METHODS & DESIGNS

Lexical ambiguity of words used in English text

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Lexical ambiguity is generally assumed to be widespread in natural languages but quantitative estimates have not been available. At least 32% of the words used in English text were found to be ambiguous in studies reported here. This figure is probably very conservative. Temporary word definitions established for special purposes occurred in 30% of a sample of texts.

This paper is concerned with lexical ambiguity, ambiguity that occurs when a word has more than one meaning. For example, in "The soldiers liked the port," the word port can refer to a wine or a harbor.

In the literature on language processing, it is widely assumed that natural languages are ambiguous (Garrett, 1970). Substantial amounts of theoretical and experimental work have been devoted to models of word and sentence processing to account for the resolution of lexical ambiguity. Apparently, no quantitative estimate of the amount of lexical ambiguity has been attempted.

Of particular interest is the frequency of ambiguity among words most commonly used in discourse. Rare words are less interesting. If a word is used rarely, it contributes little to the ambiguity encountered by language processors. About 41% of the words appearing in Kučera and Francis' (1967) word frequency count occurred only once in the million-word sample. All of these words combined constitute only 2% of the words used in English text.

If lexical ambiguity is extensive among words used in English text discourse, as has been generally assumed, then further investigation of processing mechanisms for resolving ambiguity may be warranted. If there is relatively little lexical ambiguity among the words commonly used in English text, then research attention might better be directed elsewhere. In this paper, lower bounds are determined for the amount of lexical ambiguity of words used in English text, two special types of ambiguity are described and quantified, and a refined method for quantifying the ambiguity of individual lexical units is presented.

STUDY 1

As a preliminary step, the ambiguity of a random sample of English words was determined.

Method

Word definitions in the *American Heritage Dictionary of the English Language* (1969) were examined. A sample of 12 page numbers was drawn by unsystematically choosing six numbers of three-digit lengths and six numbers consisting of four digits from a table of random numbers. Independently, the first or second column on each page was selected randomly. A total of 257 words comprised the final sample. Within the entry for each word, each meaning with a separate number was counted separately. Meanings marked regional, archaic, or slang, and abbreviations were excluded from the analysis.

In cases where the word was of two parts of speech listed under separate entries, meanings that were similar for the two were excluded.

Results and Discussion

Figure 1 shows the frequency of the various numbers of meanings for the 257 words. The distribution of meanings per word is markedly skewed. The number of meanings ranges from 1 to 30, and there is more than one meaning for 44% of the words.

A random sample of words is not representative of words commonly used in discourse, so the sample included many words that are rarely used in written or spoken discourse. Estimates of ambiguity based on such
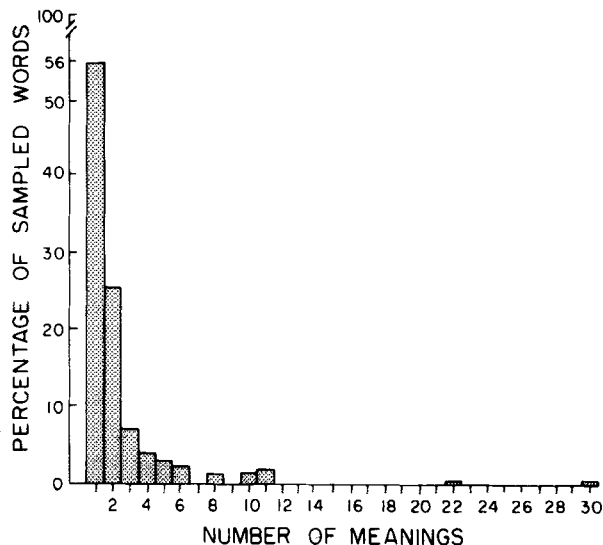

Figure 1. Distribution of number of dictionary meanings of a sample of English words.

a sample do not reflect the ambiguity encountered under natural conditions. More accurate estimates can be obtained by giving greater weight to words that are most commonly used in discourse.

STUDY 2

The 100 most frequent English words account for 47% of the words occurring in written English (Kučera & Francis, 1967). This is a substantial fraction of the words encountered by readers. In Study 2, the lexical ambiguity of these words was determined by consulting dictionary definitions.

Method

The American Heritage Dictionary of the English Language (1969) was consulted to determine the number of meanings listed for the 100 most frequent English words. Several of the words were not listed separately: For example, "is," "was," "be," "are," "were," and "been" were all listed under "be." For words of this type, the number of meanings of the primary word was tabulated. Similar meanings were excluded, using a conservative criterion tending to reduce the number of meanings. Otherwise, the procedures were the same as for Study 1.

Results and Discussion

Table 1 shows the number of meanings recorded for each word. Figure 2 shows the distribution of the number of meanings per word, which range from 1 to 31. The median is seven: 93% of the words have more than one meaning.

For each of the 100 most frequent words, Kučera and Francis (1967) report the absolute frequency. The 93 lexically ambiguous words account for 460,459 of the Kučera and Francis list of 1,014,232 words, or 45%. Assuming that the Kučera and Francis sample is representative of words used in English text, at least 45% of the words that occur in text have more than one dictionary meaning.

Using a dictionary to determine the number of meanings may lead to an overestimate of the amount of lexical ambiguity that readers encounter. The dictionary includes many meanings that are rarely used and may not even be known to the average reader. In addition, distinctions between dictionary meanings are often very fine, perhaps finer than those used by most readers. A more conservative estimate of lexical ambiguity can be made by excluding meanings that occur very rarely, and by combining meanings that are similar.

STUDY 3

Some meanings of a word are used more often than others. Lorge and Thorndike (1938) report a semantic frequency count of the frequency of occurrence of each of the meanings of all words appearing in a 5-million-word sample of English text. The distinctions between meanings were based on the *Oxford English Dictionary* (1937). If a particular meaning did not occur in the

Table 1
Number of Meanings of the 100 Most Frequent English Words

Frequency Rank	Word	Meanings Counted Study 2	Study 3	Parts of Speech Study 4	H Value Study 7
1	the	8	3	1	
2	of	18	8	1	2.96
3	and	4	2	1	1.20
4	to	21	9	3	
5	a	5	3	1	.36
6	in	13	8	2	
7	that	2	5	3	
8	is	8 (be)*	4 (be)	1	
9	was	8 (be)	4 (be)	1	
10	he	2	1	1	
11	for	28	8	1	2.95
12	it	8	2	1	.92
13	with	26	5	1	2.52
14	as	9	9	2	
15	his	2	1	1	
16	on	9	6	1	2.53
17	be	8	4	1	
18	at	13	5	1	2.47
19	by	13	6	2	
20	I	1	4 (me)	1	.82
21	this	5	2	2	
22	had	31 (have)	5 (have)	1	1.29
23	not	1	1	1	
24	are	8 (be)	4 (be)	1	
25	but	9	2	1	.59
26	from	9	2	1	1.23
27	or	3	2	1	.16
28	have	31	5	1	1.29
29	an	1	3 (a)	1	.36
30	they	3	1	1	
31	which	6	2	1	
32	one	7	5	1	2.24
33	you	4	1	1	
34	were	8 (be)	4 (be)	1	
35	her	3	1	1	
36	all	10	3	2	
37	she	3	2	1	.50
38	there	4	4	1	1.30
39	would	16 (will)	5 (will)	1	1.58
40	their	1	2	2	
41	we	4	1	1	
42	him	6	1 (he)	1	
43	been	8 (be)	4 (be)	1	
44	has	31 (have)	5 (have)	1	1.29
45	when	6	2	2	
46	who	3	3	1	
47	will	16	5	1	1.58
48	more	2	1	2	
49	no	3	1	2	
50	if	4	4	1	1.16
51	out	2	6	1	2.15
52	so	8	4	2	
53	said	1	2 (say)	1	.67
54	what	3	4	3	
55	up	17	7	2	
56	its	2	1	1	
57	about	8	3	2	
58	into	7	2	1	.92
59	than	3	1	1	
60	them	4	1	1	
61	can	7	3	2	
62	only	2	2	1	.80
63	other	7	2	1	

Table 1 Continued

Frequency Rank	Word	Meanings Counted		Parts of Speech Study 4	H Value Study 7
		Study 2	Study 3		
64	new	8	3	1	.76
65	some	4	2	2	
66	time	16	5	1	2.44
67	could	7 (can)	3 (can)	2	
68	these	5 (this)	2 (this)	2	
69	two	2	2†	1	
70	may	7	4	1	1.68
71	then	6	3	1	.97
72	do	16	8	1	2.23
73	first	5	2	2	
74	any	4	2	1	1.32
75	my	3	2	1	.57
76	now	7	2	2	
77	such	5	4	1	1.94
78	like	8	3	3	
79	our	1	1	1	
80	over	15	4	2	
81	man	15	6	2	
82	me	6	4	1	.82
83	even	14	2	2	
84	most	2	2	1	1.40
85	made	4	7 (make)	2	
86	after	15	5	3	
87	also	1	1	2	
88	did	16 (do)	8 (do)	1	2.23
89	many	2	2	1	1.19
90	before	9	2	3	
91	must	6	2	1	.67
92	**F				
93	through	9	4	2	
94	back	31	7	3	
95	years	9	3	1	.95
96	where	4	2	1	.75
97	much	2	6	2	
98	your	4	1	1	
99	way	17	6	1	1.80
100	well	12	5	2	
101	down	15	4	3	

Note—Words and frequency ranks were taken from Kučera and Francis (1967). In their table, the 92nd rank is occupied by nonword formulas. This rank was not considered in the analyses reported here. The 92nd rank was replaced by the word ranked 101 by Kučera and Francis. Because the nonword formulas were excluded, this table included the 100 most frequent words. The numbers of meanings counted for words in Study 2 were taken from the American Heritage Dictionary of the English Language; those for Study 3, and the numbers of parts of speech for words in Study 4, were taken from West (1953).
*Words in parentheses indicate the word listed in the second column did not appear as a separate entry in the dictionary. The word in parentheses is the word for which the number of meanings was recorded.
†The word "two" was not listed by West (1953). The number of meanings and number of parts of speech shown here were taken from the American Heritage Dictionary listing.

sample, it was excluded from further analyses. This is the first of several sources of conservative bias in the estimates of lexical ambiguity to be presented here.

Lorge and Thorndike's (1938) data were used by West (1953) in preparing a semantic frequency count, in which the fine distinctions between meanings used in

the *Oxford English Dictionary* were "grouped more coarsely" (West, 1953, p. vii). This was done by combining word meanings judged to be similar (West, 1953, p. xiii). West excluded meanings that occurred with very low frequency.

In making the count reported here, I excluded meanings that are idiomatic in the sense that the meaning depends on the word's appearance in a stereotyped phrase. The reason for this exclusion is that when the rest of the stereotyped phrase is present, the word is not ambiguous; when the phrase is not present, the idiomatic meaning does not come into play. These procedures should assure a relatively conservative estimate of the lexical ambiguity of the 100 most frequent English words.

Method

The 100 most frequent English words reported by Kučera and Francis (1967) were identified by West (1953), and the number of separate meanings for each word was tabulated. Idiomatic meanings were excluded. Some words were listed under other words; in these cases the number of meanings of the primary word was tabulated. Some examples of West's entries may be useful to convey the flavor of this little-known document. The word "by" is the 19th most frequent word in English text and is about .5% of the words that appear in English text (Kučera & Francis, 1967). The entry from West (1953) is shown in Table 2, along with the entries for "the" and "down," the most frequent and 100th most frequent words.

The first column lists the word and its parts of speech. The second column lists the meanings, numbered consecutively, with similar meanings given the same number but lettered consecutively. In the counts reported here, similar meanings were excluded. In the third column, examples of the usage are provided. In the fourth column, the percent of occurrences of each meaning is listed. These were not calculated by Lorge and Thorndike (1938) for "the."

Results and Discussion

Table 1 shows the number of meanings for each word. Figure 3 shows the frequency of the various numbers of meanings. The distribution is markedly less skewed than Figures 1 and 2. The number of meanings ranges from one to nine. The median is three, and there is more than one meaning for 85% of the words.
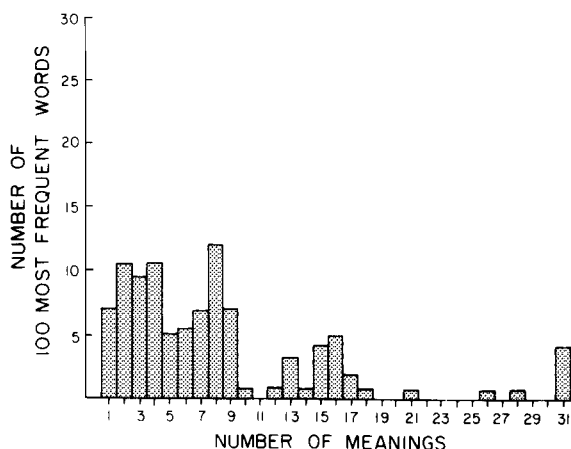

Figure 2. Distribution of number of dictionary meanings of the 100 most frequent English words.

Table 2
Typical Entries From West (1953)

Word	Part of Speech	Meaning	Examples of Usage	Occurrence*
By	Preposition	1a position near	Stand by his side; close by; I always keep some by me (=in store).	
		1b motion near	Pass by your window; passed him by.	5.6
		2 before	Do it by Wednesday.	1.3
		3 during	By day; by night.	.4
		4 as a measure	Paid by the hour; moved by inches; little by little; strawberries by the handful; six feet long by four feet wide; better by far.	6.0
		5a instrument	All due by kindness; worked by electricity; done by mirrors; French by birth; lead by the hand; see by your face; know you by your laugh; tell by looking at you; send it by rail; multiply by 10; live by writing.	
		5b instrument or cause	By reason of his ill temper, he lost the position.	31.5
		6 agent	Done by his agent; written by Shakespeare; proved by time.	48.0
	Adverb		Stand by! A house nearby; I saw him pass by.	.8
The	Definite Article	1a denoting some particular person or thing; "you know the one I mean"	The man standing there (whom we saw yesterday, etc.).	
		1b denoting some well known person or thing	The sun; the king.	**
		2 used emphatically	The man for the job.	
		3 used of a class, equivalent to a plural.	The horse is an animal (=horses are animals).	
Down	Adverb and Preposition	1 to or in a lower position	Let down (the cliff) on a rope; mud carried down by the river; sit down, lie down, put down; the tide is down.	54.0
		2 idea of illness or defeat	We are 14 points down in the game; down with influenza.	24.0
		3 idea of lowness as on a list or scale	From the richest down to the poorest; prices marked down; down to the present day.	8.0
		4 idea of decrease of size or activity	Grind down; wear down; calm down; die down.	3.0
	Adjective		The down train.	6.0

*Percent of occurrence with given meaning.
**Not calculated.

The 85 ambiguous words account for 434,100 of the million or so words, or 43%. Thus, at least 43% of the words in English text are lexically ambiguous, even when quite conservative procedures are used to determine whether a word has more than one meaning.

It may be argued that some lexical ambiguity can be resolved by certain grammatical mechanisms. It is possible to refine the estimate to take this possibility into account.

STUDY 4

Some of the 100 most frequent words have meanings in two or more different parts of speech. In these cases, the sentence frame in which the word appears might allow the reader to exclude one part of speech because of grammatical constraints, and all the meanings associated with that part of speech could be ignored, assuming that the grammatical constraints operated prior to semantic ones.

For words with more than one part of speech, part or all of the ambiguity might be resolved by grammatical
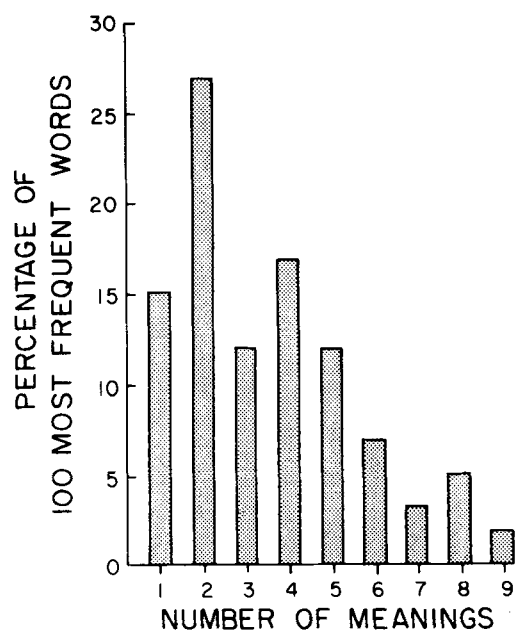

Figure 3. Distribution of number of meanings of the 100 most frequent English words with rare and idiomatic meanings excluded and similar meanings combined.

calculations, without recourse to semantics. For ambiguous words with only one part of speech, grammatical considerations of this type cannot be used to resolve the ambiguity. In Study 4 the number of parts of speech of each word was determined.

Method

For each of the 100 most frequent words, the number of parts of speech was determined by consulting West (1953). The resulting data were entered into Table 1.

Results and Discussion

Table 3 shows the proportions of the 100 most frequent words in the various categories. For words with multiple meanings and only one part of speech, the ambiguity cannot be resolved even partially by determining the part of speech. For these words, ambiguity must be resolved semantically or by separate grammatical means. These constitute 32% of the words used in English text and this figure is the lowest estimate of amount of lexical ambiguity. This is an appreciable fraction of the words that language processors encounter.

Words with only one meaning and one part of speech are not lexically ambiguous. These constitute at least 4% of the words used in English text, an appreciable fraction of the words encountered by readers.

For words with one meaning but more than one part of speech, ambiguity is grammatical, that is, the part of speech of the word is uncertain. These constitute less than 1% of the language.

STUDY 5

Whenever a pronoun occurs, the reader must supply the referent if it is to be understood correctly. Pronouns thus constitute a class of words that are essentially ambiguous. In Study 5 a lower bound for the frequency of this type of ambiguity was determined.

Method

The frequency of occurrence of the 15 pronouns represented among the 100 most frequent words was determined from Kučera and Francis (1967).

Results and Discussion

Pronouns constitute 56,748 of the words in Kučera and Francis' (1967) sample, or some 6% of English text.

Table 3
Proportions of 100 Most Frequent Words With One or
More Than One Meanings or Parts of Speech

Number of Parts of Speech	Number of Meanings			
	One		More Than One	
One	12	(4%)	54	(32%)
More Than One	3	(1%)	31	(12%)

Note—Percentages indicate proportion of words used in English text constituted by these words.

Pronouns provide a situation where the "context," which is so often implicated in discussions of the resolution of ambiguity, is unitary (the referent) and is limited to a particular verbal unit whose location in time and space is known. Presumably, the mental operations involved in remembering a definite referent can be brought under experimental scrutiny easily, because the referent can be precisely specified and controlled.

STUDY 6

Quite apart from the meanings specified in dictionaries, authors and speakers often define special or restricted meanings for important words on the occasion of their first occurrence in a passage. When this occurs, the reader or listener is expected to recover the previously specified meaning if the word occurs again later. In Study 6 the frequency in English prose of this form of lexical ambiguity was determined.

Method

A sample of English prose was selected from the list of non-fiction documents provided by Kučera and Francis (1967). The list is a representative sample of English prose used in their analyses. A total of 26 documents were specified by Kučera and Francis (1967), with sufficient bibliographic information to enable an individual to locate them in a library. Of these only 16 were obtainable at the University of Iowa and in local libraries in Iowa City, Iowa. These were examined for exemplars of special purpose definitions according to two criteria: (1) The word was defined by the document's author in a special or restricted sense that differed from any of the meanings provided in the *American Heritage Dictionary of the English Language* (1969); and (2) the term was used repeatedly later in the passage in the special or restricted sense. I made the first judgments. Then, Professor James V. Hinrichs of the Department of Psychology at the University of Iowa made independent judgments for each document. The results include only those exemplars on which both judges agreed.

Results and Discussion

Among the 16 documents, 5 contained clear exemplars of special purpose definitions (Ashford, 1961; Driver, 1961; Fulbright, 1961; Miller, 1961; Vedder, 1965). The characteristics of these can best be expressed by example. In Fulbright (1961), the term "community" is defined as "a feeling and deep conviction of shared values and interests, a feeling that effective communication is possible, a feeling of trust and confidence in each other's purpose" (p. 3-4), and later used repeatedly in that sense, "such a community," "a genuine community," "a limited community," and so on.

In Ashford (1961) the term "commune" is defined in the third sentence of the article as "the basic unit of local reform." This definition does not appear in the dictionary; in fact, it is quite remote from any of the dictionary meanings. The first later use of the term is "Preparations for elections began slightly more than a year after independence with the first steps to organize rural communes" (p. 2). Since none of the dictionary

definitions make reference to elections in relation to communes, a reader who used only a dictionary definition would have difficulty understanding the relation between elections and communes. The meaning would be clear to a reader who remembered the special purpose definition of "commune."

About 30% of the documents examined in this study contained exemplars of special purpose definitions. It appears that such definitions are relatively common in English text. Informal observations suggest that readers are able to cope with them without difficulty.

The import of Studies 5 and 6 is that word meanings need not be permanently engraved into semantic memory in order to function effectively in language processing. Temporary word meanings are routinely established to function during · small segments of a passage, as in the case of pronouns, or for larger units of text including whole passages. The relative ease with which such temporary meanings can be established, utilized, and abandoned suggests that semantic memory and the associated processing mechanisms may be more flexible and labile than present conceptions imply.

STUDY 7

The measure of lexical ambiguity used in the preceding studies was the number of meanings. In Study 7 a more refined measure is proposed that takes into account the frequency of the different meanings.

This measure is $H = -p_i \log_2 P_i$, the Shannon-Wiener measure of average uncertainty of information (Attneave, 1959). As applied to word meanings, it is a measure of semantic uncertainty. To apply this measure, it is necessary to know the probability (P_i) of the different alternative outcomes in a situation. This information was provided for word meanings by West (1953).

Method

Of the 100 most frequent words, 12 are not lexically or grammatically ambiguous and 3 are grammatically but not lexically ambiguous. These words, constituting 5% of the words used in English text, have no semantic uncertainty: $H = 0$.

Of the remaining 85 words, 31 have more than one meaning and some semantic uncertainty, but they also are of more than one part of speech, and are thus grammatically ambiguous as well. The relative contributions of semantic and grammatical features to the uncertainty of words are beyond the scope of this paper, and these words were not considered further.

There remain the 54 words that have more than one meaning but only one part of speech; these constitute about 32% of the words used in English text. Of these, the frequencies of the different meanings are not listed by West (1953) for the words "the," "who," "which," "other," "two," and "be" and the forms of "be": "is," "are," "was," "were," and "been." These constitute 11% of the words used in English, leaving 21% for the remaining 42 words.

For each of these 42 words, the frequency of the different meanings was determined from West (1953). In most cases the frequencies reported (as percentages) by West did not sum to 100%. The missing information represented the meanings that had been excluded by Lorge and Thorndike (1938), or by West,

as too rare. The logic of H requires that the probabilities sum to 1. Therefore, the residual percentage was calculated and added as a single additional meaning. For each word, the H value was computed using tables of $-p_i \log_2 P_i$ (Alluisi, 1965).

Results and Discussion

Figure 4 shows the distribution of H values for the 42 words considered in this analysis. For comparison, the letters a through h are placed below the scale, representing the H value of a hypothetical word with only one meaning (a), two equiprobable meanings (b), three equiprobable meanings (c), and so on, up to a word with eight equiprobable meanings (h). The median H value of the 42 words is 1.23.

GENERAL DISCUSSION

At least 32% of the words that occur in English text are lexically ambiguous by the conservative criteria used in Study 4. This estimate is an extreme lower bound for the amount of lexical ambiguity in English text, because only 54 of the 100 most frequent English words are considered. Inclusion of the remaining 200,000 or so words would contribute additional ambiguity. So an appreciable fraction of the words used in English text are ambiguous.

Nevertheless, it could be argued that lexical ambiguity is relatively unimportant in text processing. One argument is that lexical ambiguities are resolved by prior context before the ambiguous word occurs, so that only one of the meanings is activated. But Foss and Jenkins (1973) found that ambiguity influenced processing even when a disambiguating prior context was present. Also, even if prior context did exclude one meaning, more than one meaning may be left; as Study 3 shows, most ambiguous words have three or more meanings.

Another argument is that grammatical ambiguity is more common than lexical ambiguity. Without a quantitative estimate of the amount of grammatical ambiguity, this argument is difficult to justify.

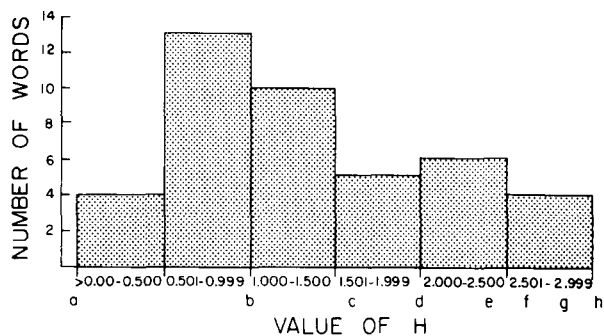With respect to the relative importance of lexical

Figure 4. Distribution of semantic uncertainty or information value for the 100 most frequent English words (exclusions described in text).

and grammatical ambiguity, consider the outcomes of the six experiments in which both lexical and grammatical ambiguities were presented to subjects (Bever, Garrett, & Hurtig, 1973; Foss, 1970; Foss, Bever, & Silver, 1968; MacKay, 1966; MacKay & Bever, 1967; Mistler-Lachman, 1972). All but one found effects for both lexical and grammatical ambiguities (Bever et al., 1973; cf. Hogoboam & Perfetti, 1975). These results do not support the hypothesis that grammatical ambiguities are more important than lexical ambiguities.

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