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Lexical Complexity and Sentence Processing

ANNE CUTLER

M.R.C. Applied Psychology Unit, Cambridge CB2 2EF, U.K.

INTRODUCTION

In the mental lexicon of speakers who know it, the word *wombat* should have a relatively simple entry, in which a single sound representation—[wDmaet] or something more abstract—is linked to a meaning representation along the lines of 'small Australian marsupial mammal'. The lexical representations of many other words, however, are likely to be a great deal more complex. Ambiguous words, such as *bark,* for instance, must have more than one semantic representation associated with a single sound representation. Idiomatic expressions, such as *break the ice,* convey a meaning which is not expressible as a direct function of the words which comprise them, and if they are listed as single units, then their lexical representation incorporates a degree of syntactic complexity. Derived words, consisting of a stem with prefixes and/or suffixes, may represent this morphological structure in their lexical entry: on this dimension the lexical representation of, say, *emit* would be more complex than that of *emir.*

Loosely speaking, then, lexical representations can vary in complexity on at least three dimensions: semantic, syntactic, and morphological. The existence of complex representations of all three types has been specifically claimed: 'Both (all) interpretations of an ambiguous word are always activated' (Foss and Jenkins, 1973); 'Idioms are stored and accessed as lexical items' (Swinney and Cutler, 1979); 'Morphological decomposition is involved in the storage and retrieval of lexical items' (Taft and Forster, 1975).

Clearly, there are fundamental differences between the phenomena which have here been given the summary title 'lexical complexity'. Ambiguous words, and idioms, are complex in the sense that they can call up more than one semantic representation in the lexicon; morphologically complex words, on the other hand, have a unitary semantic representation, but are complex in that different parts of the word may correspond to different parts of the semantic representation. Nevertheless, in this chapter 'lexical complexity' will for the purposes of the argument be treated as a unitary phenomenon. A negative definition is that lexical complexity occurs wherever lexical entries are not simple; lexical simplicity is the case when a phonetic representation of a word evokes a single lexical entry which contains only a single word class representation and a single semantic representation. The existing evidence on this heterogeneous phenomenon (plus some fresh evidence to be presented below) does in fact, it will be argued, produce a coherent picture; these vastly different kinds of complexity indeed have something in common. Two questions will be posed in this investigation: (a) can there be mental representations of words which are complex in the way that has been claimed? and (b) if so, are words with complex lexical entries in any way more difficult to retrieve from the mental lexicon than words with simple entries? It will be argued, to cut the next twenty-odd pages short, that the answer to (a) is 'yes', the answer to (b) 'no'.

The evidence on which these conclusions are based is extensive and varied. Clearly, the two questions raise different methodological issues; whereas an answer to (a) can be sought via a variety of tasks which measure priming and interference, (b) requires the use of specific techniques to assess lexical access difficulty. Since it is to be argued that lexical complexity exerts *no* effect on difficulty of lexical access, it is appropriate to establish at the outset that other variables do have such an effect. The two tasks which have been most frequently used as measures of lexical access time, for example, are lexical decisions (in which subjects make a word-nonword judgement on a string of letters presented in isolation) and phoneme-monitoring (in which subjects listen within sentences for a word beginning with a specified sound). For the former, Whaley (1978) has presented a comprehensive review of the relative effects of a number of variables on lexical decision time; frequency of occurrence, meaningfulness, word length, and several other factors exert strong effects on response time in this task. For the latter, both Cutler and Norris (1979) and Foss and Blank (1980) have argued strongly that phoneme-monitoring response time can provide a measure of the time required to understand the word which precedes the target-bearing word in the sentence[1]; Foss and Blank show, for instance, that phoneme-monitoring responses are sensitive both to frequency of occurrence and word-nonword status of the word preceding the target-bearing item. In the following sections it will be seen that measures of lexical access time consistently fail to show effects of lexical complexity; but the reliable effects of frequency and other factors demonstrate that this failure simply is not due to the lack of a suitable metric by which to assess variations in lexical access time.

SEMANTIC COMPLEXITY

Semantic complexity covers a fairly wide range of variations between words. Firstly, there is lexical ambiguity, cited above as an example of semantic complexity; but ambiguity itself is not a unitary phenomenon. It includes: (a) unsystematic ambiguity, i.e. words with multiple quite unrelated senses *(bear);* (b) systematic ambiguity, i.e. words with related senses in different categories *(glue);* but also (c) words with closely related senses which nevertheless have quite distinct referents (e.g. *run* of people, water, or roads). Secondly, the meanings of words contain information of more central and less central nature; thus the most important part of the definition of the words *beer* and *brandy* is that they each describe a kind of alcoholic drink; but in the sentence "This container holds the equivalent of a bottle of---, they call up our knowledge that beer comes (in civilised countries at least) in small bottles and brandy in large ones; while 'He drank brandy in everyone else's round but beer in his own' appeals to our stored knowledge that brandy is a comparatively expensive drink, beer a relatively cheap one.

Certain words carry implications about their surrounding sentence context as part of their intrinsic meaning. Selection restrictions work this way: only horses can be *piebald,* only round things can *roll.* Factive verbs imply, similarly, the truth of their complements: 'I regret that Australian beer bottles hold 26 fluid ounces' is factive; 'I think that Australian beer bottles hold 26 fluid ounces' is not. Finally, the negative element of otherwise unmarked negative words such as *doubt* or *reluctant,* or the causative element in verbs such as *kill* or *dye,* could be held to make the semantic representations of such words more complex than those of words which are neither negative nor causative.

Again it should be made quite clear that disparate phenomena are being treated as if they were alike. Having more than one meaning, as ambiguous words do, is not at all the same thing as having, say, a meaning which can only be conjoined with a very few other concepts, as is the case with the meaning of *piebald.* But selection restrictions, factive presuppositions and negative implications are indisputable components of the meaning of words, with clear distributional and syntactic consequences, just as ambiguity is indisputable. The evidence to be cited in this section will show that the processing of a word necessarily involves access of whatever such indisputable information is associated with it in the lexicon. In this the different varieties of semantic complexity are alike. The case of causativity, however, involves lexical structure which is not indisputable but highly contentious; and, indeed, the review of the evidence on this issue will suggest that there is no validity to the claim that semantic decomposition is a lexical reality analogous to the other types of semantic complexity.

Lexical ambiguity

This is one of the most heavily investigated topics in Psycholinguistics. There is good evidence, particularly from quite recent research, that multiple meanings of a lexically ambiguous word are stored together in the lexicon. The evidence is provided by studies which show that occurrence of an ambiguous word makes both its relevant and its irrelevant senses momentarily available, even if sentence context makes it quite clear which sense is appropriate. Swinney (1979) presented listeners with sentences containing an ambiguous word, and required them to make a word-nonword decision about a string of letters presented visually exactly at the point at which the ambiguous word occurred in the auditory channel. The letter strings might be nonwords, words unrelated in meaning to the ambiguous word, or words related to one or the other meaning. For example, a sentence might contain the ambiguous word *bug*, with the visually presented words being *ant*, *spy* or *sew*. Both the related words *(ant* and *spy)* were responded to faster than the unrelated word *(sew)* even when the context resolved the ambiguity; Swinney argued that both meanings of the ambiguous word must have been activated since associates of both meanings have been primed. Similarly, Lackner and Garrett (1972) presented listeners dichotically with two competing messages, one of which was a sentence to which the listeners were required to attend and which they had to paraphrase immediately after hearing it. Some of the sentences contained ambiguous words. In the unattended channel other material was presented (which subjects could not later report), and this material resolved the ambiguity. Lackner and Garrett found that subjects' paraphrases reflected the particular sense expressed by the disambiguating unattended message, and argued that since either meaning could be chosen according to which biasing context was presented, both meanings of the lexically ambiguous word must have been momentarily accessed from the lexicon. Finally, an experiment by Conrad (1974) required subjects to name the colour of the ink of printed words, some of which expressed meaning related to the ambiguous word which had occurred in a previously heard sentence; colour naming time was longer for words related to *either* meaning of the ambiguous word than to unrelated words.

Thus there is a good deal of support for the contention that accessing a lexically ambiguous word involves accessing all its senses. There is no evidence, however, that accessing a word with more than one sense incurs greater processing cost than accessing a word with a single sense. Phoneme-monitoring studies which claimed to demonstrate an increase in processing load associated with the occurrence of a lexical ambiguity (Foss, 1970; Foss and Jenkins, 1973; Cairns and Kamerman, 1975) appear to have confounded the ambiguity variable with physical differences between ambiguous words and their unambiguous controls (Mehler, Segui, and Carey, 1978; Newman and Dell, 1978); when these factors are controlled, sentences containing lexical ambiguities produce phoneme-monitoring reaction times no longer than those for matched unambiguous control sentences (Newman and Dell, 1978; Norris, 1980), and manipulation of the physical factors can make sentences containing an ambiguous word produce *shorter* reaction times than their controls (Mehler, Segui, and Carey, 1978).

The currently available evidence therefore suggests that lexical ambiguity is not associated with an increase in the difficulty of lexical access. It should be noted, however, that judging a string of words to be an acceptable sentence is more difficult if the sentence contains an ambiguous word than if it does not (Mistler-Lachman, 1975; Holmes, Arwas, and Garrett, 1977). Similarly, if a subject is required to comprehend time-compressed sentences presented at a very rapid rate and also to recall a list of words presented after each sentence, then fewer words from the list are recalled correctly when the sentence contains a lexical ambiguity than when it does not (Chodorow, 1979). These results perhaps reflect the development of an interpretation of the sentence as a whole. That is to say, although tasks which specifically measure lexical access difficulty show that ambiguous words are no harder to access than unambiguous words, it may well be the case that it is more difficult to construct a semantic representation of the sentence as a whole when the sentence contains an ambiguous word, and it is thus more difficult to integrate the sentence into actual or potential context. A similar suggestion has recently been put forward by Onifer and Swinney (1981) to account for the effects of frequency of meaning. It has been claimed (Hogaboam and Perfetti, 1975; Holmes, 1979) that the various senses of an ambiguous word are accessed in order of their frequency (i.e. the 'blow' reading of *punch* before the 'drink' reading) and that access of more than one sense only occcurs when a less frequent sense is required. However, Onifer and Swinney showed that priming of words related to both senses of a lexically ambiguous word occurs even when the context demands the most frequent reading; they argued that the apparent effects of frequency of meaning reflected a 'post-access decision process'. If the lengthened acceptability judgement times which Mistler-Lachman and Holmes *et al.* found for sentences containing an ambiguity indeed reflect difficulty of integrating the ambiguous word into sentence context, then it is reasonable to expect that there should be less difficulty in the sentence acceptability judgement tasks when the sentence expresses the more frequently used meaning of the ambiguous word than when it embodies the less frequently used meaning. Exactly this was found to be the case by Holmes (1979). Similarly when a word is used in its most frequent sense, and is therefore easily integrated into its context, it may be difficult to make judgements upon it with relation to other contexts, for example to decide whether or not it is ambiguous. This is what Hogaboam and Perfetti (1975) found.

The processing of semantically complex words in sentence context will be discussed again below. With regard to lexical access alone, the ambiguity studies strongly indicate that all senses of an ambiguous word are accessed but that lexical access itself is no more difficult for ambiguous than for unambiguous words. Lexical ambiguity thus offers a standard against which other types of semantic complexity, on which there is much less evidence available, can be compared.

Factivity

A predicate is said to be factive when it implies that its sentence complement expresses a true proposition. Factivity is thus an instance of lexical presupposition (see Morgan, 1969, on the distinction between lexical and sentential presupposition). There exists a whole class of factive words (Kiparsky and Kiparsky, 1971) comprising verbs such as *regret* and *know*, and adjectives such as *important* and *crazy* (cf. 'Bruce thought the decision *crazy*' versus 'Bruce thought the decision likely'). It is reasonable to assume that lexical presupposition in general, and factivity in particular, is an inseparable part of the definition of such words (the *Concise Oxford Dictionary*, for example, defines *regret* as 'be distressed about or sorry for (event, fact)'). Hence it should be incorporated in the mental representation of a factive verb or adjective, and when such a word occurs in a sentence, retrieval of its meaning from the internal lexicon should include retrieval of its presuppositional implications with respect to its complement. It thus becomes legitimate to query whether the occurrence of a factive is associated with greater processing difficulty as a result of the implications it involves, in comparison with otherwise similar but non-factive words. No existing evidence on this question is available in the literature; the data below come from studies of my own.

Again, it appears that lexical complexity does not imply difficulty. In a phoneme-monitoring experiment run by David Swinney and myself in Swinney's laboratory at Tufts University, response time was compared to target sounds preceded (a) by factive verbs or adjectives, or (b) by non-factive control words matched with the factives on frequency and length in syllables. An example sentence is:

(1) The retired general deplored/declared a continued readiness for war on the part of the NATO partners.

In this example the target sound is /k/ and the target-bearing word therefore 'continued'. The factive words produced reaction times not significantly different from those produced by the non-factives (see Table 2.1), ($F_1(1;30) = 1.25, p > .25$).

Thus lexical access of a factive word seems to involve no greater processing difficulty than access of a non-factive. In contrast to the ambiguity case,

Table 2.1 Phoneme monitoring latencies (msec) to target words preceded by a factive or a non-factive verb or adjective

Average latencies	
Factive	Non-factive
515	506

however, factivity also exhibits no effect on the time required to judge whether or not a sentence is acceptable. In a follow-up to the previous experiment, conducted at Sussex University, I used the same set of factive words in a sentence classification experiment; again each sentence occurred in two versions, one containing the factive and another a non-factive verb or adjective matched on frequency and length in letters, for example:

(2) The retired general deplored/declared the army's readiness for war.

The response time to classify the sentences as acceptable or not did not differ significantly across the two conditions (Table 2.2) ($F_1 < 1$).

Thus factivity, unlike ambiguity, does not appear to be associated with any difficulty of integration into an overall representation of the sentence. Factive verbs and adjectives are as easy to process at all levels as non-factive verbs and adjectives.

Table 2.2 Time (msec) required to classify sentences containing factive versus non-factive verbs or adjectives

Average classification time	
Factive	Non-factive
2068	2064

Selection restrictions

Many verbs and adjectives are severely constrained with respect to the nouns of which they are predicated. Only liquids can *spray,* for example, or be *lukewarm,* whereas only adult females can *be pregnant.* When such words are applied to nouns not meeting the relevant restrictions ('pregnant silence', 'a lukewarm reception') they are understood to be used metaphorically, i.e. the restrictions are observed in the breach.

Selection restrictions of this kind must form part of the restricted word's lexical entry. (Again we can call on the testimony of printed dictionaries, which commonly state the selection restrictions at the outset of a definition: 'of liquids'; 'of a woman or a female aninal'; etc.) Thus the lexical entry for a word which involves selection restrictions is more complex than for one which does not, in that accessing the word will automatically produce the information that the set of nouns of which it can be predicated is severely limited. Is a restrictive lexical representation more difficult to process at any level than a non-restrictive one?

Once more, the answer is no. In fact, the reverse is true: words embodying selection restrictions can be very efficient at selecting a set of appropriate associates, and the consequent priming between words can result in sentences containing restrictive verbs or adjectives being easier to process than sentences with similar but non-restrictive words. Again the evidence is provided by unpublished work from the University of Sussex laboratory. Norris (1980) compared sentences like (3a), in which the verb embodies selection restrictions, with sentences like (3b), containing a non-restrictive verb, in a sentence classification task.

(3) a. The ink sprayed the customer, b. The ink annoyed the customer.

Norris found that the acceptability judgement times were shorter for the restrictive-verb versions. That is, construction of an overall sentence representation appears to be easier when the sentence contains a restrictive rather than a non-restrictive verb. This implies that retrieval of words from the mental lexicon does include retrieval of any selection restrictions associated with them; but the extra complexity of the information retrieved does not mean that linguistic processing becomes harder as a result.

Lexical negatives

Negation increases response time in a large number of psycholinguistic tasks (Wason, 1959, 1961; Just and Carpenter, 1971; Chase and Clark, 1972). Single lexical items can be in themselves negative—for instance, when they have a negating prefix *(unhappy, dislike),* or when they imply a negative *(doubt* = not believe; *vacant* = not occupied). The syntactic behaviour of affixed and implicit negatives is in many cases exactly like that of explicit negative elements (Klima, 1964). One must ask therefore whether negative lexical items are by themselves associated with an increase in processing difficulty, since they would seem to constitute an outstanding instance of lexical complexity which is likely to imply processing complexity.

Indeed, Clark and Clark (1977) have reported that the familiar response time deficit assocated with negation also appears when implicit negatives are used in a verification task (in which subjects judge whether or not a sentence accurately describes the content of a visual display, whether a sentence is true or false, or whether or not two sentences have the same meaning). A series of experiments by Sherman (1973, 1976) has investigated the contribution of explicit, implicit, and affixal negatives to reaction time to judge the 'reasonableness' of a proposition. He found that all types of negative elements, including lexical negatives, led to an increase in time to make the decision, in comparison with latency to judge the reasonableness of a sentence which contained no negative elements.

None of these tasks, however, measured direct lexical access or even sentence comprehension time. All of them required the subject to make a judgement about the content of the sentences presented—truth, reasonableness, accuracy in describing a picture, or identity with another sentence's content. Thus the effect of negation on response time might apply to any of several components of the subject's task: comparison or verification time as well as comprehension time. It does not necessarily follow from these results that affixed or implicit negatives are more difficult to access from the mental lexicon than non-negative words, or that sentences containing affixed or implicit negatives are more difficult to comprehend than sentences without any such words.

Again the only specific investigations of lexical access and sentence processing time with this variable are unpublished studies from the University of Sussex laboratory. The evidence indicates that negative lexical items, like other semantically complex words, are no more difficult to process than comparable simple words. In a phoneme-monitoring study, I measured reaction time to targets preceded by afffixed or implicitly negative verbs or adjectives in comparison with non-negatives matched on frequency and length in syllables, as in (4) and (5), in both of which the target sound is /b/:

(4) The recommendations of the environmental impact study were sure to disappoint/gratify backers of the new development.

(5) The dog sniffing round the yard stuck its nose into the empty/yellow bucket under the hedge.

As can be seen from Table 2.3, the effect of negation was not significant

Table 2.3 Phoneme monitoring latencies (msec) to target words preceded by implicit and affixed negative and non-negative verbs and adjectives

	Average latencies		
	Negative	Control	Average
Implicit	434	417	423
Affixed	436	447	441
Average	435	432	

Table 2.4 Lexical decision latencies (msec) to implicit and affixed negative and non-negative verbs and adjectives

	Average latencies		
	Negative	Control	Average
Implicit	635	659	647
Affixed	708	710	709
Average	672	684	

($F_1 < 1$). Since no attempt was made to match across the two sets of negative words, no estimate of the comparative difficulty of affixed and implicit negatives can be made on the basis of these data.

The same negative words were also included in a simple visual lexical decision (word-nonword) experiment, along with three sets of control words: one set matched with the negatives on length in letters and frequency; another set matched on length but not on frequency; and a third set matched on frequency but not on length. Although both the length ($F_1(3,57) = 4.23$, $p < 0.01$) and frequency ($F_1(3,57) = 15.95$, $p < 0.001$) manipulations produced the predicted significant effects, there was no significant effect of negation ($F_1(1,19) = 1.71, p > 0.2$) as Table 2.4 shows.

Thus it is clear that lexical access per *se* takes no more time for a negative than for a non-negative word. Nor, it appears, is the process of simply understanding a sentence containing a lexical negative difficult in itself. The same 24 negative words used in the preceding two experiments were also incorporated in a sentence classification experiment in which subjects were asked to judge the acceptability of sentences containing either one of the negative words or a non-negative word matched on frequency and length in letters, for example:

(6) The headmaster will forbid/ compel the boys to stay at school.
(7) The conservative vicar disliked/approved the choice of hymns.

Response time did not vary significantly as a function of the presence or

Table 2.5 Classification times (msec) for sentences containing implicit and affixed negative and non-negative verbs and adjectives

	Average classification times		
	Negative	Control	Average
Implicit	1912	1983	1947
Affixed	2114	2088	2102
Average	2013	2035	

absence of a lexical negative, as is clear from Table 2.5, ($F_1(1,26) = 2.05$, $p > 0.15$).

We can summarize the evidence on lexical negation as follows: the fact that implicit and affixed negatives behave like explicit negative elements in verification tasks argues strongly that the processing of such lexical negatives involves processing of the negative element. That is, it is apparent that part of the lexical representation of an affixed or implicit negative is a representation of negation. Nonetheless, no reflection of additional processing complexity as a result of the presence of a single negative element shows up in tasks which measure lexical access or sentence comprehension time. From this we are forced to conclude that the response time decrement associated with single negative lexical items in verification tasks must result from other requirements of the task than sentence comprehension *per se.* Lexical negatives, like other semantically complex words, contain additional information (a negative element) in their lexical entry, but are not by virtue of this more difficult to understand.

However, although a sentence containing a single negative item is no more difficult to understand than an all-affirmative sentence, it is well known that as the number of negatives in a sentence increases, the sentence rapidly becomes extremely hard to interpret:

(8) Few Australians would fail to deny their reluctance not to doubt that the Tasmanian devil no longer exists.

But again, this effect appears to operate on the construction of a semantic representation of the sentence as a whole. Conceivably, construction of an overall sentence representation involves setting a truth index (one model incorporating such an index is given by Clark and Clark, 1977), and each additional occurrence of a negative item would require that the truth index be reset. If it were the case that this setting and resetting process is hard to keep track of, then competing representations of the sentence might become simultaneously available, leading to difficulty in deciding upon a final interpretation. In any case, it is clear that the difficulty associated with the occurrence of negation in sentences like (8) inheres in the construction of an integrated sentence representation; the experiments on single lexical negatives demonstrate convincingly that it is not a lexical access effect.

Semantic decomposition

Some linguists, Lakoff (1965), for example, or Postal (1970), have argued that the lexical representations of several classes of single words are expressed in terms of the meaning of other words or phrases, specifically, concepts corresponding to components of their semantic representation. Thus causative verbs such as *kill* or *dye* might be expressed as CAUSE (die) or

CAUSE (acquire colour). More generally, word meanings might be defined in terms of superordinate concepts, e.g. *man* as (adult) (male) (human) (animate), etc.

A good deal of controversy has surrounded this claim, both in linguistics and in Psycholinguistics. It is discussed here because it makes clear predictions about added complexity resulting from the lexical access of, for instance, causative verbs. That is, if the correct semantic analysis of a sentence such as 'the dingo killed the wombat' is a structure containing two propositions, one with an explicit verb of causation and the other with an inchoative (unanalysed) verb, i.e. 'The dingo caused (the wombat die)', then a listener's comprehension of this superficially single-proposition sentence must involve reconstruction of the two-proposition underlying representation and must therefore involve greater perceptual complexity than comprehension of a sentence not containing a causative. But a number of experiments, mainly by Kintsch (1974), have failed to show any effect on processing difficulty of semantic complexity of this kind. For instance, Kintsch found that causative verbs were not associated with any increase in difficulty in comparison with inchoative verbs when processing difficulty was measured by sentence initiation time, sentence completion time, or phoneme-monitoring response latency. Similarly, unpublished experiments in our laboratory at Sussex have failed to find an effect of semantic complexity of verbs on (a) time to read a sentence, (b) latency to answer a question, and (c) lexical decision response time, i.e. lexical access time.

This is not more than the previous catalogue of findings on multiple meanings, presuppositions, selection restrictions, and negative marking would have led us to expect; all of these types of information are incorporated in lexical representations, are activated in the course of lexical access, but do not lead to an increase in processing difficulty. Yet there are strong reasons for believing that semantic decomposition is a very different case from the other four kinds of semantic complexity discussed above: to wit, there is no evidence that the lexical representations of, say, causative verbs are in fact decomposed, and there is even a certain amount of evidence that they are not decomposed. Fodor, Garrett, Walker, and Parkes (1980), for instance, conducted a series of experiments in which they elicited subjects' judgements of how closely related were two words within a sentence. This test proved sensitive to differences in underlying structure, for instance between sentences with *expect-type* verbs and *persuade-type* verbs. Thus, in (9) the underlying structure of the *expect* version has the two words, 'captain' and 'passengers', in different clauses (9'), whereas in the *persuade* version both words occur in the main clause (9").

(9) The captain expected/persuaded the passengers to stay calm.
(9') The captain expected (the passengers stay calm).
(9") The captain persuaded the passengers (the passengers stay calm).

As predicted, the words 'captain' and 'passengers' were judged significantly more related in the *persuade* version than in the *expect* version of (9). However, no corresponding differences were found between the relatedness judgements for 'workers' and 'paint' in a comparison of causative verbs with matched non-causatives, as in (10):

(10) The workers spilled/found some paint.

although if the causative verb had been decomposed in comprehension, the underlying structure of the causative sentence would presumably have contained the two tested words in different underlying clauses:

(10') The workers caused (paint spill).

Similarly, Fodor, Fodor, and Garrett (1975) found standard performance decrement effects of negative marking in affixed and implicit negatives in a verification task similar to that used by Sherman (1973), but found no such effects for words whose decomposed definitions should contain a negative element, e.g. *bachelor.* Fodor *et al.* concluded that since these words do not act as though they contain a negative element in their semantic representation, they are presumably not decomposed into simpler elements in the process of being understood.

Kintsch (1974) found that words with decomposable definitions did not produce more errors than matched inchoative words on a simple memory task, although in prior research (Kintsch, 1972) he had found evidence that other kinds of lexical complexity (see the discussion of morphological complexity in the following section) were associated with poorer memory task performance. In another experiment, Kintsch used sentences containing decomposable words (e.g. *convince)* in a recall task and found that words representing a base component of the meaning of the experimental words (in this instance *believe)* were effective recall cues—as effective as high associates (e.g. *persuade)* though not as effective as the complex word itself. (None of the components were themselves high associates of the experimental words; but note that Fischler, 1977, has shown that any semantically related word will prime as efficiently as a high associate). Thus definitional elements of the decomposable word's meaning are effective primes for that word, but the processing (understanding and memory storage) of a decomposable word does not necessarily involve decomposition into its components; if it did, one might have expected Kintsch's component words to have provided as effective a recall cue as the complex words themselves.

The evidence seems clear: semantic decomposition, like other forms of semantic complexity, is not associated with added processing difficulty. In fact, it appears that it may not even be analogous to other kinds of semantic complexity discussed above, since not even an indirect reflection of decomposition in sentence comprehension has been found. Decomposable words such as *kill, bachelor,* or *convince* may have lexical representations which overlap enough with those of other words to evoke these other words as associates; but there is no evidence that the component concepts are actually contained in the definition of complex words. Certainly the strongest possible version of the decomposition hypothesis is not valid—decomposable words are not accessed via the lexical representation of other words corresponding to components of their semantic representation. And like other semantically complex words, words with decomposable definitions are not more difficult to access from the lexicon than words with simpler definitions.

MORPHOLOGICAL COMPLEXITY

Morphological complexity has not always been considered as an issue separate from semantic complexity. In the same way that the lexical representation of *kill* was hypothesized to be constructed from the lexical representation of *cause* and *die,* so for instance the lexical form of a derived word such as *wisdom* was hypothesized to be constructed from that of its base word, in this case *wise.* It should be noted that all of Kintsch's experiments described in the previous section examined morphologically complex words (abstract and agent nouns such as *ability* and *speaker)* as well as causatives and other decomposable words; the results reported did not differ significantly across type of word. But the two cases have been separated in this discussion for a good reason, namely that whereas there is no evidence that decomposable words contain within their lexical entry a representation of the base words which supposedly comprise their meaning, there is abundant evidence that morphologically complex words do contain within their lexical representation the details of their morphological structure.

Prefixed words

This topic has attracted a number of recent studies: Taft and Forster (1975); Taft (1979); Stanners, Neiser, and Painton (1979); Fay (in press); Rubin, Becker, and Freeman (1979). Taft and Forster's study investigated the time to reject nonwords in a lexical decision tasks as a function of whether or not the nonwords were stems of existent prefixed words: *e.g. juvenate* from *rejuvenate* was compared with *pertoire* from *repertoire,* which is not prefixed. The *juvenate* type of nonwords took significantly longer to reject than *the pertoire* type. This response time difference also held when the items were presented bearing pseudoprefixes *(dejuvenate* versus *depertoire).* Taft and Forster argued that prefixed words are stored in the lexicon under a heading which corresponds to their stem, that is, *rejuvenate* is actually stored as *juvenate.* In direct support of this conclusion they reported another experiment in which they examined real words which occurred also as stems. In some cases the prefixed form was much more common than the stand-alone form (as is the case with *prevent* versus *vent),* in others the prefixed form was less common than the stand-alone form *(e.g. card* versus *discard).* Lexical decision reaction time to words like *vent* was slower than reaction time to words which only occurred alone; but this was not the case for words like *card.* Taft and Forster's explanation of this finding involved interference from the higher-frequency forms which could not stand alone and on which a 'yes' response could therefore not be based. This particular result, however, is highly likely to be artefactual. The stand-alone roots were matched with their controls on frequency of the surface form alone, not including the frequencies of other regular inflected forms. In this experiment 16 of the 20 *vent-type* words were matched with controls which had a much higher frequency when other inflections are taken into account. *Pending* and *picking,* for instance, have a surface frequency of 14 each, but the combined frequency of *pick* plus *picked plus picking plus picks* is 151, whereas the combined frequency of all forms of *pend* is still 14 (Kucera and Francis, 1967). This fact alone could have accounted for the reaction time difference found in this condition; in the *card* condition, where no reaction time difference was found, there was also no imbalance between roots and controls on the combined frequency measure. (As will be seen in the following section, the evidence is very clear that regular inflections for tense and number do not produce separate lexical representations for each form. It is therefore very important to take this fact into account when constructing frequency-matched materials).

Taft (1979) reported a further experiment in which pairs of words were compared which themselves had the same frequency of occurrence (e.g. *reproach* and *dissuade)* but differed in the frequency of occurrence of their same-stem relatives *(approach* is more frequent than *persuade).* In each case the relatives were higher in frequency than the stimulus words (though higher by different amounts) so that the interference effects as claimed in the Taft and Forster experiment should have been equivalent in this case. The words with comparatively high-frequency same-stem relatives were responded to significantly faster than their frequency-matched controls with comparatively low-frequency relatives. Thus the reaction time advantage of a high-frequency word can carry over to its morphological relatives, indicating that, according to Taft, the lexical representations of morphologically related words are closely connected with the frequency rating for the entire group determined most probably by the aggregate of all the related forms.

Stem defined lexical representation is also postulated by Fay (in press) on the basis of a study of prefix errors in spontaneous speech. Substitution errors often occur in which a prefixed word is replaced by another word with the same stem but different prefix (11), or by a non-occurring combination of prefix with the target stem (12):

(11) . . . the sewing *constructions* (Intended: *instructions)*
(12) .. . to which I would like to become *concustomed* (Intended: *accustomed).*

Fay argued that these errors are best explained in terms of a model of the mental lexicon in which prefixed words are accessed via their stems; in the production case, the correct stem is accessed but the wrong prefix attached to it, resulting in a typical prefix error.

However, there are two recent pieces of evidence which indicate that it may not be the case that the lexical representation of a prefixed word is simply and only in terms of its stem. Stanners, Neiser, and Painton (1979) used the repetition priming effect (the reaction time to the second presentation of a particular word in a list of lexical decision items is speeded; Forbach, Stanners, and Hochhaus, 1974) to investigate the effectiveness of morphological components as primes for a morphologically complex word. They found that stem and prefix presented separately (either alone, or as part of other words) earlier in the list significantly facilitated lexical decision response time to a later representation of a prefixed word in comparison with the same word presented without preceding primes. However, they also found that priming with the word itself was significantly more effective than priming with its morphological components presented separately. They argued that the model of the lexicon best supported by their results was one in which each prefixed word had a unitary undecomposed representation—so that the word itself was its own best prime—but the representations of all words with the same stem were connected, perhaps via a representation of the stem, so that accessing any one activated, to some extent, the others; thus the morphological components were also effective primes. In another experiment Stanners *et al.* found that words with independently meaningful prefixes (e.g. *un-, de-)* were as effective at priming their stem words as the stem words themselves; that is, *unaware* was as good a prime for *aware* as *aware* itself.

A similar conclusion to that drawn by Stanners *et al.* was suggested by Rubin, Becker, and Freeman (1979). Lexical decision reaction times were found by Rubin *et al.* to be faster for prefixed words *(remark)* than for pseudo-prefixed words *(reckon)* when the rest of the list consisted of prefixed words and 'prefixed' nonwords *(retext),* but not when the rest of the list consisted of non-prefixed words and nonwords. More recently, Taft (1981) found a *naming* reaction time deficit for pseudoprefixed words, even when subjects saw no really prefixed words at all; but Henderson, Wallis and Knight (1983) failed to find any *lexical decision* reaction time deficit for pseudoprefixed words in a mixed list. Rubin *et al.* proposed morphological decomposition of a prefixed word in lexical access as an optional strategy—not necessary, since prefixed words have a unitary representation, but possible, since they *can* be accessed via their stem. For this mode of access to be at all possible the morphological structure information must be incorporated in the lexical representation; either all words with one stem are listed conjointly, with access to the stem activating them all, or prefixed words have two unconnected representations, one unitary and one headed by the stem. The former alternative is the one most compatible with the Stanners *et al.* results as well as with those of Taft, of Fay, and of Rubin *et al.*

Finally, another experiment by Fay (1980) supports this kind of mixed model. In a lexical decision experiment, prefixed words *(institute)* did not differ in response time from non-prefixed words *(assassin),* but prefixed nonwords composed of nonexistent combinations of real stems and prefixes *(abvention)* were significantly more difficult to reject than non-prefixed nonwords. Fay interpreted this finding as indicating that prefixed words could be accessed holistically, but that access via the stem was also possible; this latter option was responsible for the interference effect with nonwords, as the entry for *vention* would have to be checked out to ensure that it could not occur with *ab-*. Taft, Forster, and Garrett (1974, cited by Taft and Forster, 1975) also found that, other things being equal, prefixed words are no more difficult to access from the lexicon than non-prefixed words. The results reported in the section on *Lexical negatives* above also include a parallel finding: in our studies of negation, words with negative prefix were no more difficult to process than non-prefixed controls. That is to say, whatever activation of morphological structure goes on in the recognition of a prefixed word, it does not make the process of recognition more difficult.

Suffixed words

Inflections

There is abundant evidence that words inflected for tense or number do not have lexical representation independent of their base form, and that base word and inflection are separated in language processing. In tachistoscopic presentation inflected words seem to be perceived as two units (Gibson and Guinet, 1971). Recall of adverbs ending in *-ly* is affected by the frequency of the base adjective rather than the frequency of the inflected adverb form (Rosenberg, Coyle, and Porter, 1966). Regular inflected forms *(pours)* show a repetition priming effect on their base words *(pour)* as strong as that of the base word itself (Stanners, Neiser, Hernon & Hall 1979; Fowler & Napps 1982), while priming with irregular inflected forms *(hung)* is less effective than priming with the base word itself *(hang)* though still significantly better than no prime at all (Stanners, Neiser, Hernon, and Hall, 1979). This kind of morphological priming is, also, somewhat more robust over time than semantic priming (Henderson, Wallis & Knight, 1983). Pretraining with an inflectional variant (e.g. *sees)* significantly facilitates later learning of a word (e.g. *seen)* in comparison with no pretraining, or pretraining with a word with as much visual similarity to the target word as the morphological relative (e.g. *seed;* Murrell and Morton, 1974). Only *regular* inflections provide effective priming, however, when the dependent variable is accuracy of report of a degraded auditory signal (Kempley and Morton, 1982). Plural morphemes tend to get detached in memory representations (van der Molen and Morton, 1979). Lexical decision reaction times are sensitive both to the frequency of occurrence of the surface form and to the combined frequency of base plus inflectional variants (Taft, 1979). Neither lexical decision reaction times nor word naming times, however, are affected simply by whether or not a word embodies an inflection (Fowler and Napps, 1982).

An argument in favour of a stemorganized lexicon has been advanced by Jarvella and Meijers (Chapter 3 of this volume). Jarvella and Meijers primed target verbs either with differently inflected forms of the same stem, or with similarly inflected forms of different stems; subjects in their experiments performed same and different stem judgements significantly faster than inflection judgements, a result which they interpreted as evidence against the independent lexical representation of inflected forms.

Similarly, it has been claimed that inflected forms are actually generated by rule during speech production. This argument has chiefly been made on speech error evidence (Fromkin, 1973; Garrett, 1976; MacKay, 1979); errors in which inflections are misplaced in an utterance are common, and the inflectional form applied in the error is usually that appropriate to the word to which it has actually been attached rather than to the word to which it was intended to be attached:

(13) I'd hear one if I knew it. (Intended: I'd know one if I heard it.)
(14) . . . in little yellow bag from the banks(s). (Intended: bags(z) from the bank.)

MacKay (1976) has made the same claim on the basis of his experimental finding that translating a present into a past tense form takes longer and is more subject to error the more complex the relation between base and inflected form. The evidence is, however, also quite compatible with representation of the appropriate inflected forms in the lexicon: not as independent, unitary entries, but as a sub-part of the lexical entry for the base word. Such a representation would have to allow for differential degrees of closeness between base and inflection, to account for the lesser effectiveness of irregular forms as primes in comparison with regular forms (Stanners, Neiser, Hernon, and Hall, 1979) and greater difficulty of translation from one to the other (MacKay, 1976); it would also account for the finding of Jarvella and Snodgrass (1974) that reaction time to judge that the same base word was involved in a pair of words (base + inflected form) was longer when the inflection was irregular *(sing-sang)* than when it was regular *(sail-sailed).* Finally, a recent experiment by Lukatela, Gligorijevic, Kostic, and Turvey (1980) investigated noun inflections in Serbo-Croatian; from the fact that lexical decision responses to nominative forms were consistently faster than responses to genitive or instrumental forms, the authors argued for a model of lexical representation of inflected forms in which the nominative comprises the nucleus of a cluster of separate entries, one for each form.

Derivational suffixes

As was mentioned above, Kintsch (1974) failed to find on-line processing effects of the derivational complexity of agent and abstract nouns. Two studies, it is true, do report a reaction time deficit associated with morphological complexity, but in each case there is reason to believe that the result may have been due to other factors. Snodgrass and Jarvella (1972) found lexical decision reaction time to be longer to prefixed and suffixed forms in comparison with their base forms; but the comparison strings were matched neither on frequency nor on length. Holyoak, Glass, and Mah (1976) found that reaction time to judge whether or not a string of words expressed a true proposition (a task which, it will be recalled, was found by Sherman, 1973, to be sensitive to lexical negation) was longer when a morphologically complex word was involved, e.g. 'knights have strength' versus 'knights are strong'. However, since the effect persisted (for some items) even when the predicate was presented (and processed) before the sentence subject, Holyoak *et al.* claimed that it constituted evidence *against* morphological decomposition; and indeed, since the authors had failed to control for length, frequency or syntactic structure, there is no lack of alternative explanations for their results. Similarly open to criticism is the finding of Kintsch (1972) that derived nouns produce poorer performance in a paired-associate learning task; when the additional variable of concreteness was controlled, the effect disappeared (Richardson, 1975). In fact, such factors as concreteness and imageability seem to have been confounded with morphological complexity in a number of other early studies of this topic; see Richardson (1977) for a review.

Thus, not suprisingly in view of all the evidence summarized hereto, there is no indication that suffixed words are more difficult to process than matched simple words. But there is evidence that morphological structure of this kind is represented in the lexicon. Kintsch (1974) found that base components of abstract and agent nouns such as *ability* and *attendant (able, attend)* were as effective recall cues as high associates of the same words *(skill, gas station).* Stanners, Neiser, Hernon, and Hall (1979; replicated by Fowler & Napps 1982) found that derived words *(selective, destruction)* produced a significant repetition priming effect for their base words *(select, destroy),* though not as large an effect as that produced by the base word itself. Bradley (1979) found that a combined frequency measure obtained by adding the frequency of the baseword to that of its derivatives was a better predictor of lexical decision response time for derived words ending with *-ness*, *-er* or *-ment* than was the frequency of occurrence of the stimulus word alone. Thus there is evidence that suffixed words, like prefixed words, have lexical entries closely connected with, but not simply subordinate to, the entries of their base words. The entries can be accessed via the base word or independently. In support of this suggestion one can cite the finding of Manelis and Tharp (1977) that reaction time to decide whether or not a pair of letter strings are both words is slower if one is suffixed and the other not *{printer slander)* than if both are suffixed *(printer drifter)* or both simple *(slander blister);* although pseudo-suffixes *(vegetable, rubbish)* do not increase response time (Henderson, Wallis & Knight, 1983). Morphological decomposition is an optional strategy; if applied inappropriately (e.g. when the processor is misled by *print* + *er* to think that *slander* can be similarly analysed), it can result in increased processing difficulty.

Independent evidence in favour of conjoint storage of suffixed words derived from the same base comes from studies of errors in spontaneous speech. Firstly, errors of lexical stress show a curious pattern, as seen in (15)-(17):

(15) ... so we don't have any conflicts.
(16) ... and all the syntax texts be lost.
(17) ... from my prosodic colleagues.

The stress is always erroneously applied to a syllable which bears stress in a morphological relative of the target word *(conflict* (verb), *syntactic,* and *prosody* respectively). Cutler (1981a) proposed that this pattern is a result of the way such errors arise: namely from confusion within the lexicon between the stress-marked syllables of conjointly stored morphological derivatives from the same stem. Interestingly, the direction of interference in these errors does not appear to be random. A subset of the lexical stress errors involves confusion between the syllable stress marking of a base word and a morphologically more complex word, and within this subset more than two-thirds involve a derived word produced with stress on the syllable which bears it in the base word (as in (17) above); fewer than one-third involve a base word stressed on a syllable which bears stress in a derivative (as in (16)), a statistically significant difference (Cutler, 1980).

Word formation errors also occur (Fromkin, 1977; McKay, 1979; Cutler, 1980), in which the wrong suffix can be applied (e.g. *self-indulgement* for *self-indulgence)* or the correct suffix can be wrongly applied (e.g. *expection* for *expectation).* Again, these errors argue that base and suffix are separable in speech production. In word formation errors, there is a significant tendency for the erroneous derived form to be more transparent with respect to its base form than the target form would have been (Cutler, 1980); thus the base word *expect* is better preserved in *expection* than in *expectation.* Similarly, the fact noted above that stress errors tend to be derived words erroneously pronounced with the stress of their base rather than vice versa also suggests that derived forms may be preferred which are closer to their base. Some experimental evidence also indicates a possible difference between transparent and opaque derived forms. For instance, the effect that Bradley (1979) found for derivations ending with *-ness, -er,* or *-merit* (all of them transparent), namely that the combined frequency of all derivatives better predicted lexical decision reaction time than the individual item frequency, did not hold for derivatives with *-ion,* which are opaque. Similarly Jarvella and Snodgrass (1974) found that pairs of words in which the derivation and the base had different spelling *(defend-defensive)* took longer to classify as being derived from the same stem than pairs in which the base-to-derivation relation was transparent *(attain-attainable).* Bradley argued that a possible explanation of her result was that transparent forms were subordinate to the lexical representation of their base forms whereas opaque forms had independent representations. However, a more conservative explanation is simply that the lexically specified relation between transparent derivatives and base is closer than that between opaque derivatives and base; this explanation is analogous to the account of lexical representation of regular and irregular inflections suggested above.

Productive morphology

Not only do speakers make errors of word formation, they also regularly create their own neologisms, that is, use their internalized knowledge of morphological structure. Examples of spontaneous neologisms from my own collection include:

(18) What I need is a de-mad-ifier.
(19) He just context-free-ized it.
(20) .. . retreat even further from empiricity.

In all such cases, the produced form is transparent with respect to its base (with certain apparent exceptions, such as (20), which will be discussed below). That this pattern reflects a real preference for transparent derivations can be shown in experiments in which subjects are asked to choose between alternative derived forms of the same base. Speakers prefer, for instance, *-ness* derivations to *-ity* derivations when the latter are opaque, i.e. result in a change in vowel quality, shift of primary stress, etc. *(sinisterness, sinisterity),* but show no preference between the two suffixes when both derivations are transparent *(jejuneness, jenunity;* Cutler, 1980). Similarly, when subjects are asked to judge whether or not possible words formed from base plus suffix are in fact English words, they accept more words formed with *-ness* than with *-ity* if the *-ity* derivatives are opaque (Aronoff and Schvaneveldt, 1978), but show no preference either way if both *-ness* and *-ity* derivatives are transparent (Cutler, 1980). However, there are exceptions to this generalization; in some cases derived words which do not preserve all of the base word, or which bear primary stress on a syllable different from the stressed syllable of the base word, prove to be quite acceptable. For instance, in an experiment reported by Cutler (1980), subjects did not show a significant preference between *excusement* and *excusion,* although the latter fails to preserve the final phoneme of the base word. Also, Aronoff and Anshen (1981) showed that possible nouns formed from adjectives ending with *-ible* are accepted more often when they are derived with *-ity (suppressibility)* than when they are formed with *-ness (suppressibleness).*

Nevertheless, it can be shown that such words are also *functionally* transparent. Thus although *suppressibility* bears primary stress on the fourth syllable, the second syllable (which bears primary stress in the base) still carries a secondary stress. And it is important to note that listeners can distinguish stressed from unstressed syllables, but not, in the absence of full information about the word, multiple levels of stress (Lieberman, 1965). Thus a listener hearing *suppressibility* registers the second syllalbe as stressed without any way of knowing that a yet more highly stressed syllable is about to come. Consonants have not been lost and vowel quality has not changed; thus the first two syllables of *suppressibility* presumably suffice to enable the listener to access the lexical entry (group of lexical entries) for *suppress.* Analogously, *empiricicity* in (20) above preserves the first syllables of *empirical,* with the second more highly stressed than the first or third.

The case is different, of course, for *suppressivity.* Adding *-ity* to *suppressive* shifts the primary stress back onto the first syllable, resulting in a change in vowel quality. Instead of beginning with [sap] like the rest of the morphological relatives of *suppress, suppressivity* begins with [sAp] like *supper, supplement* and *suppurate,* and could initially mislead the language processor towards the lexical entries for these words. The criteria for functional transparency appear to be crucially concerned with the initial portions of the word. It has been suggested (Cutler, 1981b) that it might be possible to specify exactly how much of the base word has to be preserved for a derived word to be functionally transparent. For each word there is a theoretically earliest point at which it can be identified, namely that point at which it becomes distinguishable from other words in the language beginning with the same sequence of sounds; Marslen-Wilson (1980) calls this the *recognition point.* In all of the *-ibility* derivatives which Aronoff and Anshen (1981) found to be acceptable, the segmental values and relative syllable stress of the base word were preserved up to the base word's recognition point (for *suppress,* for instance, this is the final sound, at which it diverges from *supremacy).* In Cutler's (1980) experiments, too, all of the non-transparent but acceptable neologisms preserved relative stress and segmental value up to the recognition point of the base (for *excuse* the recognition point is [j]).

Preserving the base word up to the recognition point allows the hearer enough information to be sure of accessing the base word's lexical entry. Thus when speakers have to choose neologisms, they prefer those which contain transparently within them their base word or, at least, those segments which are crucial for auditory recognition of the base word. The implication of this preference is that speakers possess general criteria for the acceptability of neologisms which are based on what will be most convenient for the hearer. As long as the hearer can access the base word's lexical entry, the neologisms can be understood by the application of morphological principles to the base word's meaning, despite the fact that no specific lexical representation for the particular nonce-form exists. Not only does the production of neologisms draw on a speaker's internalized knowledge of morphological structure, but it expresses the speaker's knowledge of how words are represented in the lexicon and how a morphologically complex word may be accessed via its base.

SYNTACTIC COMPLEXITY

This final section considers three ways in which lexical representations may incorporate syntactic complexity. Firstly, there is systematic ambiguity—one word with more than one form class. Secondly, there is the holistic representation of multi-word units. And thirdly, there is the case of subcategorization restrictions on verbs, a lexically specified syntactic constraint.

Systematic ambiguity

A special case of lexical ambiguity arises when one considers ambiguity across form class. Words with multiple unrelated meanings do not necessarily maintain form class across meanings (e.g. *bear);* moreover, huge numbers of words can be used—with closely related meanings—in more than one form class, particularly as nouns and verbs *(doubt, crown, fuse,* etc.). Syntactic structure usually constrains interpretation completely with respect to form class; one might think that syntactic structure would provide sufficient cues on the basis of which to select the correct, and only the correct, reading of a word ambiguous across form class where the only alternative interpretation was of a form class different from that demanded by the context. Therefore, it might be expected that no evidence of lexical activation of the alternative interpretations should be found. However, Prather and Swinney (1977), using Swinney's cross-modal priming task described earlier, found that when ambiguous words of this type were incorporated in sentences in which the syntactic context completely constrained which reading was appropriate—the noun readings were preceded by *the,* the verb readings by to-words related to both the appropriate and the inappropriate (different form class) meaning were primed. Moreover, this was true both of unsystematic (non-meaning-related) and systematic (meaning-related) ambiguities. This finding suggests that multiple meanings of words may be stored together irrespective of form class, i.e. the lexicon can contain syntactically heterogeneous word conglomerates.

A similar finding to Prather and Swinney's is that of Tanenhaus, Leiman, and Seidenberg (1979), who found that presentation of a syntactically ambiguous word in an unambiguous syntactic context (e.g. 'they all rose') significantly facilitated naming latency to an associate of the contextually inappropriate meaning of the ambiguous word (e.g. flower). Again, this suggests that despite constraining syntactic context both noun and verb readings of the ambiguous word were momentarily activated.

A somewhat different picture is offered by an experiment conducted by Ryder and Walker (1982). Subjects were asked to judge whether or not two words were semantically related. When one of the words was semantically ambiguous *{duty-tax)* reaction times were longer than when both words were unambiguous *(city-town).* Moreover, this was true irrespective of whether the dominant or infrequent meaning was required for the relatedness judgement *(duty-responsibility; duty-tax).* Systematic (cross-category) ambiguities, on the other hand, only produced an interference effect when the judgement involved the infrequent reading *(cart-carry),* not when it involved the dominant reading *(cart-wagon);* the latter type of pair was responded to as quickly as unambiguous pairs. Ryder and Walker argued that in the access of cross-category ambiguities only the primary meaning (that is, the primary form class) is activated at first, in contrast to the case of semantic ambiguity, where all meanings are automatically activated at once.

An analogous conclusion can be drawn from an experiment by Forster and Bednall (1976), who measured subjects' reaction time to judge the acceptability of two-word strings, in each case a noun or verb preceded by *to* or *the.* When systematically ambiguous words were presented in their dominant sense *(the cage, to blame),* reaction time was as fast as to unambiguous words *(the wife, to greet);* but reaction times to the infrequent senses of systematically ambiguous words *(to cage, the blame)* were significantly slower.

How are these results to be reconciled with the findings that appear to show that all meanings of a systematic ambiguity are activated? It should be noted that both the Prather and Swinney and the Tanenhaus *et al.* studies demonstrated an effect of semantic priming due to the contextually inappropriate meaning, the dependent variable in each case being time to respond to a word which was not itself the systematically ambiguous word. As such they constitute robust evidence that priming did occur. The Ryder and Walker and the Forster and Bednall studies, on the other hand, measured reaction time to some judgement made about the systematically ambiguous word itself—its relatedness to another word, or its acceptability in combination with a preceding function word. Their findings are quite compatible with the suggestion that although both meanings are accessed, the dominant form class interpretation is retrieved first and is therefore able to be judged more rapidly than the later-activated infrequent interpretation. In this there seems to be a real difference between non-systematic and systematic ambiguity: although in both cases all meanings of a word constitute part of the same lexical grouping, in the case of systematic ambiguity the less frequent interpretation may only be accessed via the dominant interpretation.

Multi-word units

A second way in which a lexical entry may be syntactically complex is that a single meaning may be associated with a string of words. An obvious instance of a multi-word unit expressing a single meaning is that of idioms; the meaning of an idiom cannot by definition be expressed as a concatenation of the meanings of its component parts. The idiomatic meaning of 'let the cat out of the bag', for instance, has nothing to do with cats or bags. Linguists (e.g. Fraser, 1970) have claimed that idioms function in the language not as phrases but as single lexical items, and that they are listed in the lexicon just as any other word is listed. Indeed, evidence that idioms are represented as holistic units in the mental lexicon was presented by Swinney and Cutler (1979) using a task which was analogous to lexical decision and sentence classification, namely phrase classification, in which subjects were presented with strings of words and asked to determine whether or not they were acceptable English phrases. Idiomatic phrases were matched with control phrases which were constructed by substituting for one word in the idiom another word of equal length and equal or higher frequency (e.g. for 'break the ice' the control was 'break the cup'). Reaction time to classify idioms was significantly faster than classification time for the control phrases, a result which was interpreted as evidence that the idioms had been accessed, in their idiomatic sense, as units; no extra time was required to integrate the separate word meanings and arrive at an acceptable interpretation of the phrase, as would have to have been done for the control phrases.

Note that an alternative view of the lexical representation of idioms has been proposed by Bobrow and Bell (1973), namely that idioms are indeed represented as units, but in a separate idiom list; when an idiom is comprehended, a literal reading is first computed and only when that fails is the phrasal meaning accessed from the idiom list. The Swinney and Cutler results provide definite evidence against this claim. Bobrow and Bell based their suggestion not on results of an on-line processing task, but on which interpretation subjects reported for a string like 'kick the bucket' (which can be meant either literally or idiomatically). The strings were presented under biasing conditions which consisted of prior presentation of (a) a number of idioms, or (b) a number of literal phrases; idiomatic readings tended to be reported when idioms had been presented, literal readings when literal phrases had been presented. Bobrow and Bell claimed that their subjects could adopt or abandon a special idiom mode of processing; but Swinney and Cutler pointed out that Bobrow and Bell's results could equally well be explained as reflecting a mental decision about the most appropriate meaning on which to base a response.

In a second experiment, Swinney and Cutler compared idioms with different levels of syntactic frozenness. Frozen idiomatic phrases convey then-idiomatic meaning in only one syntactic form (e.g. 'jump in the lake' cannot undergo the simplest syntactic operations: 'Joylene's jumping in the lake was desired' does not convey the idiomatic reading), whereas others are less frozen or virtually unfrozen ('bury the hatchet', for instance, retains its idiomatic interpretation through most syntactic permutations). No difference was found between more frozen and less frozen idioms; all showed an equivalent advantage over literal control strings.

In a further unpublished experiment carried out at the University of Sussex, idioms with literal interpretations (such as 'break the ice' and 'kick the bucket') were compared with idioms which have no literal interpretation (e.g. 'by and large', 'in the know'); again both types of idiom showed an equivalent reaction time advantage in comparison with literal strings.

Thus it appears to be the case that multi-word idioms have unitary lexical representation. Supporting evidence for this model comes from an experiment by Ortony, Schallert, Reynolds, and Antos (1978) who found that comprehension of idiomatic phrases in contexts which demanded their idiomatic reading took no longer (in fact was often faster) than comprehension of the same phrases in contexts requiring a literal interpretation. Moreover, Gibbs (1980) found that paraphrase judgements were faster for the idiomatic than for the literal reading of an idiom irrespective of whether the idiomatic string had been preceded by appropriate preceding context, or no context. These results indicate that accessing the idiomatic lexical entry may be easier than accessing the multiple entries for the separate items in the string; which in turn suggest that there should in general be a bias to perceive idiomatic readings. This is indeed the case. Van Lancker and Canter (1981) had subjects record idioms in contexts which forced either literal interpretation or the idiomatic reading, then excised the relevant strings from context and played them to listeners in an attempt to determine whether the productions had included disambiguating acoustic information. They found that listeners could readily distinguish the idiomatic and literal interpretations one from the other when they were presented together; but when the productions were presented in isolation, listeners showed a strong preference for the idiomatic interpretation irrespective of the context from which the utterance had been taken. And in another unpublished study by Swinney and Cutler, carried out at Tufts University, phoneme-monitoring reaction time was measured to targets immediately following idiomatic phrases: in contexts which were biased towards the idiomatic interpretation of the phrase, no difference was found between the idiomatic and matched control phrases, but when the context was biased towards the literal interpretation, reaction time to targets following the potential idioms was somewhat longer than to targets following the unambiguous controls—indicating interference from competing access of the idiomatic reading.

This is not to say that when an idiomatic entry is available, no activation of the component words' literal meaning takes place; it does, as has been shown by another cross-modal priming study by Swinney (1981), in which words in an idiomatic string (e.g. 'kick the bucket') primed related words as they occurred ('hit' was primed as subjects heard 'kick', 'pail' was primed as they heard 'bucket'), as well as words related to the idiomatic meaning of the whole phrase ('die'). But as we would expect from all the evidence cited in this chapter, it is not the lexical access process itself which becomes more difficult—resulting in a reaction time decrement—but post-access decisions of one kind or another.

A further reflection of the unitary lexical status of idiomatic strings appears in the results of another unpublished study by Swinney and myself. We reasoned that if idioms are unitarily represented, then their syntactic structure (particularly for the more frozen idioms) is predictable. This fact might be then expected to be reflected in speech production processes. It is established, for example, that the relative strength of syntactic boundaries influences the amount of phrase-final lengthening which occurs immediately before a boundary, so that speakers produce a greater amount of lengthening before boundaries dominated by high nodes in the syntactic structure tree of an utterance than before boundaries dominated by lower nodes (Cooper, Paccia, and Lapointe, 1978). Thus we predicted that speakers would treat syntactic boundaries occurring within an idiom as less strong than the same boundaries occurring within the same phrase used in a non-idiomatic sense, and that this difference would result in less phrase-final lengthening before the boundary in the idiom than in the literal version. We chose seven idioms which could also be interpreted literally, and embedded each in two disambiguating paragraph contexts, one appropriate for the literal and the other for the idiomatic reading. An example is given in (21); the idiom 'let the cat out of the bag' contains an internal boundary before the prepositional phrase 'out of the bag'.

(21) a. We have to keep the animals apart while we're in the car or they might start fighting and distract the driver. So please be careful not to let the cat out of the bag. I'll keep the dog in this basket.
b. We want the party to be a complete surprise to her, and we'd be really upset if she found out. So please be careful not to let the cat out of the bag. I'll be responsible for getting her there on time.

Six speakers who were unaware of the purpose of the experiment recorded all fourteen paragraphs. The durations of the syllables preceding the syntactic boundary (in (21), the duration of 'cat' which preceded the prepositional phrase 'out of the bag') were measured with the aid of a waveform editing program. Table 2.6 presents the results. This difference was statistically significant ($F_1(1, 5) = 9.68$, $p < 0.03$) and thus provided support for the prediction that syntactic boundaries within idioms have less strength in speech production than boundaries within comparable non-idiomatic phrases.

Similar results were reported by van Lancker, Canter and Terbeek (1981), who also found that other phonological processes sensitive to syntactic boundary strength produced evidence that the same boundaries were weaker in an idiomatic than in a literal version* of a given phrase.

Finally, there is an interesting parallel between idioms and ambiguous words to be noted. Recall (from the section on *lexical ambiguity* above) that sentence classification time for sentences containing an ambiguous word is longer than for unambiguous sentences. This is also the case with sentences containing an idiom which could also have a literal interpretation; and idioms are also associated with longer reaction time for same-different meaning judgements on pairs of sentences (both results from Brannon, 1975). As we would expect on the basis of the earlier explanations, this was true only of idioms which could also be literal phrases. Idioms which had no literal sense ('in the know'), produced significantly *faster* reaction times in the sentence classification task than strings which could be either literal or idiomatic. Like ambiguous words, therefore, idioms can take longer to integrate into the

Table 2.6 Mean duration (msec) of syllable produced before a syntactic boundary in idiomatic and literal use of the same phrases

Average duration	
Idiom	Control
228	240

context of a whole sentence—as long as they allow more than one interpretation.

The idiom studies show that multi-word units can have holistic lexical representation. We should suspect that idioms are not the only such syntactically complex unit; for instance, compound nouns *(hotrod, garbage truck)* are similarly very likely to have unitary entries. The same goes for many familiar phrases ('How do you do?'). No relevant experimental evidence has as yet been collected on these types of phrase.

Verb subcategorization

Another possible case of syntactic complexity in the lexicon arises in the form of restrictions on syntactic contexts in which a word can occur, of which verbs provide the classic case: transitive versus intransitive, complementizing versus non-complementizing. Some verbs can take no object or complement: 'Bazza exists', but not 'Bazza exists a peanut', or 'Bazza exists that the peanut was rotten'. Others can take an object or not: 'Bazza eats'; 'Bazza eats a peanut'. Still others can take a complement or not: Bazza stated his name'; Bazza stated that the peanut was rotten'. Others must have a complement:' Bazza seems to be a peanut'. Others can have all three modes: 'Bazza believes'; 'Bazza believes me'; 'Bazza believes that the peanut is edible'. Is this kind of constraint incorporated in the lexical entries of verbs, and if so, does it affect the ease with which different kind of verbs are processed?

Fodor, Garrett, and Bever (1968) compared complementizing with non-complementizing verbs and found that sentences containing complementizing verbs were more difficult to paraphrase. Subjects also made more errors with sentences containing complementizing verbs on a task in which they had to rearrange shuffled sentences—although there was no difference between the two types of sentence with respect to time taken to complete rearrangement. Fodor *et al.* argued that lexical access reveals whether or not the verb can take a complement and proposed an on-line effect of this type of complexity of the following kind: if a verb allows more than one possible syntactic continuation (e.g. *believe),* then more hypotheses will be computed about the syntactic structure of the sentence than in the case of a syntactically simpler verb (e.g. *eat).* This was also argued by Bever (1970).

However, on the balance of the evidence it appears most likely that verb complexity does not exercise its effects on lexical access time. Hakes (1971) replicated Fodor *et al.*'s paraphrase results, but failed to find any effect at all of verb complexity on phoneme-monitoring reaction time. Hakes (1972a) again failed to find a phoneme-monitoring effect of verb structure, and also reported an unpublished result of Garrett and Chodorow, in which verb complexity had no effect on time to decide whether or not a given word had appeared in a sentence.

In line with our earlier arguments, we would therefore suspect that if no effect of verb complexity on lexical access time can be detected, then the added difficulty associated with complementizing verbs in the paraphrase and sentence rearrangement tasks must be due to post-access processes—integration of a complete sentence representation. Indeed, Chodorow (1979) reported that lists of words were recalled worse when recall was also required of sentences with indeterminate structure, in comparison with sentences with simple transitive verbs, or with complementizing verbs followed by the complementizer *that* (which resolves the ambiguity). Recall that lexical ambiguity was also associated with a performance decrement in this task. Thus the existence of more than one possible sentence interpretation seems to be a factor which causes processing difficulty; the locus of the difficulty is however not at the lexical access level, either—as argued earlier—in the case of lexical ambiguity or in the case of verb structure ambiguity. (Note that complementizing verbs did not produce a performance decrement when they were followed by *that*, only if the structure of the sentence was temporarily indeterminate. Not surprisingly, the performance deficit for complementizing verbs in the paraphrase task also disappeared when the explicit complementizer was included (Hakes, 1972b).)

Verb subcategorization thus appears to be yet another case in which variable amounts of lexically represented information do not have an effect on difficulty of lexical access *per se;* yet the same information can lead to multiple possible interpretations of a sentence becoming available, which in turn can result in added processing difficulty in a task requiring computation of and/or decision about the meaning of a sentence as a whole.

CONCLUSION

The purpose of this chapter was to consider all the various ways in which lexical representation of words could deviate from simplicity, and to determine whether it would be possible, despite the heterogeneity of the phenomena involved, to draw some generalization from the available evidence. This indeed proved possible, and two clear conclusions have emerged, namely that lexical representations are very rarely simple, but that the process of lexical access is not made easier or more difficult by the complexity of the contents of the lexical entry. In the first section it was shown, for instance, that processing an ambiguous word involves access to all its semantic representations. Similarly, access of the entry for a lexical negative provides the information that its meaning includes negation, and access of the lexical entry for a restrictive verb selects the set of concepts of which it can be predicated. An exception to the representation of semantic complexity in the lexicon, however, is the disputed case of semantic decomposition, which, it was argued, is not lexically represented at all; not only are decomposable words no harder to process in any way, they simply do not seem to be decomposed at any level of processing. In no case was any type of semantic complexity found to be associated with greater difficulty of lexical access, when all confounding factors were controlled.

In the second section it was seen that morphologically complex words are also no more difficult to access from the lexicon than morphologically simple words; but there was abundant evidence that the mental representations of words contain information about morphological structure, and that speakers draw on this information in creating new words. The third section showed that a single lexical entry can embrace more than one form class and even a phrasal unit, and that information about the complement structure of verbs is also lexically represented; again, none of these factors was found to cause lexical access to become more difficult.

On the other hand, it was shown that many types of lexical complexity can lead to greater processing difficulty just in the case that (a) the task taps the time to construct a representation of an entire sentence and/or to make a judgement about it, *and* (b) the effect of the lexically complex word is to enable more than one representation of the sentence to be acceptable. The locus of the processing difficulty is not, however, at the level at which the information is retrieved from the lexicon; it is at the level at which it is integrated into a representation of the sentence as a whole.

The chapter began with a reference to a lexically simple word, *wombat.* Let us now consider what the lexical representation of a complex word might be like. *Discount* is a word which is semantically ambiguous: it can mean 'deduction from price' or 'not take seriously, not consider'. It has more than one form class, with all meanings originally systematically related; but the verb-meaning 'deduct from price' is closer to the noun-meaning than is the verb-meaning 'not take seriously'. It is morphologically complex, consisting of a prefix plus stem. The prefix incorporates a representation of negation (see Figure 2.1).

Although *discount* can be stressed on either the first or second syllable, segmental quality remains the same (there is no vowel reduction), so that we can consider the string [diskaont] as a fair representation of all interpretations of the word. Stress varies with the speaker: some give the word initial stress in all readings; others give the noun initial stress and the verb final stress irrespective of meaning; still others give initial stress to the verb, as to the noun, in the 'deduct from price' reading ('they gave me a discount'; 'they discounted it for me'), but use final stress in the other verb reading ('We discounted the tobacco firm's lung cancer statistics'). I am one of the latter group; in my lexicon the price-deduction verb and noun are closely connected, with the 'not consider' verb separate.

Let us consider, then, that *discount* has three basic nodes (lexical entries), two of which are systematically related. Any of these nodes can be separately

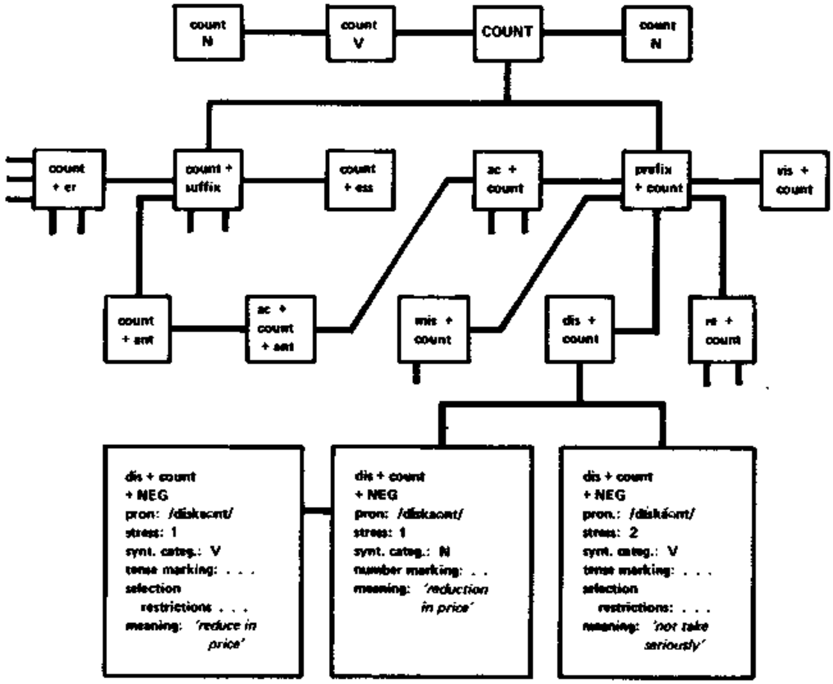

Figure 2.1 The lexical representation of *discount*

accessed; but if *discount* is heard with initial stress, of the two possible meanings to be activated the noun one will be first, the verb second (see *'Systematic ambiguity').* On the other hand, access of any node activates the others (see *'Lexical ambiguity'). Discount* can also be accessed via its stem, *count* (see *'Prefixed words');* this itself is a node of the conglomerate lexical entry for *count*, which is semantically and systematically ambiguous, having one noun reading ('nobleman') unrelated to the main verb meaning ('enumerate'), which itself has a closely associated noun ('enumeration'). Thus *count* has three major lexical nodes associated with it, plus a node for *count + prefix* and another for *count + suffix;* the former has a major branch for *dis-*, another for *ac-*, another for *mis-*, and a fourth which leads to *viscount;* the suffix node is connected to entries for *counter* (itself with half a dozen different readings), *countable, countess* etc.; the prefix and suffix nodes together dominate nodes for *accountant, uncountable*, etc. Entries for any kind of multi-word unit which includes *count (lose count; no-account; don't count your chickens)* will also be associated with the conglomerate. Semantic groupings include a separate cluster of *count* (nobleman), *countess,* and *viscount;* a major grouping of every word that has anything at all to do with the numeration meaning of *count* (including all the readings of *discount);* a 'negative' grouping comprising only the various readings of *discount* and *miscount,* etc. Within each node for *discount* there will be, at least, its sound representation and its meaning, a representation of its syntactic category, and any further refinements of this *(discount* the verb can only be transitive, for instance), how it should be inflected, its stress pattern, a negative marker. Besides all the structural connections within the lexical conglomerate, each word and semantic grouping will have associative connections with semantically related words, *rebate, disregard, number, baron, token,* or whatever.

In contrast, a word like *wombat* may have a number of associative connections *(emu, muddle-headed,* etc.), but no structural connections at all. It is clear, however, that the *wombats* are in the minority—there are many more words like *discount.* Lexical complexity is the norm. Under these circumstances, it is fortunate that lexical complexity does not in itself cause language processing difficulty.

NOTE

1. Under appropriate conditions phoneme-monitoring response time also provides a measure of the time required to understand the target-bearing word itself; see Cutler and Norris (1979) and Foss and Blank (1980) for further discussion of these issues. In all the phoneme-monitoring studies reported below, the target-bearing item followed the word on which the independent variable was manipulated.

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