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Ambiguity advantage revisited: Two meanings are better than one when accessing Chinese nouns

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Abstract

This paper revisits the effect of lexical ambiguity in word recognition, which has been controversial as previous research reported advantage, disadvantage, and null effects. We discuss factors that were not consistently treated in previous research (e.g., the level of lexical ambiguity investigated, parts of speech of the experimental stimuli, and the choice of non-words) and report on a lexical decision experiment with Chinese nouns in which ambiguous nouns with homonymic and/or metaphorical meanings were contrasted with unambiguous nouns. An ambiguity advantage effect was obtained—Chinese nouns with multiple meanings were recognized faster than those with only one meaning. The results suggested that both homonymic and metaphorical meanings are psychologically salient semantic levels actively represented in the mental lexicon. The results supported a probability-based model of random lexical access with multiple meanings represented by separate semantic nodes. We further discuss these results in terms of lexical semantic representation and how different experimental paradigms result in different ambiguity effects in lexical access.

Keywords: Ambiguity advantage; Homonymy; Polysemy; Lexical decision; Metaphor and metonymy

1. Introduction

Does the ambiguity associated with a word facilitate or hinder lexical access? Previous attempts to answer this question have produced ambivalent results. Ambiguity advantage was observed by some (Borowsky & Masson, 1996; Hino & Lupker, 1996; Hino et al., 2006; Jastrzembski, 1981; Jastrzembski & Stanners, 1975; Kellas et al., 1988; Millis & Button, 1989; Rubenstein et al., 1970). Others obtained ambiguity disadvantage (Rodd et al., 2002) as well as a null effect (Clark, 1973; Forster & Bednall, 1976; Gernsbacher, 1984). As the literature shows, there is yet no agreement on the ambiguity effect. The issue of efficiency in accessing a word regarding its (number of) meanings is, nevertheless, critical as it sheds light on the representation of meanings in the mental lexicon as well as the amount of semantic information that is required to access a word. So far, these contradictory results regarding lexical ambiguity have not been settled.

Two main types of models have been proposed in the literature for the semantic activation of a word. A *localist* model assumes *passive competition* among the different meanings of a word (Millis & Button, 1989; Morton, 1979; Rubenstein et al., 1970). Word meanings are represented separately and accessed locally. As soon as enough information associated with a stimulus string is accumulated, this string can be recognized as a word. Variants of this model adopt *random access* (predicting advantage in recognizing words with greater numbers of meanings as they have more semantic nodes distributed in the mental lexicon, therefore standing a higher probability for any of these nodes to be accessed; Rubenstein et al., 1970) or *serial access* (predicting advantage for words with meanings that are higher in frequency; Forster & Bednall, 1976). The second type of model assumes *active competition* among the distributed semantic nodes (e.g., Rodd et al., 2002). Based on the connectionist

assumption that the multiple nodes of a word engage in a competition (McClelland & Rumelhart, 1981), active competition models predict that words with many meanings are harder to recognize, as the nodes of different meanings compete and inhibit the activation of one another. Hybrid models have also been proposed, particularly models of parallel distribution that allow the multiple semantic nodes of a word to facilitate rather than compete with one another (at least at the initial stage of lexical access), thus producing an advantage effect for accessing ambiguous words (Borowsky & Masson, 1996; Joordens & Besner, 1994; cf. Kawamoto, Ferrar, & Kello, 1994).

The goal of this article is to clarify various issues that were not consistently treated in previous research and present evidence for an ambiguity advantage. The results will support accounts that assume the random access of lexical meanings and those that allow the various semantic nodes of a word to facilitate rather than inhibit each other during lexical access.

An important cause of confusion resulted from the term *lexical ambiguity* itself being ambiguous. Research in the past has loosely used lexical ambiguity as a cover term for any orthographic or phonological form being associated with multiple meanings. The different natures of these meanings were not considered. In the lexical semantics literature, however, it has been well recognized that *homonymy* and *polysemy* are distinct types of lexical ambiguity (e.g., Allan, 1986; Goddard, 1998; Lyons, 1977, 1995; Palmer, 1981; Saeed, 1997; Ullman, 1957). Homonymy refers to different words that happen to be identical in orthography or sound. These words usually have distinct etymological origins. A typical example is the word *bank*, which means both “the slope along a river” and “a financial institution.” Polysemy refers to *a* word being associated with multiple (related) meanings. For instance, the word *bank* as a financial institution can be extended to refer to places where things can be safely kept (e.g., *a*

sperm bank). Even though both homonymy and polysemy, superficially, are examples of lexical ambiguity, the fact that the meanings associated with a homonymous form are not derivationally or etymologically related while those with a polysemous word are is a crucial distinction that needs to be addressed in the semantic representation of a word. In fact, such a distinction has received empirical support from previous psychological investigations of meanings and senses (Frazier & Rayner, 1990; cf. Klein & Murphy, 2001, 2002).[1] By tracking eye fixations during sentence reading, Frazier & Rayner (1990) found that words with polysemous senses were read faster than those with homonymous meanings. Their results demonstrated that when reading words in sentences, the processor does not need to select among the polysemous senses of a word. However, it has to select an appropriate meaning of a homograph to fit into the context. During sentence comprehension, therefore, polysemous senses can be underspecified while homonymous meanings have to be specified.[2]

The homonymy/polysemy distinction has been extended to one between metaphor and metonymy (Ahrens et al., 1998; Johnson & Lakoff, 1980; Lakoff, 1987; Pustejovsky, 1991). Within polysemous words, a word's meanings can be related in different ways. Metaphorical extensions cross conceptual domains. The word *tragedy*, which originally meant "a dramatic genre with unhappy endings," has been extended to signify tragic events in real life—an example of a meaning shifting from the literary domain to the domain of life experiences. Metonymy, on the other hand, extends a word's meaning within the same conceptual domain. It is characterized by systematicity in sense derivation. For instance, a book refers to both its physical existence and

[1] In the literature, meanings and senses are used to refer to homonymous meanings and polysemous meanings, respectively. In this article, we follow this convention with some additional clarification. *Sense* is used to refer to the polysemous meaning of a word. *Meaning* is used to refer to the meaning of a homonym and as a general term that means the significance of an expression. Note, however, that Ahrens et al. (1998) adopted the terms *senses* and *meaning facets*. In the section where we discuss Ahrens et al.'s (1998) computational semantic framework, we will stick to their terms.

[2] Klein and Murphy (2001, 2002), on the other hand, showed that the polysemous senses of a word have separate representations, and semantic overlap is relatively little.

the information contained in it. Thus, *Harry Potter* signifies both the physical copy of the book (as in, *I spilled some coffee on my Harry Potter*) and the content of the book (as in, *I enjoyed reading my Harry Potter*). A limited set of rules has been postulated as the possible ways of metonymic extensions. For instance, after analyzing corpus data in Chinese extensively (CKIP, 1993), Ahrens et al. (1998: 57) proposed eight derivational rules for Chinese nominals.[3] According to the principle of *agentivization*, media content can be extended to refer to its creator. This rule applies to all words in the general semantic domain of publications. Thus, *magazines*, *newspapers*, and *dictionaries* all have similar metonymic senses. A conceptual advantage for such a generative theory of metonymy is that a large number of word senses can be derived by applying a limited set of metonymic rules (with contextual coercion), thus keeping the semantic representation in the lexicon simple.[4]

The distinction between metaphor and metonymy is supported not only by linguistic analyses (e.g., Lakoff, 1987) and computational semantic theories (Ahrens et al., 1998; Pustejovsky, 1991) but also by behavioral studies. Klepousniotou (2002), for instance, investigated whether the three types of lexical ambiguities discussed (i.e., homonymy, metaphor, and metonymy) are distinguishable in semantic access. Using an auditory sentence to prime either the dominant or the secondary meaning of the target word in a visual lexical decision task (i.e., cross-modal lexical decision tasks with the lexical decisions following each auditorily presented sentence), he found greater priming effects on words with metonymic senses than on

[3] Ahrens et al. (1998: 57) provided meronymic and metonymic extensions as two main ways to derive meaning facets. Meronymic extensions involve part/whole relations, by which part stands for whole or whole stands for part. Metonymic extensions are different from meronymy in that the extended meaning, though related to, is not inherent to the basic sense. Metonymic extensions include: (a) agentivization: information media → information creator; (b) product instantiation: institution → product; (c) grinding: individual → mass; (d) portioning: information media → information, container → containee, body part → function; (e) space mark-up: landmark → space in vicinity, structure → aperture, institution → locus; (f) time mark-up: event → temporal period, object → process, locus → duration.

[4] This systematicity in shifting polysemous senses is also what Pustejovsky's (1995) theory of Generative Lexicon aims to capture.

words with metaphorical senses and those with homonymic meanings. His results suggested that homonymy and metaphor were similar in response to the priming, while greater priming effects were obtained on metonymic senses. He concluded that homonymy and metonymy are at the two ends of the continuum of lexical ambiguity, and metaphor lies in between.

Based on the discussion so far, it is necessary to distinguish between words with metonymic senses and those with metaphorical senses and/or homonymic meanings. However, research on the ambiguity (dis)advantage effect has not consistently addressed this issue. When dealing with word meanings, most studies relied on dictionary definitions (e.g., Borowsky & Masson, 1996; Gernsbacher, 1984; Jastrzembski, 1981; Jastrzembski & Stanners, 1975). Even though studies such as Azuma and van Orden (1997) paid attention to the semantic relations between meanings, their semantic relatedness was simply measured by collecting subjective ratings on the relatedness among the meanings listed in the dictionary they consulted (cf. Durkin & Manning, 1989). The linguistic nature of the meanings listed was not considered. Rodd et al. (2002) paid attention to the distinction between homonymy and polysemy. Nevertheless, the distinction between homonymy and polysemy was still based on whether the meanings were listed under the same lexical entry or across distinct entries in the dictionary.

In the study hereby reported, we specifically contrasted *true* ambiguous words (i.e., words with multiple homonymic meanings and/or metaphorical senses) with unambiguous words (i.e., words that may have metonymic senses but *not* homonymic or metaphorical meanings). We adopted the linguistic tests designed by Ahrens et al. (1998) to determine if the meanings of a word should be regarded as distinct meanings or merely as metonymic senses. In the following, we sketch the lexical semantic framework proposed by Ahrens et al. (1998).

Ahrens et al. (1998: 53) proposed a computational framework of lexical semantic representation, which distinguished two levels of lexical meanings—*senses* and *meaning facets*. The senses of a word correspond to what we called "homophonic or metaphorical meanings," previously. Meaning facets, on the other hand, are aspects of a sense that can be fine-tuned to fit into the context. A word's senses have the following characteristics:

A) a sense is not an instance of metonymic or meronymic extension but may be an instance of metaphorical extension;

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).

Meaning facets have the following properties:

A) meaning facets are instances of metonymic or meronymic extension;

B) nouns of the same semantic classes will have similar extension links to related meaning facets;

C) a meaning facet can appear in the same context as other meaning facets.

Two meanings are distinct senses if they involve different conceptual domains. They are meaning facets if the relations between the meanings are productive among words of the same semantic class and if these meanings can easily co-exist in the same linguistic context. Take the word *huoguo* in Mandarin Chinese, for example; it has two senses and two meaning facets under the first sense:

火鍋 *huoguo*

Sense$_1$: a pot, used as a container above the fire when cooking

-- **Meaning facet$_1$**: *physical object: hot pot, the container*

-- **Meaning facet$_2$**: *the food contained (e.g., soup)*

Sense$_2$: a blocked shot, a term in basketball games

The different senses of a word do not usually co-exist unless a pun is intended. However, the two meaning facets of *huoguo* can easily co-exist in one sentence:

這　　火鍋　　裡　有　許多　青菜

zhe　huoguo　li　you　xuduo　qingcai

this　hot pot inside　EXIST　many　vegetables

'There are many vegetables in the hot pot / chafing dish.'

Ahrens et al.'s (1998) framework makes it possible to examine the effect of lexical ambiguity with the distinct levels of polysemy investigated separately. This methodology is also consistent with Klepousniotou's (2002) empirical evidence, which showed that homonymy and metaphor form a group in processing that is distinct from metonymy.

To sum up, lexical semantic theories have come to the point of distinguishing between homonymy and polysemy and between metaphor and metonymy. These different types of lexical ambiguity have been shown to involve distinct psychological processes. We therefore propose that it is necessary to address these distinctions in the study of lexical ambiguity effect.

As mentioned, previous research did not take into consideration the different types of lexical ambiguity largely due to researchers relying on published dictionaries to determine the meanings of a word (e.g., Gernsbacher, 1984; Jastrzembski, 1981; Jastrzembski & Stanners, 1975; Rodd et al., 2002). This included those who collected meanings from human participants but eventually matched the participant meanings with dictionary definitions for meaning calculation (e.g., Azuma & van Orden, 1997). Dictionaries, as we have argued previously (Lin & Ahrens, 2005), do not necessarily adopt consistent linguistic criteria in providing definitions. Different sets of definitions are provided, and different ways to organize these meanings are

adopted in different dictionaries. Our informal survey of ten words randomly selected from Azuma and van Orden's (1997) first experiment demonstrated differences in the numbers of meanings listed in two dictionaries (Table 1). While some words had similar numbers of meanings in both dictionaries (e.g., *rare*, *trap*, *file*), others differed in the numbers of meanings (e.g., *cast*, *round*).

Table 1: The Number of Meanings of Ten Words Provided by Webster's Third New International Dictionary, Unabridged (1976), and Random House Dictionary of the English Language, Unabridged (1967)

Word	NOMs in Webster (1976)	NOMs in Random House (1967)	Word	NOMs in Webster (1976)	NOMs in Random House (1967)
pound	15	26	**cast**	33	76
rare	8	6	**check**	43	48
trap	25	26	**round**	58	75
bomb	9	13	**file**	20	19
slip	50	68	**cover**	34	48

NOTE:
Webster (1976) = *Webster's Third New International Dictionary, Unabridged* (1976)
Random House (1967) = *Random House Dictionary of the English Language, Unabridged* (1967)

Another problem of relying on dictionary meanings is the discrepancy between meanings compiled for (pedagogical) reference and the active semantic knowledge of the current speech community. In a survey, Gernsbacher (1984) found that even well-educated subjects such as college professors could report only a small proportion of the meanings listed in a dictionary.[5]

[5] For instance, for the word *gauge*, which has thirty dictionary meanings, several college professors provided only

Our own survey of ten college students showed such discrepancies as well. For example, a popular Chinese dictionary published in Taiwan (*Gwoyeuryhbaw Dictionary*, 1989) listed only two meanings for the word *xiaodi*: "the youngest brother," and "a modest term for oneself." The ten college students we surveyed provided four meanings: a young boy (9), a waiter (7), a person at a lower rank (4), and a modest term for oneself (2). (The number following each definition represents the number of subjects that provided this meaning.) The apparent mismatch between participant meanings and dictionary definitions should be taken seriously.

In addition to clarifying the levels of meanings investigated, issues such as the ways meanings are collected, the types of non-words used in lexical decisions, the parts of speech of the stimuli, and the kinds of experimental paradigms adopted should also be taken into consideration. In the following, we discuss each of these factors in turn.

The collection of meanings

Discrepancy existed in the different ways language users were asked to demonstrate their semantic knowledge. Some researchers collected the *first* meanings the participants thought of (Forster & Bednall, 1976; Rubenstein et al., 1970, 1971). Others collected the *total* number of meanings a language user was able to provide (Azuma & van Orden, 1997; Millis & Button, 1989). Still others simply asked their participants to determine whether a word was ambiguous or not without asking what these meanings were (Borowsky & Masson, 1996; Hino & Lupker, 1996; Kellas et al., 1988). Millis and Button (1989) argued that dictionary meanings and the first meanings a participant can think of do not produce an ambiguity advantage because these methods do not adequately measure one's semantic knowledge. They suggested that the total and average numbers of meanings participants provided for each word better estimated the

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two meanings.

participants' semantic knowledge.[6] In our study, we collected the *total* number of different meanings produced by all participants, since this method has been argued to provide the amount of semantic knowledge that language users are able to actively access on-line.

Non-words used in the lexical decision tasks

Azuma and van Orden (1997) suggested that when non-words are more word-like, participants are more likely to access their semantic knowledge in making lexical decisions. Borowsky and Masson (1996), for example, found an ambiguity advantage in the recognition of real words when they used legal non-words (i.e., pronounceable non-words like BELF), but not when they used illegal non-words (i.e., unpronounceable non-words like BLFE). Azuma and van Orden (1997) found ambiguity advantage when they used pseudohomophones (i.e., non-words that have the same pronunciations as real words, e.g., BEAF), but not when they used legal non-words. The use of non-words that are more word-like ensures that participants actually use their lexical semantic knowledge, rather than rely on superficial orthographical or morphological features, in making lexical decisions. Pseudohomophones, as the most word-like non-words, have therefore been adopted in recent studies (e.g., Azuma & van Orden, 1997; Rodd et al., 2002). In the current study, we also adopted pseudohomophones as the non-words. Pseudohomophones in Chinese are non-words that are pronounced the same as real words but they have different orthographic forms at the character level. As an example, 剩立 is not a real word in Chinese (though the characters 剩 and 立 both exist); however, its pronunciation *sheng-li* is the same as 胜利, which means 'victory.'

Parts of speech

[6] This may be the reason why Clark (1973) and Forster and Bednall (1976), who used subjects' first meanings, and Gernsbacher (1984), who used dictionary meanings, did not find an ambiguity advantage effect.

The syntactic category of the stimuli is a factor that has not been attended to in previous studies (e.g., Azuma & van Orden, 1997; Klepousniotou, 2002; Millis & Button, 1989; Rodd et al., 2002). Words across different syntactic categories (primarily nouns and verbs) were adopted as the experimental materials. However, previous research showed that words of different syntactic categories, particularly nouns and verbs, involved distinct psychological processes (Chiarello et al., 1999; Deutsch et al., 1998; Druks, 2002; Kim & Thompson, 2000; Marinellie & Johnson, 2004; Sereno & Jongman, 1997; Shapiro & Caramazza, 2003; Spenney & Haynes, 1989; Tyler et al., 2004; among others). More importantly, if the ambiguity of a lexical item involves noun/verb alternations (e.g., *bank* used in *I went to the bank to withdraw money* and in *I banked the check*), it would be dangerous to assume that these words are processed the same way as ambiguous words of only one syntactic category.

In fact, research on the mutability of the meanings of nouns and verbs has revealed differences in sense extensibility of different grammatical categories. Ahrens (1999) and Gentner and France (1988) showed that verbs are more likely to extend their senses than nouns when a contradictory set of noun and verb are placed within one sentence. For instance, the sentence *The dog is thinking* is preferably interpreted as 'the dog is thinking like a person' rather than 'the person who looks or behaves like a dog is thinking.' This was true both in English and in Chinese, suggesting that the semantic properties of nouns and verbs can be so different that when they are both under the force of contextual coercion, they showed different degrees of sense mutability.[7]

[7] Ahrens (1999: 358) proposed that nouns and verbs differ in semantic mutability in the sense that "verbs are more likely to change in meaning under coercive situations when the change in semantic features is not crucial to its meaning," while "nouns are more likely to change in meaning under non-coercive situations when the change in semantic features brings about a more specific interpretation."

To our knowledge, none of the previous studies on lexical ambiguity has controlled for this factor. Their experimental items are composed of a mixture of nominal and verbal meanings. While English words often involve alternations between nouns and verbs, disyllabic words in Chinese are less polysemous, therefore making it possible for us to select as experimental materials words that belonged to only *one* syntactic category (i.e., nouns). In our study, words with noun-verb alternations were altogether avoided.

Experimental paradigms

Recently, researchers have looked at the mixed advantage and disadvantage results of lexical ambiguity in terms of the different experimental paradigms adopted (Hino et al., 2002, 2006; Piercey & Joordens, 2000; Siakaluk et al., 2007). An ambiguity advantage was obtained when the task only required the activation of *any* meaning associated with a word (e.g., lexical decision tasks (LDTs)).[8] When a particular meaning has to be selected in a sentential context (such as in eye-tracking sentence comprehension tasks)[9] or for semantic judgments (e.g., semantic categorization tasks and semantic relation tasks), then an ambiguity disadvantage was obtained. The facilitatory and inhibitory effects regarding semantic ambiguity demonstrated that different degrees of semantic access were required to carry out the different experimental tasks. In the study presented, we adopted LDTs as our experimental paradigm. In the general discussion, we present an attempt to accommodate the facilitatory and inhibitory results in the literature by considering the nature of different experimental paradigms and the different levels of lexical access that may be involved.

[8] However, not all studies using LDTs obtained an ambiguity advantage (e.g., Rodd et al., 2002).
[9] Studies of lexical ambiguity in sentential context using cross-modal lexical decision tasks (Onifer & Swinney, 1981; Swinney, 1979) showed that all meanings of a word are actually activated initially, though the parser soon settles on the appropriate meaning that fits the sentential context.

In summary, previous research, whether arguing for or against the ambiguity advantage, has not consistently treated the various factors discussed. In the lexical decision experiment reported following, we collected meanings generated by human participants and analyzed and calculated meanings based on the computational semantic theory of Ahrens et al. (1998) (thus taking into consideration the different types of lexical ambiguity in terms of homonymy, metonymy, and metaphor as well as the generative properties of polysemy; Pustejovsky, 1991). We used pseudohomophones as non-words and adopted only nouns as the experimental items. The specific control of all of these factors, we believe, provides a new and rigorous perspective to re-evaluate the ambiguity effect in lexical decisions.

The following experiment that we report includes two off-line rating tasks and one on-line lexical decision experiment. Questionnaire 1 collected meanings of the experimental items; Questionnaire 2 collected the word familiarity ratings. Based on the meaning generation tasks and familiarity ratings, we selected experimental items for the lexical decision tasks to examine the effect of lexical ambiguity in accessing Chinese nouns.

2. Method

2.1. Off-line ratings 1: meaning generation

A questionnaire was designed to collect word meanings from native speakers of Mandarin Chinese spoken in Taiwan. This questionnaire produced a database of word meanings that was later used to select experimental materials for the on-line lexical decision tasks.

Three hundred and thirty-six undergraduates (219 females, 117 males) from National Cheng-Chi University participated in the meaning generation task. All the participants were native speakers of Mandarin who were exposed to both (and only) Mandarin Chinese and Taiwan Southern Min (a dialect of Chinese spoken in Taiwan) before the age of seven. Two

hundred disyllabic Chinese nouns were selected from a frequency corpus published by CKIP (1993). Half of the words were potentially ambiguous nouns and the other half unambiguous nouns. These two groups were matched for both word frequency and character frequency based on the CKIP balanced corpus of Chinese (CKIP, 1993, 1995). The stimulus items were randomly assigned to ten questionnaires of twenty words each. Each questionnaire was organized into two random orders.

The participants were randomly given a questionnaire. Without a time limit, they were asked to write down as many meanings as they could think of for each word and to provide a sentence for each meaning they generated. A hundred and thirty six participants were screened out due to their linguistic background.[10] Data from 200 participants (126 females, 74 males) were used for the analysis. Twenty participants provided meanings for each of the 200 words. Two experimenters then independently decided the number of different meanings each participant provided for each word based on the criteria of senses and meaning facets set forth by Ahrens et al. (1998). Metaphorical meanings were treated as independent meanings; metonymic senses were treated as under the same core meaning. After independently calculating the numbers of meanings for each word, the experimenters together went through the items on which their analyses differed. Only the items on which both experimenters reached an agreement were used in the on-line experiment. The total numbers of different meanings all participants provided for each word (following Azuma & van Orden, 1997, and Millis & Button, 1989) were hence obtained. To exclude idiosyncratic responses, meanings provided by fewer than 15 percent of the participants (i.e., three out of twenty) were excluded.

2.2. Off-line ratings 2: experiential familiarity

[10] These participants had been exposed to other dialects or languages before the age of seven.

Gernsbacher (1984) showed that a word's experiential familiarity is a crucial factor to control for in on-line lexical processing. We collected experiential familiarity ratings of the experimental items to ensure that they were not a confounding factor. Forty-two Chinese-speaking undergraduates (twenty-nine females, thirteen males) from National Cheng-Chi University participated in the rating of experiential familiarity. Fourteen participants (twelve females, two males) were screened out due to unsuitable linguistic backgrounds. The ratings of twenty-eight valid participants (seventeen females, eleven males) were used for the analysis.

One hundred and eighty-six words were included in this task, among which 142 were from the original 200 words that appeared in meaning generation. Forty-four words of low frequency were added to the list to vary the range of word frequency. The materials were randomly ordered into a questionnaire. Participants were given as much time as needed to rate the experiential familiarity on a 7-point scale (1 = very unfamiliar, 7 = very familiar). They took approximately ten minutes to complete the whole booklet.

The 142 words used in the meaning generation tasks were homogeneous concerning familiarity (*SD* = 0.68). All of them were above 5.89 on the familiarity scale; the mean familiarity was 6.75. These data ensured that experiential familiarity would not be a confounding factor in the lexical decision tasks.

2.3. Experiment: lexical decision tasks

The goal of this experiment is to examine the effect of lexical ambiguity on lexical access using lexical decision tasks. We adopted Chinese disyllabic nouns as the stimuli. As stated earlier, disyllabic Chinese words are less ambiguous than monosyllabic ones; this property allowed us to find words with only *one* meaning and contrast them with words that had more

than one meaning. We were also able to exclusively use nouns as the stimuli, thus avoiding interference from multiple grammatical categories and noun-verb alternations.

2.3.1. Participants

Thirty-four undergraduates (twenty-eight females, six males) from National Taiwan University with normal or corrected-to-normal vision were paid to participate in the experiment. Participants were all native speakers of Chinese and screened for brain injury that could affect cognitive ability.

2.3.2. Materials

One hundred and forty disyllabic Chinese nouns were selected from off-line ratings as stimuli in the lexical decision tasks. One hundred and forty pseudohomophones were created as non-words. No characters (i.e., the basic monosyllabic writing units of Chinese) occurred more than once. Forty-eight words were used to verify the ambiguity effect. Half of these words had one meaning; the other half had an average of 3.33 meanings [SD = 0.64]. The numbers of meanings for these two groups were significantly different [$t(23) = 17.94$, $p < 0.001$].

These two experimental groups were equated for printed word frequency [M_1 = 782.41, SD_1 = 1998.54; M_2 = 784.33, SD_2 = 2089.21, respectively]; character frequency [1st character: M = 17906.1 and 14533.0, SD = 15635.8 and 14715.4; 2nd character: M = 12362.7 and 12311.3, SD = 14807.2 and 16650.7]; and experiential familiarity [M_1 = 6.78, SD_1 = 0.17; M_2 = 6.74, SD_2 = 0.17, respectively].[11] We ran paired-samples t-tests, which showed no significant differences regarding these factors. The stimuli are provided in the appendix.

2.3.3. Procedure

[11] A character is a monosyllabic unit of orthography in Mandarin Chinese. The disyllabic words used in this experiment each contained two Chinese characters. The frequency of each character was controlled across conditions. According to Caramazza et al. (2001), the frequencies of individual homophones, not the cumulative frequencies of the homophones, affect naming latencies. In the current study, the frequencies of the ambiguous words were calculated by counting all occurrences of the identical printed forms in the corpus.

Participants were tested individually. At the beginning of each trial, a fixation point (+) was presented in the center of the screen for 500 ms, after which a stimulus item appeared to replace the fixation point. It remained on the screen for 2000 ms or until the participants responded. The offset of the stimulus item was followed by an interval of 1500 ms before the next trial began. The stimuli were viewed at a distance of 30 cm. Participants' attention was focused on the middle of the screen by means of a black mask over the screen that allowed only a small area (5 x 3 cm) to be visible. The participants were instructed to always keep their hands on the two buttons of a button box, to press the right button (marked "word") with their right hand if the stimulus was a word, and to press the left button (marked "non-word") with their left hand otherwise. They were instructed to respond as quickly and as accurately as possible. To familiarize the participants with the task, twenty practice trials (ten words and ten non-words) were presented prior to the experimental trials. An internal dedicated CPU in the button box measured the time from the presentation of the target till a response was made on the button box or till 3500 ms had passed, whichever was earlier. The measurements were accurate to the thousandths of a millisecond (.001 ms) and were recorded to the nearest millisecond. The entire experiment lasted fifteen minutes.

2.3.4. Results

The data of four participants (three females, one male) were excluded because of mistakes in more than 20 percent of the trials (including both words and non-words) or unexpected external interference during the experiment. The results were taken from the correct responses of the remaining thirty participants (twenty-five females, five males).

Response times (RTs) were faster to words with multiple meanings [M = 549 ms, SD = 49] than to words with one meaning [M = 577 ms, SD = 49] in both participants analysis and items

analysis [$F1(1, 29) = 34.17$, $p < 0.001$, $MS_e = 357.07$; $F2(1, 23) = 5.02$, $p < 0.05$, $MS_e = 2232.46$]. The mean RTs, standard deviations, and error rates are provided in Table 2.

Table 2: Mean reaction times (in ms), standard deviations, and error rates (%)

	Number of meanings	
	One meaning	Multiple meanings
RT(SD)	577 (49)	549*** (49)
Error rate	3.75	1.81

*** $p < 0.001$

The results confirmed the effect of an ambiguity advantage (Borowsky & Masson, 1996; Hino & Lupker, 1996; Jastrzembski, 1981; Jastrzembski & Stanners, 1975; Kellas et al., 1988; Millis & Button, 1989; Rubenstein et al., 1970; Rubenstein et al., 1971). Words with more meanings were recognized faster in lexical decision tasks. This effect was found when we contrasted unambiguous nouns with nouns that have multiple meanings in Mandarin.

3. General discussion

The goal of this research was to reexamine the effect of lexical ambiguity on word recognition. Since previous investigations showed mixed results of both ambiguity advantage and disadvantage, we took into account factors that were not examined previously. Crucial improvements of our experiment over previous ones included specifying the level of ambiguity under investigation and focusing on a single grammatical category (i.e., nouns). Relying on dictionaries for meaning enumeration, most previous studies failed to consider the different kinds of lexical ambiguity involved (e.g., homonymy, metaphor, and metonymy). Our study defined

lexical ambiguity as involving homonymic and metaphorical meanings but not metonymic senses. Such definition was in line with the computational generative theory of lexical semantics (Ahrens et al., 1998; Pustejovsky, 1991) and psycholinguistic investigations of lexical ambiguity in sentential and priming contexts (Frazier & Rayner, 1990; Klepousniotou, 2002).

In addition, no previous study has yet managed to control for the issue of different parts of speech. We controlled for factors such as word frequency, character frequency, experiential familiarity, and, most importantly, the grammatical categories involved. Contrasting words with multiple meanings (average 3.3 meanings) with unambiguous words (i.e., words with only one meaning) in lexical decision tasks, we obtained an ambiguity advantage. Our study showed that ambiguity advantage exists in Chinese, a language that has a different form-to-meaning relationship from English. So far, the only other non-English investigations into the ambiguity advantage effect were made in Japanese by Hino and colleagues (Hino & Lupker, 1996; Hino et al., 2002; Hino et al., 2006; Pexman et al., 2004).

Our experimental results have important implications considering the various factors that we controlled for. In the experiment presented, lexical ambiguity was defined as words associated with multiple homonymic and metaphorical meanings generated by language users. These meanings were each analyzed by the experimenters based on formally stated linguistic tests. We avoided the confounding issue of functional shifts by focusing solely on nouns in Mandarin. This allowed us to evaluate the effect of lexical ambiguity at the level of meanings that are most distinguishable since these meanings examined were more lexicalized. We suspect that one possible reason why previous studies failed to find an ambiguity advantage effect was due to the numbers of meanings being confounded by cross-categorical alternations and/or metonymic senses.

In terms of the semantic representation of a word, we showed that by distinguishing the different kinds of lexical ambiguity (i.e., homonymy, metaphor, and metonymy), and counting on homonymy and metaphors as the levels with distinct meanings, we were able to observe the ambiguity advantage effect. Metaphorical and homonymic meanings are therefore reasonable levels of semantic representation for lexical access. Whether individual metonyms are also represented separately in the mental lexicon and can produce ambiguity effects is an empirical issue that should be further studied (cf. Klein & Murphy, 2001; Klepousniotou, 2002; Rodd et al., 2002).

While lexical ambiguity produced an advantage for word recognition in lexical decision tasks, it results in a disadvantage (incurring longer reading times) when the ambiguous words were presented in sentences (Frazier & Rayner, 1990) and when the tasks called for decisions based exclusively on semantic comparisons (e.g., semantic categorization tasks by Hino et al., 2002; Hino et al., 2006; relatedness decision tasks by Pexman et al., 2004). Taking into consideration both the ambiguity advantage effect in our lexical decision study and the ambiguity disadvantage effect found in other semantic tasks, two levels of semantic access ought to be distinguished. Lexical access involves an initial shallow stage of semantic access followed by a post-lexical selection stage. At the initial stage of word recognition (as required by lexical decision experiments), the processor aims at retrieving just one semantic node or a portion of the semantic representation to recognize a stimulus string as a word. At this stage, semantic access need not be exhaustive. The ambiguity advantage effect found in lexical decision studies, such as ours and others' (Borowsky & Masson, 1996; Hino & Lupker, 1996; Hino et al., 2006; Jastrzembski, 1981; Jastrzembski & Stanners, 1975; Kellas et al., 1988; Millis & Button, 1989;

Rubenstein et al., 1970), can be accounted for by this shallow level of incomplete semantic access.

Two possible explanations can be proposed to account for this early effect. According to a probability-based model of random lexical access, words with multiple meanings have more semantic nodes randomly distributed across the semantic space (Rubenstein et al., 1970). Thus, ambiguous words stand higher chances of retrieval. A second possibility is that ambiguous words create a "blend state," which makes them easier to get at than unambiguous words (Piercey & Joordens, 2000). As suggested by classic studies of lexical ambiguity, such as Onifer and Swinney (1981) and Swinney (1979), all or at least most of the meanings associated with a word are initially activated (Ahrens, 1998, 2001, 2006; Onifer & Swinney, 1981; Swinney, 1979). We propose that this initial activation of all associated meanings creates a semantic cluster (similar to the "blend state" of Piercey & Joordens, 2000; see also Joordens & Besner, 1994) that gives ambiguous words an edge for shallow semantic access. The ambiguity advantage found in lexical decision tasks thus can be taken as resulting from the easier access to any of its associated semantic nodes or the semantic blend state. The multiple semantic nodes associated with an ambiguous word do not compete with one another at this initial stage of lexical access as we observed no inhibition on ambiguous words.

At a subsequent stage, depending on what the task requires, a certain meaning needs to be selected to fit into a sentential context (Frazier & Rayner, 1990) or to be compared with other meanings and/or other members of a semantic category. Lexical ambiguity at this stage produces a disadvantage as selection is costly and multiple meanings associated with a word may compete to be selected, therefore producing inhibition and difficulty in processing. The tasks that require semantic selection include semantic categorization, in which participants are asked to decide if

the meaning(s) of a word belong to a particular semantic category (Hino et al., 2002; Hino et al., 2006), and relatedness decisions, which require participants to decide if pairs of words were related in meaning (Pexman et al., 2004). These tasks require consciously sorting through the meanings and focusing on one or several of them.[12] Processing difficulty thus results from several potential causes. The selection among a greater number of meanings may itself be more costly. Multiple meanings can also engage in greater competition. Lastly, the disadvantage may be interpreted as ambiguous words taking longer to "escape the blend (Piercey & Joordens, 2000: 657)."

The advantage and disadvantage effects associated with lexical ambiguity across experimental tasks are reminiscent of the neighborhood density effect in word recognition and word production.[13] Literature on neighborhood density also demonstrated complicated effects of facilitation, inhibition, and null effects across experimental paradigms on words versus non-words and in perception and production tasks (see Forster & Shen, 1996, and Vitevitch & Stamer, 2006, for reviews). The effect of neighborhood density, namely that words with more neighbors (i.e., words that differ only by changing one letter) are recognized faster, was obtained only in lexical decision tasks (particularly with low-frequency words) (Andrews, 1989, 1992; Carreiras et al., 1997; Forster & Shen, 1996). If we think of the semantic entries associated with one orthographic form as being analogous to the neighbors of a lexical item, then the facilitatory effect found on the ambiguous words in our experiment (LDTs) can also be seen as analogous to the effect of words with greater neighborhood density being recognized faster.[14] Dense

[12] It is worth noting, however, that the subsequent ambiguity disadvantage effect has also been seen as a result of decision-making (to select among multiple candidates and make "analytical" decisions (Hino et al., 2006)) rather than an effect of semantic access (Siakaluk et al., 2007). See Hino et al. (2006) for a review of the role of semantic-processing versus decision-making in semantic categorization.

[13] We thank the anonymous reviewer for making suggestions on the phonological density effect in language perception and production.

[14] Note that the ambiguity advantage effect was found regardless of the frequency of the lexical items.

neighborhoods can be seen as providing larger gravitation for lexical retrieval, thus facilitating lexical access. Such an account would seem in line with the blend-state hypothesis of Piercey and Joordens (2000).

Similar facilitations were also found in picture-naming tasks, where words with dense neighborhoods took less time to produce, suggesting that in word production as well, neighbors facilitate lexical retrieval (Dell, 1986; Vitevitch, 2002). Noteworthy, however, was the effect of competition (and thus disadvantage) in spoken word recognition, where words with sparse neighbors were actually recognized faster. This suggests that competition and selection slowed down the recognition of a spoken word when it had dense neighbors. Effects of facilitation and inhibition regarding lexical ambiguity discussed in our study thus have implications for other aspects of word recognition.

Future studies on the number-of-meaning effects may investigate the different kinds of lexical ambiguity discussed (e.g., metaphor and metonymy) within sentential contexts, as the current study has focused solely on the ambiguity of metaphorical and homonymic senses so as to maximize sense distinctions. Since metonymy is derived within sentential contexts, the process of meaning coercion and its interaction with the number of meaning facets needs to be investigated in sentential contexts. The relative frequencies of the senses associated with a word can also be studied within sentential contexts since sentences can be designed to bias towards certain meanings (e.g., the primary or the secondary meanings). In addition, since our study focused exclusively on nouns, investigation on how ambiguous verbs are accessed is also an area for future research. As nouns and verbs have distinct semantic properties, comparing the access of ambiguous verbs and that of ambiguous nouns will be an important next step to take.

Neighborhood density effect was, however, observed robustly only on low-frequency words.

In conclusion, we demonstrated that lexical ambiguity facilitates the recognition of Chinese nouns in lexical decisions. Specifically, the ambiguity advantage effect was found at the level of homonymy and metaphor. Our experimental result has critical implications for both lexical semantic theorization and the role of semantic information in lexical access. In terms of lexical semantic representation in the mental lexicon, it suggests that both homonymic and metaphorical meanings are psychologically salient semantic levels represented in the mental lexicon since they produce processing advantages in lexical access. It also suggests that homonyms and metaphors may be taken as lexicalized semantic representations. Whether the semantic level of metonymy is equally effective and lexicalized is left for future investigation. Regarding the role of semantic information in lexical access, we propose that different experimental tasks require different degrees of semantic access, reflecting the different stages of lexical and post-lexical access. Lexical decision tasks require only partial access to the whole semantic representation. Words with multiple meanings are therefore recognized faster as the semantic nodes associated with an ambiguous word form larger semantic clusters and are therefore easier (and more likely) to be accessed. At a subsequent, possibly post-lexical stage, ambiguous words take longer to respond to since selection and competition may be involved when the ambiguous words are placed in sentential contexts or when the word meanings have to be compared or categorized.

Appendix

The following are the ambiguous and unambiguous Chinese nouns contrasted in the lexical decision experiment. Metaphorical meanings of the ambiguous words are indicated by an "[M]". All and only the meanings provided by the participants in the meaning-generation task are included.

Words with one meaning

Word	**Pinyin**	**Meaning**
前妻	qian2-qi1	'ex-wife'
車速	che1-su4	'car-speed'
法官	fa3-guan1	'judge (n.)'
居所	ju1-suo3	'residence'
清晨	qing1-chen2	'early morning'
勁敵	jin4-di2	'strong enemy'
睡眠	shui4-mian2	'sleep (n.)'
心願	xin1-yuan4	'hope (n.)'
體能	ti3-neng2	'fitness'
石塊	shi2-kuai4	'rock (n.)'
感觸	gan3-chu4	'thoughts'
設備	she4-bei4	'equipments'
作物	zuo4-wu4	'produce (n.)'
政府	zheng4-fu3	'government'
其他	qi2-ta1	'other things'
外號	wai4-hao4	'nickname'
請帖	qing3-tie3	'invitation'
證件	zheng4-jian4	'document'
聯考	lian2-kao3	'joint exam'
雨傘	yu3-san3	'umbrella'
傷勢	shang1-shi4	'condition of an injury'
鋼筋	gang1-jin1	'structural steel'
真理	zhen1-li3	'truth'
班級	ban1-ji2	'class'

Words with multiple meanings

Word	**Pinyin**	**Meanings**
經典	jing1-dian3	1. [M] classic work 2. literary and philosophical texts 3. religious scriptures
兩極	liang3-ji2	1. [M] extremes 2. the two poles of the earth 3. (Physics) the two poles (positive and negative)
黃金	huang2-jin1	1. gold (metal)

Word	Pinyin	Meanings
		2. excrement
		3. [M] things of great value or goodness
跳板	tiao4-ban3	1. [M] a stepping stone
		2. a diving board
		3. a springboard used in gymnastics
呼聲	hu1-sheng1	1. [M] support
		2. a yell or shout
		3. a snore
		4. the sound of exhaling while breathing
牛郎	niu2-lang2	1. a male prostitute
		2. (Proper Noun) the name of a cowboy in Chinese folklore
		3. a cowboy hired to tend cattle
		4. Altair, the name of a star
杜鵑	du4-juan1	1. azalea, a flower
		2. a cuckoo bird
		3. a psychiatric hospital
明日	ming2-ri4	1. tomorrow
		2. [M] the near future
		3. the shiny sun
斷層	duan4-ceng2	1. (Geology) a fracture in the rock formation
		2. [M] a gap or discontinuity in knowledge
		3. a type of brain scan (computerized axial tomography)
小弟	xiao3-di4	1. a younger or the youngest brother
		2. a waiter
		3. a novice follower in the gangs
		4. a male person in a lower rank
		5. a younger male, a boy
低潮	di1-chao2	1. [M] the condition of feeling depressed
		2. the lowest point of the tide
		3. [M] (Economics) recession
精神	jing1-shen2	1. vitality, energy
		2. [M] essence, gist, spirit
		3. mental state, consciousness
同志	tong2-zhi4	1. a homosexual
		2. people of the same interest
		3. a comrade of the Communist Party in Mainland China
單位	dan1-wei4	1. the basic unit for calculation
		2. a functioning unit within a larger institution
		3. a single seat
地方	di4-fang1	1. a place, a location
		2. locality, relating to or characteristic of a particular place
		3. a part, a point
家教	jia1-jiao4	1. a home tutor
		2. family education, upbringing
		3. the practice of private teaching

Word	Pinyin	Meanings
少爺	shao4-ye2	1. son of a rich family 2. a waiter 3. a male flight attendant
學院	xue2-yuan4	1. a college in a university 2. an academy 3. scholarly to the point of being unaware of the outside world
格局	ge2-ju2	1. arrangement of space 2. [M] a situation 3. [M] vision, insight
輪廓	lun2-kuo4	1. contour of the human face 2. [M] a general idea about an event 3. the configuration or shape of an object
逃兵	tao2-bin1	1. a deserter in the military 2. [M] a dodger who avoids difficult situations 3. the act of evading military obligation
靈魂	ling2-hun2	1. the soul 2. a ghost 3. the mental state 4. [M] the essential, indispensable part 5. (music) soul
龍頭	long2-tou2	1. the leader, the most important person 2. the head of a dragon 3. a (water) faucet 4. the head of a dragon boat
頻率	pin2-lü4	1. the number of times an event occurs within a period of time 2. (Physics) frequency 3. a unit of locating a radio station 4. [M] a way of thinking

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