frequency > Morphemic Frequency				Word Frequency < Morphemic Frequency			
	High Word Frequency		Low Word Frequency		High Word Frequency		Low Word Frequency	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word Frequency	103	46.5	46.5	23.6	78.7	67.3	23.5	15.8
Morphemic Frequency	23.6	16.9	22.9	17.3	103.4	64.9	103.2	65
N	3.2	3.1	2.6	1.9	3.2	2.8	3.2	3.0
Mean No. of higher neighbors	0.4	0.9	0.4	0.7	0.6	0.8	0.6	0.9
M bigram frequencies	2.8	0.2	2.6	0.5	2.6	0.4	2.9	0.3
Letter length	5.2	1.2	5	1.2	5.2	1.3	6.1	1.5

Note. N, No. of orthographic word neighbors.

($t(18) = 1.30$, $p > .10$), N value ($t(18) = .485$), number of higher frequency neighbors ($t(18) = 0$), letter length ($t(18) = .348$) or morphemic frequency ($t(18) = .514$). This was also true of Word Frequency < Morphemic Frequency pairs (respectively, $t(18) = 1.643$, $p < .10$; $t(18) = 0$; $t(18) = .542$; $t(18) = 1.347$, $p > .10$; and $t(18) = .006$). The training and experimental lists were the same as in Experiment 2A.

Subjects. Thirty-one third-year psychology students from the University of Nice–Sophia Antipolis who had not participated in the earlier experiments served as subjects and were given academic course credit.

Procedure. The procedure was the same as in Experiment 2A.

Results and Discussion

The results are presented in Fig. 3.

A significant main effect of Word Frequency was observed in this experiment ($F_1(1,30) = 11.51$, $p < .0025$; $F_2(1,36) = 4.25$, $p < .05$) but no significant effect of Word/Morphemic Frequency Relationship (both F's < 1). More importantly, these two factors interacted significantly ($F_1(1,30) = 32.95$, $p < .001$; $F_2(1,36) = 4.66$, $p < .05$) with an effect of Word Frequency for Word Frequency > Morphemic Frequency words ($F_1(1,30) = 37.29$, $p < .001$; $F_2(1,18) = 6.65$, $p < .025$) but not for Word Frequency < Morphemic Frequency words ($F_1(1,30) = 1.35$, $p > .10$; $F_2 < 1$). No significant effects emerged in the analysis of error rates. For Word Frequency > Morphemic Frequency words error rates were 1.9 and 2.9% for high Word Frequency and low Word Frequency, respectively, and for Word Frequency < Morphemic Frequency words they were 2.9 and 3.8%.

The results obtained in the experiment are exactly as predicted from the notion that a representation of the word competes with a representation of the combinatory base morpheme and that their relative frequency determines which one controls the lexical decision response. Only when the word form is the most frequent member of its morphological family does word frequency have an effect. The lack of a Word Frequency effect for Word Frequency < Morphemic Frequency words suggests that the frequency effect that is typically observed in lexical decision experiments arises because the words used (particularly the high frequency ones) are more likely to be

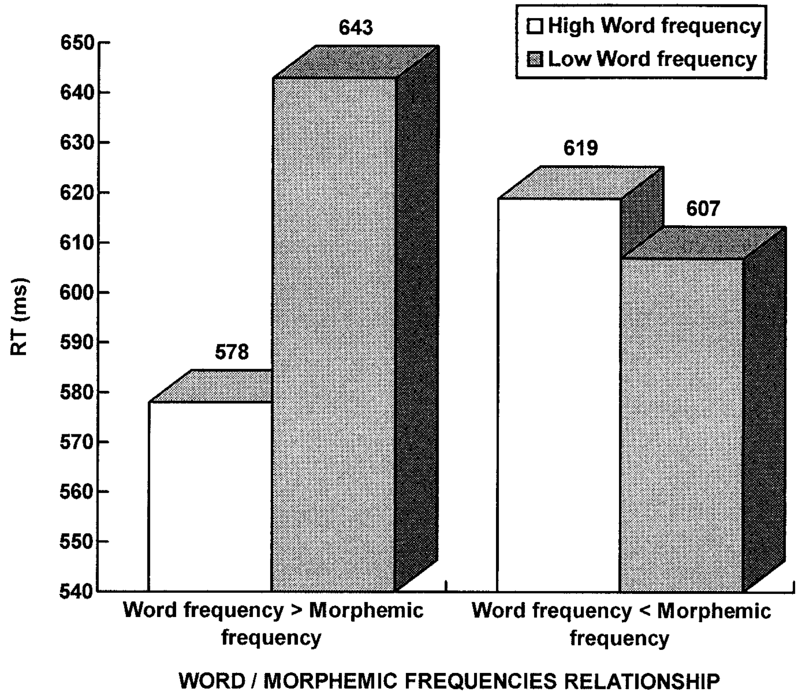

FIG. 3. Mean lexical decision times (ms) as a function of Word Frequency and Word/Morphemic Frequencies Relationship of test-words in Experiment 3.

used as a free form rather than as a derivational base. If they were not, the present results suggest that a Word Frequency effect should not be observed.

GENERAL DISCUSSION

Reaction times to words with a Word Frequency superior to their Morphemic Frequency (Word Frequency > Morphemic Frequency items) were not sensitive to the manipulation of Morphemic Frequency (Experiment 2A, if the trend toward inhibitory effects is ignored, and Experiment 2B), but were affected by their Word Frequency (Experiment 3), suggesting privileged access to these words as a free lexical form rather than a morphemic one. The opposite pattern of results was observed for words with a Word Frequency inferior to their Morphemic Frequency (Word Frequency < Morphemic Frequency items). Reaction times to such words were sensitive to the manipulation of Morphemic Frequency (Experiments 2A and 2B) and not to Word Frequency (Experiment 3), suggesting privileged access to the morphemic status of these words.

Just as the (English) free form VENT and the unrelated morphemic form of #VENT (found in PREVENT and INVENT) are thought to possess separately accessible representations in the lexical system, the suggestion is being made here that so too do free forms and morphemic forms when they are actually morphologically related, for example, the (French) word VOL and the VOL# of VOLER and VOLEUR. If they were not independently accessible, a systematic effect of Morphemic Frequency should have been observed in the present experiments, but it was not.

To account for the results of Experiments 2A and 3, we suggest that the lexical decision response is made on the basis of the free form when it is more frequent than the morphemic form, and on the basis of the morphemic form when that form is the more frequent. Such a suggestion, however, requires the assumption that a lexical decision response can be made on the basis of the morphemic form alone (when Morphemic Frequency is greater than Word Frequency) and this appears to be unsustainable. First, if the response is made on the basis of the morphemic representation, one could not discriminate words from pseudo-words which are also bound stems (e.g., #SPECT) if no post-access check is assumed. To counter this argument, however, it can be noted that the pseudo-words used in the experiments were never bound stems, so the subjects would have been safe in relying on the morphemic representation for their response.

An alternative interpretation would assume that the lexical decision response is always made on the basis of the word representation and that access to the morphemic representation can lead to competition. If we assume that such competition only occurs when the morphemic representation and the word representation are accessed at approximately the same time, the pattern of results can be explained. Looking first at Experiment 2A, response times were slower when Word Frequency and Morphemic Frequency were similar to each other since this is when the two forms would be accessed at approximately the same time. Thus, competition would occur with Word Frequency > Morphemic Frequency words when Morphemic Frequency is high, and with Word Frequency < Morphemic Frequency words when Morphemic Frequency is low, thus producing the interaction that was observed. For Word Frequency > Morphemic Frequency words whose Morphemic Frequency is low, the word representation will be accessed well before the morphemic form, while for Word Frequency < Morphemic Frequency words whose Morphemic Frequency is high, the morphemic representation will have already been accessed and found to be inappropriate before the word form has been accessed. Note that it is possible that the latter situation will lead to some delay in responses to the word and this would explain the slower responses to Word Frequency < Morphemic Frequency words compared to Word Frequency > Morphemic Frequency words. Also contributing to this main effect would be the potentially greater competition of the morphemic form with the word form for low Morphemic Frequency words in the Word Frequency < Morphemic Frequency condition compared to high Morphemic Frequency words in the Word Frequency > Morphemic Frequency condition, arising from the morphemic form being accessed just prior to the word form in the former case, but just afterwards in the latter case.

The results of Experiment 3 can be explained as follows. For Word Frequency > Morphemic Frequency items, low Word Frequency words will be responded to more slowly than high Word Frequency items because the word form will be accessed more slowly. In addition, because the Morphemic Frequency is more similar to the Word Frequency of the low Word Frequency words than to the high Word Frequency words, there will be some competition with the morphemic form for the low Morphemic Frequency words, thus increasing the Word Frequency effect. For Word Frequency < Morphemic Frequency items, on the other hand, the faster access to the high Word Frequency words than the low Word Frequency words will be counteracted by the fact that Word Frequency and Morphemic Frequency are more similar for the high Word Frequency words than for the low Word Frequency words. Thus, the former will experience more competition with the morphemic form than will the latter and this, in combination with the faster access to the word form, could explain the lack of any observable effect of word frequency.

As for the results of Experiment 1, whether one finds slower or faster responses to high Cumulative Frequency than to low Cumulative Frequency words will depend upon the relationship between Word Frequency and Morpheme Frequency in the experiment. The fact that many more of the high Cumulative Frequency items than the low Cumulative Frequency items had morphemic frequencies which were similar to their word frequencies, could explain the tendency toward the negative effect of having a high Cumulative Frequency.

The conclusion that there are separate word and morphemic representations which compete with each other may at first seem compatible with the AAM Model (e.g., Caramazza et al., 1988) since there is both a whole word and a morphemic access system. However, because the latter is always slower than the former (and in fact only comes into play with pseudo-words), the frequency of the morphemic form should be irrelevant. Furthermore, if the morphemic form has its frequency boosted by all members of the morphological family, its frequency should reflect the cumulative value (i.e., Word frequency + Morphemic Frequency) rather than morphemic frequency alone. In fact, the AAM Model was developed on the basis of studies in Italian where there exists no free form independent of the morphemic base (e.g., the PORT of PORTO does not exist as a free form). It would presumably be possible to modify the AAM Model so that it also embraces free forms and accounts for the present results, but in so doing it would essentially become no different from other activation models (also modified appropriately in the light of the present results), like the hierarchical model of Taft (1991, 1994). In both types of model, there needs to be independent representation of the free form and the morphemic form, and activation of the latter must produce competition only when it is active at about the same time as the free form. This situation is depicted in Fig. 4 which uses the hierarchical activation framework.

It can be seen in the figure that the derived and free forms of a morphological family are all represented by units at the word-level, but that the former are activated via a morphemic representation and the latter is not. The derived and free forms are related only by virtue of the fact that they share units of activation at the graphemic level as well as at the semantic level.

The competition that is being proposed to explain the results of the present experiments could arise in several different ways. First, it may be that there are inhibitory links hardwired between the morphemic form and the free form, or alternatively between the various derived forms and the free form. These inhibitory links serve to suppress activation of the free form when the derived form is appropriate, and vice versa.

A second possibility is that there are no inhibitory links, but that a decision must be made about the appropriateness of any unit after it has been activated. Competition would then arise at this decision stage. If the activation of morphemic units can play a role at this stage, then one would have to make a decision like: ‘‘Can the accessed item stand on its own and therefore be considered to be a word?’’ The answer to this would be harder to reach when a morphemic unit is activated at the same time, suggesting that maybe the item cannot stand on its own. An alternative possibility is that the decision that needs to be made is simply whether the activated word-level unit is the correct one. Here the competition to the monomorphemic form would arise when there are derivational forms active at about the same time.

One possible way to differentiate which type of decision is involved would be to look at the effect of the Word Frequency/Morphemic Frequency relationship using derived words as stimuli rather than using the monomorphemic free forms. If the competition arises from a decision about which activated word-unit is the appropriate one, the effects should be the same for derived words as it is was for the free forms, since they are all competing with each other. On the other hand, if the competition arises from a decision about whether the item really can be a free form, then this will be relevant only to free forms and not to derived words.

Whether competition actually arises at the decision stage, rather than from the existence of inhibitory links, might be tested using a naming task instead of lexical decision. That is, it might be supposed that the decision stage is specific to the lexical decision task and,

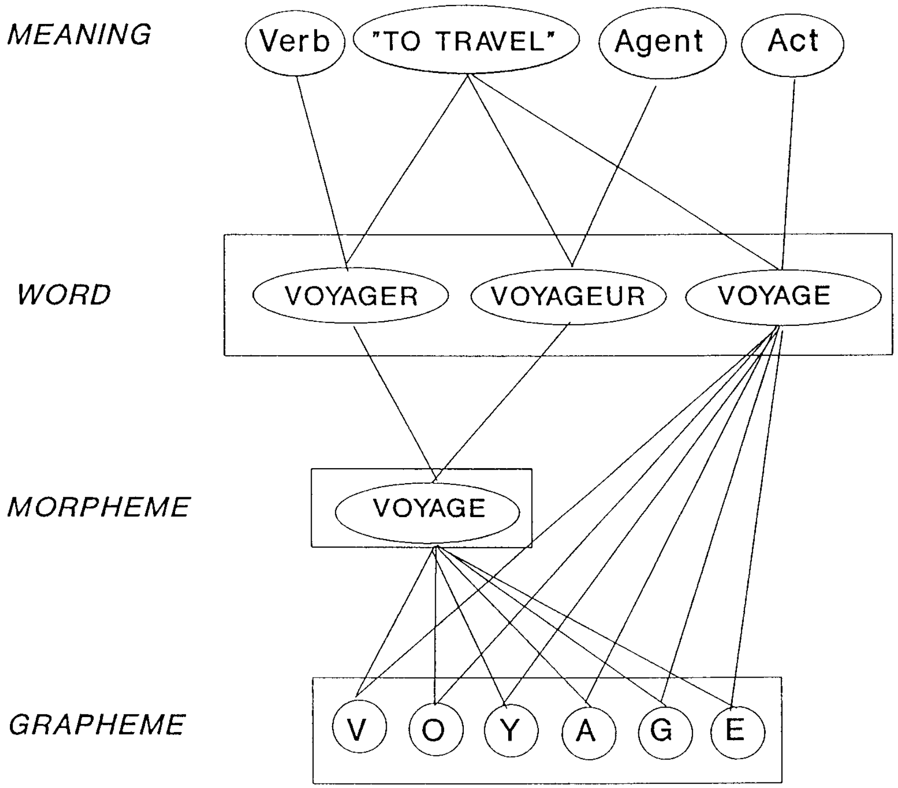

FIG. 4. An illustration of the hierarchical network incorporating separate word and morphemes levels.

therefore if the same effects are observed in the naming task as in lexical decision, it must be the case that they arise from hard-wired inhibition. The differential Morphemic Frequency effect observed on Word Frequency > Morphemic Frequency words and on Word Frequency < Morphemic Frequency words in Experiment 2A and 2B is in favor of the hard-wired inhibitory hypothesis.

Finally, the idea of competition between representations competing for output has been raised in connection with a quite different line of research, namely, when words sharing spelling units with a target word compete with responses to that target word. For example, Glushko (1979) demonstrated a delay in naming responses to words that contained a component that could be pronounced differently when occurring in other words, as with BEAD where EAD is pronounced differently in HEAD, DEAD, BREAD, etc. Kay and Bishop (1987) and Jared, McRae, and Seidenberg (1990) went on to show that this slowing of responses occurred only when the number of words with a pronunciation inconsistent with the target (what Jared et all call ''enemies'') was greater than the number with a consistent pronunciation (i.e., ''friends''). It may be possible to relate this result to the current study, if we consider that the word representation (e.g., VOL) and the morpheme representation (i.e., VOL#) are ''enemies'' that compete with each other and that this has an impact on response times only when the frequency of the enemies to the target word (i.e., its morpheme frequency) is superior to the frequency of the target word (i.e., its word frequency). However, such a parallel can be drawn so far. The competition being proposed here between morpheme and word representations occurs when the two have a similar frequency, not simply when the morpheme frequency exceeds the word frequency. Therefore, whether it is useful to try to equate morphological competition with phonological competition is questionable.

One aspect of the findings, however, is clear. The experiments presented here demonstrate the need for separate and competing representations of words and morphemes as units for lexical access, even when they are clearly semantically related.

APPENDIX

Experiment 1

Surface frequency and cumulative frequency

High Cumulative Frequency	RT	Low Cumulative Frequency	RT
flux (20; 53)	762	gaz (24; 27)	556
bord (141; 661)	644	mur (195; 233)	603
servir (249; 553)	558	perdre (249; 509)	566
taille (11; 101)	601	cire (12; 17)	635
tour (270; 1108)	594	tard (272; 420)	583
tuer (126; 194)	596	boire (123; 140)	528
peser (59; 108)	590	nier (55; 79)	658
vendre (50; 102)	633	plume (51; 55)	599
gros (155; 325)	570	groupe (140; 186)	577
porter (381; 980)	817	forme (396; 703)	555

Experiment 2A

Test-words with a Word Frequency superior to a Morphemic Frequency (Word Frequency-Morphemic Frequency)				Test-words with a Word Frequency inferior to a Morphemic Frequency (Word Frequency-Morphemic Frequency)			
High Morphemic Frequency	RT	Low Morphemic Frequency	RT	High Morphemic Frequency	RT	Low Morphemic Frequency	RT
danger (77; 67)	511	hiver (83; 4)	543	colle (4; 33)	609	olive (4; 12)	572
voyage (120; 60)	514	voisin (120; 20)	616	cueillir (15; 69)	614	coudre (12; 25)	632
duc (57; 52)	612	plume (51; 4)	556	croix (32; 83)	522	traduire (35; 60)	609
patron (60; 21)	545	sable (64; 7)	580	discret (22; 50)	581	flux (20; 33)	712
monstre (38; 28)	569	poisson (36; 2)	606	camp (56; 120)	554	aide (56; 104)	564
classe (92; 36)	543	courage (98; 20)	536	vol (38; 93)	519	gêne (31; 48)	631
drap (40; 29)	547	chat (43; 10)	517	appui (41; 62)	583	vendre (50; 52)	602
nier (55; 24)	631	trou (58; 9)	552	gouverner (24; 207)	652	vaincre (28; 132)	613
abri (42; 24)	587	trésor (37; 9)	550	servir (249; 304)	577	perdre (249; 260)	543
louer (26; 17)	553	gaz (24; 3)	550	taille (11; 90)	515	séduire (13; 35)	611

EXPERIMENT 2B

Test-words with a Word Frequency superior to a Morphemic Frequency (Word Frequency-Morphemic Frequency)				Test-words with a Word Frequency inferior to a Morphemic Frequency (Word Frequency-Morphemic Frequency)			
High Morphemic Frequency	RT	Low Morphemic Frequency	RT	High Morphemic Frequency	RT	Low Morphemic Frequency	RT
courage (98; 20)	513	colère (119; 4)	498	cueillir (15; 69)	522	coudre (12; 25)	555
voyage (120; 60)	509	voisin (120; 20)	518	discret (22; 50)	545	dicter (22; 42)	641
tapis (35; 17)	490	trésor (37; 9)	522	vol (38; 93)	534	vendre (50; 52)	527
toucher (169; 106)	498	tuer (126; 68)	515	charge (47; 184)	487	chaîne (40; 57)	472
parfum (44; 13)	494	poisson (36; 2)	499	coupe (25; 149)	486	croix (32; 83)	491
comédie (42; 12)	510	colline (46; 4)	490	essai (39; 181)	488	équipe (23; 37)	528
duc (52; 57)	509	date (52; 16)	502	fumer (42; 96)	541	flot (41; 65)	551
patron (60; 21)	479	plume (51; 4)	486	brouille (6; 93)	539	balai (7; 22)	507

EXPERIMENT 3

Test-words with a Word Frequency superior to a Morphemic Frequency (Word Frequency-Morphemic Frequency)				Test-words with a Word Frequency inferior to a Morphemic Frequency (Word Frequency-Morphemic Frequency)			
High Word Frequency	RT	Low Word Frequency	RT	High Word Frequency	RT	Low Word Frequency	RT
jardin (150; 19)	560	patron (60; 21)	619	mentir (54; 120)	596	vaincre (29; 132)	612
hiver (83; 4)	615	trône (15; 4)	736	complet (84; 110)	601	merveille (35; 101)	619
courage (98; 20)	551	mine (45; 20)	717	respect (65; 86)	597	croix (32; 83)	580
mur (195; 38)	549	classe (92; 36)	600	appui (41; 62)	611	cueillir (15; 69)	595
louer (26; 17)	550	gaz (24; 3)	565	flux (20; 33)	657	colle (3; 33)	605
école (104; 21)	550	nier (55; 24)	647	gêne (31; 48)	691	discret (22; 50)	595
tuer (126; 68)	570	danger (77; 67)	617	perdre (249; 260)	575	juge (61; 253)	589
orgueil (85; 19)	663	chiffre (35; 18)	613	vol (38; 93)	591	taille (11; 90)	584
chat (43; 10)	556	sucre (20; 12)	566	gros (155; 170)	546	vouer (7; 179)	670
voisin (120; 20)	572	abri (42; 24)	612	vendre (50; 52)	598	nouer (20; 42)	602

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