

The processing of inflected words

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Summary. Is an inflected word identified by first decomposing it into stem plus suffix or, instead, is it recognized as a whole? Several lexical decision experiments studied the recognition of inflected words in English (a language with few inflections) and Serbo-Croatian (a heavily inflected language). If recognition depended on decomposition, preceding the inflection with a brief exposure of the stem (<100 ms) should have primed the lexical entry for the stem and, therefore, facilitated recognition of the whole inflected word that followed. It did not. It was also found that the speed of recognizing an inflected word was more strongly associated with the frequency of the whole inflected form than with the frequency of its stem. The results suggested that in word recognition, lexical contact is first made with the whole word form. Nevertheless, morphological decomposition may still occur in subsequent processing.

Introduction

From a linguistic point of view, the study of derivational and inflectional morphology is largely a matter of discovering the ways morphological variants relate to more basic, primary, forms. For example, the English adjective *national* is derived from the noun *nation* by addition of the suffix *-al*. The past tense verb *walked* is an inflected variant of the stem *walk*; addition of the suffix *-ed* to a regular verb stem changes it to the past participle. To the linguist, there is no question that the relation between a variant and its primary form can be described in terms of compositional processes such as these; the variant is composed of the stem plus a morpheme that syntactically modifies the original meaning of the stem.

In contrast, a serious question remains for the psychologist, who asks whether the linguistic evidence of componentiality reflects the processing these forms undergo when they are perceived. For the psychologist, the question is: Does the process of understanding a derived or inflected word involve the morphological components of the word as distinct entities or, instead, are these words understood by reference to the whole word form, without any utilization of their components?

A refinement of the question is necessary. When we hear a variant for the first time, it is undeniable that we shall apply our tacit knowledge of morphology to an analysis of the separate components in order to interpret the meaning. When you read the novel sentence, "He Nixoned out of it", you understand that the name of an American ex-president is being used as a past-tense verb form, even though you may never have seen this form before. There is no other way to explain how we can understand *Nixoned* except by an appeal to a process that analyzes it into its components. But a question still remains for variants that are heard more frequently and, therefore, are familiar. For example, it is far less clear that we make a componential analysis of *walked* when we hear the sentence, "He walked out of it." In contrast to *Nixoned*, we have heard and read the form *walked* many times; because of this, it may be understood via a process that avoids the more complex route by which novel forms must be processed. Instead, we may process the familiar form as an unanalyzed whole.

This paper will present some new experimental evidence that addresses the processing question. We shall limit the discussion to the processing of inflection partly in order to make the discussion manageable, but mainly because inflectional morphemes are more likely than derivational morphemes to be candidates for componential processing, as we shall show. Thus, inflection provides us with a generous test of the conjecture that stem and morpheme are habitually processed independently; if separability cannot be demonstrated for inflection, it is unlikely that it exists for derivation either. But before considering the evidence from laboratory experiments, I would like to consider, briefly, evidence from what we might call "nat-

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ural" experiments: those that produced the languages of the world.

Linguistic evidence

It can be shown that the inflectional morphemes in many languages were, in earlier forms of the language, separate words: distinct lexical items. As the language changed, those items that were associated with stems of a particular word class became attached to (and sometimes fused with) the stems they were associated with. For example, Greenberg (1978) shows that gender markers on nouns were sometimes, at an earlier stage in the history of a language, separate demonstrative pronouns. Over time the pronouns migrated to the noun they described, mutated phonologically, and fused with the noun in the form of an affix. The processing implication of this is that because the inflection was once not only a distinct concept, but also a distinct lexical item, it may be only weakly fused to the stem and, therefore, may be easily detached from the inflected stem during processing. This implication is, of course, far from compelling, but nevertheless is suggestive.

The argument that inflection is only weakly attached to the stem is bolstered by another universal linguistic fact. When a derivational and an inflectional morpheme occur together in a word, the inflection is always farther from the stem than the derivation (Greenberg, 1966). The greater fusion of the derivational morpheme with the stem is consistent with the idea that it is more idiosyncratically associated with that particular stem; it can be applied less consistently to *other* items in that stem's word class. Moreover, it changes the meaning of the stem more than does the inflection (Bybee, 1985). Consider the following example: the plural of the word *doll* is the inflected word *dolls*; the diminutive (derivational) form of *doll* is *dolly*; when the two are combined, the form is *dollies*. No language would produce the reverse order *doll-s-y* to convey the same meaning.¹ Thus, there is a gradient of fusion; even if derivational morphemes turn out to be fused inseparably to the stem, inflectional morphemes may be less strongly attached.

Experimental evidence

One way of posing the question of processing separability more precisely is to ask whether the mental lexicon contains a separate entry for each morphological variant or, instead, contains only one single form, the stem. If only one exists, then the processing system would have to separate the stem within any variant from the rest of the form so that the stem could be recognized lexically. The remaining morpheme (the inflectional or derivational morpheme) would have to be analyzed by some additional process, which might be characterized as a syntactic process. On the other hand, the lexicon might contain the stem (but only if

it is a complete word, as is the usual case in English) and all variants. In this second possibility, the stem and its variants would each have the status of a separate word. We used two experimental paradigms to investigate this question. In the first, the rationale was to facilitate the recognition of an inflected word by presenting it in a way consistent with the subject's hypothesized processing structure. If we assume that the processing system prefers to recognize the stem and the inflection as separate components, recognition of the inflected word should be best when the components themselves are presented to the subject as distinct entities. Thus, we structured the stimulus presentation so that the word was already divided into its components when it was perceived by the processing system; the stimulus word was preanalyzed for the subject. We looked for improvement in the speed of word recognition for these divided stimuli.

The second paradigm arose from the adoption of the opposite assumption: if the lexicon contains both the stem and each of the whole-word-inflected variants, then the speed of word recognition for any given word form should be related to its frequency of occurrence – the frequency of that specific whole-word form. Alternatively, if it is only the stem that is in the lexicon, then recognition speed ought to be related to the frequency of the stem because it is the stem component that is common to them all and is the basis for lexical activation.

Experiment series 1: Dividing the inflected word into stem and suffix

Assume, for the moment, that the lexicon contains only stems. If so, then the processing system should recognize stems more quickly than it recognizes inflected forms because inflected forms must first be decomposed, i.e., analyzed into stem and inflection, before the stem will match, and therefore be able to activate, its lexical representation. Therefore, if the inflected word that is presented to the subject is first divided by the experimenter into its stem and inflection, the processing system should have easy access to the stem and will recognize the inflected word quickly. In order to accomplish this, we divided a stimulus word temporally, creating a stimulus onset asynchrony between stem and inflection.

Experiments in English

One hundred regular English verbs were selected. All were in the past tense and all ended in *ed*. They were selected so as to cover a wide range of frequency of occurrence. An equal number of pseudowords was selected. Their stems were generated by the alteration of one or two letters of real English verbs (not verbs used in this experiment) and all were "inflected" with *-ed* to create pseudo-past-tense forms. Thus, the pseudowords had pseudostems, but real inflections.

On each trial, subjects were presented with a fixation point in the middle of a computer screen (500 ms), followed first by a verb stem and then by the addition of a suffix inflection "ed" to the stem. The letters were black on

¹ I know of only a few exceptions; these can be accounted for by the assumption that the inflected form has, itself, become lexicalized: that it is, in effect, a stem: e.g., in German we have *das Kind*, and *die Kinder*, but *die Kinderchen* (not *Kind-chen-er*).

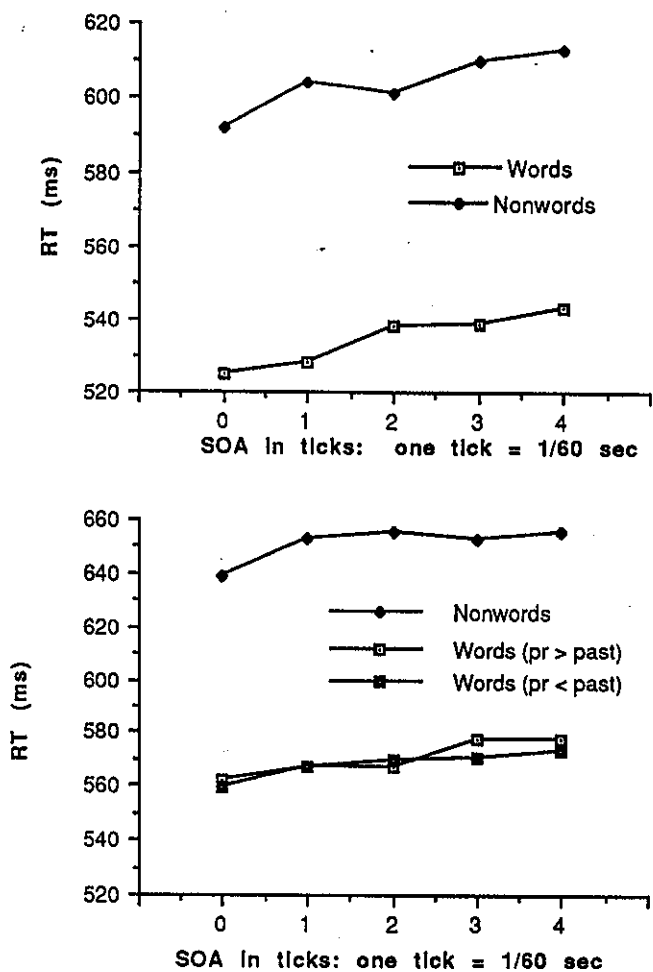


Fig. 1. Stimulus-onset asynchrony between stem and inflection for regular past-tense verbs.

a white background. Stimulus-onset asynchronies (SOA) between the onset of the stem and the subsequent addition of the inflection were measured in "ticks", the noninterlaced refresh rate of the computer monitor: one tick equalled 1/60 of a second. Five SOAs were used: zero (i.e., no delay between stem and inflection), and 1 to 4 ticks. In each stimulus list, an equal number of words and pseudowords received each of the 5 SOAs. Five lists were created such that each stimulus received all 5 SOAs across the lists.

Error rates for individual subjects were not allowed to exceed 10% on either words or pseudowords. Six subjects were run on each of the five lists for a total of 30. A small number of other subjects was discarded for exceeding the error criterion. Subjects received 40 practice trials, at the end of which they were given feedback on errors and response speed. A given subject saw only one of the five lists.

Recall the prediction: If only stems exist in the lexicon, then stimuli should be recognized more slowly at an SOA of zero than at one or more of the other SOAs. At zero SOA, the processing system must find the stem, which is necessary for lexical access according to the hypothesis. But the stem is embedded in the whole word so that some

processing energy and (presumably) time must be allocated to the extraction of the stem. On the other hand, at one or more of the other SOAs, the system might process the stem until lexical activation occurs and, without missing a beat, then allocate processing to the inflection. We should therefore find the fastest recognition times at one of the nonzero SOAs.

Figure 1 presents a graph of the results: RT is plotted against number of ticks. Clearly, the fastest RTs occurred at zero ticks, when the stem and the inflection came on simultaneously. Thus, past-tense verb forms were recognized fastest when they were presented undivided; in contrast, when they were presented so as to give the stem processing precedence over the suffix, recognition was slower.

The experiment was replicated with a different set of regular verbs. It was thought that those verbs whose past tense is more frequent may not be decomposed, but verbs whose present tense is more frequent might show the expected effect in which zero SOA is slower than one of the others. In the second experiment, half the verbs were more frequent in their present-tense and half were more frequent in their past-tense form. Despite this change, the SOA effect was similar to that in the first experiment, for both types of verbs, as the graph in the bottom half of Figure 1 shows.

Other possible artifacts were also explored. Suppose that subjects simply ignored the suffix. In principle, a stimulus word could have been recognized by processing the stem alone. The *-ed* suffix was, in fact, redundant: All stimuli, stems and pseudostems alike, had the same suffix. No information was really carried by the inflection. Note that this accounting does not adequately explain why zero SOA should be fastest; it seems reasonable that other SOAs, in which the stem was initially exposed without the "extraneous" inflection, should still be easier to process. Nevertheless, perhaps the subsequent appearance of the suffix following the stem did take up processing capacity of some other kind (attentional, perhaps), thus slowing the recognition RT. In order to test this explanation, we changed the composition of the pseudowords in the third experiment so as to require subjects to attend to the suffix (leaving the words as they were). Of the 100 pseudowords, 20 were replaced with words that had real verb stems, but pseudosuffixes. The suffixes *-eg*, *-el*, *-ev*, and *-en* were added to real stems to produce pseudowords like "walkeg" and "playel". The remaining 80 pseudoverbs contained nonstems and the real *-ed* suffix (e.g., *refeamed*). Thus, a correct response could not be made on the basis of identifying the stem alone; instead, subjects had to attend to the entire word.

Despite the changes, the results of Experiment 3 were, in part, indistinguishable from those of the previous two; recognition of words was fastest at zero SOA and rose slowly as SOA increased further. Clearly, failure to attend to the inflection did not account for the previous result with words. However, the result for pseudowords was different; a significant curvilinear function for RT was obtained. The fastest pseudoword rejection was at 2 ticks (33 ms). For the 5 SOAs from 0–4 ticks, respectively, RTs in milliseconds were 653, 642, 639, 646, 650.

Despite the last pseudoword result, the major results suggest that when we break apart the past-tense verb into word stem and *-ed*, we seem to be breaking apart a word that is ordinarily recognized as a whole, despite the fact that, linguistically, the division is on a morphological boundary. This indicates that we ought to get the same result if we break apart a word that contains no morphological units, a word that is an indivisible whole, morphologically, such as the word *select*. What would happen if we divided such a word into two arbitrary pieces in a manner that was analogous to the inflected word – the difference being that the new word, unlike the inflected word, would not be divided into two morphemes (stem and inflection)? What would happen to recognition latency of the word *select* if we manipulated the SOA between the initial letter string *sele* and the final letter string *ct*? Such an experiment had been run three years earlier (Macaruso & Katz, 1986) and the outcome had been the same: zero SOA was fastest and RTs increased slowly with increasing SOA. Although inflected verbs had not been included and, therefore, no quantitative comparison of slopes is possible, qualitatively, *select* behaves like *walked*; the implication is that the former is as unitized as the latter.

Finally, we ran a variation in which the *-ed* was presented first, before the stem. The rationale for this procedure was the notion that the processing system might normally process the inflection *before* recognizing the stem and that therefore, one of the nonzero SOAs would be optimal for stem recognition. Some researchers (e.g., Forster, 1976) have proposed a prelexical-affix-stripping mechanism that is consistent with this rationale. In our suffix-first procedure, the *ed* came on the screen 0–4 ticks before the stem. The spatial positions of the two morphemes remained as in normal print; only the temporal order was reversed. The results were, again, quite indistinguishable from the conditions in which the stem appeared first: recognition under zero SOA was faster than under any other delay. The recognition system preferred the past-tense verb as a complete unit.

Experiments in Serbo-Croatian

Several lexical-decision SOA experiments were run in Serbo-Croatian, which is a highly inflected language, so that one might expect to get more positive evidence of decomposition than in English. Because most word stems have many inflectional variants, and many of these variants are in frequent use, it would seem that the processing system could benefit from the great reductions in storage that would result from storing only stems in lexicon. First, a series of experiments was run in which the target stimulus was a future-tense verb. In Serbo-Croatian, the future is regularly formed by the attachment of a person-number suffix inflection to the verb stem. For example, the verb *raditi* (to work) forms the future first-person singular by taking the verb stem *radi-* and adding the inflection *-cu* to form *radicu* (I shall work). The experiments consisted of presenting the stem 0–4 ticks before the appearance of the inflection, as in the English experiments. In spite of our expectations that Serbo-Croatian would show a decom-

position effect, the results were similar to the results we reported for English; responses were fastest for zero SOA and increased monotonically from 0 to 4 ticks.

A second series of lexical decision experiments was run using inflected nouns and adjectives. In Serbo-Croatian, the case inflection of an adjective or noun occurs as a suffix. The inflection is very informative syntactically; it indicates number, gender, and one of seven cases. Kostić (1991) presents a more complete description of the Serbo-Croatian cases. The design of all the experiments was similar. Only a single SOA was used and there were three main conditions: (1) the stem and inflection appeared simultaneously; (2) the stem preceded the appearance of the inflection; or (3) the inflection preceded the stem. Both parts of the word remained on the screen together until the subject responded (up to 2 s). Some of the pseudoword stimuli had nonword stems and some had legal stems, but were paired with illegal inflections (the latter were comparable to the English pseudowords, discussed above, such as *walkeg*). The inflection or pseudo-inflection was always two letters long. Average latencies ranged between 600 and 800 ms and error rates were below 6%.

In the first experiment, SOA was fixed at 2 ticks (33 ms) for all conditions. In order to manipulate the amount of processing time given to each stem, half the stems were one syllable in length and half were two syllables. The inflection was always one syllable long. For one-syllable stems, reaction time to simultaneous presentation was slightly slower (679 ms) than reaction time to stem first (665), although not significantly so. For the inflection-first condition, RT was significantly slower (693). Thus, the results were in the expected direction (stem first was faster), but were not statistically significant. For two-syllable stems, the results again showed no statistical difference between simultaneous (661) and stem first (664) and a significant difference between these conditions and inflection first (693).

In subsequent experiments, the SOA was changed to 3 ticks (50 ms). For one-syllable stems, the simultaneous, stem-first, and inflection-first conditions gave latencies of 685, 690, and 711. But for two-syllable stems, the stem-first condition became significantly slower than the simultaneous condition (673 vs. 690) although the inflection-first condition remained significantly slowest of all (733 ms). Additional experiments supported this pattern: stem first was roughly equivalent to simultaneous appearance (either slightly faster or slightly slower, although not significantly so) as long as the stem was not too long (i.e., one syllable). This suggested that the early part of the word-recognition process involved the first part of the word (the leftmost letters). Was this simply due to the fact that the first letters of a word are more informative than the final letters? Or was it due to the particular morphological separation between the first and last letters? In other words, should the results be attributed to the particular lexical and syntactic statuses of, respectively, the stem and inflection or not?

To answer this question, we ran a final lexical-decision experiment. The word stimuli were one-syllable masculine-gender nouns presented in the nominative case; such words are citation forms whose stems do not require any

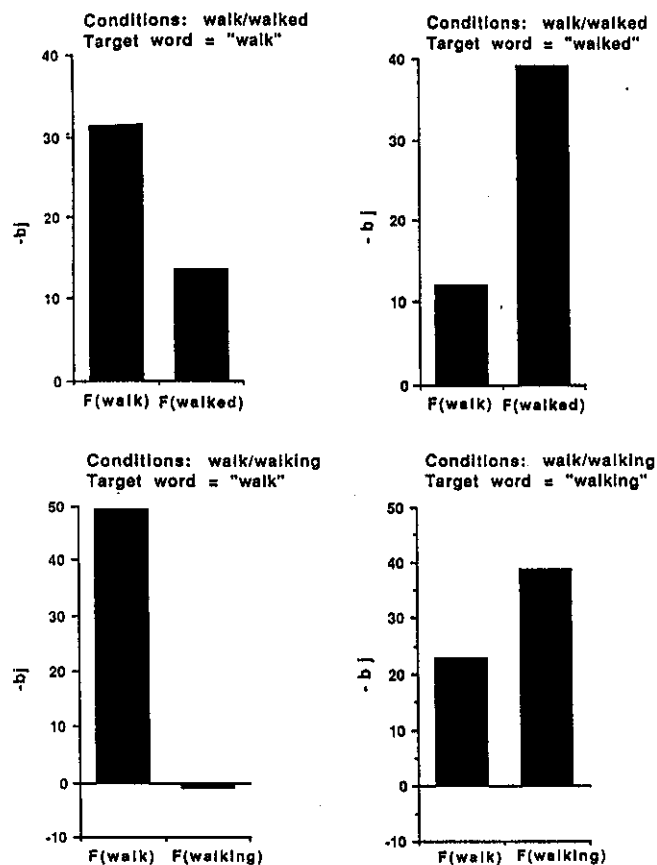


Fig. 2. Partial regression weights (b_j) for log frequency of verb-stem form or log frequency of the inflected form as predictors of lexical-decision time.

inflection: the entire form is a stem. Other cases in the declension append an inflectional suffix to the nominative form. Linguists describe this form as having a "null inflection". Thus, no suffixed words were presented to the subject. As before, the stimuli were presented (1) all letters simultaneously, (2) the first letters preceding the last two, after an SOA of 3 ticks, or (3) the last two letters preceding the first by 3 ticks. The critical difference from the previous experiments was that the first letters in condition (2) were not the stem of the whole word, and the two letters in condition (3) were never a legal inflection. Thus, the division of the word was entirely arbitrary, like the arbitrary division made in the English experiment described above in which words such as *select* were divided into *sele* and *ct*. The results contrasted with the previous Serbo-Croatian experiments in which the words were divided morphologically. Simultaneous presentation produced a recognition time of 673 ms. When the first letters preceded, RT was significantly slower, 712 ms, and when the last two letters preceded, RT was 729 ms. Thus, when the first few letters did not correspond to a lexical entry (i.e., did not correspond to a stem), recognition time appeared to be delayed when compared to that of the earlier experiments in which the stem was presented intact.

The Serbo-Croatian experiments taken together suggest, then, that whether the stimulus is a whole inflected word or a stem, subjects have about equal access to it. This

was the case for both stems that were complete words in themselves and stems that were not. Thus, the Serbo-Croatian results suggest something a little different than the English results. For Serbo-Croatian, the stem may have a lexical representation distinct from the whole inflected form. Nevertheless, there was no evidence that recognition of the inflected form proceeds via decomposition.

Experiment series 2: Using a word's frequency of occurrence

After our inability to find any substantial evidence for the hypothesis that the stem alone is involved in accessing inflected forms, we decided to take a different tack and explore the consequences of the opposite hypothesis: that the different inflectional variants are instantiated separately in lexicon. What kind of results should we expect if inflected verbs are, in fact, represented as a separate form from the stem in the lexicon? Assuming that *walk* and *walked*, for example, are both in the lexicon, the lexical-decision time for each form ought to be a function of that form's specific frequency of occurrence. For example, the recognition time for *walked* should be a function of the frequency of *walked* and should not be related to the frequency of *walk*. In contrast, if inflected verbs are decomposed into stem and inflection during the process of recognition, then recognition time should be controlled by the time it takes to contact the stem in the lexicon; therefore, lexical-decision time should be related to the frequency of the stem. Thus, the relevant question is: what predicts RT to a word form better – the frequency of occurrence of that specific form or the frequency of the word's stem?

We abandoned the SOA procedure of the previous set of experiments and, instead, adopted a more standard lexical-decision paradigm. On each trial a single word or pseudo-word was presented undivided. Our main tool was word frequency of occurrence, according to the Kučera-Francis corpus (Kučera & Francis, 1967). We selected 100 regular verbs covering a wide range of frequencies. Subjects saw lists of verbs and pseudoverbs in which present-tense and inflected forms were mixed randomly from trial to trial. Each subject saw all 100 verbs and 100 pseudoverbs twice, once in each of two lists separated by an unrelated secondary task of 10-minutes duration. If a word had been presented in the present-tense in the subject's first list, it was inflected in the subject's second list (and vice versa).

Two experiments were run. In the first experiment, half the verbs and pseudoverbs were in present-tense form (e.g., *walk*) and half were in past-participle form (e.g., *walked*). In the second experiment, half the verbs and pseudoverbs were again in present-tense form, but the other half were in present-participle form (e.g. *walking*). The present participle is typically much less frequent than the present-tense form and, so, it provides a rather strong test of the hypothesis that form-specific frequency drives recognition time.

There are two methods that can be used reasonably to index the frequency of a word's stem. One method counts the total occurrence of the stem accumulated over every

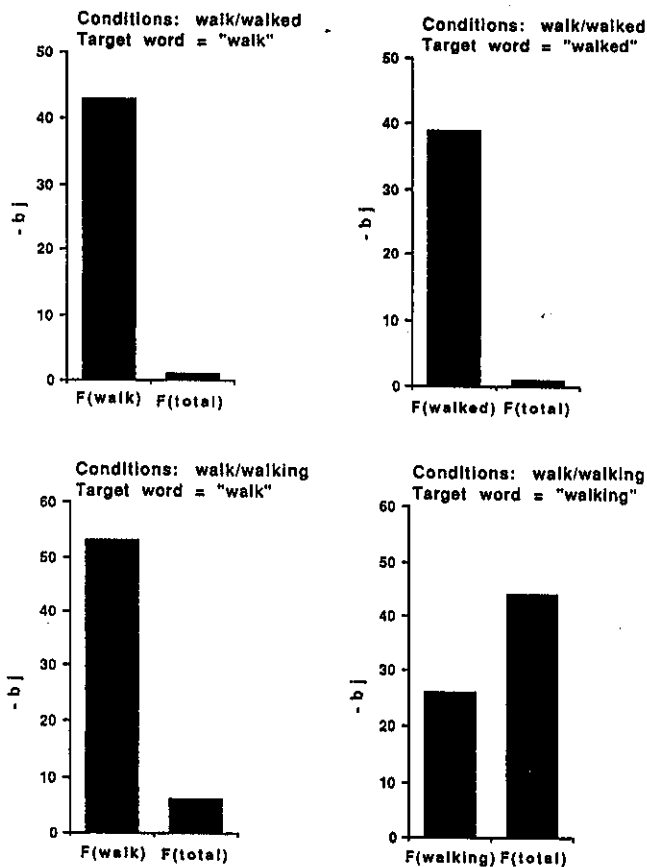


Fig. 3. Partial regression weights (b_j) for log frequency of verb-stem form or log of total-stem frequency (all forms) as predictors of lexical-decision time.

inflected and derived form of the word (but only those derived forms in which the stem remains unaltered) plus, of course, the occurrence of the pure stem by itself. Reaction time should be a function of this total frequency according to a model in which the stem is extracted from a morphologically complex word and used for lexical access; recognition means matching the stem that was extracted from the stimulus with its identical lexical representation. But for a model that does not make this assumption, i.e., the model in which an inflected form has a separate lexical status from the stem, separate frequencies of the occurrence (of the pure stem by itself and of the inflected form by itself) are appropriate. We present the data for two experiments, analyzing both experiments first according to the frequency of the specific form and then according to the total stem frequency.

For each stimulus, response times were averaged over subjects and then analyzed by multiple regression. RT was regressed on log Kucera – Francis frequency (F) for the present tense and log F for the past tense. In the top half of Figure 2 are the results of the first experiment. The histograms present the partial regression coefficients, i.e., the b weights, for present-tense and past-tense log frequencies (F) as predictors of RT in the regression equation: $RT = a + b_1F(\text{present}) + b_2F(\text{past})$. The b weights are either negative (i.e., RT decreases as frequency increases) or are statistically zero. Results for trials when the target was a

present-tense verb form (e.g., *walk*) are on the left, and past-tense verb forms (e.g., *walked*) are on the right. It is clear from the analysis that when a target verb was in the present, the frequency of its present-tense form predicted RT better than the frequency of its past. In contrast, when a verb was in the past tense, it was the past-tense frequency that was the better predictor. In fact, the inappropriate frequencies were not statistically significant in these data although the appropriate frequencies are.

A second experiment was run in which the present-tense form was mixed with trials of the present-participle form of the verb (e.g., *walking*). In the bottom half of Figure 2, we see again that RT is best predicted by the frequency of the actual form that was presented. The one change from the previous results is that, when the present participle is presented, RT is also significantly – although secondarily – related to the present-tense form's frequency.

Similar results are obtained when we regress RT on an index of stem frequency which counts, cumulatively, the total occurrence of every inflected and derived form. Figure 3 presents new regressions on the same responses presented in Figure 2, but now the partial regression coefficients represent the log total frequency of the stem in addition to the log frequency of the actual form that was presented. In the top half of Figure 3 are the results of the first experiment. Trials when the target was a present-tense verb form are on the left and past-tense trials are on the right. It is clear from the analysis that when a target verb was in the present, the frequency of its present-tense form predicted RT better than total frequency. Only the coefficient for present-tense frequency is significant. Similarly, when a verb was in the past tense, it was the past-tense frequency that was the significant predictor, not total frequency.

In the bottom half of Figure 3 are the corresponding results for the second experiment, in which the stimuli consisted of the present tense and the present participle. When the stimulus was in the present tense, present-tense frequency was, again, a better predictor than total frequency. However, the results look somewhat different when the stimulus was the present participle; total frequency is the stronger predictor here, although both coefficients are significant ($p < .001$). This latter significance is the only outcome that suggests that total frequency can have an effect on recognition time over and above the stimulus form's actual frequency. We have no explanation for this latter result except that it may be related to the large difference in actual and total frequencies.

Discussion

In the Introduction we discussed the universal linguistic facts that suggest that inflections may be only weakly attached to stems. In spite of this evidence, the experiments presented were not able to find clear evidence in favor of one implication of this suggestion, viz., that the lexicon contains only the stems of inflected words. Instead, our results suggest that inflected forms are recognized as wholes and that the morphological information contained

in them is not referenced during that process. These results echo the structural explanation given by Lukatela, Gligorićević, Kostić, and Turvić (1980) for the organization of Serbo-Croatian inflected nouns. For Lukatela et al., each inflected case had an independent representation in the lexicon; however, all these representations of a given lexeme were linked.

Our results are also consistent with a model for lexical access of letter strings proposed by Caramazza and his associates, the Augmented Addressed Morphology model or AAM (Caramazza, Laudanna, & Romani, 1988). They suggest that the lexicon contains both a whole-word representation and a morphologically decomposed representation. Of these two forms, the one that determines the lexical-decision response itself depends on which one is activated beyond threshold first. According to Caramazza et al., this form will be the whole-word form when the word is not novel to the subject.

An additional consistency between the AAM model and the present data is found in the pseudoword results. Because pseudowords are novel stimuli for the subject, they ought to be morphologically decomposed before processing. Therefore, in the SOA experiments, we would expect a pseudoword in which the stem and inflection are presented simultaneously to be rejected more slowly than a presentation in which the pseudostem is presented first. This result did obtain for the SOA experiment in which the suffix stimulus was sometimes an illegal inflection such as "eg" appended to a real word stem. According to the model, a componential analysis of the stimulus will determine the response if no entry for the whole word is found in lexicon. Because an inflected pseudoword has no entry in the lexicon, its morphological components will be analyzed, an operation that will increase its recognition time. This disadvantage can be countered, evidently, if the pseudoword is presented with its morphemes already divided temporally by a stimulus – onset asynchrony.

However, we still need to explain why the same process did not also occur in the two prior experiments in which the pseudowords carried only legal inflections. In these two experiments, the pseudowords behaved like the familiar real words. Perhaps the reason for the difference is that, in the two prior experiments, subjects did not attempt to process the inflection at all because it was redundant. The word – nonword decision could be made on the basis of the stem alone, which was always either a real stem (and, therefore, a real word) or not. Such a strategy could not work in the third study where real stems were sometimes combined with illegal suffixes (e.g., "walkeg"). Note, however, that even if subjects did adopt a different strategy in the third experiment, the same result was obtained for real words as in the two previous experiments.

In spite of this evidence against decomposition, there are still plenty of reasons for believing that linkages among inflectional relatives exist. We interpret our findings to suggest that inflectional analysis does not take place prior to the initial lexical activation of a word (each inflected variant seems to have a separate lexical status). Analysis may follow or, instead, activation of a target word's relatives may occur after activation. Consistent with this idea are the data from paradigms in which priming occurs over

a long delay between the prime and its relative, e.g., the repetition-priming paradigm and the paradigm in which the prime and the target are embedded in different lists. Using the former, our colleagues at Haskins Laboratories, Laurie Feldman and Carol Fowler and their associate Shirley Napps have shown morphological processing effects that are distinct from episodic and semantic/associative effects (e.g., Fowler, Napps, & Feldman, 1985; Napps, 1989).² For example, in contrast to semantic/associative priming effects which occur only when the prime and target are contiguous items and are temporally close, morphological effects can be found at long lags between prime and target. Thus, there is reason to suspect that the mechanisms that underly semantic priming and morphological priming follow different time courses. We may speculate that the morphological process, which has the slower decay time, may also have the slower onset as well. Murrell and Morton (1974) showed morphological priming effects when the prime was a variant in a list that preceded the presentation of the target list. In this case, as well, there is no compelling reason to believe that what was activated by the prime was the stem that is common to all relatives. Instead, the representation that was contacted in lexical access could have been the specific form, i.e., the variant itself; the facilitatory effects may have been a result of a consequent activation of the target's relatives via structural linkages between those relatives.

In addition, several studies using the lexical-decision paradigm have been interpreted as consistent with a post-access origin for morphological priming. Macaruso (1988) used a lexical-decision paradigm with cross-modal priming which precluded priming artifacts based on orthographic relations between prime and target. He found both variant-specific effects and evidence of linkage between relatives. In this issue, Sánchez-Casas, García-Albea, and Bradley demonstrate a morphemic effect using two-syllable bimorphemic words with a presentation SOA similar, in part, to ours. Notably, however, they could find an effect only when the SOA between morphemes was increased to 200 ms, much longer than our own maximum of 67 ms. This suggests that their effects were generated relatively late in the processing of the word. Finally, Nagy, Anderson, Sommer, Scott, and Stallman (1989) used a design in which only word and nonword stems were presented to the subject; this effectively precluded the subjects from adopting a strategy based on morphological decomposition because they never saw any morphologically complex forms. In analyses similar to those we have presented here, lexical-decision latency to the stem was regressed on several variables, including stem frequency, total frequency of inflectional relatives, total derivational frequency, and others. Overwhelmingly, the primary predictor was stem frequency itself, which accounted for 43% of the variance. The frequency of the stem's inflectional relatives was not significant (although it appears to have been confounded with a word's age of acquisition, which was significant). Derivational frequency was significant, but accounted for

² However, Feldman (1991) also presents evidence of a failure to find decomposition effects.

only an additional 5%, by itself and in interaction with an index of the word's part of speech. Nevertheless, in several analyses of subsets of the data, significant and slightly more substantial effects of a stem's morphological relatives were found. This mix of results about the effects of a word's relatives lead them to the conclusion that "... morphologically related words are grouped together under the same entry in the internal lexicon, or perhaps in linked main entries." That is, all variants exist in the lexicon and either the stem is the point of lexical access or each variant is accessed directly. In either case, there probably exists a linked network among all the members of the family such that, when one is accessed, all are activated.

Thus, we do not abandon the notion that morphological information is activated during the processing of words. Moreover, it seems reasonable to suspect that the processing of the two kinds of morphology, derivation and inflection, may differ between themselves. The former may not be analyzed apart from the stem or root: at least, not as consistently as inflection may be. Derivation is likely to be fused more closely to the stem or root, as we have indicated in the introduction to this article. Related to the difference between inflections and derivations is the relative consistency of the position of inflection in relation to the stem; this may be important in determining whether the component is processed separately from the stem or not. Clearly, when the morpheme follows the stem, it is possible for the processing system to operate on line in a way that takes advantage of knowledge provided by the stem (i. e., lexical information about the kinds of arguments and morphemes appropriate to that stem), thereby facilitating the perception and integration of the morphemic information with the stem information. Inflection tends to be a suffix process in languages that have inflection. Even in languages that are not considered inflectional languages, such as Chinese, there are often some inflection-like morphemes (e. g., a past-tense marker) and these are typically suffix morphemes. The implication of this is that there is something natural about processing an inflection after the stem. To bolster the claim that suffix morphology is more natural, note that there are no languages that are exclusively prefixing languages (Greenberg, 1966). Prefixing is used only in addition to (but never instead of) suffix morphology.

In conclusion, it is suggested that the lexicon's representation of the whole-word form (undecomposed) is the first point of lexical contact in the recognition of familiar forms, including morphologically complex forms. Whether or not a word undergoes subsequent morphologi-

cal analysis remains to be explored. However, it seems that we should now focus our research efforts on the likelihood that the activation of morphological information occurs later in processing, after initial lexical activation.

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