Morphological Structure and Lexical Access

Cristina Burani and Dario Salmaso
Institute of Psychology, Rome, Italy
Alfonso Caramazza
The Johns Hopkins University, Maryland

The three experiments reported in this paper addressed the question of whether the frequency of the root-morpheme of a word (e.g., *sent* from *sentire*, to hear) or the frequency of the surface form of a word (e.g., *sentito*, heard) determines decision latencies in a lexical decision task. The results indicate that both root-morpheme and word surface frequency contribute to variation in lexical decision times supporting previously reported experiments by Taft (1979). We argue that these results support a model of lexical organization that represents words in morphologically decomposed form. We also propose, however, that the address procedure for these representations does not require that the stimulus input be parsed into roots and affixes but that they can be addressed through a whole word address system.

An issue of central importance in lexical processing concerns the relationship between the mechanisms of lexical access and the morphological structure of words. Specifically, the issue concerns whether the address system of the lexical access procedure is based on whole-word or root-morpheme units, and whether a word stimulus must be parsed into its component morphemes in the course of lexical access. This issue has received considerable attention in recent years (e.g., Kempley & Morton, 1982; Forster, 1976; Manelis & Tharp, 1977), but neither the theoretical discussions nor the empirical evidence on which these discussions are based is particularly clear: The theoretical accounts of the structure of the input lexicon and the mechanisms of lexical access have remained relatively vague, and the experimental results are inconclusive.

In contrast to the issue of the specific nature of lexical access procedures which remains unsettled, the question of whether we must assume a level of representation within the lexical system at which root-morphemes and affixes are represented independently, is less problematical. There are compelling arguments and unequivocal experimental results in favor of a view of the lexicon that represents words in morphologically decomposed form (but see Butterworth, 1983). The arguments for proposing that the lexicon represents words in morphologically decomposed form are relatively straightforward, and concern the productive nature of language. Speakers of a language use words productively so that once the form class of a word has been

Visible Language, XVIII 4 (Autumn 1984), pp. 348-358.
Caramazza's address: Department of Psychology, Johns Hopkins University, Baltimore, MD 21218.

specified (e.g., verb) they can use the various inflected forms of that word in both language comprehension and production. Thus, if we know that *lavare* (to wash, in Italian) is a verb we would recognize *lavo* (I wash), *lavato* (washed), *lavassero* (would wash), and so on, as specific inflected forms of *lavare*, and we would be able to produce the various inflected forms of *lavare* in appropriate contexts, even if we have never seen or heard any of these specific forms. Obviously this capacity is only possible if lexical representations specify independently the root morpheme of words and the permissible affixal elements for each root morpheme.

The empirical evidence in favor of this view of the structure of the lexicon is equally compelling. Research on lexical processing with various experimental paradigms in which morphological factors have been manipulated has produced results consistent with a view of the lexicon which postulates that lexical information is represented in morphologically decomposed form. Research in word recognition (Murrell & Morton, 1974; Kempley & Morton, 1982),, lexical decision (Taft, 1979; Taft & Forster, 1975; Manelis & Tharp, 1977), word production (Mackay, 1978), speech errors in normal speakers (Garrett, 1980), and speech errors in aphasic and dyslexic patients (Caramazza & Berndt, in press) has demonstrated clearly the critical role played by morphological structure in lexical representation and lexical processing. For example, Garrett (1980) has demonstrated that the distribution of speech errors produced by normal subjects for bound-morphemes (e.g., -ed, -s) is different from that for root-morphemes (e.g., walk-). The differential distribution of bound- and root-morpheme errors has been interpreted by Garrett (1980) as evidence for a morphologically decomposed lexicon.

While there is rather compelling empirical evidence in support of a model of lexical representation that distinguishes between affixes and root-morphemes, there is a paucity of clear evidence directly relevant to the structure of the mechanisms of lexical access. What evidence there is on this latter issue is open to various interpretation. Specifically, much of the research presumably relevant to the structure of lexical access mechanisms can also be interpreted as reflecting post-access effects. This is most clearly evident in the case of the repetition effect for morphologically related words (Stanners, Neiser, Hernon, & Hall, 1979).

The repetition effect is the phenomenon in which performance in recognizing a word or in deciding whether a string of letters forms a word improves if it has been preceded by that same word for up to an hour before (Forbach, Stanners, & Hochaus, 1974). In various experiments this phenomenon has been extended to morphologically related words. Thus, for example, Murrell & Morton (1974) have shown that the recognition of a visually presented word such as CARING is facilitated by the earlier presentation of the morphologically related word CARE but not by the visually (but not morphologically) related word CARS. Results of this type have been interpreted as support for the view that the address system (logogens in Morton's model [1969]) consists of morphemic units. However, the reported result could just as easily be attributed to an effect arising at the level of post-access mechanisms—addressing the lexical entry CARE activates the morphologically related word CARING which facilitates its retrieval as a whole word at a later point in time. This ambiguity—that of attributing an effect of morphology at the level of access or post-access mechanisms—is present in all experiments in lexical processing, but especially those that have relied on the repetition effect as a means of addressing the issue of whether the units of lexical access are morphemes or whole-words (Stanners et al., 1979).

This problem of interpretation is not present in those experiments that have used "morphological" characteristics of nonwords (e.g., Taft & Forster, 1975). However, results in this area have been inconclusive (e.g. Manelis & Tharp, 1977).

Another approach that has been used to assess whether the units of lexical access are morphemes is based on the well known effect of word frequency on lexical decision (and word recognition)—decision latencies are related linearly to the logarithm of the frequency of a word (Scarborough, Cortese, & Scarborough, 1977). Various accounts have been given for the locus of the frequency effect in lexical decision. The most widely accepted view is that the threshold values (or activation gradients [Gordon, 1983]) of address units (logogens) to the lexicon are a direct function of the number of times (frequency) an address unit has been activated (Morton, 1979).

If the address units correspond to whole words, then the determining factor for decision latencies should be the frequency of individual words—surface frequency (e.g., the frequency of WALKED, CAR, RETAKEN). If, instead, the address units correspond to morphemes, then the critical factor that determines decision latencies should be the cumulative frequency of morphologically related words—root frequency (e.g., the summed frequency of TAKE, TAKEN, TAKES, and so on). Taft (1979), exploiting this logic, compared lexical decision times for words of equal surface frequency but different root frequencies and found that root frequency contributed to lexical decision latencies. He also found that surface frequency contributed to lexical decision time independently of root-morpheme frequency. He interpreted these results as evidence for a model of lexical access based on root-morpheme address units (see Forster, 1976). As we will argue later in this paper, these results are not necessarily incompatible with a whole-word address system model of lexical access. In this latter case, however, they do have rather important implications for the organization of the lexicon and the mechanism by which activation thresholds of address units are modified through exposure to morphologically related words. Clearly, then, the results reported by Taft are important and it is crucial that they be replicated. In this paper we report a series of experiments, carried out with Italian speakers, to evaluate the reliability of the results reported by Taft, as well as their generality across languages.

The experimental paradigm used in this investigation was, as in Taft's experiments, the lexical decision task. A series of letters that form either a word or a nonword is presented briefly to the subject and s/he must decide whether the letter string does or does not form a word. The logic of the research is the following. It is

Table I. Examples of three types of word stimuli used. Experiments 1a and 1b.

	1	2	3
Word type	HR-HW	HR-LW	LR-LW
Example of word	SENTITO	CHIAMAVI	FIUTAVO
Mean Root frequency	368.3	366.5	3.7
Mean Word frequency	70.7	1.7	1.7

HR = High frequency root LR = Low frequency root
HW = High frequency word LW = Low frequency word

known that reaction times in lexical decision tasks are affected by word frequency. Thus, if the word *walked* is of higher frequency than *kicked*, the time to decide that *walked* is a word should be less than the time to decide that *kicked* is a word. Furthermore, if the words *kicked* and *tested* are of equal frequency, then decision times for these two words should be the same. Consider, however, the case where the distribution of occurrence of the morphologically related words of *walked*, *kicked*, and *tested* (i.e., walk, walking, walks, kick, kicks, etc.) are such that the cumulative frequency (root-morpheme frequency) for the set *walk* (i.e., walk, walked, walking, walks) and *kick* are equal and are larger than that for *test*. What would be our expectation for decision times for the three words we have considered? Clearly, if surface frequency is the critical variable in determining decision times, then the expected pattern of reaction times is walked > kicked = tested. In contrast, if root-morpheme frequency is the determinant of decision times, then the expected pattern is walked = kicked > tested. These predictions were assessed in the following experiments.

EXPERIMENT ONE

Method

Subjects. Forty-one students attending Rome University were paid five thousand Lire, for their participation in one of the experiments. All were native speakers of Italian. No subject participated in more than one of the present experiments.

Materials. Three sets of words were used. They were all inflected verb forms, and were selected on the basis of the Bortolini, Tagliavini, & Zampolli (1971) frequency norms for Italian, which were calculated on an overall number of 500,000 occurrences. Table I presents examples of the stimuli used in the experiments and the factors considered. One set of words, exemplified in Table I by *sentito*, had both high word (surface form) and high root-morpheme frequency (HR-HW). One set of words, exemplified by *chiamavi*, had high root-morpheme frequency but low word frequency (HR-LW). The third set of words, *fiutavo*, had both low word and low root-morpheme frequency (LR-LW).

The words in the three sets were of equal mean length (mean length in letters = 6.75). The various types of inflectional suffixes were counterbalanced across groups. The test words in the two experiments were selected with the following constraints: all were regular verbs, none were prefixed, none were homographs, and none had final syllable stress. In experiments 1a and 1b we used 20 verbs in each of the three categories, for a total of 60 test items. In addition to these test items there were 60 other words of different form class (nouns, adjectives, and adverbs) that served as fillers. The filler-words were of varying frequencies, and were of the same mean length (6,75) as were the test items. Words which were prefixed, compounds, homographs, or had final syllable stress were not included in the filler set. No root-morpheme was used twice (e.g., we didn't include both a noun and a verb with the same root-morpheme).

One hundred twenty orthographically legal nonwords were included. The nonwords in these experiments were constructed by changing two or more letters of each word in the experimental list. The total experimental list included 240 items, 120 words and 120 nonwords.

The only difference between experiment 1a and 1b was that in experiment 1b a more stringent constraint in the construction of the nonwords was introduced. In experiment 1b two letters were changed in the word from which the nonword was derived. The letter change occurred ⅓ of the time in the initial, ⅓ in the medial and ⅓ in the final part of the word. In this way we made sure that the nonwords had both endings and initial parts that respected closely the distribution of suffixes and root-morphemes in the word set.

There was also one additional list which served as practice and was not scored. Fifteen words and 15 nonwords were included in this list, and they were matched for lexical type, frequency and length with items in the experimental list.

Procedure. Stimuli were displayed in upper-case letters on a black and white monitor (Phillips, model LDH 2123) controlled by an Apple computer. A subject's task in both experiments was to press one button if the letter string presented was a word and another button if it was a nonword.

Both reaction times and type of response were recorded. The subjects were given written instructions and they were told to respond as accurately and as quickly as possible. Each subject was given two blocks of 15 practice trials before being tested with the test items. Following the two blocks of practice trials, four blocks of test trials were presented. Each block had 60 test items. Test items were presented in random order, with the only constraint that no more than four words or four nonwords and no more than three experimental verbs should follow in sequence.

Each trial started with a warning signal, followed after 800 msec by the presentation of a fixation point in the center of the screen. The fixation point remained on

Table II. Latencies (in msec) and percent errors. Experiments 1a and 1b.

	HR-HW	HR-LW	LR LW
Experiment 1a	646-(3.0)	687 (3.0)	745 (9.0)
Experiment 1b	624 (3.0)	664 (6.0)	730 (15.0)

for 400 msec, after which a letter-string (word or nonword) was displayed immediately below the fixation point with the third letter of each string placed directly below the fixation point. The display of the letter-string was terminated either by the subject's response or after 2000 msec had elapsed.

Response time feedback was shown on the screen for 2000 msec if the subject responded correctly, otherwise an error signal appeared on the screen. Trials in which an incorrect response was made were not replaced. A constant interstimulus interval of 2000 msec was programmed between the letter-string display and the start of the next trial. The subject was seated 40 cm from the screen. At that distance each letter (5x7 mm) subtended a visual angle of $0.72° \times 1.00°$. There was a one minute rest between blocks followed by a signal that the subject could continue the experiment by a button press when ready. The experiment was conducted in a single session that lasted about 45 minutes.

Results

The results for both experiment 1a and 1b are summarized in Table II, which gives the mean latencies and percent errors for each test condition. Analyses of variance with both subject and item means as units were computed. Min F′ statistics were calculated. In both experiments there was a significant effect of word type, min $F'(2.95) = 9.34$, $p > .001$ for experiment 1a; min $F'(2.94) = 13.11$, $p > .001$ for experiment 1b. Post-hoc analysis revealed further that the difference between word types HR-HW and HR-LW versus LR-LW was reliable (p at least less than .05 in all cases) in both experiments (t-tests for simple effects, Exp. 1a: HR-HW vs. LR-LW; $t(57)=3.39$; HR-LW vs. LR-LW, $t(57)=2.31$; Exp. 1b: HR-HW vs. LR-LW, $t(57)=4.92$; HR-LW vs. LR-LW, $t(60)=3.02$) while the difference between HR-HW and HR-LW was only reliable in experiment 1b (Exp. 1a: $t(57)=1.08$; Exp. 1b: $t(60)=1.88$).

The pattern of results for the error data closely paralleled those of the reaction time data, min $F'(2.90) = 3.72$, $p > .05$ for experiment 1a; min $F'(2.96) = 7.38$, $p > .001$ for experiment 1b.

The pattern of results obtained do not correspond to either of the two predicted patterns. It appears that there is an effect of both word and root morpheme frequency although the effect of word frequency is not as strong as that of root morpheme

Table III. Examples of three types of word stimuli used. Experiment 2.

	1	2	3
Word type	HR-HW	HR-LW	LR-LW
Example of word	SENTITO	SENTIVI	FIUTAVO
Mean Root frequency	351.4	351.4	3.7
Mean Word frequency	69.9	1.8	1.8

HR = High frequency root LR = Low frequency root
HW = High frequency word LW = Low frequency word

Table IV. Latencies (in msec) and percent errors. Experiment 2.

HR-HW	HR-LW	LR-LW
592 (2.0)	647 (15.0)	712 (23.0)

frequency. Before accepting this result we wanted to make sure that the difference obtained between HR-HW and HR-LW did not result from some strange selection of words such that the letter combinations for the HR-HW were more familiar than those of the HR-LW. This possibility was controlled in experiment 2.

EXPERIMENT TWO

The procedure in experiment 2 was identical to experiments 1a and 1b. The only change introduced in experiment 2 was the structure of the stimuli. In this experiment the words used in conditions HR-HW and HR-LW were selected from the same verb root (see Table III). So, for example, for the verb *sentire* whose root (*sent-*) is of high frequency, we chose two forms corresponding to a high and low surface frequency of occurrence—*sentito* has a high frequency, *sentivi* has a low frequency of occurrence. Any difference in reaction time for these two classes of words cannot be attributed to differences in the structure of the root morpheme since root morphemes are the same in the two conditions. The verbs in the LR-LW condition were a subset of those used in the first two experiments.

Method

Subjects. Subjects were 20 native Italian speakers who were students at the University of Rome. They were paid five thousand Lire for their participation in the experiment. None of these subjects had participated in either of the two previous experiments.

Materials. In this experiment we used 10 words in each of the three experimental conditions. Since words in the first two conditions had their root-morpheme in common, it was important that no subject saw both forms of the same verb. Hence, subjects were assigned randomly to one of two distinct lists: In each of the two lists 5 of the 10 words in each experimental condition were present. Thus, for example, subject 1a was assigned to list A which contained the word *sentito* while subject 1b was assigned to list B which contained the word *sentivi*. Two subjects assigned to two complementary lists constituted an experimental subject, for a total of 10 experimental subjects. Words and nonwords used as fillers were the same across lists. Each subject saw 15 experimental verbs, 36 filler words and 51 filler nonwords, for a total of 102 items.

Procedure. The same procedure used in experiments 1a and 1b was used in experiment 2. Each subject was presented with two blocks of 15 practice trials followed by two blocks of 61 test trials each.

Results

The results for experiment 2 are presented in Table IV. The pattern of results confirms that obtained in experiments 1a and 1b. There was a main effect of Type of word, min $F'(2.44) = 6.73$, $p > .005$, and again the pattern of errors paralleled the reaction time results, min $F'(2.45) = 3.82$, $p > .05$.

Post-hoc analyses confirmed the results found in experiment 1b: Both the difference between word types HR-HW and HR-LW versus LR-LW (t-tests for simple effects: HR-HW vs. LR-LW, $t(27)=3.88$; HR-LW vs. LR-LW, $t(27)=2.11$), and the difference between HR-HW and HR-LW ($t(27)=1.78$) were reliable—there is both an effect of word and root-morpheme frequency.

Discussion

The results we have reported confirm those obtained by Taft (1979). There are two significant aspects to these results. First, we have confirmed that the root-morpheme frequency of a word is a major determinant of reaction times in a lexical decision task. Second, we have confirmed that the surface frequency of a word also contributed significantly to decision latencies in lexical access. These results are compatible with the lexical access model proposed by Taft—an extension of the lexical search model proposed originally by Forster (1976). Taft's proposal is that the address system to the lexicon operates on the basis of root-morphemes. To activate a root-morpheme unit, the stimulus word must first be stripped of all affixes (both prefixes and suffixes) and a search procedure begins for the remaining root-morpheme. The search process in this model is frequency-sensitive since address units are organized by the frequency of the root-morpheme. Thus, since the frequency of a root-morpheme is determined by the cumulative frequency of morphologically related words, search times for two words of equal surface frequency but unequal root-morpheme frequency will be different—the decision time for the word with the higher root-morpheme frequency will be faster than for the word with the lower root-morpheme frequency.

The model proposed by Taft is much less clear about the mechanism that gives rise to the observed differences due to the surface frequency of words. His proposal is that once a root-morpheme entry is found in the access file, this entry provides an address for surface forms of words stored in a master lexicon. This process involves ascertaining that the root-morpheme activated in the access file plus the stripped affix(es) corresponds to a particular entry in the master lexicon. Presumably this latter process is also frequency sensitive but the bases for this claim are left unspecified in the proposed model, reducing considerably its explanatory power.

While the reported results are compatible with the search model adopted by Taft, they are *not* incompatible with an alternative formulation of the lexical access system that is based on a whole-word address system. In this alternative formulation it is assumed that the access system is based on whole-word units which address morphologically decomposed lexical representations. Thus, for example, the stimulus word *boys* would activate an access unit corresponding to the whole word *boys* which in turn would serve to address the representation BOY- and -S in the root-morpheme and grammatical morpheme lexicon, respectively—a similar proposal has been made by Manelis & Tharp (1977). To explain the reported result (and those of Taft (1979)) we must make a number of assumptions regarding the organization of the address system and the functioning of this system.

One assumption that is made is that whole-word address units are activated in a passive, logogen-like fashion (e.g., Morton, 1979; Gordon, 1983) and that the activation function (Gordon, 1983) or thresholds (Morton, 1979) are influenced directly by the number of times that these units have been activated. Thus, for example, every time the address unit for *boys* is activated, it leads to a lowering of that unit's activation threshold (or increase in its activation function). With this assumption about the structure of the address system it is possible to explain the effect of the surface frequency of a word on lexical decision times. To account for the effect of root-morpheme frequency on lexical decision times we must assume that the activation of any member of a morphologically related set of words leads to the activation of the remaining words in that set. Thus, for example, the activation of WALKED leads to the activation of WALK, WALKS, WALKING, WALKER, and WALKERS and a consequent lowering of the activation thresholds of the address units for these words. However, the magnitude of the threshold lowering is not equal for the directly activated (WALKED) and indirectly activated address units. We assume instead that there is a larger threshold lowering for the directly activated address unit than the indirectly activated units (e.g., WALK) but that the threshold values of these latter units are, nonetheless, lowered significantly. In this way we are able to account for the effect of the root-morpheme frequency on lexical decision times.

This account of the structure of the lexical access procedure forms part of a larger model of lexical processing which we have called the Addressed Morphology Model (Caramazza, Miceli, Silveri, & Laudanna, in press). In this model morphologically decomposed representations in the orthographic lexicon are addressed directly through whole-word addresses. However, various sorts of empirical evidence, as well as theoretical arguments require that this model be modified to include a procedure that allows lexical access through root-morpheme addresses (Taft & Forster, 1975; Laudanna & Caramazza, Note 1; see Caramazza et al., in press, for discussion). This modified model—the Augmented Addressed Morphology Model—allows access of lexical representation through both whole-word and root-morpheme addresses (Caramazza et al., in press).

The Augmented Addressed Morphology Model can account for the reported morphological effects in lexical decisions while proposing a whole-word address system for lexical access. By contrast, the Lexical Search Model proposed by Taft encounters difficulties in explaining several experimental results concerning lexical decisions for affixed (e.g., sender) and pseudo-affixed (e.g., sister) words. The assumption, in this latter model, that lexical access proceeds through a parsing stage in which affixes are "stripped off" a word and then the root-morpheme serves as the basis for lexical access, has not been confirmed (Rubin, Becker, Freeman, 1979; Henderson, Wallis, & Knight, 1984; Manelis & Tharp, 1977). Specifically, no support has been obtained for the hypothesized distinction between lexical decision latencies for affixed and pseudo-affixed words, suggesting that lexical access for known words proceeds through a whole-word address procedure.

In conclusion, the results we have reported confirm those reported by Taft (1979). Specifically, we have shown that both root-morpheme and surface frequency contribute to lexical decision times. In contrast to Taft, however, we do not think that these results require a lexical address system based exclusively on root-morpheme units. Instead, they are explicable within the Addressed Morphology Model that allows access of morphologically decomposed lexical representations through whole-word addresses.

1. Laudanna, A., & Caramazza, A. (1984). *Morphological parsing and lexical access.* Unpublished manuscript. The Johns Hopkins University.

The research reported here was supported in part by NIH grant HS 14099 to The Johns Hopkins University. We thank Domenico Parisi and Bobbi Goodman for their comments on the work reported here.

References

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

Butterworth, B. (1983). Lexical representation. In B. Butterworth (Ed.), *Language Production* (Vol. 2). London: Academic Press.

Caramazzaa, A., & Berndt, R. S. (in press). A multi-component deficit view of agrammatic Broca's aphasia. In M. L. Kean (Ed.), *Agrammatism.* New York: Academic Press.

Caramazza, A., Miceli, G., Silveri, M. C., & Laudanna, A. (in press). Reading mechanisms and the organization of the lexicon: Evidence from acquired dyslexia. *Cognitive Neuropsychology.*

Forbach, G. B., Stanners, R. F., & Hochhaus, L. (1974). Repetition and practice effects in a lexical decision task. *Memory and Cognition, 2,* 337-339.

Forster, K. I. (1976). Accessing the mental lexicon. In R. J. Wales & E. Walker (Eds.), *New approaches to language mechanisms.* Amsterdam: North-Holland.

Garrett, M. F. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language Production.* New York: Academic Press.

Gordon B. (1983). Lexical access and lexical decision: Mechanisms of frequency sensitivity. *Journal of Verbal Learning and Verbal Behavior, 22,* 146-160.

Henderson, L., Wallis, J., & Knight, D. (1984). Morphemic structure and lexical access. In H. Bouma, D. G. Bouwhuis (Eds.), *Attention and Performance X: Control of Language Processes.* Hillsdale: Lawrence Erlbaum Associates.

Kempley, S. T., & Morton, J. (1982). The effects of priming with regularly and irregularly related words in auditory word recognition. *British Journal of Psychology, 73,* 441-454.

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

Manelis, L., & Tharp, D. A. (1977). The processing of affixed words. *Memory & Cognition, 5,* 690-695.

Morton, J. (1969). The interaction of information in word recognition. *Psychological Review, 76,* 165-178.

Morton, J. (1979). Word recognition. In J. Morton & J. Marshall (Eds.), *Psycholinguistics 2: Structures and Processes.* Cambridge: MIT Press.

Murrell, G. A., & Morton, J. (1974). Word recognition and morphemic structure. *Journal of Experimental Psychology, 102,* 963-968.

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

Scarborough, D. L., Cortese, C., & Scarborough, H. S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 1-17.

Stanners, R. F., Neiser, J. J., Hernon, W. P., & Hall, R. (1979). Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior, 8,* 399-412.

Taft, M. (1979). Recognition of affixed words and the word frequency effect. *Memory and Cognition, 7,* 263-272.

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