Morphological Structure and Semantic Retrieval

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The relationship between the effects of morphological complexity and associative production frequency (PF) was investigated in two experiments on sentence verification. Subjects were timed as they evaluated low- and high-PF sentences with predicates containing words that were morphologically either basic or derived (e.g., *Birds have feathers* vs. *Birds are feathered*). In the first experiment sentences with basic predicates were verified more quickly than sentences with derived predicates, and high-PF sentences were verified more quickly than low-PF sentences. The advantage of basic over derived forms was reduced for the high-PF sentences. In the second experiment, the predicate of each sentence (e.g., *are feathered*) was presented for 2 sec before the subject word appeared. In this delay condition the basic and derived versions of high-PF sentences were verified equally quickly; but for low-PF sentences, the basic form was still evaluated more quickly. The fact that the effect of morphological complexity was not necessarily eliminated after a delay suggested that the main difficulty of derived forms arises not during initial comprehension, but during a later stage in the comparison of the subject and predicate concepts.

An intriguing property of natural languages is the existence of words that are constructed from other words by the addition of affixes (e.g., *break–breakable*, *feather–feathered–featherless*, *close – closed – unclosed*, *brilliant – brilliance*). The meaning of derived words is generally at least partly predictable from the meaning of the root or basic word. For example, an adjective created by adding the suffix *able* to a verb usually means "able to be *V*ed" (e.g., *breakable* means "able to be broken"). Such correspondences between meanings and morphological structure raise a number of important questions as to how derived words are first learned by the child, and then produced and comprehended by the adult.

One basic issue is whether derived words can be comprehended in the same manner as basic words, or whether it is necessary to decompose the meaning of derived words by means of derivational rules. This issue is related to a linguistic debate, recently reviewed by Kintsch, concerning the status of derived words. According to the transformational view, derived words do not have independent entries in the lexicon, but rather are introduced into the phrase structures underlying sentences by means of syntactic transformations (Lakoff, 1970a, 1970b; Lees, 1960; McCawley, 1969). The lexicalist position, on the other hand, assumes that derived words are stored in the lexicon, and that the morphological and semantic correspondences between basic and derived forms are expressed by lexical redundancy rules rather than by syntactic

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transformations (Chomsky, 1970; Jackendoff, 1972, 1975).

Kintsch (1974) concludes that the linguistic evidence concerning these two hypotheses is as yet inconclusive. However, there seem to be a variety of linguistic arguments that appear quite damaging to the transformational view (Jackendoff, 1975). The general problem is that while the relationships between derived and basic words are partially rule-governed, the representation of derived words must also include a great deal of idiosyncratic information that is not predictable from general rules. First of all, many possible derived forms simply do not exist (e.g., *arrive* yields *arrival*, but *derive* does not yield **derival*). In addition, many derived words have meanings that are more specific than would be predicted by the general semantic rule alone. For example, *readable* does not simply mean "able to be read"; rather, it means "able to be read easily (because it is well written)." Other words parallel derived forms in all respects, except that the apparent root form is not a lexical item (e.g., *malleable* does not have a corresponding verb **malle*). The transformational view therefore leads to the position that the lexicon does not contain the actual word *malleable*, but rather the pseudoword **malle* (Lakoff, 1970a). Such a conclusion appears to have little if any psychological plausibility. Finally, the general semantic and morphological rules themselves are not related in an entirely regular way. Different affixes are sometimes interpreted by the same semantic rule; for example, the derived forms *discussion* (from *discuss*) and *argument* (from *argue*) both have roughly the meaning "abstract result of (someone's) act of *V*ing." Conversely, the same affix is sometimes interpreted by different rules. Thus *congregation* (unlike *discussion*) and *government* (unlike *argument*) both have the meaning "group that *V*s."

As Chomsky (1970) and Jackendoff (1975) have argued, it seems difficult or impossible to formulate such idiosyncratic information in transformational terms without trivializing the notion of a syntactic transformation. The lexicon, on the other hand, has always been viewed as the natural place to list idiosyncratic facts about words. It follows that a derived word must have its own lexical entry, which will at least list such unpredictable information as the fact that the word exists, what lexical redundancy rules are applicable, and any aspects of the word's meaning that are not predictable from rules.

However, even if the lexicalist view is accepted as the basis for a psychological performance model, the question of the relative processing difficulty of derived and basic words remains open. As Jackendoff (1975) points out, there are at least two different formulations of the lexicalist hypothesis. One possibility is that the lexical entry for a derived word contains only the information not predictable from rules. The rule-governed part of the word's meaning would then have to be computed at the time of comprehension by applying the appropriate semantic rules. In contrast, a second possibility is that the lexical entry for a derived word lists the predictable as well as the idiosyncratic part of the word's meaning. In this view, the rules relating basic and derived words are primarily used to facilitate initial learning of vocabulary items, rather than in the comprehension process. The former version of the lexicalist view predicts that it will be more difficult to retrieve the full meanings of derived as opposed to basic words, while the latter version suggests that the two types of words need not differ in difficulty.

Kintsch (1972, 1974) has reported a number of experiments which compared the difficulty of derived and basic words in various experimental paradigms. He found no differences between derived and basic words in a variety of memory, comprehension, and production tasks (Kintsch, 1974). The one positive result was that nouns derived from verbs were remembered less well than basic nouns in a paired-associate task (Kintsch, 1972). However, when the source verbs were substituted for the derived nouns in the task, the basic verbs were also remembered less well than the basic nouns. This suggests that the derived nouns were remembered less well not because of any initial processing difficulty, but because their underlying meanings, like those of verbs, were somehow less memorable than those of basic nouns. In general, Kintsch's results are consistent with the position that the lexical entries of derived nouns are complete. Unfortunately, however, this view is always equivalent to the null hypothesis in Kintsch's studies. A more positive test of the hypothesis that derived words have complete lexical entries has yet to be made.

The present study compared the difficulty of derived and basic words in a semantic question-answering paradigm. People were timed as they decided on the basis of their semantic knowledge whether simple sentences were true or false. This general paradigm has been studied extensively in recent years (Collins & Quillian, 1969; Glass, Holyoak, & O'Dell, 1974; Holyoak & Glass, 1975; Rips, Shoben, & Smith, 1973); however, it has not been used previously to compare the processing of basic and derived words. Kintsch (1974) generally compared performance with derived words to performance with semantically-unrelated basic words of the same syntactic class (e.g., derived nouns such as *kindness* and nonderived nouns such as *orchestra*). This type of comparison is somewhat problematic, since the derived and nonderived words express entirely different meanings. It seems preferable to compare the difficulty of sentences that express the same or nearly the same meanings, but which incorporate either a derived word or its basic form. At the same time, it is desirable to control such extraneous factors as sentence length and syntactic form as closely as possible.

Two classes of derived words in English appear to provide minimal pairs of the desired type. One class consists of adjectives derived from nouns by the addition of the suffix *ed* (e.g., *feather–feathered*). These forms can be used in near-synonymous sentences with either the basic noun (e.g., *Birds have feathers*) or the derived adjectives (e.g., *Birds are feathered*). Here the *have Noun* form is basic, and the *is Adjective* form is derived (the criteria for deciding which form is basic are discussed below). In contrast, there are other noun–adjective pairs where the adjective is morphologically basic and the noun is derived. These are pairs such as *brave–bravery*, *strong–strength*, and *sweet–sweetness*. The addition of any of a variety of different suffixes such as these can produce abstract nouns which roughly mean "The abstract property of being *Adjective*." These pairs can be used in near-synonymous sentences such as *Boxers are strong* vs. *Boxers have strength*, where the *is Adjective* form is morphologically basic and the *has Noun* form is derived.

The two experiments reported here compared people's reaction time (RT) to verify simple sentences such as the above examples. We wished to determine whether the derived forms are relatively difficult to process, and if so, to investigate the source of such extra difficulty. In addition to this variable of morphological complexity, we also compared sentences that differed in the degree of semantic association between the subject and predicate concepts, as measured by production frequency (PF) (Glass & Holyoak, 1974; Glass et al., 1974; Holyoak & Glass, 1975). PF measures were obtained by giving incomplete sentences such as *Zebras are* ______ or *Zebras have* ______ to normative subjects, and asking them to provide true one-word completions of each sentence. Previous semantic–memory studies have shown that sentences with relatively high PF can be verified more quickly than sentences with lower PF. We have argued elsewhere that PF is a measure of the order in which information about the meanings of words is retrieved from memory (Glass & Holyoak, in press; Holyoak & Glass, 1975). Accordingly, if derived words do not have complete lexical entries, but rather access the entries of their basic counterparts, then the PF of the basic forms should predict the order of verification times for the derived forms as well as the basic forms themselves. For example, the same PF norms that predict that *Zebras have stripes* will be verified more quickly than *Zebras have hoofs* should also predict that *Zebras are striped* will be verified more quickly than *Zebras are hoofed*. The additional increment of time necessary to decompose the derived words in the latter versions of the sentences would, therefore, be purely additive.

EXPERIMENT I

Method

Subjects were timed as they decided whether sentences of the form *Noun are Adjective* and *Noun have Noun* were true or false.

Materials. A set of 208 items, with equal numbers of true and false sentences, was constructed for the experiment. The true sentences were selected on the basis of production frequency measures. Twenty-eight common concrete nouns were used as the subjects of incomplete sentences of the form *Noun are* ______ and *Noun have* ______. The *are* and *have* forms were ordered randomly in separate booklets. These booklets were then given to 32 Stanford undergraduates, who were asked to list up to three adjective completions of the *are* sentences and up to three noun completions of the *have* sentences. The subjects were told to only give predicates that were true of at least some member of the subject category. Each subject completed both booklets, and the order of the two booklets was counterbalanced across subjects. The frequency of each response was then tabulated across all subjects.

Twenty-six pairs of sentences with basic predicates were then selected from the norms. The subject noun was the same for both members of each pair, but the two predicates differed in production frequency. The high-PF predicates were given by a mean of 47% of the respondents, and the low-PF predicates by a mean of 3%. As much as possible, each predicate was used in both a high-PF and a low-PF sentence for different subject nouns; for example, *Horses have hoofs* was a high-PF sentence, while *Zebras have hoofs* was a low-PF sentence. Each sentence was then written in both a basic and a derived form, producing four true sentences for each of the 26 subject nouns. For 13 of the 26 sets the *have Noun* forms were basic, while for the other 13 sets the *are Adjective* forms were basic. Examples of the resulting sentence types are given in Table 1. Note that the PF of the derived forms was measured by the PF of the basic forms;

TABLE 1

EXAMPLES OF THE SENTENCES USED IN EXPERIMENT I

Sentence type		Production frequency	
True sentences			
	Have Noun Basic	High	Low
Basic	Leopards have	spots	whiskers
Derived	Leopards are	spotted	whiskered
Basic	Knights have	armor	gloves
Derived	Knights are	armored	gloved
	Are Adj Basic		
Basic	Knights are	strong	gallant
Derived	Knights have	strength	gallantry
Basic	Blossoms are	fragrant	smooth
Derived	Blossoms have	fragrance	smoothness
False sentences			
	Have Noun Basic	*Are Adj* Basic	
Basic	Pages have bruises	Silks are brave	
Derived	Pages are bruised	Silks have bravery	
Basic	Birds have fins	Blossoms are strong	
Derived	Birds are finned	Blossoms have strength	

for example, *Knights are armored* was counted as a high-PF sentence because the basic form *Knights have armor* had relatively high PF. The question of whether the PF of the basic or of the derived form is the better predictor of RT to verify the derived form will be addressed below.

The criterion for deciding which form was more basic was morphological simplicity: The form with a suffix added was taken to be derived. For the basic *have Noun* sentences, the suffix added was usually *ed* (e.g., *spots/spotted*), although there were a few exceptions (e.g., *fur/furry*). The semantic relation expressed by the verb *have* was usually "has-as-part" (e.g., *Fish have fins*), although it sometimes expressed alienable possession of a physical object (e.g., *Boxers have gloves*), or some other relation (e.g., *Patients have diseases*). In most cases the adjective form appeared to be derived directly from the noun, as in *gloves/gloved*. In some cases, however, the adjective corresponded to the past participle form of a verb (e.g., *bruised*). Such adjectives appear to have roughly the meaning "being in the state that results from being *V*ed," and correspond to a noun, with the same spelling as the verb, that means "the result of being *V*ed." It is not always clear in these cases whether either the verb or the noun is more basic (e.g., *to bruise* could be defined as "to cause bruises"). However, both the noun and the verb form are morphologically simpler than the adjective. For the purpose of the present experiment, sentences such as *Boxers have bruises* were defined as basic, while sentences like *Boxers are bruised* were defined as derived.

For the cases where the adjective was basic, the nouns were derived by the addition of a variety of suffixes, some of which are quite productive in modern English (like *ness*), and some of which only appear in a few old English words (such as the *ength* in *strength*). In all these cases the meaning of the noun is roughly "the abstract property of being *Adj*." The derived *have Noun* forms are somewhat stilted in isolation (e.g., *Professors have intelligence*), although they sound fairly natural with an appropriate modifier (e.g., *Professors have considerable intelligence*).

To create the false sentences, the subject and predicate words were re-paired so that the resulting sentence was necessarily false (e.g., *Horses have roofs/are roofed*). Other predicates had to be substituted in a few cases to make all the sentences false. Both basic and derived versions were used for the false as well as the true sentences, but production frequency was not systematically varied for the false sentences. Each subject noun and most predicates thus appeared in both true and false sentences.

Procedure. The sentences were presented to the subjects by means of a tachistoscope. The subject initiated each trial by pressing a "start" button. After a 1-sec delay, a sentence appeared in the viewer, and the subject pressed one of two response buttons connected to a timer to indicate whether or not the sentence could possibly be a true assertion. A blank "stare" field was in view except when a sentence was being presented. Assignment of dominant hand to "true" response button was counterbalanced across subjects. Subjects were instructed to treat the sentences as if they were quantified by *some*; that is, a sentence was to be considered true even if it was not universally true (e.g., *Animals have wings*). Subjects were also told not to be disturbed if some of the sentences sounded a little awkward, but simply to trust their intuitions as to whether the sentence was plausible. They were instructed to respond as quickly as possible without making errors. The test sentences were presented in a different random order to each subject, and were preceded by 20 practice trials.

Sixteen Stanford undergraduates participated in the experiment in order to satisfy a course requirement. Data from one other subject who made over 20% errors was discarded.

Results and Discussion

The mean RT and error rate for each condition are reported in Table 2. Both subjects and items were treated as random effects in all analyses of variance reported in the present paper, and quasi *F*-ratios were calculated (Clark, 1973; Winer, 1971). For the "true" decisions, sentences with basic words were verified 153 msec more quickly than sentences with derived words, $F'(1, 39) = 46.7$, $p < .001$; and high-PF sentences were verified 170 msec more quickly than low-PF sentences, $F'(1, 39) = 54.1$, $p < .001$. However, the effects of production frequency and of morphological complexity were not entirely independent. Rather, the extra time required to verify sentences with a derived word was 67 msec greater for the low-PF than for the high-PF sentences, $F'(1, 39) = 4.57$, $p < .05$.

The PF and complexity effects did not vary significantly between the items for which the *have Noun* form was basic and those for which the *are Adj* form was basic. In particular, there was no trend for the derived *have Noun* form (e.g., *Professors have intelligence*) to be more difficult than the derived *are Adj* form (e.g., *Leopards are spotted*), even though the former sentence type seems stylistically more awkward. This suggests that subjects were able to follow the instructions to ignore such awkwardness. Overall, there were no significant differences between the sentences with a noun as opposed to an adjective in the predicate, or with the verb *have* as opposed to *are*.

We also wished to evaluate a variety of possible explanations of the morphological complexity effect that have not yet been considered. Morphological complexity is unavoidably confounded with at least three other factors that might plausibly contribute to longer RT. First, derived words are simply longer than basic words, because they are constructed by the addition of an affix. Second, derived words are generally used less frequently than basic words. Third, derived predicates are given less frequently as completions in a production task than are basic predicates, suggesting that the degree of semantic association between the subject and predicate concepts might be less when the predicate is derived. This third possibility is particularly plausible, since unlike the first two factors, associative production frequency has been clearly shown to predict verification latencies in experiments similar to the present one. So far we have defined the sentences with derived words as either high- or low-PF on the basis of the PF of the corresponding basic form. However, the PF of the derived form itself was generally lower than the PF of the basic form. It is possible, therefore, that the apparent effect of morphological complexity could be predicted on the basis of production frequency.

Since it is virtually impossible to vary the above variables orthogonally with complexity, we used multiple regression analyses to compare the effectiveness of all these variables as predictors of true RT in the present experiment. Five measures were simultaneously correlated with RT. Three of these reflected

TABLE 2

MEAN RT[a] AND ERROR RATE[b] FOR SENTENCES IN EXPERIMENT I

Sentence type	True sentences production frequency: High	True sentences production frequency: Low	False sentences
Have Noun Basic	976(2.4)	1149(8.2)	1151(4.1)
Are Adj Derived	1097(5.3)	1335(23.1)	1173(4.3)
Are Adj Basic	959(1.0)	1061(4.8)	1093(3.4)
Have Noun Derived	1077(3.4)	1247(18.3)	1197(6.5)

[a] In milliseconds.

[b] Percentage of error is given in parentheses.

the three confounded factors outlined above: the number of letters in the predicate word; the frequency of the predicate word in the Kučera and Francis (1967) norms; and the production frequency of the actual sentence. The other two variables were those on the basis of which the sentences were initially selected: the production frequency of the basic form, and a dichotomous variable corresponding to basic versus derived forms of the sentences. The results were clear-cut. The latter two variables entered into the regression equation as independent factors. The effects of both variables were highly significant: $F(1, 102) = 33.3$. $p < .001$ for morphological complexity, and $F(1, 101) = 24.17$, $p < .001$ for the PF of the basic form. Together these two factors had a multiple correlation of .63 with RT. Furthermore, when any one of the remaining three variables was forced into the regression equation first, the effects of both basic PF and complexity remained significant beyond the .001 level. Word frequency entered the regression equation as a third factor, $F(1, 100) = 6.19$, $p < .025$, but word length and the PF of the actual sentence had no significant relationship with RT when the variance attributable to the other factors was accounted for.

These results suggest that the PF of the basic form is actually a better predictor of RT for the corresponding derived form than is the PF of the derived form itself. This possibility was tested directly in a second set of regression analyses that included only the derived sentences. These analyses simply compared basic and derived PF as predictors of RT to verify the derived sentences. Although the two PF measures were moderately correlated ($r = .57$), the results were again clear-cut. Basic PF had a correlation of $-.45$ with RT, $F(1, 50) = 12.7$, $p < .001$; when the variance attributable to this factor was accounted for, the partial correlation of derived PF with RT was negligible ($r = .02$). In contrast, basic PF still correlated significantly with RT ($p < .01$) even after derived PF was forced into the regression equation. These results demonstrate that the PF of the basic form of the sentence is the better predictor of RT to verify not only the basic form, but the derived form as well. This is consistent with the view that both basic and derived forms are verified on the basis of information that is stored in memory in a form more closely related to the basic form. It might also be the case, however, that basic PF is a better measure simply because it is based on a greater number of actual responses, and hence is more reliable than derived PF. In other words, since people are less likely to produce any derived forms as sentence completions, the differences in association strength among sentences may be masked when derived PF is used as a measure.

Table 2 also presents the mean RTs for the basic and derived forms of the false sentences in Experiment I. Sentences with derived predicates were rejected 63 msec more slowly than sentences with basic predicates, $F(1, 55) = 14.6$, $p < .001$, although this effect was mainly due to those sentences for which the *are Adj* form was basic, $F'(1, 48) = 5.66$, $p < .05$. The effect of morphological complexity for the false sentences was thus smaller and less stable than the comparable effect obtained with the true sentences. This suggests that subjects were sometimes able to retrieve enough information to determine that a sentence was false without analyzing the derived predicate as extensively as would have been required to be sure that a sentence was true. As with the true sentences, there was no significant overall difference between the RT to reject sentences with a noun as opposed to an adjective in the predicate, or with the verb *have* as opposed to *are*.

The overall error rate in Experiment I was 6.4%, and across conditions the error rate consistently increased with RT, with the bulk of the errors occurring in the low-PF derived true sentences.

In general, then, the results for true sentences in Experiment I are compatible with the view that verification time is determined by two factors: morphological complexity, which influences the time required to access the semantic representation of the proposition expressed by the sentence, and production frequency, which measures the time required to retrieve sufficient information to decide that the proposition is true. However, the fact that the complexity effect was reduced for high-PF sentences presents a problem for this "two additive factors" hypothesis. While this small interaction in itself is only a small discrepancy from the predictions of the above model, it becomes more important in the light of Experiment II. The implications of this result will be discussed more fully below.

Experiment II

The results of Experiment I demonstrated that sentences with morphologically derived words are verified more slowly than near-synonymous sentences containing nonderived words. Furthermore, this complexity effect does not appear to be due to differences in word length, word frequency, or associative production frequency. However, the actual source of the extra difficulty caused by the use of derived words still remains unclear.

There seem to be two classes of possible explanations for the effect of morphological complexity on semantic verification. One possibility is that the effect is directly due to the difficulty of retrieving the meanings of derived words. This is the assumption underlying the "two additive factors" model outlined previously, which assumes that to understand a derived word people have to decompose its meaning into a representation based on that of the corresponding basic word. A second possibility, however, is that the difficulty arises not in understanding the derived word itself, but in evaluating the semantic relationship between the subject concept and the predicate containing the derived word; that is, the difficulty comes during a later comparison process, rather than during initial encoding of the sentence. The former view assumes that predicates with a basic or a derived form (e.g., *have feathers* vs. *are feathered*) are both mapped onto a single memory representation, although with more difficulty for the derived form. In contrast, the latter view might assume that the immediate semantic representations of such predicate pairs are distinct, but that the equivalence of the two representations can be determined later in the decision process, perhaps by means of an inference rule (Leech, 1974).

Experiment II provided a test of these two alternative hypotheses by presenting the predicates of sentences of the type used in Experiment I for 2 sec before the subject noun appeared. In this delay paradigm, the person should have enough time to fully comprehend any predicate word, whether basic or derived, before he begins to verify the full sentence. If the difficulty with sentences containing derived words is solely due to the extra time required to comprehend the derived word, then allowing the person to first comprehend the predicate should eliminate the effect of morphological complexity on verification latency. However, if the major difficulty arises when the subject and predicate concepts are compared, then the extra time required to verify derived forms should remain even after the predicates have been comprehended.

Method

The item set used in Experiment II consisted of 128 sentences, which were a subset of those used in Experiment I. These sentences represented all the experimental conditions included in the first experiment, again with equal numbers of true and false sentences. The true sentences consisted of 16 sets of four sentences. Each set of four was constructed by factorially combining the factors of morphological complexity (basic vs. derived) and production frequency (high vs. low). The *have Noun* form was basic for eight of the sets, while the *are Adj* form was basic for the remaining eight sets. These sentences were selected so as to provide the strongest possible controls for extraneous differences between the words used in high- and low-PF sentences. Each predicate was paired, in both its basic and its derived form, with both a high- and a low-PF subject category (e.g., *Zebras have stripes/are striped* vs. *Fish have stripes/are striped*). In addition, in 11 of the 16 cases the same subject word appeared in both a high-PF and a low-PF sentence across item sets (e.g., *Zebras have stripes* vs. *Zebras have hoofs*). False sentences were again constructed by re-pairing the subject categories and the predicates used in the true sentences.

Each sentence was typed on two lines on a 5 × 8 inch white card. The subject word (e.g., *Zebras*) was centered on the upper line, while the predicate (e.g., *are striped*) was centered on a line 10 cm lower. The two parts of the sentence could then be displayed separately. The equipment used was the same as in Experiment I. The subject initiated each trial by pressing the "start" button. The predicate was then displayed alone for 2 sec, at which time the subject word also appeared. The entire sentence then remained in view until the subject pressed a response button. The subject was told to read and understand the predicate as soon as it appeared in order to be able to reach a correct decision as quickly as possible. The instructions and procedure were otherwise identical to those employed in the previous experiment. Twenty practice trials again preceded the test sentences.

Pilot subjects performed the task with varying delays between presentation of the predicate and the subject category, and they reported that the predicate could always be understood easily in 1 sec. The 2-sec delay used in the actual experiment therefore allowed more than ample time to comprehend the predicate. It seems unlikely that any process requiring a longer delay could play a role in initial comprehension. The relatively long delay of 2 sec would be expected to maximize the probability of eliminating the effect of the morphological form of the predicate on verification time.

Sixteen Stanford undergraduates participated in the experiment in order to satisfy a course requirement.

Results and Discussion

The mean RT and error rate for each condition are displayed in Table 3. The results for true sentences clearly demonstrate that the effect of morphological complexity on verification time does not necessarily disappear even after the predicate has been comprehended. As in Experiment I, high-PF sentences were verified more quickly than low-PF sentences, $F'(1, 27) = 43.5$, $p < .001$, and sentences with basic predicates were verified more quickly overall than sentences with derived predicates, $F'(1, 27) = 8.39$, $p < .01$. However, this difference between the basic and derived forms was entirely due to the low-PF sentences, $F'(1, 27) = 11.7$, $p < .01$. For the low-PF sentences (e.g., *Fish have stripes/are*

TABLE 3

MEAN RT[a] AND ERROR RATE[b] FOR SENTENCES IN EXPERIMENT II

Sentence type	True sentences production frequency: High	True sentences production frequency: Low	False sentences
Have Noun Basic	823(0.8)	1018(10.2)	944(4.3)
Are Adj Derived	816(3.1)	1207(21.1)	1015(5.5)
Are Adj Basic	803(3.1)	970(11.7)	1041(4.3)
Have Noun Derived	783(3.9)	1067(13.3)	1042(7.8)

[a] In milliseconds.

[b] Note: Percentage of error is given in parentheses.

striped), the basic form was verified 132 msec more quickly than the derived form. This difference was only 43 msec smaller than that found in the first experiment without a delay. However, the effect of complexity on RT disappeared entirely with the high-PF sentences (e.g., *Zebras have stripes/are striped*). For these sentences, the RT difference was a nonsignificant 14 msec in favor of the derived forms, with a 1.6% advantage in error rate for the basic forms. As in Experiment I, there were no significant differences as a function of whether the *have Noun* or the *are Adj* form was basic.

For the false sentences, the effect of complexity on RT differed between the sentences with a basic *have Noun* form and those with a basic *are Adj* form, $F'(2, 45) = 3.96$, $p < .05$. The basic *have Noun* sentences were rejected 71 msec more quickly than the derived *are Adj* sentences, but there was no difference in RT between the basic *are Adj* and the derived *have Noun* forms (although there was a small difference in error rate favoring the basic form). This relation between which form was basic and the size of the complexity effect was the reverse of that found in the first experiment, reinforcing the conclusion that the complexity effect is, in general, smaller and less reliable for false sentences.

In addition to providing evidence regarding the source of the complexity effect, a comparison between Experiments I and II is relevant to an entirely different issue not yet discussed. All the production frequency measures so far presented, both in this and earlier papers (Glass & Holyoak, 1974; Glass et al., 1974; Holyoak & Glass, 1975), have involved the generation of predicates to fit a presented subject category (e.g., *Professors are* ______). This procedure presumably provides a measure of the ease of searching in memory from the subject to the predicate concept. However, it is conceivable that sentence verification may also be affected by the ease of reaching the subject concept from the predicate. The sentence-memory model of Anderson and Bower (1973) explicitly assumes that memory search proceeds simultaneously from both the subject and the predicate. It should be possible to estimate the ease of traversing a path from a predicate to a particular subject category by measuring the frequency with which people provide that subject as a true completion of an incomplete sentence (e.g., ______ *are intelligent*). We therefore obtained such norms for the 32 true sentences with basic predicates that were used in both experiments. Thirty-two Stanford undergraduates each provided subject completions for all these sentences, using the same procedure as was used to collect the subject-to-predicate PF norms discussed in Experiment I.

We then used multiple regression analyses to compare the effectiveness of forward (subject-to-predicate) and backward (predicate-to-subject) PF as predictors of RT to verify the sentences in the no-delay procedure (Experiment I). The question of interest was whether sentence verification is equally a function of search from both the subject and the predicate (Anderson & Bower, 1973), or whether memory search is primarily initiated from the subject concept. The present data can only be suggestive on this issue, since forward and backward PF were quite highly correlated for the sentences examined ($r = .78$). Nevertheless, a difference did emerge. The correlation with RT was higher for forward PF ($r = -.57$) than for backward PF ($r = -.40$). The variance attributable to forward PF was highly significant, $F(1, 30) = 14.4$, $p < .001$, and when the effect of forward PF was accounted for, the partial correlation of backward PF and RT was negligible ($r = .08$, $F < 1$). In contrast, the effect of forward PF was still highly significant ($p < .01$) even when backward PF was forced into the regression equation first. These results argue, therefore, that at least for the kinds of sentences included in the present study, verification time is primarily determined by how easily the predicate can be accessed from the subject concept.

However, there was reason to expect that search from the predicate concept might play a more important role in Experiment II, where the predicate was presented 2 sec before the subject category. Loftus (1973) measured people's RT to decide that an exemplar (e.g., *canary*) was a member of a given category (e.g., *bird*). She varied whether the exemplar was presented prior to the category (by 2 sec), or whether the category was presented before the exemplar. She found that verification time was mainly a function of exemplar-to-category PF when the exemplar appeared first, but that category-to-exemplar PF was dominant when the category appeared first. The Loftus' results therefore indicate that in a delay paradigm people tend to initiate a memory search from whatever concept is first presented. In Experiment II the first concept to appear was the predicate.

Another set of multiple regression analyses was therefore performed to compare forward and backward PF as predictors of RT in the delay paradigm of Experiment II. Forward PF was still a slightly better predictor of RT than was backward PF ($r = -.58$ vs. $-.52$), but this difference was no longer reliable. As soon as either PF variable was entered into the regression equation ($p < .01$ in both cases), the residual effect of the other variable became nonsignificant. While this result is therefore inconclusive, the possibility that search proceeds from the predicate when it is presented first cannot be ruled out.

General Discussion

Let us briefly recapitulate the major results of the two experiments, Experiment I demonstrated that sentences containing morphologically derived words (e.g., *Zebras are striped, Boxers have strength*) are verified more slowly than other sentences that are nearly synonymous, but which contain only non-derived words (e.g., *Zebras have stripes, Boxers are strong*). More detailed analyses indicated that the extra difficulty of derived forms is not attributable simply to differences in word length, frequency of usage, or associative production frequency. In addition to the complexity effect, sentences with high production frequency were verified more quickly than sentences with relatively low production frequency. The effects of complexity and PF were not entirely independent, since the extra difficulty of the derived forms was reduced for the high-PF sentences.

The nonadditivity of the effects of complexity and PF was magnified in Experiment II, when the predicate of each sentence was presented for 2 sec before the subject word appeared. In this delay condition, the derived forms of low-PF sentences still took longer to verify than did the basic forms; however, the complexity effect was entirely eliminated for the high-PF sentences. This interaction was obtained even though the same predicates were used in both the high-PF and low-PF sentences (e.g., *Horses have hoofs/are hoofed* vs. *Zebras have hoofs/are hoofed*). In both experiments an effect of morphological complexity was also found with the false sentences, although it was smaller and less consistent than the comparable effect obtained with the true sentences.

The goal of the present study was to provide psychological evidence that might help decide how morphologically derived words are represented in memory. Linguistic arguments suggested strongly that a derived word has its own lexical entry; however, it was not clear whether this entry completely specifies the meaning of the word, or whether part of the meaning has to be recovered by decomposing the derived form into a representation similar to that of the corresponding basic form at the time of comprehension.

The results of Experiment II for low PF sentences provide evidence against the decomposition hypothesis, since sentences with derived words were still verified more slowly than sentences with basic words even though people were given ample time to comprehend the predicate. The present results are thus reminiscent of those of Gough (1966), who found that the extra time required to verify truncated passives as opposed to active sentences is not eliminated by a 3-sec delay. Gough's finding suggested that the difficulty of syntactically derived sentences is not entirely due to initial comprehension, while the present results support a similar conclusion for sentences with morphologically derived words. The obtained pattern of results suggests that both basic and derived words correspond to fully specified concepts, and that the main difficulty of derived forms arises not during initial comprehension, but during the comparison of the meanings of the subject and predicate. The fact that high-PF basic and derived predicates produce equal decision times after a delay can be explained by assuming that a person is able to anticipate high-PF subject categories from both basic and derived predicates. For example, whether he first sees *has hoofs* or *is hoofed*, the person will probably anticipate the subject *horses*. But if the actual subject word (e.g., *zebras*) forms a low-PF sentence, the person will then be forced to compare the subject and predicate in order to reach a decision. If the predicate is derived, the person may have to apply an inference rule to relate the representation of the derived predicate to a representation that is stored in memory with the subject concept (assuming that low-PF derived predicates are usually not stored with the subject concept directly). However, this step will not be taken until the subject word has been presented. Accordingly, the complexity effect is not eliminated for low-PF sentences even after the person has had time to comprehend the predicate.

One question that remains is exactly how the person is able to anticipate high-PF subject concepts from either a basic or a derived predicate. One possibility is that a high-PF subject category may be stored with both predicate forms. The link between the subject and the basic form may be more accessible than the link with the derived form; however, given a delay, the person will be able to access the subject category from either predicate form. This assumption of redundant storage can also explain the attenuation of the complexity effect for high-PF sentences, found in Experiment I, that occurs even without a delay. High-PF derived forms might sometimes be verified directly, rather than by applying an inference rule to relate them to the corresponding basic forms. Low-PF derived forms, on the other hand, will virtually always require the use of an inference rule.

Another possibility is that people are able to anticipate high-PF subject categories on the basis of a more superficial analysis of the meaning of the predicate. For example, a person may "see" the word *hoof* either in *hoofs* or in *hoofed*, which will trigger the association *horse*. He will therefore be able to anticipate a high-PF subject when cued with either the basic or the derived predicate, without using the predicate's full meaning. But regardless of the exact mechanism that allows a person to anticipate high-PF subject categories, it is still the case that the extra difficulty of derived forms does not disappear for low-PF sentences, even after a delay. It is therefore clear that people do not immediately encode derived and basic words onto a single representation.

The present position, based on differences in processing difficulty for basic and derived forms, is similar to that advanced by Kintsch (1974). Both sets of conclusions assume that the meaning of a derived word need not be decomposed into the representation of the basic form in order for the word to be understood. We are also in accord with Kintsch (1974) in rejecting the hypothesis that people typically store semantic information only once in memory. The present results, which suggest that people have different representations for the basic and derived forms of predicates, provide a further argument against the principle of "cognitive economy" in memory (see also Conrad, 1972; Holyoak, Glass & Bower, in press). It appears that "cognitive redundancy" is actually the rule rather than the exception in memory storage.

The present conclusion also argues against the common assumption that synonymous sentences always have identical immediate semantic representations. Rather, it seems necessary to assume that sentences like *Birds have feathers* and *Birds are feathered* have distinct representations that are marked as equivalent by inference rules. Leech (1974) has formulated a number of such rules in order to represent the semantic equivalence of syntactically diverse sentences such as *Jerry loves music* and *Jerry is a music-lover*. It may be possible to formulate such rules in terms of a search through a semantic network, but this issue is beyond the scope of the present paper.

It would be of considerable interest to investigate the processing of other types of derived words in a semantic verification paradigm (e.g., verb-based adjectives such as *breakable* or nouns such as *destruction*). In addition to exploring the role of morphology in comprehension more fully, an important research goal should be to determine how children first learn morphological rules and the corresponding semantic regularities. Such investigations will hopefully provide additional information about the organization of lexical information in memory.

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