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How Many Meanings Does a Word Have? Meaning Estimation in Chinese and English

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Abstract

This chapter explores the psychological basis of lexical ambiguity. We compare three ways of meaning calculation, including meanings listed in dictionaries, meanings provided by human subjects, and meanings analyzed by a linguistic theory. Two experiments were conducted using both Chinese and English data. The results suggest that while the numbers of meanings obtained by different methods are significantly different from one another, they are also significantly correlated. Different ways of meaning calculation produce distinct numbers of meanings, though on a relative scale, words with more meanings tend to have greater numbers of meanings throughout. Dictionary meanings are to be distinguished from meanings obtained from subjects both in content and in

numbers. These results are then discussed with regard to their methodological implications for further research on psycho-semantics and semantic change.[1]

1. Introduction.

In human language, words and meanings do not always form one-to-one correspondences. The majority of the human lexicon is, in fact, extensively associated with multiple meanings — what we refer to as *lexical ambiguity*.[2] A word like *board* means both a flat piece of wood, and a group of people who manage something together. Homophones such as *board* and *bored* can be confusing when spoken in isolation. The multiple meanings associated with a word can be etymologically associated, but language users do not necessarily have such knowledge. Another mismatch between words and meanings is *synonymy*, where several words mean roughly the same thing. For example, *like*, *favor*, *admire*, *enjoy*, and *love* are synonyms meaning having preference.[3] The associations between meanings and words are thus many-to-many in nature. A word has many meanings, and many words can mean the same thing.

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[1] We are grateful for the research grant 9010001 from City University of Hong Kong to the first author during his visiting scholarship, and to the National Science Council of Taiwan for a research grant to the second author (NSC88-2411-H-002-051-M8). We also thank the audience at the First Workshop on Language Acquisition, Change, and Evolution in 2001 for valuable discussions. We are thankful to Tamiko Azuma for providing the English raw numbers of meanings, making the comparison between Chinese and English data possible. All remaining errors are our own.

[2] Britton (1978) estimated 32% of the words in English texts to be ambiguous. Huang (1994) surveyed the first thousand pages of entries from *Longman Dictionary of Contemporary English* and found 39% of the entries polysemic; the average number of senses of these words is 3.02. Hue, Yen, Just, and Carpenter (1994) estimated 11.43% of the Chinese words in a dictionary to be ambiguous.

[3] They are also called *near synonyms*, if we take the position that no two words can be taken to mean exactly the same thing.

If we see words as boxes and meaning as the contents, then it is easy to understand the relation between words and meaning in the evolution of language. On the one hand, we do not want too many boxes because they occupy a lot of space for storage. On the other hand, we do not want to put too many different things in one box because this would make it difficult to find an item. There is thus this tension between using the same linguistic symbol for different meanings (for *economy*'s sake) and using distinct symbols for different concepts (for *clarity*'s sake). The cost of economy is confusion; the cost of clarity is excessive burden on memory and processing. In the history of a language, a word tends to develop meanings and undergo semantic developments, so that it is sufficiently utilized in the mental lexicon. Well-attested semantic developments include metaphorization and grammaticalization (e.g. Traugott and Dasher, 2001). However, not too many unrelated meanings are allowed to associate with one single word; otherwise, it would be difficult to communicate without having to repetitively request further clarification.[4]

This article is concerned with the methodological issues concerning the numbers of meanings associated with words. Psycholinguistic studies have been interested in how the semantic ambiguity of a word affects its processing both in isolation (e.g. Azuma and Van Orden, 1997; Rodd, Gaskell and Marslen-Wilson, 2002) and in sentences (e.g. Onifer and Swinney, 1981). A critical issue when doing such research is to determine the number of meanings a word has, and the kind of ambiguity this word demonstrates. As outlined above, a word's number of meanings is usually confounded with several factors. A word can have many meanings that are closely related to one another. Another word can

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4 There are two possibilities for unrelated meanings to be associated with one lexical item. It could be accidental; two different words somehow got pronounced the same way and then further spelled the same way. It could also be a distant development of the core sense, the relation of which might be hard to establish out of that context especially when the successive intermediate stages are no longer available.

have a few distinct senses. Which word is more ambiguous? Lexical ambiguity is itself an ambiguous notion. In this paper, we compare three approaches that researchers have adopted to determine the numbers of word meanings — meanings listed in standard dictionaries, meanings produced by language users, and meanings processed by lexical semantic theory. Through the present investigation, we wish to provide future studies of lexical semantics, psycholinguistics, and natural language processing with the nature and limitations of different ways of semantic representation, and the compatibility among them. Section 2 of this chapter introduces these different ways of meaning calculation. Section 3 presents an experiment comparing meaning metrics of Chinese nouns using these different methods. Section 4 presents a similar experiment on English words as a cross-linguistic confirmation. Section 5 discusses the implications of the results and concludes.

2. Meanings in Dictionaries, in Language Users, and in a Semantic Theory

To a psycholinguist, the goal of a semantic representation is to reflect how the meanings of a word are represented in the human mind. One way of testing these representations is to examine how meanings are accessed in isolated words or in sentential contexts. To show the diverse ways of meaning calculation and their effects, we take as an example the paradigm of ambiguity advantage in isolated word recognition.

Since the 1970s, there has been continuing interest in ambiguity effect and lexical access. The effect of *ambiguity advantage* has been reported, stating that words with greater numbers of meanings are recognized faster than words with few meanings. How these researchers determined a word's number of meanings is the issue we will focus on here. Some researchers consulted dictionaries (Gernsbacher, 1984; Jastrzembski, 1981; Jastrzembski and Stanners, 1975; Rodd et al., 2002); some asked language users to decide

whether a word is ambiguous or not (Borowsky and Masson, 1996; Hino and Lupker, 1996; Kellas, Ferraro and Simpson, 1988); some collected definitions from language users (Azuma and Van Orden, 1997; Millis and Button, 1989); some used linguistic definitions to determine the numbers of different meanings language users provided (Lin, 1999; Lin and Ahrens, 2000). These researchers found conflicting results as to whether ambiguity advantage exists. A reasonable question to ask is whether the meanings from these different sources are compatible if we want to compare the results of different research. We will now consider *dictionary meanings*, meanings provided by language users (i.e. *semantic intuition*), and meanings determined by consulting a linguistic theory (i.e. *linguistic senses*) in turn.

2.1 Dictionary meanings

Psycholinguistic research in the 70s and 80s usually used dictionaries as the source of a word's number of meanings (e.g. Gernsbacher, 1984; Jastrzembski, 1981; Jastrzembski and Stanners, 1975). These researchers checked their materials in published dictionaries for meaning enumeration. Till recently, dictionaries are still important references. For example, Azuma and Van Orden (1997) matched the meanings they collected from language users to those listed in a dictionary; Rodd et al. (2002) consulted the on-line *Wordsmyth English Dictionary-Thesaurus* to decide a word's ambiguity.

Dictionary meanings are favored by researchers because they are standardized, comprehensive, and easy to obtain. The use of dictionary meanings in experiments, however, has its limitations. First of all, researchers consult different dictionaries, which inevitably have distinct editing styles and meaning presentations.[5]

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[5] For instance, Jastrzembski and Stanners (1975) used Random House Dictionary of the English Language, Unabridged (1967). Jastrzembski (1981)

To name a few editorial differences in different dictionaries, some dictionaries list distinct meanings as separate lexical entries; others tend to group them under one entry. Some dictionaries treat meaning extensions under one semantic entry; others put them in separate entries. The line to separate closely related meanings is hard to draw. Different dictionaries inevitably make different decisions concerning these finer semantic distinctions. Therefore, researchers referring to different dictionaries would come up with different numbers of meanings for the same sets of words. Second, dictionaries are designed for language users' reference, thus representing the "standard" uses of the lexicons some time ago. The definitions, hence, include archaic ones and lack the novel meanings that are emerging. Gernsbacher (1984) found in an informal survey that even well-educated subjects such as college professors could report only a small portion of the meanings actually listed in a dictionary.[6] Our own survey of ten college students also showed that subjects frequently provided meanings that are quite different from dictionary definitions. Sometimes these meanings have such a high frequency that they should be considered well-established; however, they are not yet listed in the dictionary. For instance, the word *xiaodi* 'little brother' in Chinese has two meanings listed in *Gwoyeuryhbaw Dictionary* (國語日報辭典) (1989): (a) the youngest brother, and (b) a modest term for oneself. A survey of 10 students provided four meanings: (a) a young boy — 9, (b) a waiter — 7, (c) a person at a lower rank — 4, and (d) a modest term for oneself — 2. (The numbers following each definition represent the numbers of subjects who provided such a meaning.) Meanings such as 'a waiter' and 'a person at a lower rank', though not found in a dictionary, were even more frequently provided by the subjects than the dictionary meaning 'a modest term for oneself'. Novel senses or

used Webster's Third New International Dictionary, Unabridged (1976). Gernsbacher (1984) used Webster's New World Dictionary, Unabridged (1976). Azuma and Van Orden (1997) consulted Webster's New World Dictionary (1980). And Rodd et al. (2002) used Wordsmyth English Dictionary-Thesaurus (1998).

6 For the word *gauge*, which has 30 dictionary meanings, several college professors provided only 2 meanings in Gernsbacher's (1984) survey.

emerging slang uses of a word that are not included in standard dictionaries may nonetheless be very important in a native speaker's knowledge of a word. There is an overt gap between dictionary meanings and the semantic knowledge subjects actually possess.

2.2 Semantic intuition.

The problems with dictionary meanings led researchers to turn to the production of meanings by language users. It is a reasonable move, since it is the semantic knowledge of language users that we are interested in. Millis and Button (1989) called this *accessible polysemy* — the number of different meanings that subjects are able to think of for a word. These meanings may be a subset of the meanings that a language user actually has, since there may be other meanings that are recognizable to a subject that he/she does not think of upon seeing the stimuli. However, the insufficiency can be compensated by collecting data from many people. We call these meanings collected from subjects the *semantic intuition* of language users. Millis and Button (1989) elicited three different kinds of accessible polysemy — first meanings, total numbers of meanings, and average numbers of meanings.

First-meaning metric refers to the collection of the first meanings subjects think of for a word in a meaning generation task. This method, used by Rubenstein et al. (1970), Rubenstein et al. (1971), and Forster and Bednall (1976), has limitations. The first meanings subjects think of are the most dominant meanings. Since meanings other than the primary ones are overlooked, this method does not adequately represent the knowledge a subject has for a word. Millis and Button's (1989) experiment also showed that lexical decision tasks using the first meanings did not produce the effect of ambiguity advantage. They are, therefore, not an appropriate choice to access people's overall semantic knowledge.

Both total meanings and the average numbers of meanings are collected by asking subjects to write down all the meanings they think of for a word without time limit. Then, researchers determine

the numbers of different meanings. A total-meaning metric is the total numbers of different meanings subjects provide for a word; an average-meaning metric is the average numbers of different meanings each subject provides for each word. Total and average meaning metrics are two psychologically real estimations of people's accessible polysemy, since Millis and Button (1989) found ambiguity advantage using both metrics.[7]

In addition to the three metrics to estimate polysemy, some researchers simply asked their subjects to decide whether a word is ambiguous or not (Kellas et al., 1988; Borowsky and Masson, 1996; Hino and Lupker, 1996). Subjects are asked to circle whether a word has no meaning, one meaning, or more than one meaning. The limitations of this method are that (1) in making a decision among the three choices, subjects may not have thought over the stimuli sufficiently enough — at least not as sufficiently as when asked to provide meanings, (2) the criteria subjects use in making such a decision are unknown, and (3) words that have more than one meaning could vary greatly in the numbers of meanings; simply asking the subjects to make a multiple choice overlooks the differences among words with many meanings. In summary, we consider asking subjects to provide *all* the meanings they could think of for a word comes closest to their semantic knowledge of the words.

2.3 Linguistic senses.

Calculation of a word's number of meanings does not end at meaning generation by subjects. Among the meanings subjects generate, how do we decide which meanings are distinct, and which meanings are the same? Lin (1999) provides an alternative to deal with the delimitation problem. He stresses the importance of

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[7] Azuma and Van Orden (1997) and Lin (1999) both adopted the total-meaning metrics in their experiments.

linguistic knowledge in delimiting word meanings, and argues for sense delimitation based on a lexical semantic theory proposed by Ahrens et al. (1998). This theory distinguishes two levels of meaning representation among Chinese nominals: senses and meaning facets. The properties of senses and meaning facets can be distinguished based on (a) the conceptual domains involved, (b) the productivity and predictability of meaning relations, and (c) the linguistic context.

The *senses* of a word have the following properties: (a) a sense is not an instance of metonymic or meronymic extension, but may be an instance of metaphorical extension;[8] (b) the extension links between two senses cannot be inherited by a class of nouns; (c) senses cannot appear in the same context (unless the complexity is triggered). A *meaning facet*, as "an extension from a particular sense" (ibid: 53), has the following properties: (a) they are instances of metonymic or meronymic extension; (b) nouns of the same semantic classes will have similar extension links to related meaning facets; (c) they can appear in the same context as other meaning facets.

Therefore, two meanings are distinct senses, when they involve different conceptual domains, and when they occur primarily in distinct linguistic contexts. When the relation between two meanings

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[8] This theory captures the essential differences between metonymic and metaphorical extensions. Metonymic relations are within the meaning facet level because they are productive, predictable, and context-dependent. Metaphorical extensions are seen as relations among different word senses, because of the different conceptual domains involved. Meronymic and metonymic extensions are two main ways of deriving meaning facets. Meronymic extensions involve part/whole relations, by which part stands for whole or whole stands for part. Metonymic extensions include: (1) agentivization: from information media to information creator; (2) product instantiation: from institution to product; (3) grinding: from individual to mass; (4) portioning: from information media to information, from container to containee, from body part to function; (5) space mark-up: from landmark to space in vicinity, from structure to aperture, from institution to locus; (6) time mark-up: from event to temporal period, from object to process, from locus to duration (Ahrens et al., 1998: 57).

is productively found among words of the same semantic class, these meanings are treated as meaning facets, which could be derived by inheritance rules. This makes the representation and processing of lexical semantics economical and efficient, since only the semantic information that cannot be derived by rules are listed as distinct semantic entries (i.e. senses). To illustrate how this theory is put into practice, we take *huoguo* (火鍋) as an example. Subjects provided two senses and two meaning facets under the first sense. The meanings of *huoguo* are represented in (1).

(1) HUOGUO

— $Sense_1$: a pot cooking on the fire
  — $Meaning\ facet_1$: physical object, hot pot, the container

— $Meaning\ facet_2$: the food contained in the hot pot
  — $Sense_2$: a blocked shot, a term in basketball games

The two senses of *huoguo* involve different conceptual domains — one in food, the other in sports. They can hardly occur in the same linguistic context. However, the two meaning facets of the first sense are both in the food domain, and can co-occur in sentences like *zuowan de huoguo hen bucuo* 'the hot pot last night was not bad'. In the following, we will use the definition of senses as the linguistic meanings

3. Experiment 1: Comparing Different Meaning Measurements in Chinese

In this section, the numbers of meanings derived from different measures are tested statistically. The numbers of meanings of 200 disyllabic Chinese nouns listed in three dictionaries, the raw meanings subjects provided, and the linguistic senses processed by a linguistic theory are compared.

3.1 Experiment 1a: Dictionary numbers of meanings.

Experiment 1a compares the meanings listed in three Chinese dictionaries, including *Gwoyeuryhbaw Dictionary* (GD) 國語日報辭典 (1989), *Revised Chinese Dictionary* (RCD) 重編國語辭典 (1997), and *The Warmth Modern Chinese-English Dictionary* (WCED) 旺文現代漢英辭典 (1997). A Chinese-English dictionary is used to see whether the cross-linguistic way of defining meaning leads to similar or different results.

3.1.1 Materials and procedures.

Two hundred disyllabic Chinese nouns were selected from *The Most Frequent Nouns in Journal Chinese and Their Classification: Corpus-Based Research Series No. 4*, published by Chinese Knowledge Information Processing Group (CKIP, 1993). These nouns were selected with an eye to including 100 potentially ambiguous nouns and 100 potentially unambiguous nouns.[9] These 200 words were checked for their number of meanings listed in the three dictionaries. The experimenter did not make any subjective judgments; the calculation of meanings was completely based on the numbers enumerated in the dictionaries.

3.1.2 Results.

Not all the items were found in all dictionaries. Forty-nine of the items were missing in GD, 9 in RCD, and 23 in WCED. The whole list of the stimulus items and the number of meanings in the dictionaries are given in the first four columns of Appendix 1. Paired-samples *t*-tests show that the number of meanings listed in

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9 The inclusion of approximately half ambiguous and half unambiguous nouns was due to further use of these data in on-line lexical decision experiments. Those experiments were designed to examine effect of ambiguity advantage, semantic relatedness, and relative meaning frequency. For details, refer to Lin (1999) and Lin and Ahrens (2000).

these three dictionaries are significantly different from one another at the level of 0.01 (GD-RCD: $t(150) = -5.46$, RCD-WCED: $t(176) = 8.33$, GD-WCED: $t(141) = 3.68$). Different dictionaries provide very different numbers of meanings for a list of words. Further investigation into the correlation among the dictionary meanings shows that these numbers of meanings listed in different dictionaries are significantly correlated ($p < .01$). The correlation is at least above 0.38. Table 1 gives the correlation matrix among the dictionary numbers of meanings.

Table 1. Correlation matrix among the dictionary numbers of meanings

	GD	RCD	WCED
GD	1.000		
RCD	0.378*	1.000	
WCED	0.568*	0.606*	1.000

* $p < .01$

Note: GD = *Gwoyeuryhbaw Dictionary* (1989) 國語日報辭典;
RCD = *Revised Chinese Dictionary* (1997) 重編國語辭典;
WCED = *The Warmth Modern Chinese-English Dictionary* (1997) 旺文現代漢英辭典

The results suggest that different dictionaries produce different numbers of meanings for the same words, even though relatively speaking, the words with more meanings in one dictionary also have more meanings in another.

3.2 Experiment 1b: Semantic intuition and linguistic senses.

This experiment collected meanings from subjects. With the meanings subjects provided, we came up with three types of meanings — subjects' raw numbers of meanings (i.e. semantic intuition), average numbers of linguistic senses, and total numbers of linguistic senses. Subjects' raw numbers of meanings are the

average numbers of meanings each subject provided for each word. These raw numbers of meanings represent language users' intuition about what the meanings of a word are. As outlined in Section 1, subjects' average and total numbers of linguistic senses are the meanings generated by subjects and then analyzed by the definition of linguistic senses. The results will further be compared with the dictionary meanings in Experiment 1a.

3.2.1 Subjects.

Two hundred undergraduates (126 females, 74 males) from National Chengchi University participated in the meaning generation task. All the subjects were native speakers of Mandarin who were exposed to both and only Mandarin and Taiwan Southern Min before the age of seven. All of the subjects rated their general proficiency of Mandarin above 5 in a 7-point scale.

3.2.2 Materials and procedures.

The stimulus items are the same as the two hundred disyllabic Chinese nouns used in Experiment 1a. These items were randomly assigned to ten booklets. Each item list in each booklet was organized in two random orders. Subjects were randomly given a booklet containing a set of instructions, a list of 20 words, and answer sheets. They were asked to write down all the meanings they could think of for each word with no time limit. They were instructed to use the word in a sentence, and define the word as they had used it in the sentence. Subjects took approximately 30 minutes to complete the booklet. Twenty subjects provided meanings for each word. At the end of each booklet, a sheet required the subjects to review the meanings they provided for each word. This helped ensure that subjects had responded to each item, and offered them a second chance to think over the meanings they provided. The experimenter calculated the average numbers of meanings based on the numbers of meanings each subject wrote on the review sheet for each word, and from this derived subjects' intuitive raw numbers of meanings.

The numbers of linguistic senses required the decision of experimenters. Two experimenters independently decided the numbers of different senses each subject provided for each word based on the definition in Ahrens et al. (1998). Then they together went through the items on which their analyses differed, and made a decision that both agreed upon. The average numbers of senses is calculated by averaging the numbers of distinct senses each subject provided for each item. The total numbers of senses are the numbers of distinct senses among all the meanings that all subjects generated for each word.

3.2.3 Results.

Twenty subjects provided meanings for each of the 200 words. To avoid idiosyncratic responses, only senses provided by more than 15% of the subjects were included. The data obtained are listed in Appendix 1. Subjects' raw numbers of meanings are given in the fifth column; average numbers of senses, the sixth; total numbers of senses, the seventh column. The numbers of meanings using different measures are compared, including dictionary meanings, subjects' raw numbers of meanings, subjects' average and total numbers of linguistic senses.

Paired-samples *t*-tests suggest that all but three pairs are significantly different from one another ($p < .01$). Table 2 gives the p values and degrees of freedom for each pair. The three pairs of meaning measures that do not differ from one another are: RCD and the total numbers of senses ($p = .359$), GD and subjects' raw numbers of meanings ($p = .164$), and WCED and subjects' average numbers of senses ($p = .143$). Most of the measures differ from one another, which demonstrates that different measures often brings forth considerably different results.

Different as most of the measures are from one another, further examination of the correlations among them show that all the measures are significantly correlated ($p < .01$). Table 3 shows the correlations among these measures. Dictionaries vary in the enumeration of word meanings. The correlations between dictionary

Table 2
P-values, *t*-values, and degrees of freedom among different measures of number of meanings in Experiments 1a and 1b

	GD 國語日報辭典	RCD 新編國語辭典	WCED 旺文漢音辭典	Ss' raw meanings	Ss' average senses	Ss' total senses
GD 國語日報辭典	–					
RCD 新編國語辭典	$t(150)=-5.46$ **	–				
WCED 旺文漢音辭典	$t(141)=3.68$ **	$t(176)=8.33$ **	–			
Ss' raw meanings	$t(150)=1.40$	$t(190)=5.61$ **	$t(176)=3.77$ **	–		
Ss' average senses	$t(150)=3.32$ *	$t(190)=7.19$ **	$t(176)=1.47$	$t(199)=-10.90$ **	–	
Ss' total senses	$t(150)=-3.65$ **	$t(190)=0.92$	$t(176)=7.72$ **	$t(199)=-7.16$ **	$t(199)=-9.87$ **	–

* $p < .01$ ** $p < .001$

Table 3
Correlations among the different measures of numbers of meanings in Experiments 1a and 1b

	GD 國語日報辭典	RCD 新編國語辭典	WCED 旺文漢音辭典	Ss' raw meanings	Ss' average senses	Ss' total senses
GD 國語日報辭典	*1.000*					
RCD 新編國語辭典	0.738*	1.000				
WCED 旺文漢音辭典	0.568*	0.606*	1.000			
Ss' raw meanings	0.645*	0.674*	0.514*	1.000		
Ss' average senses	0.634*	0.665*	0.471*	0.949*	1.000	
Ss' total senses	0.599*	0.616*	0.461*	0.793*	0.816*	1.000

* $p < .01$

numbers of meanings and all other meaning measures vary from .738 to .461. The numbers of meanings in the RCD are relatively better correlated with subjects' responses than WCED. RCD thus seems to be a dictionary that is closer to subjects' semantic knowledge. The *t*-tests also showed no significant difference between RCD and the total numbers of linguistic senses ($p = .359$).

In summary, we find that the different measurements of the numbers of meanings among Chinese nominals produce significantly different numbers of meanings. These numbers are, however, significantly correlated at a relative number-of-meaning scale. That is, words with many meanings have greater numbers of meanings in all measurements. In Section 3, we will examine if such patterns can be found when measuring numbers of meanings among English words.

4. Experiment 2: Comparing different meaning measurements in English.

Are the results of Experiment 1 to be found in linguistic data other than those of Chinese? To investigate the different measures cross-linguistically, we conducted a similar experiment on English data, using definitions listed in two English dictionaries and the data collected by Azuma and Van Orden (1997).

4.1 Subjects, materials, and procedures.

Azuma and Van Orden (1997) collected meanings from one hundred introductory psychology students at Arizona State University, who were all native speakers of English. Twenty participants provided meanings for each word. Sixty-nine English words were taken from the stimulus items used in the experiments of Azuma and Van Orden (1997). These words were checked for the

numbers of lexical entries in the third edition of *American Heritage Dictionary of the English Language* (1992), and for the numbers of lexical entries and the numbers of semantic entries in *Webster's Third New International Dictionary of the English Language, Unabridged* (1981). In addition to dictionary meanings, we compared subjects' raw, average, and total numbers of meanings.[10] The average and total meanings were derived by matching subjects' meanings with the definitions in *Webster's New World Dictionary* (1980). Those not found in the dictionary were not included. The full list of English data and numbers of meanings is given in Appendix 2. These data represent the dictionary meanings, subjects' raw intuition, and subjects' meanings matched with dictionary meanings.

4.2 Results

All the measurements are significantly different from one another except the numbers of lexical entries listed in *Webster's Third New International Dictionary of the English Language* and subjects' total numbers of meanings ($p < .001$). This finding is similar to the results found for the Chinese data. Table 4 gives the matrix of paired-samples *t*-tests.

Though different measures render rather different results, most of the numbers of meanings are correlated to one another. Table 5 shows that except meanings found in *American Heritage Dictionary*, all other meaning measurements are significantly correlated with one another. The numbers of semantic entries in the unabridged *Webster's Third New International Dictionary of the English Language* showed highest correlations with the numbers of meanings provided by language users. They also correlated with the

[10] Tamiko Azuma provided us with the raw, average, and total numbers of meanings of the English data, part of which were published in Azuma (1996) and Azuma and Van Orden (1997).

Table 4
P-values, *t*-values, and degrees of freedom among different measures of number of meanings in Experiment 2

	American Heritage	Webster's 1	Webster's 2	Ss' raw meanings	Ss' average meanings	Ss' total meanings
American Heritage	–					
Webster's 1	$t(68)=-13.48$ **	--				
Webster's 2	$t(68)=-12.10$ **	$t(68)=-11.11$ **	–			
Ss' raw meanings	$t(68)=-4.64$ **	$t(68)=8.59$ **	$t(68)=11.89$ **	–		
Ss' average meanings	$t(68)=-4.48$ **	$t(68)=8.67$ **	$t(68)=-4.48$ **	$t(68)=4.54$ **	–	
Ss' total meanings	$t(68)=-10.69$ **	$t(68)=-1.73$ $p = .088$	$t(68)=11.23$ **	$t(68)=-10.19$ **	$t(68)=-10.27$ **	–

** $p < .001$

Note American Heritage = lexical entries in *The American Heritage Dictionary of the English Language* (1992)

Webster's 1 = lexical entries in *Webster's Third New International Dictionary of the English Language, Unabridged* (1981)

Webster's 2 = semantic entries in *Webster's Third New International Dictionary of the English Language, Unabridged* (1981)

Table 5
Correlations of different measures of the English data in Experiment 2

	American Heritage	Webster's 1	Webster's 2	Ss' raw meanings	Ss' average meanings	Ss' total meanings
American Heritage	1.000					
Webster's 1	0.719**	1.000				
Webster's 2	0.109	0.440**	1.000			
Ss' raw meanings	0.043	0.266*	0.461**	1.000		
Ss' average meanings	0.042	0.272*	0.459**	0.997**	1.000	
Ss' total meanings	0.090	0.301*	0.620**	0.621**	0.623**	1.000

* $p < .05$ ** $p < .01$

numbers of lexical entries found in the same dictionary, which suggest that when a word is associated with more lexical entries it is also more likely to be associated with more semantic entries. The numbers of meanings (raw, average, and total) provided by subjects are most highly correlated to one another.

These results suggest that choosing different English dictionaries for reference may also lead to very different results. The unabridged version of Webster's Dictionary showed more resemblance with the data provided by participants; however, a more recently-published and learner-oriented abridged dictionary like the American Heritage showed less comparable similarity with both the unabridged dictionary and meanings provided by subjects.

5. General discussion.

In Experiment 1, we examined the relationship among dictionary meanings, linguistic senses, and participants' semantic intuition for Chinese disyllabic words. Most of these different measures of word meanings led to significantly different numbers of meanings for the same set of words. Therefore, without considering the fundamental differences among these different methods, researchers who randomly selected a dictionary or any method to measure word meanings may obtain rather different results, which are not suitable for comparison. The significant correlations, however, indicate that even though these measures are very different from one another, they derive quite consistent results at a relative scale. Words with more meanings according to one way of calculation also have relatively more meanings in another. Namely, different measures of a word's numbers of meanings reflect quite similar patterns, though qualitatively these meanings may be very different in content. The reason for such high correlations among these different methods is that the materials being delimited by these different methods are roughly the same across the board. An ambiguous word like *mean*, which has three meanings listed in *American Heritage Dictionary*,

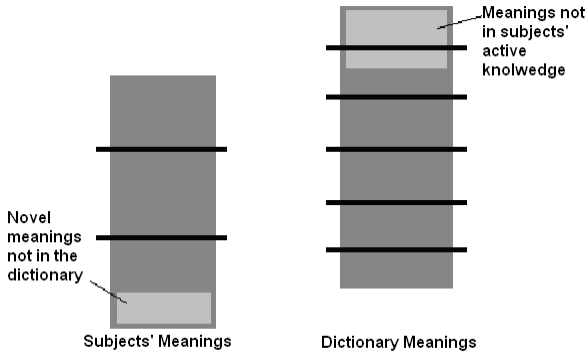
has nine meanings listed in *Webster's*. A less ambiguous word like *chest* has only one meaning in *American Heritage Dictionary* and only two in *Webster's*. Whatever the method is, a highly ambiguous word that has many meanings is listed with more meanings. A less ambiguous word likewise has fewer meanings listed in any dictionary. However, these different methods do produce different numbers of meanings, depending on what is taken as a distinct meaning. Subjects' meanings are most highly correlated to one another because they are from the same source — meanings provided by language users; dictionary meanings, however, differ from the senses entailed by current users for reasons that have been addressed in Section 2.

The correlations between numbers of senses and subjects' raw numbers of meanings (r = 0.949 and 0.793) suggest that language users are rather conscious of *senses* as a salient semantic level. It is noteworthy that the scales of meaning estimations are different using different measures. The numbers of dictionary meanings are generally higher than the average numbers of linguistic senses. That is, dictionaries cut meanings of the same lexical items into smaller pieces and include many that are not in a speaker's active semantic consciousness. Figure 1 illustrates this point. Using different measures is like using different scales to cut pieces of paper of different lengths. The smaller the scale, the more pieces we get. Though the same paper might be cut into different numbers of pieces by different scales, the longer paper (words with more meanings) is generally cut into more pieces than the shorter one (words with fewer meanings).

The English data show a similar trend. Certain dictionary meanings (such as those in *American Heritage Dictionary*) show less resemblance with the results of other measures, while meanings obtained from subjects show higher correlations to one another. Depending on lexical or semantic entries in the dictionaries also brings about very different results. The numbers of semantic entries are more correlated with subjects' meanings than lexical entries.

Overall, the results suggest that there is a distinction between dictionary meanings and the meanings obtained from subjects. They

Figure 1. Meaning delimitation using different methods.



differ not only in the way of meaning calculation but also with regard to the content. Content-wise, meanings fluctuate in the history of a language. Some meanings in the dictionary are no longer in use, while language users are constantly developing novel uses of existing words. A closer look at the meanings listed in different dictionaries and those generated by language users gives us insight on how similar and different they are. This also illustrates semantic changes in short-term language history. For example, the word *danwei* (單位) has three meanings in both subjects' total number of senses and in the dictionary RCD. The three senses given by the subjects are (1) the basic unit for calculation, (2) an official unit or department in an institution, and (3) a single seat. The dictionary listed the first two meanings; the third meaning was not 'a single seat, but 'the seats for monks' — a meaning rarely used anymore. The word *menkan* (門檻) also has three dictionary meanings — (1) a piece of wood or stone placed beneath a door, a doorsill, (2) a method or means of doing something, and (3) the capability of finding a method, among which only the first one was given by the subjects. Subjects provided yet a second sense not found in the dictionary — 'the minimum, the lowest bounds permitted', which is a metaphorical extension of the first sense. Examples like these illustrate the change of lexical meanings in progress. What used to

be important meanings were included in dictionaries edited some time ago. These meanings may no longer be available to language users today. The current semantic knowledge of a word may differ both in content and in frequency from dictionary meanings. This is especially important to researchers interested in psychosemantic research. Meanings should be extracted from real language users if our goal is to access the current semantic competence of the subjects.

An additional supporting evidence for the use of linguistic senses comes from our experiments on ambiguity advantage (Lin, 1999; Lin and Ahrens, 2000). We ran lexical decision tasks (in which participants were instructed to decide if the stimuli they saw were words or non-words) using the same set of Chinese data in this research. In three experiments differing in the timing of stimuli presentation, we consistently found the effect of ambiguity advantage — words with many linguistic senses are recognized faster than words with only one sense. Factors such as sense frequency and sense relatedness were controlled for. This suggests that senses as defined by our linguistic theory are psychologically valid, since the time subjects take to access a word is sensitive to the number of senses that a word has. The results converge with our finding that subjects' raw numbers of meanings and the linguistic senses are highly correlated.

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Appendix 1. Numbers of meanings/senses of 200 Chinese nouns.

Word	Dictionary meanings			Ss' raw Mns	Linguistic Senses		Word	Dictionary meanings			Ss' raw Mns	Linguistic senses	
	GD	RCD	WCED		Aver-age	Total		GD	RCD	WCED		Aver-age	Total
經典 jingdian	2	3	3	1.7	1.6	3	前妻 qianqi	–	1	2	1.05	1.05	1
待遇 daiyu	2	2	2	1.7	1.7	2	油價 youjia	–	–	–	1.4	1.6	2
兩極 liangji	2	3	2	2	1.85	3	車速 chesu	–	1	1	1.05	1	1
中央 zhongyang	2	3	2	2	1.95	3	品質 pinzhi	1	1	2	1.3	1	1
傢伙 jiahuo	2	3	–	2.15	1.95	2	螞蟻 mayi	1	1	1	1.5	1.05	1
元宵 yuanxiao	2	2	2	1.8	1.75	2	菜餚 caiyao	–	1	1	1.05	1	1
人馬 renma	–	3	1	1.35	1.25	2	言論 yanlun	1	1	1	1.25	1	1
花瓶 huaping	2	2	1	2	1.95	2	死屍 sishi	1	1	1	1.25	1.2	1
後台 houtai	3	2	2	1.85	1.85	2	書本 shuben	1	1	1	1.05	1	1
回音 huiyin	2	1	3	1.85	1.8	2	年次 nianci	–	–	–	1.05	1	1
點滴 diandi	1	3	2	2.05	1.9	2	眼淚 yanlei	1	1	1	1.45	1.15	1
悲劇 beijyu	2	2	1	1.9	1.7	2	慣例 guanli	1	1	1	1.5	1	1
裂痕 liehen	2	2	1	1.8	1.8	2	雜糧 zaliang	1	1	1	1.05	1.05	1
角度 jiaodu	2	2	2	2	1.8	2	工資 gongzi	1	1	1	1.15	1.05	1
手腕 shouwan	2	2	1	1.9	1.9	2	沙灘 shatan	1	1	1	1.1	1.05	1
黃金 huangjin	2	3	1	2.3	2.05	3	法官 faguan	1	2	1	1.2	1.05	1
跳板 tiaoban	2	2	2	1.95	1.9	3	居所 jusuo	–	1	–	1	1	1
捷徑 jiejing	2	2	1	1.9	1.85	2	遺址 yizhi	–	1	1	1.05	1	1
籌碼 chouma	2	2	1	1.75	1.7	2	清晨 qingchen	1	1	1	1.15	1	1
牛郎 niulang	3	4	–	2.4	2.45	4	勁敵 jindi	1	1	–	1	1	1
杜鵑 dujuan	2	2	2	2	2	3	睡眠 shuimian	1	1	1	1.05	1	1
指標 zhibiao	2	1	1	1.8	1.65	2	深夜 shenye	–	1	–	1.05	1	1
傳奇 chuanqi	2	4	2	1.75	1.6	2	國王 guowang	3	3	1	1.2	1.15	1
鴨蛋 yadan	2	2	1	2.2	2.05	2	墨鏡 mojing	1	1	1	1.25	1.1	1
出路 chulu	2	3	2	1.85	1.8	2	常態 changtai	1	2	1	1.4	1	1
丈夫 zhangfu	2	3	2	1.8	1.65	2	瓦斯 wasi	1	3	1	1.95	1.75	2
公安 gongan	1	3	1	1.65	1.65	2	定存 dingcun	–	–	–	1.05	1.05	2
明日 mingri	1	1	2	1.65	1.65	3	心願 xinyuan	1	1	1	1.05	1	1
呼聲 husheng	–	2	1	2.2	2.2	4	校友 xiaoyou	–	1	1	1.2	1.15	2
細胞 xibao	1	1	1	1.55	1.4	2	水災 shuizai	1	1	1	1.2	1.2	2
銀牌 yinpai	–	2	1	1.5	1.5	3	畫室 huashi	–	1	1	1.3	1.2	2
龍頭 longtou	3	4	2	1.8	1.8	4	疑點 yidian	–	1	1	1.3	1	1
分數 fenshu	2	3	2	1.95	1.85	2	美女 meinyu	1	1	–	1.45	1.15	2
模型 moxing	1	1	2	1.4	1.35	2	房租 fangzu	1	1	–	1	1	1
偶像 ouxiang	2	2	1	1.95	1.6	2	肥料 feiliao	1	1	1	1.2	1	1
口氣 kouqi	2	4	3	1.8	1.5	2	平原 pingyuan	1	1	1	1.4	1.35	2

Word	Dictionary meanings			Ss' raw Mns	Linguistic Senses		Word	Dictionary meanings			Ss' raw Mns	Linguistic senses	
	GD	RCD	WCED		Aver-age	Total		GD	RCD	WCED		Aver-age	Total
果實 guoshi	2	2	2	1.95	1.85	2	財富 caifu	1	1	1	1.35	1.35	2
斷層 duanceng	–	1	1	2.05	2	3	體能 tineng	1	1	–	1	1	1
泡沫 paomo	1	1	1	1.9	1.55	2	鞭炮 bianpao	1	1	2	1.05	1.05	1
份量 fenliang	3	3	1	2.45	2.15	3	竹林 zhulin	–	2	1	1.4	1.3	2
空檔 kongdang	--	3	1	1.7	1.6	2	村落 cunluo	1	1	1	1.05	1	1
小弟 xiaodi	2	3	--	2.35	2.35	5	石塊 shikuai	–	1	1	1.3	1.05	1
半天 bantian	3	3	2	1.85	1.8	2	時光 shiguang	1	1	2	1.3	1	1
臉色 lianse	–	2	2	2.15	2.05	2	邦交 bangjiao	1	1	1	1.1	1.1	1
長短 changduan	3	4	3	1.95	1.9	3	節慶 jieqing	–	–	–	1.4	1	1
爵士 jueshi	1	1	2	2.1	1.95	2	魔術 moshu	1	1	1	1.45	1.4	2
軍機 junji	2	2	2	1.75	1.7	2	往事 wangshi	1	1	1	1.05	1	1
便衣 bianyi	2	2	2	1.8	1.45	2	信譽 xinyu	–	2	1	1.15	1	1
黑箱 heixiang	–	–	–	2.05	2.05	2	感觸 ganchu	1	1	1	1.15	1.15	1
低潮 dichao	–	2	1	1.95	1.9	3	雙腳 shuangjiao	–	–	–	1.25	1.1	1
世界 shijie	3	4	1	1.9	1.75	2	設備 shebei	2	3	1	1.35	1.1	1
商場 shangchang	2	2	1	1.8	1.7	2	歲月 suiyue	1	1	1	1.3	1.05	1
儀表 yibiao	3	3	1	1.75	1.7	2	君主 jyunzhu	–	1	1	1.25	1.05	1
先生 xiansheng	6	7	4	2.95	2.75	4	營運 yingyun	1	1	–	1.35	1.25	2
公公 gonggong	3	5	3	2.95	2.9	4	通則 tongze	1	1	1	1.05	1.05	1
同志 tongzhi	2	4	1	2.05	2.35	3	作物 zuou	1	1	1	1.25	1.1	1
單位 danwei	2	3	2	2	2	3	政府 zhengfu	1	2	1	1.1	1	1
地方 difang	5	5	4	2	1.75	3	其他 qita	1	1	1	1.2	1	1
壓力 yali	2	4	2	1.95	1.85	2	股票 gupiao	1	1	1	1.2	1	1
家教 jiajiao	3	2	1	1.85	1.7	3	外號 waihau	1	1	1	1.1	1.05	1
少爺 shaoye	2	2	2	2.2	1.65	3	請帖 qingtie	1	1	1	1	1	1
意思 yisi	5	5	5	2.5	2	5	用途 yongtu	1	1	1	1.1	1	1
麻雀 maque	2	2	1	1.65	1.35	2	茶壺 chahu	–	1	1	1.5	1.3	1
把柄 babing	2	5	1	1.7	1.65	2	病菌 bingjyun	1	1	1	1.15	1.15	1
排骨 paigu	2	2	1	2	2.7	2	青銅 qingtong	2	2	1	1.35	1.05	1
學院 xueyuan	–	3	1	1.25	1.25	3	證件 zhengjian	–	1	1	1.05	1	1
搖籃 yaolan	2	2	1	1.8	1.85	2	圈套 qyuantao	1	1	1	1.55	1.35	2
旋風 xuanfong	1	3	1	1.95	1.75	2	泳裝 yongzhuang	–	1	–	1.1	1	1
曲線 qyuxian	2	2	1	1.95	1.9	3	牙科 yake	–	1	1	1.6	1.35	2
會計 kuaiji	2	2	2	1.65	1.35	2	專題 zhuanti	–	1	1	1	1	1
東西 dongxi	2	4	4	2.55	2.3	3	期限 qixian	1	1	1	1.3	1.2	2
架子 jiazi	2	6	4	2.1	2.1	3	粉狀 fenzhuang	–	–	–	1.25	1.1	1
格局 gejyu	1	2	1	1.45	1.45	3	聯考 liankao	–	1	–	1.15	1	1
火鍋 huoguo	3	3	1	1.65	1.5	2	步驟 buzou	1	2	1	1.1	1.05	1
禮拜 libai	2	3	4	2.2	2.1	2	樓梯 louti	1	1	1	1.05	1.1	1

Word	Dictionary meanings			Ss' raw Mns	Linguistic Senses		Word	Dictionary meanings			Ss' raw Mns	Linguistic senses	
	GD	RCD	WCED		Aver-age	Total		GD	RCD	WCED		Aver-age	Total
算盤 suanpan	2	2	1	1.95	1.8	2	面容 mianrong	–	1	1	1.6	1.55	3
精神 jingshen	3	5	4	2	1.95	3	市民 shimin	1	1	1	1.1	1	1
飯碗 fanwan	2	2	2	2	1.95	2	泥沼 nizhao	–	2	1	1.7	1.7	2
老大 laoda	3	4	3	2.65	2.4	3	當晚 dangwan	1	1	–	1.1	1	1
背景 beijing	4	4	1	2.1	2	2	勤務 qinwu	1	1	1	1.05	1	1
藍圖 lantu	2	2	1	1.7	1.55	2	坦克 tanke	–	1	1	1.5	1.05	1
調幅 tiaofu	2	1	1	1.45	1.45	2	布條 butiao	–	–	–	1.25	1.25	2
輪廓 lunkuo	2	2	1	1.65	1.6	3	雨傘 yusan	1	1	1	1.05	1	1
逃兵 taobing	2	2	1	1.9	1.8	3	傷勢 shangshi	–	1	1	1	1	1
門檻 menkan	3	3	1	1.85	1.85	2	範疇 fanchou	1	1	1	1.25	1	1
陰影 yinying	2	2	2	2.1	1.95	2	弊端 biduan	1	1	1	1.1	1.05	1
靈魂 linghun	3	3	1	2.4	2.3	5	鋼筋 gangjin	1	1	1	1.1	1.1	1
師父 shifu	3	3	2	1.85	1.75	3	新片 xinpian	–	–	–	1.8	1.65	3
下文 xiawen	2	2	2	1.65	1.6	2	真理 zhenli	1	1	1	1.3	1.1	1
味道 weidao	1	4	1	2.25	1.85	2	服裝 fuzhuang	–	1	1	1.45	1	1
磁性 cixing	2	2	1	1.9	1.85	2	獵槍 lieqiang	–	1	1	1	1	1
惡夢 emong	–	1	1	1.75	1.75	2	鬧鐘 naozhong	1	1	1	1.2	1.1	1
妹妹 meimei	1	3	1	2.37	2.15	3	喉嚨 houlong	1	1	1	1.2	1.05	1
綠燈 lyudeng	–	2	2	2.1	2.1	3	歸宿 guisu	1	3	1	1.45	1.5	3
嘴巴 zuiba	1	2	2	1.95	1.45	2	菁英 jingying	–	1	–	1.15	1.15	1
八卦 bagua	1	1	1	2.2	2.15	4	黨魁 dangkui	–	1	1	1.05	1.05	1
假名 jiaming	–	5	2	1.15	1.15	2	告示 gaoshi	–	2	1	1.55	1.35	2
漏洞 loudong	2	2	2	1.9	1.75	2	貴賓 guibin	2	2	1	1.65	1.5	2
江湖 jianghu	5	3	3	1.85	1.85	3	程式 chengshi	2	3	2	1.55	1.5	3
頻率 pinlyu	1	2	1	2.05	2.05	4	班級 banji	–	2	1	1.15	1.05	1

Note: GD = *Gwoyeuryhbaw Dictionary* (1989) 國語日報辭典
RCD = *Revised Chinese Dictionary* (1997) 重編國語辭典
WCED = *The Warmth Modern Chinese-English Dictionary* (1997) 旺文現代漢英辭典

APPENDIX 2

English data of dictionary meanings, subjects' raw numbers of meanings, subjects' average numbers of meanings, and subjects' total numbers of meanings (part of the data can be found in Azuma and Van Orden, 1997)

Word	Dictionary			Subjects			Word	Dictionary			Subjects		
	AH	W1	W2	Raw	Aver-age	Total		AH	W1	W2	Raw	Aver-age	Total
ball	2	3	12	2	2	4	mean	3	9	33	2.25	2.25	3
bark	3	5	16	2.25	2.25	4	mine	2	5	18	2.25	2.25	4
bill	3	7	25	2.5	2.5	6	page	2	4	11	2.35	2.35	3
blank	2	4	28	2.05	2	6	park	1	2	14	1.8	1.8	2
bomb	1	2	9	2.35	2.35	4	pitch	2	4	38	2.1	2.1	7
bound	4	7	21	2.65	2.65	9	plot	1	3	15	2.2	2.2	6
calf	2	2	7	2	2	2	pound	3	6	15	2.55	2.55	4
card	2	4	20	2.5	2.4	3	rake	3	8	32	1.5	1.5	2
cast	1	5	33	2.95	2.95	8	rare	2	5	8	2.1	2.05	3
charm	1	4	13	2	2	4	rich	1	2	13	2.3	2.3	4
check	1	5	43	3.45	3.45	9	ring	2	5	59	2.95	2.95	9
chest	1	2	7	2.05	2	2	round	2	6	62	2	2	13
chip	3	6	24	2.8	2.8	6	rule	1	2	13	2.05	2	3
clean	1	4	17	2.15	2.1	7	safe	1	5	12	2.1	2.1	3
club	1	3	11	2.9	2.9	6	scale	3	11	47	2.9	2.9	9
coat	1	2	9	2.05	2.05	4	seal	2	5	17	2.45	2.45	4
cover	1	2	34	2.55	2.45	10	shape	1	2	21	2.3	2.2	3
cross	1	5	52	2.55	2.55	6	share	2	2	11	2.25	2.25	6
date	2	3	20	2.95	2.85	4	sharp	1	4	16	2.55	2.55	7
draw	1	2	19	2.8	2.8	10	ship	1	4	22	2	2	2
drink	1	2	14	1.75	1.7	3	shop	1	2	10	2.2	2.2	3
dull	1	2	12	2.3	2.3	4	slip	3	8	50	2.85	2.85	8
dump	1	5	22	2.6	2.6	6	smoke	1	2	26	2.2	2.2	8
dust	1	2	23	1.7	1.7	3	soil	3	6	18	1.85	1.85	2
faint	1	5	12	1.85	1.85	4	sound	4	8	30	2.05	2	8
fast	2	7	23	1.8	1.75	3	spoke	2	4	13	1.95	1.95	2
file	3	11	24	2.9	2.9	8	stick	1	6	44	2.7	2.7	8
fine	3	7	21	3.3	3.3	9	stock	1	5	74	3.1	3.1	7
firm	2	4	10	2.05	2	4	story	2	3	14	2.2	2.2	3
floor	1	4	16	2.25	2.25	6	strip	2	7	54	2.75	2.7	7
game	2	4	9	1.95	1.95	4	tire	3	8	16	1.9	1.85	3
hide	3	5	11	1.75	1.75	2	trap	3	6	25	2.15	2.05	4
land	1	4	14	2.45	2.45	4	trip	1	3	28	2.6	2.6	4
limit	1	2	13	1.55	1.5	3	watch	1	3	25	2.15	2.1	4
lock	2	5	19	2.3	2.3	6							

Note: AH = lexical entries in *The American Heritage Dictionary of the English Language* (1992)

W1 = lexical entries in *Webster's Third New International Dictionary of the English Language, Unabridged* (1981)

W2 = semantic entries in Webster's Third New International Dictionary of the English Language, Unabridged (1981)