Article

Language and Linguistics
16(4) 587–614

DOI: 10.1177/1606822X15583240
lin.sagepub.com

Conventionalization of Lexical Meanings and the Role of Metaphoricity: Processing of Metaphorical Polysemy Using a Cross-modal Lexical Priming Task*

Yuchun Chang,[1] Chien-Jer Charles Lin,[2] and Kathleen Ahrens[3]

Ludwig-Maximilians-Universität München[1]
Indiana University Bloomington[2]
Hong Kong Baptist University[3]

Decades of lexical ambiguity research has rigorously studied effects of relative sense frequency on sense disambiguation in biased contexts, while fundamental semantic issues such as distinction of different types of ambiguities, or influences from lexical meanings' semantic nature (e.g., literal or metaphorical) as well as these meanings' degrees of conventionalization, have received less attention. In particular, while previous experimental works tend to focus on stimuli having dominant concrete meanings, a large amount of words having dominant abstract meanings are overlooked. This study focused on lexemes that contain related literal and metaphorical senses (i.e., *metaphorical polysemies*) in Mandarin Chinese, and examined meaning activation patterns of literal-dominant lexemes (having dominant literal senses and subordinate metaphorical senses, e.g., 廢物 *fèiwù* 'waste; a good-for-nothing') and metaphor-dominant lexemes (having dominant metaphorical senses and subordinate literal senses, e.g., 角度 *jiǎodù* 'spatial angle; viewpoint') in literally-biased, metaphorically-biased, and control neutral contexts in an online cross-modal lexical priming task. While both senses of literal-dominant lexemes appeared to be accessed regardless of contextual bias, only metaphorical senses of metaphor-dominant lexemes showed signs of activation in compatible contexts. The results are discussed in terms of influences from different degrees of conventionalization of literal and metaphorical senses as well as time course of meaning activation for these two types of lexemes.

Key words: contextual effect, conventionalization, lexical ambiguity, metaphorical polysemy, sense frequency

1. Introduction

In the past few decades, lexical ambiguity researchers have rigorously studied effects of relative sense frequency on sense disambiguation in biased contexts due to their crucial implications for

* This research was financially supported by grants from the National Science Council of Taiwan to Chien-Jer Charles Lin (NSC 97-2410-H-003-044). We appreciate comments from the editors, two anonymous reviewers, and participants at the 7th Conference on Language, Discourse, and Cognition (CLDC 2014). The first author would like to extend his deep gratitude for the advice and support from Hintat Cheung, Chu-Ren Huang, Jia-Fei Hong, Shu-ping Gong, Siaw-Fong Chung, along with many others who provided tremendous help with recruiting participants or recording auditory stimuli, in particular Ya-Fen Yang, Yi-Wei Lin, and Sheng-Rang Wang. Any remaining errors are our own responsibility.

theories of cognitive processing (Giora 2003; Onifer & Swinney 1981; Simpson 1981; see also Ahrens 2006; Forster & Bednall 1976; Gernsbacher 1984; Klepousniotou & Baum 2005a; McClelland & Rumelhart 1981; Rubenstein et al. 1970; Seidenberg et al. 1982; Swinney 1979; Tabossi & Zardon 1993; Traxler & Tooley 2007; Williams 1992). For example, how the two meanings of *angle*, referring either to 'space formed by two intersecting lines or planes' or 'viewpoint in observing specific events', are activated in (in)compatible contexts is important because it impacts the way psycholinguists and computational neuroscientists establish cognitive models that simulate language processing.

To address these lexical processing issues, at least three major theoretical accounts have been proposed (Giora 2003; see also Ahrens 2012, 2015), including the modular view (Fodor 1983; Kintsch & Mross 1985; Onifer & Swinney 1981; Seidenberg et al. 1982; Swinney 1979; Tanenhaus et al. 1979), the interactionist view (Tabossi 1988; Tabossi & Zardon 1993; see also Simpson & Burgess 1985), and the hybrid view (Chen & Boland 2008; Giora 2003; Kawamoto 1993). The modular view contends for independent modules for processing of lexical- and contextual-level information. All meanings of a lexical item are autonomously activating a lexical access module upon encountering the word at an early processing stage. And higher-level contextual processes only come into play at a later stage to select the contextually appropriate meaning. The interactionist view instead allows contexts to constrain lexical access at an early stage, such that appropriate meanings may be selected upon the word's encounter. Based on this view, for example, participants immediately access the appropriate 'viewpoint' meaning when reading {*The man tried to look at misfortunes in life from a different angle.*}. More recently, a hybrid view represented by the graded salience hypothesis (Giora 2003; Peleg et al. 2001, 2008) postulates, similarly to the modular view, two distinct mechanisms for lexical- and contextual-level processing. Unlike the modular view, however, it assumes that these two mechanisms run *in parallel without initial interaction*, and that lexical access is *salience-based* (i.e., ordered according to meaning dominance and not all at once; see Simpson & Burgess 1985). It predicts *dominant* (*salient*) meanings are always activated *before* subordinate meanings and regardless of contextual bias.[1]

While much emphasis has been placed on whether meanings are activated or not, these lexical access models, however, have not adequately addressed crucial aspects of semantics such as the dynamic meaning extension/variation process resulting from usage conventionalization (which changes lexical meanings' relative frequencies over time), or even the fundamental representation and categorization of lexical meanings, which has much to do with lexical items' inherent semantic contents and characteristics, such as, whether the meanings are literal or metaphorical.

For example, one type of lexeme widely used in daily conversation is the so-called *metaphorical polysemy* (e.g., 廢物 *fèiwù* 'waste; a good-for-nothing' or 角度 *jiǎodù* 'spatial angle; viewpoint'), which is typically associated with a more concrete literal meaning and a more abstract metaphorical meaning extended from the core meaning through the link of metaphor. In the Academia Sinica

[1] Giora (2003) does not seem to make a strong claim concerning subordinate meanings. In the case of metaphor comprehension, for example, Giora claims that literal meanings, which may or may not be the subordinate meanings, may be availed for metaphorical interpretations in metaphorically-biased contexts.

Balanced Corpus of Modern Chinese (version 4.0, http://www.sinica.edu.tw/SinicaCorpus/), the Chinese word 角度 *jiǎodù* 'spatial angle; viewpoint' is used only 15.6% of the time in its core literal spatial meaning, but 84.4% of the time in its extended metaphorical 'viewpoint' meaning. In contrast, the Chinese word 廢物 *fèiwù* 'waste; a good-for-nothing' is used 87.5% of the time in its core literal 'waste' meaning and only 12.5% of the time in its extended metaphorical 'a good-for-nothing' meaning in the same corpus (see §2 for details). Hence, it is not clear whether the meaning activation pattern of 角度 *jiǎodù* 'spatial angle; viewpoint', whose extended metaphorical meaning has become so conventionalized and more frequent than its core literal meaning, may or may not differ from that of 廢物 *fèiwù* 'waste; a good-for-nothing'.

For one thing, these lexemes' core and extended meanings are different as to whether they are literal or metaphorical. Since metaphor by definition is a conceptual mechanism that allows people to understand *relatively abstract* matters in terms of *more concrete* matters (Lakoff 1993; see also Ahrens 2010; Barcelona 2000; Stringaris et al. 2007), literal meanings in these metaphorical polysemies are typically more concrete than the metaphorical meanings.[2] For another, these lexemes' core and extended meanings differ in their relative frequencies in corpus. Based on Schmid (2010, 2014; see also Schmid 2000, forthcoming), this indicates that these meanings differ in their degrees of conventionalization in the speech community, which in turn correlates with frequency and strength of association of the word forms 廢物 *fèiwù* and 角度 *jiǎodù* with their literal or metaphorical meanings (concepts) in individual minds.

Processing differences may thus arise. First of all, given the more frequent/stronger association of the word form 角度 *jiǎodù* with its extended metaphorical (and abstract) sense, for example, this lexeme may be perceived as overall more abstract than the word form 廢物 *fèiwù*, and therefore it may be generally harder to detect meaning activation for 角度 *jiǎodù* or similar lexemes (Barber et al. 2013). Second, the metaphorical relationship between the meanings may play a role. In fact, based on corpus analyses, Svanlund (2007:47) claims that when the extended metaphorical meaning becomes so highly frequent and conventionalized, it may even be the case that people hardly activate any source domain concepts anymore (e.g., the word *comprehend* which literally meant 'hold tightly' in Latin; see also Ahrens et al. 2007; Blank 1988; Geiger & Ward 1999; Giora 2003; Tyler & Evans 2001). After all, one major function of metaphor is to help people understand intangible abstract concepts via more accessible concrete concepts (Ahrens 2002; Barcelona 2000; Lakoff 1993). And this implies an asymmetry in metaphorical comparisons (Lakoff 1993; Ortony et al. 1985) where conceptual mappings generally go from the source domain (literal meanings or concepts) to the target domain (metaphorical meanings or concepts). Once the abstract metaphorical meanings have become so highly conventionalized and accessible, it may be less indispensable for the cognitive system to initiate the conceptual mapping process again to avail the source domain concepts.

[2] Note that based on the definition of Lakoff (1993), literal meanings are *relatively* more concrete compared to their own extended metaphorical meanings (i.e., the comparison is within the same metaphor or metaphorical polysemy) and not compared to other literal meanings in different metaphors or metaphorical polysemies. Also, metaphorical polysemies are to be distinguished from other types of lexemes whose core meanings may 'literally' refer to something abstract (e.g., 'justice') but do not necessarily have metaphorically extended meanings.

These semantic issues, however, were not actively considered in previous lexical access models. As indicated in Lin & Ahrens (2010:2), for example, the term *ambiguity* in previous studies may cover 'any orthographic or phonological form being associated with multiple meanings', such as *bank* (a homonymy having unrelated meanings denoting either 'financial institution' or 'riverbank'), *angle* (a polysemy having related literal and metaphorical meanings), and *flower–flour* (homophones; Onifer & Swinney 1981). Even in recent studies where a distinction was made between homonymy and polysemy (Beretta et al. 2005; Frazier & Rayner 1990; Klein & Murphy 2001; Rodd et al. 2002) or between homonymy, metaphorical polysemy (i.e., polysemy with related literal and metaphorical meanings, e.g., 角度 *jiǎodù* 'spatial angle; viewpoint'), and metonymical polysemy (i.e., polysemy with related literal and metonymically-extended meanings, e.g., *pine* referring either to the tree or its smell; Klepousniotou 2002; Klepousniotou & Baum 2005a, 2005b, 2007; Klepousniotou et al. 2008, 2012; Taler et al. 2009), dominant meanings in the stimuli were the core concrete (or literal) meanings rather than the extended meanings. As described in Vigliocco & Vinson (2007), most previous lexical memory studies tend to focus on 'nouns referring to concrete objects', thus ignoring a large amount of words having dominant abstract meanings, whose activation patterns remain yet to be explored.

Along with this inadequacy, confusion arose in these studies since the distinction between homonymy and polysemy has long been criticized as cognitively imprecise (Croft & Cruse 2004; see also Cruse 2011). That is, meanings may be synchronically unrelated but diachronically or etymologically related, and the perceived degrees of relatedness may vary due to individual background knowledge (e.g., a lexicographer versus non-linguistic professionals) or different operational criteria (e.g. different dictionaries). Hence the same lexical item may fall under different categories of ambiguities among different studies (e.g., *coach* as a homonymy in Klepousniotou & Baum 2007, but a polysemy in Rodd et al. 2002).

To compare meaning activation patterns between lexemes with dominant concrete meanings and those with dominant abstract meanings, therefore, this study focuses on lexemes that contain related literal and metaphorical meanings (traditionally termed as *metaphorical polysemies*), and manipulates relative frequencies of their two meanings such that either their literal or metaphorical meanings are dominant. Meanwhile, to avoid potential confusion from categorizing ambiguity items solely based on meaning relatedness, a more recent distinction between *senses* and *meaning facets* is introduced which is based on objective linguistic tests, such as whether two meanings or interpretations may simultaneously exist in the same contexts (i.e., *meaning facets*) or not (i.e., *senses*; Ahrens et al. 1998, 2003; Croft & Cruse 2004). On the one hand, such a context-based criterion has the advantage of being irrespective of the meanings' diachronic or etymological relations (as in the homonymy–polysemy distinction). On the other hand, this approach is particularly relevant for experiments that explore effects of contextual bias on lexical meaning activation, because two or more facet-level meanings may by definition coexist in the same contexts (i.e., regardless of the contextual bias), and hence with this distinction we may focus on lexical items with *only* sense-level meanings and no facet-level meanings (see §2 for specific methods) for a clear observation of contextual bias effects.

In all, we investigate how literal and metaphorical senses of literal-dominant lexemes and metaphor-dominant lexemes are activated in literally-biased, metaphorically-biased, and control neutral contexts, in order to tap into effects of conventionalization of literal and metaphorical senses on their activation. It is hypothesized that meaning activation patterns of literal-dominant lexemes will differ from those of metaphor-dominant lexemes. In particular, since previous studies suggest that once metaphorical senses become highly frequent and conventionalized, people may have difficulty activating the literal concepts (Svanlund 2007), it is likely that we detect activation of metaphor-dominant lexemes' metaphorical senses but not their literal senses.

2. Methods

A cross-modal lexical priming task (Ahrens 2001, 2002, 2006, 2015; Nicol et al. 2006; Swinney et al. 1979) was run to examine activation of (in)frequent literal and metaphorical senses of literal- and metaphor-dominant lexemes in literally-/metaphorically-biased and control neutral contexts. This task required participants to listen to sentential contexts which embed these literal-/metaphor-dominant lexemes and are biased to their literal or metaphorical senses, as well as control neutral sentential contexts which embed control-unrelated lexemes matched to the literal-/metaphor-dominant lexemes for relevant psycholinguistic variables (e.g., length, number of senses, etc., see below) but semantically unrelated to their literal or metaphorical senses. Upon offsets of critical lexemes (literal-dominant/metaphor-dominant/control unrelated lexemes), two characters appeared on the screen, which formed either words related to literal-/metaphor-dominant lexemes' literal or metaphorical senses or legal non-words (nonsensical combination of Chinese characters, e.g., 刁啓 *diāoqǐ*), for participants to quickly decide whether the characters made up a word or not.[3] Reaction times to these visual probes were then analyzed to detect priming of literal-/metaphor-dominant lexemes' literal/metaphorical senses in different contexts.

2.1 Participants

Twenty-eight undergraduate students (mean age = 20.8 years, SD = 1.2 years, 13 males) from National Taiwan University participated in the experiment (seven in each list). They were native speakers of Mandarin Chinese, right-handed, had normal or corrected-to-normal eyesight and hearing ability, and were screened for neurological diseases and brain injury. None had lived abroad for more than one year before the age of seven. All were paid NT$100 for participation.

2.2 Materials and design

2.2.1 Literal-dominant and metaphor-dominant lexemes

To prepare critical auditory primes, 16 literal-dominant and 16 metaphor-dominant lexemes were selected from Chinese WordNet (http://cwn.ling.sinica.edu.tw/), an online lexical database

---

[3] This task thus has the advantage of playing natural spoken discourse similar to those in non-experimental settings to participants, while detecting priming effects during the ongoing discourse and disallowing the participants to have time to consciously reflect on the relationship between the visual probes and the auditory sentential stimuli, and therefore it is appropriate for study of lexical meaning activation during sentence comprehension (Ahrens 2002, 2015).

Table 1: Sample stimuli

Auditory sentential contexts	**Visual probes**
Literal-dominant lexeme: 廢物 *fèiwù* 'waste; a good-for-nothing' ***Control unrelated lexeme***: 門禁 *ménjìn* 'entrance controller'	
Literally-biased contexts 化學肥料工廠依規定須妥善處理加工過程中產生的**廢物**‸，不可隨便。 'According to the law, chemical fertilizer factories must deal with ***wastes***‸ generated during production with great care.' ***Metaphorically-biased contexts*** 從小祖母就諄諄告誡他：不要做個混吃等死的**廢物**‸，要做有用的人。 'Ever since childhood his grandmother admonished him: Don't be ***a good-for-nothing***‸ who knows nothing but eating till death; be a useful person.' ***Control neutral contexts*** 某些大學的宿舍爲了確保同學安全設有**門禁**‸，限制深夜同學的出入。 'Certain college dormitories have an ***entrance controller***‸ that limits entrance and exit at night to ensure safety.'	***Literal probe*** 殘渣 *cánzā* 'residue' ***Metaphorical probe*** 累贅 *léizuì* 'nuisance'
Metaphor-dominant lexeme: 角度 *jiǎodù* 'spatial angle; viewpoint' ***Control Unrelated lexeme***: 類型 *lèixíng* 'type (n.)'	
Literally-biased contexts 專家測量的結果證實，比薩斜塔傾斜的**角度**‸近百年來有增加的趨勢。 'Results of experts' measurements proved the tendency that *Torre pendente di Pisa*'s leaning ***angle***‸ increased in the past century.' ***Metaphorically-biased contexts*** 人生在世挫折、痛苦經常在所難免；學習換一個**角度**‸想會有所幫助。 'Frustrations and pains are often unavoidable in life; learning to think from another ***angle***‸ may be helpful.' ***Control neutral contexts*** 荷花和睡蓮雖然外表相似，但仍可細分成屬於兩種不同**類型**‸的植物。 'Although lotus and water lily look similar, they are categorized as two different ***types***‸ of plants.'	***Literal probe*** 數値 *shùzhí* 'number' ***Metaphorical probe*** 看法 *kànfǎ* 'viewpoint'
Filler lexeme: 行爲 *xíngwéi* 'deed'	
Filler contexts 校長稱許學生奮不顧身搭救溺水孩童的**行爲**‸，並對此感到非常欣慰。 'The principal approved the student's brave ***deed***‸ of saving the drowning child regardless of his own safety, and was gratified with that.'	***Legal non-word*** 刁啓 *diāoqǐ*

established by Academia Sinica, Taiwan, which, like its English counterpart, constructs a network of conceptual-semantic and lexical relationships among the words and, in addition, defines Chinese words based on Ahrens et al.'s (1998, 2003) sense delineation criteria. All these lexemes were disyllabic, had sense-level literal and metaphorical meanings (identification of metaphorical senses was based on WordNet's lexicographic custom to add 比喻 *bǐyù* 'metaphorically referring to' in the definitions to indicate a sense is metaphorical), and did not have any facet-level meanings, cross-categorical meanings (e.g., simultaneously having nominal, adjectival, or verbal meanings), or homophonic/homographic meanings (see Table 1 for sample stimuli).

Importantly, these lexemes were chosen based on their senses' relative frequencies in the Academia Sinica Balanced Corpus of Modern Chinese (version 4.0, http://www.sinica.edu.tw/SinicaCorpus/). Relative sense frequencies for these words' senses were calculated by manually coding the words' keyword-in-context (KWIC) data in corpus according to their Chinese WordNet sense definitions, and then dividing the number of tokens used in a certain sense by the total number of occurrences of the word. For example, the word 角度 *jiǎodù* 'angle (in its literal spatial sense); viewpoint' has 538 tokens in the corpus totally, among which 84 tokens are used in its literal sense 'space formed by two intersecting lines or planes', and 454 tokens are used in its metaphorical sense 'viewpoints in observing specific events'. Hence the relative sense frequencies for the words' literal and metaphorical senses respectively are 15.6% and 84.4%.

For all literal-/metaphor-dominant lexemes used in this study, the dominant senses' relative sense frequencies were never less than 65.0%, and the subordinate senses' relative sense frequencies were never more than 35.0%. Altogether, the dominant literal senses and subordinate metaphorical senses of literal-dominant lexemes had a mean relative sense frequency of 84.1% (raw mean sense frequency = 130.1) and 11.5% (raw mean sense frequency = 17.3), respectively; and the dominant metaphorical senses and the subordinate literal senses of metaphor-dominant lexemes had a mean relative sense frequency of 86.1% (raw mean sense frequency = 231.3) and 10.4% (raw mean sense frequency = 18.8), respectively. The literal-dominant and metaphor-dominant lexemes' dominant senses did not differ in their relative sense frequencies, $t(30) = -0.48$, $p > .63$, nor did their subordinate senses, $t(30) = 0.28$, $p > .78$. The literal-dominant and metaphor-dominant lexemes also did not differ in their total number of senses, $t(30) = 1.69$, $p > .26$ (see Table 2 for a summary of descriptive statistics for auditory primes and visual probes used in this study).

2.2.2 Control unrelated lexemes and visual probes

The next steps involved preparing appropriate stimuli for control unrelated lexemes that were matched to the selected literal-/metaphor-dominant lexemes, as well as stimuli for visual probes related to either literal or metaphorical senses of the literal-/metaphor-dominant lexemes. In selecting these stimuli, the current study particularly chose *monosemies* which had only one sense in the Chinese WordNet/Revised Mandarin Chinese Dictionary. This criterion for stimulus selection was adopted mainly to minimize artificial priming effects due to semantic overlapping between the probes/control unrelated lexemes. Note that since these visual probes had only one literal or metaphorical sense, and literal-/metaphor-dominant lexemes' literal senses typically are more concrete than their metaphorical senses (see §1), it is expected that literally-related probes will be more concrete than metaphorically-related probes (see §4.3 for discussions on limitations of stimulus selection).

Thirty-two disyllabic monosemies were chosen from the Chinese WordNet as control unrelated lexemes. The selection criteria were the same as those for literal-/metaphor-dominant lexemes, except that each word had only one sense-level meaning. In addition, for each literal-/metaphor-dominant lexeme, two disyllabic monosemies from the Chinese WordNet/Revised Dictionary of Mandarin Chinese (National Languages Committee 1994) were selected as visually presented probes in the formal experiment, such that one of them was related to the literal sense and the other to the metaphorical

Table 2: Descriptive statistics for metaphorical polysemies and their corresponding control unrelated lexemes, and for literally-related and metaphorically-related probes. Relative sense frequencies for literal and metaphorical senses of literal-/metaphor-dominant lexemes are reported in percentages with raw mean sense frequencies in the parentheses. Scores under *compatible/incompatible/neutral* indicate mean ratings of relatedness between probes and primes when the primes are embedded in compatible, incompatible, or control neutral context conditions.

Condition		**Mean frequency**			**Relatedness**			**Concrete-ness**	**Famili-arity**
		Word	**Literal sense**	**Meta. sense**	**Com-patible**	**Incom-patible**	**Neutral**		
Literal-dominant lexemes & relevant items									
Primes	Literal-dominant lexemes	153.0	84.1% (130.1)	11.5% (17.3)	–	–	–	5.6	6.5
	Control unrelated lexemes	146.6	–	–	–	–	–	5.5	6.5
Probes	Literal probes	347.8	–	–	5.3	4.2	1.3	5.4	6.9
	Metaphorical probes	248.8	–	–	5.7	3.6	1.4	4.5	6.7
Metaphor-dominant lexemes & relevant items									
Primes	Metaphor-dominant lexemes	265.3	10.4% (18.8)	86.1% (231.3)	–	–	–	4.2	6.4
	Control unrelated lexemes	248.4	–	–	–	–	–	4.0	6.2
Probes	Literal probes	174.3	–	–	4.9	3.4	1.2	5.2	6.7
	Metaphorical probes	347.8	–	–	5.4	3.3	1.4	4.3	6.8

sense of the metaphorical polysemy. They did not involve any homographic/homophonic meanings or contain characters appearing in their corresponding literal-/metaphor-dominant lexemes. The literal-dominant lexemes, metaphor-dominant lexemes, as well as their control unrelated lexemes were matched for word frequency, $F(3, 60) = 0.81$, $p > .49$, and so were literally- and metaphorically-related probes of literal- and metaphor-dominant lexemes, $F(3, 60) = 0.61$, $p > .61$.

2.2.3 Familiarity and concreteness ratings

Degrees of familiarity (Gernsbacher 1984) for literal- and metaphor-dominant lexemes and their matched control unrelated lexemes, and for the four groups of monosemous visual probes, were respectively rated by two groups of 60 and 20 native speakers who did not participate in the formal experiment on a 7-point Likert scale (1 = very unfamiliar; 7 = very familiar). The literal-dominant/metaphor-dominant lexemes and their paired control unrelated lexemes did not differ in familiarity, $F(3, 60) = 1.96$, $p > .12$, nor did literally- and metaphorically-related probes of literal- and metaphor-dominant lexemes, $F(3, 60) = 0.43$, $p > .73$ (see Table 2 for details of ratings).

Furthermore, degrees of concreteness for literal- and metaphor-dominant lexemes and their matched control unrelated lexemes, and for the four groups of monosemous visual probes were respectively rated by two groups of 30 and 24 native speakers who did not participate in the formal experiment on a 7-point Likert scale (1 = very abstract; 7 = very concrete). It is expected that literal-dominant lexemes and literally-related visual probes will be more concrete than metaphor-dominant lexemes and metaphorically-related visual probes (see earlier discussion). Hence the aim of such ratings in the current study is to match degrees of concreteness between the critical literal- or metaphor-dominant lexemes and their paired control unrelated lexemes and between literal-dominant and metaphor-dominant lexemes' visual probes, while also showing concreteness differences between literal-dominant lexemes and metaphor-dominant lexemes (and their respective control unrelated lexemes) and between literal and metaphorical visual probes.

The concreteness rating tasks indeed showed that: (1) in general, literal-/metaphor-dominant lexemes did not differ from their paired control unrelated lexemes in degrees of concreteness, $t(60) = 0.67$, $p > .50$, while literal-dominant lexemes and their paired control unrelated lexemes were respectively more concrete than metaphor-dominant lexemes and their paired control unrelated lexemes, $t(60) = 3.99$, $p < .001$; $t(60) = 4.10$, $p < .001$ (results of planned contrasts based on an F-test on these four groups of lexemes, $F(3, 60) = 11.06$, $p < .001$); and (2) literal-dominant lexemes' probes did not differ from metaphor-dominant lexemes' probes in degrees of concreteness, $t(60) = 0.66$, $p > .50$, while literal-dominant lexemes' literal probes and metaphor-dominant lexemes' literal probes were respectively more concrete than literal-dominant lexemes' metaphorical probes and metaphor-dominant lexemes' metaphorical probes, $t(60) = 2.71$, $p < .01$; $t(60) = 2.54$, $p < .02$ (results of planned contrasts based on an F-test on these four groups of lexemes, $F(3, 60) = 4.75$, $p < .01$; see Table 2 for details of ratings).

2.2.4 Sentential stimuli

After the critical word stimuli were prepared, the 32 literal-/metaphor-dominant lexemes were each embedded in two sentential contexts at sentence-medial position, with one sentence biasing toward the literal sense and the other biasing toward the metaphorical sense (mean length = 30.03 characters, SD = 0.17 characters; mean distance from offsets of literal-/metaphor-dominant lexemes to end of sentences = 7.55 characters, SD = 1.67 characters). A separate group of 39 native undergraduate students from National Taiwan University/National Taiwan Normal University participated in a sentence completion task where these sentences were cut off right before the literal-/metaphor-dominant lexemes for the participants to complete the fragments so as to ensure the contexts were biased to the intended meanings (Ahrens 2001, 2002, 2006). Thirty-two control contexts were likewise created embedding the 32 monosemous control unrelated lexemes, which were paired to the 32 literal-/metaphor-dominant lexemes (length = 30 characters; mean distance from prime offsets to end of sentences = 9.03 characters, SD = 2.28 characters). In addition, 64 filler sentences (length = 30 characters) were created, embedding 64 filler lexemes at a random position in the sentential contexts. In the main experiment, these sentences were paired with 64 legal non-word visual probes.

2.2.5 Relatedness ratings

A relatedness rating pretest including the experimental and filler sentences and the corresponding visual probes (filler sentences were paired with another 64 related/unrelated filler lexemes) was conducted and 29 undergraduate students from National Taiwan University rated the degrees of relatedness between the visual probes and the critical literal-/metaphor-dominant lexemes/control unrelated lexemes on a 7-point Likert scale (1 = strongly unrelated; 7 = strongly related). Kruskal-Wallis tests showed that literally-/metaphorically-related probes were sufficiently related to their corresponding literal-/metaphor-dominant lexemes in literally-/metaphorically-biased contexts, as compared to control neutral contexts ($p < .001$; literal versus control neutral contexts, metaphorical versus control neutral contexts, ps < .001; literal versus metaphorical contexts, ps < .03). No difference in terms of degrees of relatedness between visual probes and the critical literal-/metaphor-dominant lexemes/control unrelated lexemes was found either between literal-dominant/metaphor-dominant lexemes ($p > .36$) or between literally-/metaphorically-related visual probes ($p > .72$; see Table 2 for details of ratings).

2.2.6 List creation

Four lists of stimuli were compiled such that each literal-/metaphor-dominant lexeme appeared only once in each list, either in literally-biased or in metaphorically-biased contexts. To that end, each list contained (1) 16 literally-biased and 16 metaphorically-biased contexts embedding the 32 literal-/metaphor-dominant lexemes and paired to 16 literally-related and 16 metaphorically-related visual probes; (2) the 32 control neutral contexts embedding the control unrelated lexemes paired to the remaining 16 literally-related and 16 metaphorically-related visual probes; and (3) the 64 filler sentences paired to legal non-word visual probes for negative responses. This led to 128 lexical decision trials per list, which were divided into eight blocks of 16 trials. Note that the current study then compared reaction times to the same visual probes appearing during presentation of literally-/metaphorically-biased or control neutral contexts. This design is considered capable of ensuring that all psycholinguistic variables in the visual probes are exactly matched across conditions and lists (McKoon & Ratcliff 1994; Nicol et al. 1994).

2.3 Procedure

Participants sat in a sound-attenuated room in front of the experimental computer screen and a button box. A video illustrating the experimental procedure was played to each participant before the experiments began. Participants were instructed to listen to the sentence played over the head-phones and to stare at a fixation point at the center of the screen, with their index fingers kept on the buttons at all times during the experiments. As soon as two characters appeared on the screen and replaced the fixation point, they had to decide whether these characters made up a Chinese word or not and make responses on the button box as quickly and accurately as possible. The visual probes were displayed for 1,000 ms at offsets of critical auditory prime words (literal-/metaphor-dominant lexemes) while the auditory sentential contexts went on playing until the end, with an inter-trial interval of 1,500 ms. Positive responses were always placed on the right and participants' handedness was controlled (all were right-handed). E-Prime measured response times in milliseconds or until 2,000 ms passed.

To prevent participants from merely concentrating on the visual lexical decision task without attending to the auditory sentential contexts in the cross-modal lexical priming experiment, each block of lexical decision trials was followed by a memory test composed of 10 visually presented sentences, half of which were the same as those heard in the previous block and the other half were slightly changed. The participants were then required to correctly decide whether the sentence presented on the screen during the memory test was the same with or different from the one they had heard during the previous lexical decision block. The order of blocks and order of trials in each block were automatically randomized by E-Prime each time an experiment ran. Before the formal sessions began, participants were given a practice session of 20 lexical decision trials and 10 practice memory tests similar to those in the experiments to familiarize them with the online experimental procedure. The whole experiment lasted for about 40 minutes.

2.4 Apparatus

Experimental scripts were compiled using E-Prime 2.0.8.22 and the experiment was run on an Intel Pentium 4 desktop computer with a Serial Response Box (Psychology Software Tools, Inc.), and a ViewSonic E773 cathode ray tube monitor. All sounds were recorded by a male native speaker of Mandarin Chinese in a sound-attenuated room, in a single channel to the hard disk of an Intel Pentium 4 computer at a sampling rate of 22,050 Hz and in bit-depths of 16, with the aid of a Computerized Speech Lab audio processing package (Model 4400, version 2.7.0). The participants sat in front of the computer and the response box at a distance of about 60 cm from the computer screen to their eyes.

3. Data analysis and results

Individual participants' raw reaction time data were submitted to R 3.1.2 for further processing and analyses. Participants' response accuracy rate overall reached 93% for lexical decisions and 77% for memory tests. Incorrect responses (131 trials) were excluded from reaction time analyses, which accounted for 7.3% of the experimental trials. Outliers were defined as reaction times 1.5 interquartile range (IQR) outside the lower and upper quartile (roughly 2.7 standard deviations away from the mean) of the data for each participant and each condition, and were replaced by the closest values in that range (59 trials in total, constituting 3.3% of all trials), resulting in a mean reaction time of 598.7 ms (SD = 150.8 ms) for all experimental trials. See Table 3 for a summary of mean reaction times and error rates, and Figure 1 for a comparison of reaction times under each condition.[4]

---

[4] The memory tests were admittedly very difficult for the participants. Only one participant made it to reach a 90% accuracy level (see Love & Swinney 1996, e.g., who adopted a 90% accuracy threshold for comprehension tests). This high level of difficulty was intended to force participants to attend to the auditory stimuli. Also it should be noted here that in three trials E-Prime unexpectedly delayed visual probe presentation for more than 30 ms and the three data points were removed; in addition, in three trials the sounds were not played normally, for which one data point was removed while two could not be located. Compared with the total amount of 1,792 trials the influence is considered small.

Table 3: Mean reaction times (ms) and error rates in each condition.

	Literal probes		Metaphorical probes	
	RT	**Error**	**RT**	**Error**
Literal-dominant lexemes				
Literal contexts	556.4	.02	589.4	.09
Metaphorical contexts	586.7	.04	581.1	.02
Control Neutral contexts	607.1	.07	631.4	.10
Metaphor-dominant lexemes				
Literal contexts	604.1	.09	607.6	.06
Metaphorical contexts	589.1	.12	582.7	.02
Control Neutral contexts	607.8	.12	598.5	.05

3.1 Reaction time analysis

This study adopted a multilevel modeling approach to analyze the reaction time data using the *lme4* (v. 1.1-7; Bates et al. 2014) and *lmerTest* (v. 2.0-20; Kuznetsova et al. 2014) packages in R. This approach has received increasingly more attention in recent years by psycholinguists due to its capacity to simultaneously model participants and items as two crossed random effects (Baayen 2008; Baayen et al. 2008; Barr et al. 2013; Locker et al. 2007), thus preventing the so-called 'language-as-fixed-effect fallacy' (i.e., the traditional by-participant analyses risk at a higher Type I error rate by neglecting the fact that language materials, given their infinite possibilities in the real world, should also be modeled as random variables; Clark 1973; Forster & Dickinson 1976; Raaijmakers 2003; Raaijmakers et al. 1999; Wike & Church 1976). Other advantages of this approach relevant to the analyses at hand lie in its unconstrained use of non-orthogonal contrasts and its ability to cope with missing/unbalanced data and asphericity (Baayen et al. 2008; see also Gelman et al. 2012).

Before models were constructed, contrasts were preliminarily set up for each fixed variable, namely *groups of lexemes* (probes of literal-dominant lexemes versus probes of metaphor-dominant lexemes, a within-participant/between-item variable), *types of visual probes* (literally-related versus metaphorically-related probes, a within-participant/between-item variable), and *types of contexts* (literally-biased versus control neutral contexts and metaphorically-biased versus control neutral contexts, a within-participant/within-item variable). A baseline model with participants and items assigned with random intercepts was initially established, with the three fixed variables (*groups of lexemes*, *types of visual probes*, *types of contexts*) and their two-way (*groups of lexemes* × *types of visual probes*, *groups of lexemes* × *types of contexts*, *types of visual probes* × *types of contexts*) and three-way (*groups of lexemes* × *types of visual probes* × *types of contexts*) interaction terms added one after another into subsequent models; and the final complete model included all fixed variables and interaction terms. Log-likelihood statistics assessing fit of the models were compared between these models using chi-square likelihood ratio tests to reveal significant predictors. Significant interaction effects were further broken down by establishing separate multilevel models for each level of the involved variable. These broken-down models were the same with the complete model except that the main effects and interaction terms involving parameters to be broken down were excluded from model

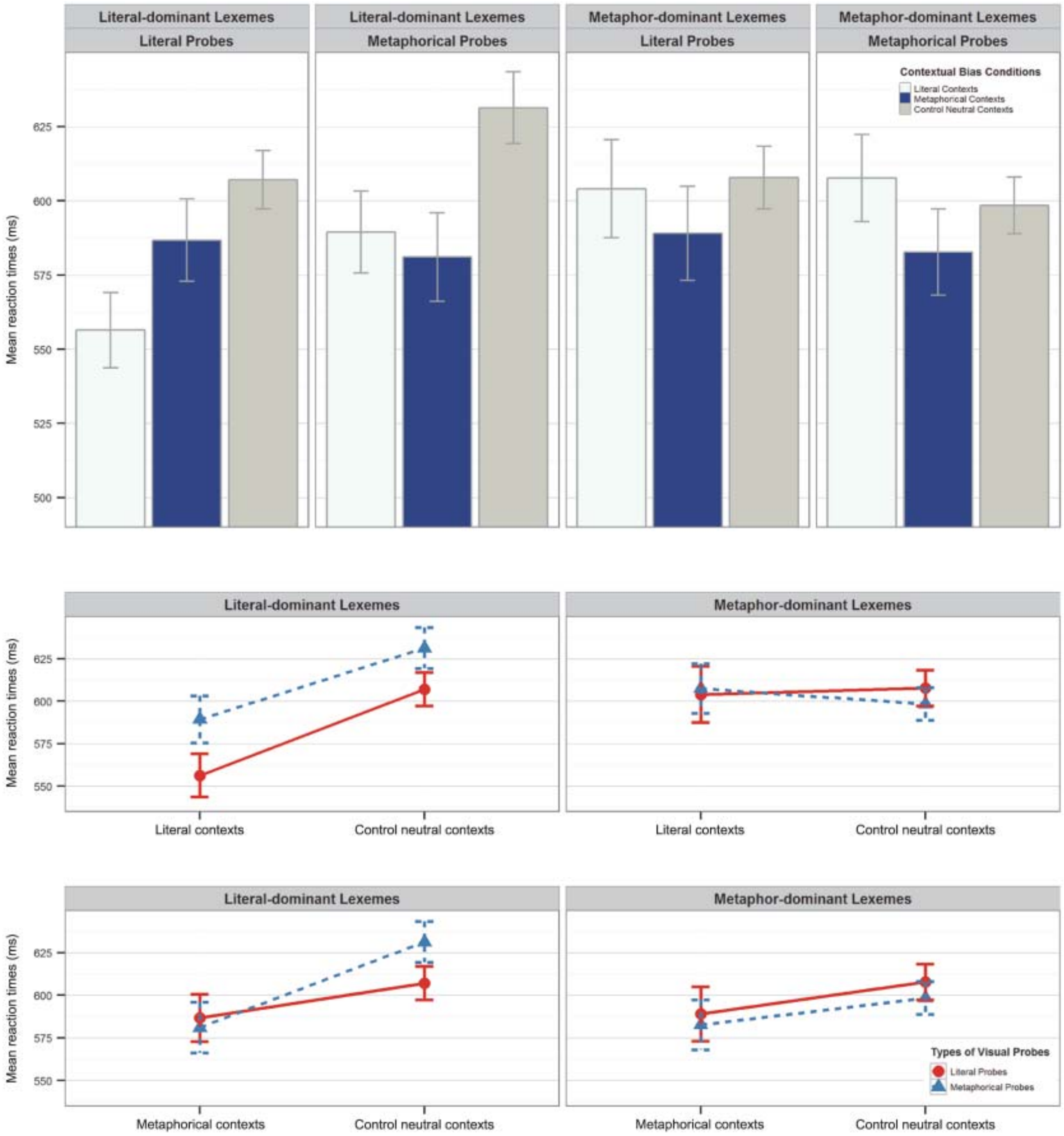

Figure 1: Mean reaction times (ms) for literal and metaphorical probes of literal-/metaphor-dominant lexemes in literally-/metaphorically-biased or control neutral contexts. Error bars indicate standard errors of the mean reaction times in each condition.

specification. Parameter coefficients in all the models mentioned were estimated using the maximum likelihood method and analyzed. Denominator degrees of freedom for *t*-tests evaluating significance of parameter coefficients in all models were approximated using the *Satterthwaite* method in the *lmerTest* package (for the following discussions, see Table 4 for coefficients, standard errors of coefficients, degrees of freedom, *t* values, *p* values, and 95% confidence intervals of parameters in the complete model and the following broken-down models, $\alpha = .05$).

Table 4: Coefficients (*b*), standard errors of coefficients (SE *b*), degrees of freedom (*df*), *t* values (*t*), *p* values (*p*), and 95% confidence intervals (95% CI) of parameters in the complete model and the following broken-down models for reaction time analysis. The parameter *Groups of lexemes* involves a contrast between probes of literal-dominant lexemes and those of metaphor-dominant lexemes, and the parameter *Visual probes* involves a contrast between literally- and metaphorically-related visual probes.

Parameters	*b*	SE *b*	*df*	*t*	*p*	95% CI	
Complete model							
Groups of lexemes	7.01	7.27	77.0	0.96	*.34*	–7.45	21.42
Visual probes	–4.04	7.27	77.0	–0.56	*.58*	–18.45	10.42
Contexts (literal versus control)	–20.89	5.91	1568.4	–3.54	*<.001****	–32.48	–9.31
Contexts (metaphorical versus control)	–25.89	5.89	1568.8	–4.40	*<.0001****	–37.43	–14.34
Groups of lexemes×visual probes	–10.50	7.27	77.0	–1.44	*.15*	–24.97	3.90
Groups of lexemes × contexts (literal versus control)	–23.49	5.91	1568.4	–3.98	*<.0001****	–35.08	–11.90
Groups of lexemes × contexts (metaphorical versus control)	–11.85	5.89	1568.8	–2.01	*.044**	–23.39	–0.30
Visual probes × contexts (literal versus control)	–4.93	5.91	1568.4	–0.83	*.40*	–16.52	6.66
Visual probes × contexts (metaphorical versus control)	11.72	5.89	1568.8	1.99	*.047**	0.18	23.27
Groups of lexemes × visual probes×contexts (literal versus control)	1.13	5.91	1568.4	0.19	*.85*	–10.46	12.72
Groups of lexemes × visual probes×contexts (metaphorical versus control)	5.62	5.89	1568.8	0.96	*.34*	–5.92	17.17
Literal-dominant lexemes							
Visual probes	–14.21	9.09	42.6	–1.56	*.13*	–32.47	3.99
Contexts (literal versus control)	–44.46	8.53	779.1	–5.21	*<.000001****	–61.20	–27.71
Contexts (metaphorical versus control)	–37.63	8.48	779.2	–4.44	*<.0001****	–54.27	–20.99
Visual probes×contexts (literal versus control)	–3.83	8.53	779.1	–0.45	*.65*	–20.58	12.91
Visual probes × contexts (metaphorical versus control)	16.96	8.47	779.1	2.00	*.046**	0.33	33.59
Metaphor-dominant lexemes							
Visual probes	6.87	11.46	36.1	0.60	*.55*	–16.12	30.04
Contexts (literal versus control)	2.40	8.21	763.0	0.29	*.77*	–13.72	18.52
Contexts (metaphorical versus control)	–14.65	8.21	763.3	–1.78	*.075†*	–30.77	1.47
Visual probes × contexts (literal versus control)	–6.40	8.22	763.0	–0.78	*.44*	–22.52	9.72
Visual probes × contexts (metaphorical versus control)	5.49	8.21	763.3	0.67	*.50*	–10.62	21.60
Literal probes							
Groups of lexemes	–4.16	11.26	35.7	–0.37	*.71*	–26.93	18.44
Contexts (literal versus control)	–26.48	7.92	762.6	–3.34	*<.001****	–42.02	–10.93
Contexts (metaphorical versus control)	–14.32	8.00	762.8	–1.79	*.074†*	–30.02	1.39
Groups of lexemes × contexts (literal versus control)	–21.84	7.92	762.6	–2.76	*<.01***	–37.39	–6.29
Groups of lexemes × contexts (metaphorical versus control)	–5.69	8.00	762.8	–0.71	*.48*	–21.40	10.02
Metaphorical probes							
Groups of lexemes	17.71	9.52	42.3	1.86	*.070†*	–1.34	36.84
Contexts (literal versus control)	–16.17	8.78	779.7	–1.84	*.066†*	–33.39	1.06
Contexts (metaphorical versus control)	–37.66	8.63	779.8	–4.37	*<.0001****	–54.59	–20.73
Groups of lexemes × contexts (literal versus control)	–25.24	8.78	779.7	–2.88	*<.01***	–42.47	–8.02
Groups of lexemes × contexts (metaphorical versus control)	–17.62	8.62	779.7	–2.04	*.041**	–34.54	–0.70

Table 4: Continued

Parameters	***b***	**SE *b***	***df***	***t***	***p***	**95% CI**	
Literal probes of literal-dominant lexemes							
Contexts (literal versus control)	–48.46	10.37	382.4	–4.67	*<.00001****	–68.84	–28.07
Contexts (metaphorical versus control)	–20.45	10.47	382.3	–1.95	*.052*†	–41.03	0.13
Metaphorical probes of literal-dominant lexemes							
Contexts (literal versus control)	–42.49	13.65	369.5	–3.11	*<.01***	–69.31	–15.66
Contexts (metaphorical versus control)	–55.04	13.34	369.6	–4.13	*<.0001****	–81.25	–28.79
Literal probes of metaphor-dominant lexemes							
Contexts (literal versus control)	–4.81	12.25	353.8	–0.39	*.70*	–28.87	19.26
Contexts (metaphorical versus control)	–9.85	12.39	354.0	–0.80	*.43*	–34.20	14.49
Metaphorical probes of metaphor-dominant lexemes							
Contexts (literal versus control)	8.66	11.27	383.1	0.77	*.44*	–13.48	30.81
Contexts (metaphorical versus control)	–20.20	11.12	383.0	–1.82	*.070*†	–42.05	1.67

***p < .001; **p < .01; *p < .05; †p < .1.

A significant main effect was found for *types of contexts*, $\chi^2(2) = 23.95$, $p < .0001$. To further inspect the effects, contrasts in the complete model were used and their parameter coefficients revealed that reaction times to visual probes presented in the literally-biased contexts condition and the metaphorically-biased contexts condition were both significantly faster than when they were presented in the control neutral contexts condition (*ps* < .001). No main effect was found for *groups of lexemes*, $\chi^2(1) = 0.09$, $p > .76$, or *types of visual probes*, $\chi^2(1) = 0.11$, $p > .74$.

Moreover, there were significant two-way interaction effects in the complete model between *groups of lexemes* and *types of contexts*, $\chi^2(2) = 16.31$, $p < .001$, and between *types of visual probes* and *types of contexts*, $\chi^2(2) = 6.61$, $p < .04$. Parameter coefficients revealed that the significant interaction effects mainly arose from interactions between literal-/metaphor-dominant lexemes and the contrast of literally-biased and control neutral contexts conditions ($p < .0001$); between these lexemes and the contrast of metaphorically-biased and control neutral contexts conditions ($p = .044$); and between the two types of visual probes and the contrast of metaphorically-biased and control neutral contexts conditions ($p = .047$). No other significant interaction effect was found in the complete model between *groups of lexemes* and *types of visual probes*, $\chi^2(1) = 1.64$, $p > .20$, or between *groups of lexemes*, *types of visual probes*, and *types of contexts*, $\chi^2(2) = 0.93$, $p > .62$. Significant interactions in the complete model, as mentioned earlier, were respectively broken down by analyzing separate multilevel models for the two levels of *groups of lexemes* and the two levels of *types of visual probes* (see Gelman et al. 2012).

In these broken-down models, main effects of the contrast between literally-biased and control neutral contexts conditions were found significant for literal-dominant lexemes ($p < .000001$), literally-related probes ($p < .001$), and marginal for metaphorically-related probes ($p = .066$). Main effects of the contrast between metaphorically-biased and control neutral contexts conditions were found significant also for literal-dominant lexemes ($p < .0001$) and metaphorically-related probes ($p < .0001$), and marginal for metaphor-dominant lexemes ($p = .075$) and literally-related probes

(p = .074). No other main effects in these broken-down models were found except a marginal one for *groups of lexemes* for metaphorically-related visual probes (p = .07).

However, in these models, the contrast between literally-biased and control neutral contexts conditions was found to further interact with literal-dominant and metaphor-dominant lexemes' literally-related probes ($p < .01$), and metaphorically-related probes ($p < .01$); and the contrast between metaphorically-biased and control neutral contexts conditions was found to interact with the two types of probes of literal-dominant lexemes (p = .046), and literal-dominant and metaphor-dominant lexemes' metaphorically-related probes (p = .041). Hence, to examine the effects, these interactions were again broken down by analyzing separate multilevel models for literally- and metaphorically-related visual probes of literal- and metaphor-dominant lexemes.

These further broken-down models revealed significant differences between literally-biased and control neutral contexts conditions for literal and metaphorical probes of literal-dominant lexemes ($p < .00001$; $p < .01$). The differences between metaphorically-biased and control neutral contexts conditions were also found significant for metaphorical probes of literal-dominant lexemes ($p < .0001$), and marginal for literal probes of literal-dominant lexemes (p = .052) and for metaphorical probes of metaphor-dominant lexemes (p = .070; see middle and bottom panels of Figure 1).

3.2 Error analysis

An error analysis using a multilevel modeling approach for binomial data (correct or incorrect responses) similar to that described above for reaction time data analysis (i.e., with participants and items simultaneously modeled as random variables and *groups of lexemes*, *types of visual probes*, and *types of contexts* modeled as fixed variables) yielded results overall corresponding to, though weaker than, those in the reaction time analysis.

A significant main effect was found for *types of contexts*, $\chi^2(2) = 8.08$, $p = .02$. An examination of parameter coefficients of contrasts in the complete model for error occurrences revealed that, compared to the control neutral contexts condition, there were significantly fewer errors in the metaphorically-biased contexts condition, $b = –0.93$, SE $b = 0.33$ (95% CI: –1.57, –0.29), $z = –2.86$, $p < .01$, and marginally fewer errors in the literally-biased contexts condition, $b = –0.50$, SE b = 0.28 (95% CI: –1.05, 0.06), $z = –1.76$, $p = .078$. No main effect was found for *groups of lexemes*, $\chi^2(1) = 0.20$, $p > .65$, or *types of visual probes*, $\chi^2(1) = 0.08$, $p > .77$.

There was also a significant two-way interaction between *types of visual probes* and *types of contexts*, $\chi^2(2) = 9.86$, $p < .01$, in the complete model for error occurrences. Parameter coefficients revealed that this significant interaction mainly arose from interactions between the two types of visual probes and the contrast of metaphorically-biased and control neutral contexts conditions, $b = 0.65$, SE $b = 0.33$ (95% CI: 0.01, 1.29), $z = 1.98$, $p = .047$. The interaction effect between two types of visual probes and the contrast of literally-biased and control neutral contexts conditions, $b = –0.51$, SE $b = 0.28$ (95% CI: –1.06, 0.04), $z = –1.81$, $p = .07$, was marginal. No other interaction effects were found (ps > .14).

The significant interaction in the complete model was, as before, broken down by analyzing separate multilevel models for the two levels of *types of visual probes*. These analyses revealed that compared to the control neutral contexts condition, there were significantly fewer errors in the literally-biased contexts condition for literally-related probes, $b = –1.01$, SE $b = 0.45$ (95% CI:

–1.90, –0.12), $z = –2.23$, $p < .03$, and in the metaphorically-biased contexts condition for metaphorically-related probes, $b = –1.57$, SE $b = 0.55$ (95% CI: –2.65, –0.49), $z = –2.84$, $p < .01$.

To sum up, overall it was found that: (1) literal senses of literal-dominant lexemes were activated in literally-biased contexts, while there were signs (given the marginal effects) that such senses were also activated in metaphorically-biased contexts; (2) metaphorical senses of literal-dominant lexemes were activated in both literally- and metaphorically-biased contexts; (3) literal senses of metaphor-dominant lexemes were not activated in any contextual conditions; (4) metaphorical senses of metaphor-dominant lexemes showed a tendency of activation in metaphorically-biased contexts.

4. General discussion

This study examined activation of literal- and metaphor-dominant lexemes' literal and metaphorical senses in literally-/metaphorically-biased and control neutral contexts, to observe how degrees of conventionalization of lexical meanings with different semantic nature (literal or metaphorical) may influence meaning activation in contexts. Results from a cross-modal lexical priming task revealed that both senses of literal-dominant lexemes appeared to be activated regardless of contextual bias. However, only metaphorical senses of metaphor-dominant lexemes showed signs of access in their compatible contexts.

4.1 Literal- versus metaphor-dominant lexemes

Given the current experimental paradigm (a cross-modal lexical priming task), timing settings (e.g., presenting visual probes for 1000 ms), and stimulus preparation methods (e.g., using monosemies as visual probes; see later sections for further discussions), we found different meaning activation patterns for literal-dominant and metaphor-dominant lexemes. In the current study, literal-dominant lexemes, similar to stimuli used in previous lexical ambiguity studies (Vigliocco & Vinson 2007), seem to show meaning activation patterns that are more compatible with the modular view (i.e., all senses are immediately activated regardless of contextual bias).

However, metaphor-dominant lexemes with dominant metaphorical senses seem to display a completely different pattern. Whereas only their metaphorical senses showed signs of activation in metaphorically-biased contexts, it was difficult to detect activation of their literal senses under whichever contextual bias condition. Moreover, their metaphorically-related visual probes were responded to even more slowly in the literally-biased contexts condition than in the control neutral contexts condition (see Table 3). These results may imply the difficulty of activating meanings in general in these more abstract polysemies, and in particular the difficulty of activating their literal, source domain concepts, as suggested in Svanlund (2007).[5]

[5] We may also consider the extreme example of Svanlund's (2007) *comprehend*, whose abstract, metaphorically-derived meaning of 'understand' is used almost all the time nowadays, and it may be difficult for anyone to activate its original meaning of 'grasp' even when it is embedded in contexts where the literal 'grasp' meaning is intended. This indicates the possibility that when the extended metaphorical meanings are so frequently used and highly conventionalized, the literal meanings in such items are not encoded in the lexical memory in the long run.

The increased difficulty of meaning activation in metaphor-dominant lexemes may have to do with a high degree of conventionalization of their metaphorical senses (as may be reflected by their high corpus relative frequencies; Schmid 2010, 2014). Conventionalization is described in Schmid (2014) as a community-level sociopragmatic process of 'continuous mutual coordination and matching of communicative knowledge and practices, subject to the exigencies of the entrenchment processes taking place in individual minds'. And since conventionalization of linguistic units correlates with an individual's frequency of usage or exposure to these units, it is considered crucially related to processing of the linguistic units in cognition, too (Schmid 2010, 2014, forthcoming; see also Gilquin & Gries 2009; Giora 2003; Gries et al. 2005, 2010; Nunberg et al. 1994; Schmid 2000, 2007, 2010).

Hence in the speech community, for example, increased occurrences of 角度 *jiǎodù* 'spatial angle; viewpoint' in its metaphorical sense contribute to the mutual exchange and co-adaptation of this usage among the speakers, making this usage highly conventionalized and more and more stable. Meanwhile, this high-frequency usage of 角度 *jiǎodù* in its metaphorical sense also contributes to a stronger association of the word form 角度 *jiǎodù* with its extended metaphorical sense, together with this sense's relevant situational contexts, communicative intentions, etc., in the individual cognitive system. On the one hand, this lexeme may be thus perceived as less concrete than 廢物 *fèiwù* 'waste; a good-for-nothing', which is strongly associated with its literal sense. On the other hand, processing of the particular form-meaning pairing of 角度 *jiǎodù* and its metaphorical sense also becomes increasingly routinized, automated, and easily accessible in the mind. In the meantime, since metaphor has an asymmetric nature in terms of the direction of conceptual mappings, that is, normally from the source domain concepts (literal senses) to the target domain concepts (metaphorical senses; Lakoff 1993), once metaphorical senses become dominant and easily accessed, it is suspected that the cognitive system may not be obliged to reinitiate the conceptual mapping process and avail literal senses all over again. This might be one possible reason why no activation (or even delayed reaction times) could be detected for literal probes of metaphor-dominant lexemes or when metaphor-dominant lexemes were embedded in literally-biased contexts. Based on the discussion, it is not unlikely that highly conventionalized metaphorical senses in metaphor-dominant lexemes at least increase the difficulty of accessing literal senses. And therefore the current results hint at a need to factor in degrees of conventionalization of metaphorical meanings when modeling resolution of lexical ambiguities in contexts, since previous studies have largely overlooked stimuli with dominant abstract or metaphorical meanings (Vigliocco & Vinson 2007).

Nonetheless, the current results should still be interpreted with caution. It may be the case that the current paradigm, timing settings, or stimulus selection criteria do not allow strong meaning activation patterns to be detected for metaphor-dominant lexemes. These limitations will be discussed in the following sections.

4.2 Time course of lexical meaning activation

One important limitation of this study is that the visual probe presentation time was set at 1,000 ms. While it is the norm to fix on a particular length of visual probe presentation time and explore the effects, Ahrens (2006; see also Ahrens 2015) reviewed previous studies that supported the modular or interactive accounts of lexical ambiguity resolution, and found that studies supporting the modular view tended to adopt a visual probe presentation time less than 1,000 ms, while studies supporting the interactive view mostly adopted a visual probe presentation time of more than 1,500 ms. She then examined meaning activation in unbalanced ambiguous nouns in a cross-modal lexical priming study and manipulated visual probe presentation time. She found that, when visual probes (related to either the dominant or subordinate meanings) were presented for 300 ms or for 750 ms at offsets of ambiguous words, both meanings of the ambiguous words were activated. However, when visual probes were presented for 1,500 ms, only the contextually appropriate meanings of the ambiguous words were activated. The results showed that there was an early processing stage where all meanings were present, and after a short while only contextually appropriate meanings were retained.

With this in view, our current timing setting for visual probe presentation (1,000 ms) is right within the time range (though at the edge) where effects compatible with the 'modular' view were mostly observed, and indeed similar effects were found for literal-dominant lexemes, which resemble stimuli used in most lexical ambiguity studies. Since metaphor-dominant lexemes are more abstract than literal-dominant lexemes, we suspect that their time window for meaning activation may be later (or earlier) than literal-dominant lexemes, and hence the current visual probe presentation time settings may not be optimal to observe significant meaning facilitation for metaphor-dominant lexemes. These timing issues for literal-/metaphor-dominant lexemes or ambiguities still require future studies.

4.3 Selection of visual probes

The methods for selecting visual probes may also influence the priming effects that may be observed. Importantly, researchers have attempted to examine differences between 'associative priming' and 'semantic priming', namely whether associatively-related targets (such as those collected from word association norms) produce different priming effects from semantically related targets (Alario et al. 2000; Balota & Paul 1996; Boring 1950; Bueno & Frenck-Mestre 2008; Deese 1965; Grondin et al. 2009; Hino et al. 1997; Hirshman & Durante 1992; Hutchison 2003; Joordens & Becker 1997; Lucas 2000; Lupker 1984; McRae & Boisvert 1998; Nelson et al. 2000; Perea & Rosa 2002; Shelton & Martin 1992; Williams 1996). While it is admittedly difficult to tease apart the two (Jones et al. 2006), possible differences between them may still be considered. Using a cross-modal priming paradigm with single word primes, Hino et al. (1997) for example found that associative priming tended to occur early, while semantic priming was only observed 750 ms after prime offset (see Alario et al. 2000). Hence, this may be an important factor to be considered for an appropriate timing setting. Since this study strictly uses monosemies from the Chinese WordNet/ Revised Dictionary of Mandarin Chinese as visual probes to avoid semantic overlappings between literal and metaphorical probes (and extra sense frequency issues), most of the visual probes were semantically related to the primes, and therefore we did not adopt a shorter visual probe presentation time.

In addition, since our monosemy criterion limits the possible range of candidate stimuli, it may disallow a maximal degree of relatedness between the visual probes and literal-/metaphor-dominant lexemes (in contrast, visual probes that are more directly related to the primes, collected based on production tasks such as meaning generation, are mostly polysemous; Ahrens 2006). It is possible to choose instead visual probes based on word association tasks (Boring 1950; Nelson et al. 2000,

2004) or other similar production tasks. In that case, however, although more intuitively-related visual probes could be used, and one may fortunately match their degrees of concreteness etc. between any two groups (i.e., such probes may contain a roughly balanced proportion of concrete and abstract senses), one must also handle the issue that multiple meanings in the probes may be simultaneously related to both literal and metaphorical meanings of literal-/metaphor-dominant lexemes. For example, many potential probes for 廢物 *fèiwù* 'waste; a good-for-nothing', such as the polysemous lexeme 垃圾 *lèsè* 'trash; a worthless person', are related to both literal and metaphorical senses of 廢物 *fèiwù* 'waste; a good-for-nothing', and thus are not appropriate probes for the observation of contextual effects, because they may be facilitated under either literally- or metaphorically-biased contexts conditions anyway.

4.4 Future work and conclusion

Future research may be conducted with an increased number of participants, since it is not unlikely that the broken-down models could show different effects with more data, particularly for the currently marginally significant parameters. Also, due to the stringent stimulus selection criteria (see §2 and §4.3), we did not plan to look into effects of lexical category (i.e., nouns versus verbs; Ahrens 1999, 2001, 2003; Huang et al. 2000; Moseley & Pulvermüller 2014) since nouns tend to occur more frequently than verbs.[6] To address this issue, more appropriate items are also required for future studies. In addition, effects of different types of probes or probe presentation times are certainly worth further investigation, as discussed in §4.2 and §4.3.

As lexical ambiguity resolution studies go towards more and more refined semantic analyses, there are in fact many more factors across different linguistic or non-linguistic levels (e.g., all sorts of neighborhoods, Vitevitch 2002; perceptual salience of the word form, Geeraerts et al. 1994; prototypicality, Rosch 1973; number of syntagmatic/paradigmatic competitors, Schmid 2014; richness of associations of lexical meanings with different linguistic/situational/social contexts, Barber et al. 2013; or speaker-related differences, Schmid forthcoming) which should be considered. Among the many factors, we attempted to cope with varied degrees of conventionalization of literal and metaphorical senses associated with literal-/metaphor-dominant lexemes. For literal-dominant lexemes, the current study found meaning activation patterns similar to previous findings that supported a modular view. However, difficulty of accessing literal senses seemed to arise for lexemes with highly conventionalized metaphorical senses. While degrees of conventionalization of metaphorical senses as well as the asymmetric nature of metaphor are considered keys to explain the differences, we hope, through this study, that more attention may be drawn to stimuli with dominant metaphorical meanings to allow a more comprehensive understanding of lexical processing.

[6] As nouns occur more frequently than verbs in corpora (e.g., 4,292,070 nouns versus 2,253,846 verbs in Academia Sinica Balanced Corpus of Modern Chinese), frequencies of nominal primes/probes were also higher than verbal primes/probes in this study, $t(40.57) = 3.18$, $p < .01$; $t(39.28) = 3.00$, $p < .01$. Although when we attempted to add lexical category (nouns versus verbs) into the multilevel model, it seems nominal stimuli gained faster reaction times than verbal ones, $\chi^2(2) = 6.53$, $p < .05$, it is uncertain whether this effect was due to the higher frequencies of nouns.

References

Ahrens, Kathleen. 1999. The mutability of noun and verb meaning. *Chinese Languages and Linguistics*, Vol. 5: *Interactions in Language*, ed. by Yuen-mei Yin, I-li Yang & Hui-chen Chan, 335–371. Taipei: Institute of Linguistics, Academia Sinica.

Ahrens, Kathleen. 2001. On-line sentence comprehension of ambiguous verbs in Mandarin. *Journal of East Asian Linguistics* 10.4:337–358.

Ahrens, Kathleen. 2002. Timing issues in lexical ambiguity resolution. *Sentence Processing in East Asian Languages*, ed. by Mineharu Nakayama, 1–26. Stanford: CSLI.

Ahrens, Kathleen. 2003. Verbal integration: the interaction of participant roles and sentential argument structure. *Journal of Psycholinguistic Research* 32.5:497–516.

Ahrens, Kathleen. 2006. The effect of visual target presentation times on lexical ambiguity resolution. *Language and Linguistics* 7.3:677–696.

Ahrens, Kathleen. 2010. Mapping principles for conceptual metaphors. *Researching and Applying Metaphor in the Real World*, ed. by Graham Low, Zazie Todd, Alice Deignan & Lynne Cameron, 185–207. Amsterdam & Philadelphia: John Benjamins.

Ahrens, Kathleen. 2012. Finding what you expect to see: theoretical modeling in psycholinguistics. *Journal of Social Sciences* 8.3:372–380.

Ahrens, Kathleen. 2015. Semantic processing: access, ambiguity, and metaphor. *The Oxford Handbook of Chinese Linguistics*, ed. by William S-Y. Wang & Chaofen Sun, 666–675. Oxford & New York: Oxford University Press.

Ahrens, Kathleen, Li-Li Chang, Ke-Jiann Chen, & Chu-Ren Huang. 1998. Meaning representation and meaning instantiation for Chinese nominals. *Computational Linguistics and Chinese Language Processing* 3.1:45–60.

Ahrens, Kathleen, Chu-Ren Huang, & Yuan-hsun Chuang. 2003. Sense and meaning facets in verbal semantics: a MARVS perspective. *Language and Linguistics* 4.3:469–484.

Ahrens, Kathleen, Ho-Ling Liu, Chia-Ying Lee, Shu-Ping Gong, Shin-Yi Fang, & Yuan-Yu Hsu. 2007. Functional MRI of conventional and anomalous metaphors in Mandarin Chinese. *Brain and Language* 100.2:163–171.

Alario, F.-Xavier, Juan Segui, & Ludovic Ferrand. 2000. Semantic and associative priming in picture naming. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology* 53.3:741–764.

Baayen, R. Harald. 2008. *Analyzing Linguistic Data: A Practical Introduction to Statistics Using R*. Cambridge & New York: Cambridge University Press.

Baayen, R. Harald, Doug J. Davidson, & Douglas M. Bates. 2008. Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language* 59.4:390–412.

Balota, David A., & Stephen T. Paul. 1996. Summation of activation: evidence from multiple primes that converge and diverge within semantic memory. *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 22.4:827–845.

Barber, Horacio A., Leun J. Otten, Stavroula-Thaleia Kousta, & Gabriella Vigliocco. 2013. Concreteness in word processing: ERP and behavioral effects in a lexical decision task. *Brain and Language* 125.1:47–53.

Barcelona, Antonio. 2000. *Metaphor and Metonymy at the Crossroads: A Cognitive Perspective*. Berlin & New York: Mouton de Gruyter.

Barr, Dale J., Roger Levy, Christoph Scheepers, & Harry J. Tily. 2013. Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language* 68.3:255–278.

Bates, Douglas M., Martin Maechler, & Steven Walker. 2014. lme4: linear mixed-effects models using Eigen and S4 (R package version 1.1-7). http://CRAN.R-project.org/package=lme4.

Beretta, Alan, Robert Fiorentino, & David Poeppel. 2005. The effects of homonymy and polysemy on lexical access: an MEG study. *Cognitive Brain Research* 24.1:57–65.

Blank, Glenn David. 1988. Metaphors in the lexicon. *Metaphor and Symbol* 3.1:21–36.

Boring, Edwin Garrigues. 1950. *A History of Experimental Psychology* (2nd edition). New York: Appleton-Century-Crofts.

Bueno, Steve, & Cheryl Frenck-Mestre. 2008. The activation of semantic memory: effects of prime exposure, prime-target relationship, and task demands. *Memory & Cognition* 36.4:882–898.

Chen, Lillian, & Julie E. Boland. 2008. Dominance and context effects on activation of alternative homophone meanings. *Memory & Cognition* 36.7:1306–1323.

Clark, Herbert H. 1973. The language-as-fixed-effect fallacy: a critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior* 12.4:335–359.

Croft, William, & D. Alan Cruse. 2004. *Cognitive Linguistics*. Cambridge & New York: Cambridge University Press.

Cruse, D. Alan. 2011. *Meaning in Language: An Introduction to Semantics and Pragmatics* (3rd edition). Oxford & New York: Oxford University Press.

Deese, James. 1965. *The Structure of Associations in Language and Thought.* Baltimore: Johns Hopkins Press.

Fodor, Jerry A. 1983. *The Modularity of Mind: An Essay on Faculty Psychology*. Cambridge: MIT Press.

Forster, Kenneth I., & Elizabeth S. Bednall. 1976. Terminating and exhaustive search in lexical access. *Memory & Cognition* 4.1:53–61.

Forster, Kenneth I., & Rod G. Dickinson. 1976. More on the language-as-fixed-effect fallacy: Monte Carlo estimates of error rates for F1, F2, F′ and minF′. *Journal of Verbal Learning and Verbal Behavior* 15.2:135–142.

Frazier, Lyn, & Keith Rayner. 1990. Taking on semantic commitments: processing multiple meanings vs. multiple senses. *Journal of Memory and Language* 29.2:181–200.

Geeraerts, Dirk, Stefan Grondelaers, & Peter Bakema. 1994. *The Structure of Lexical Variation: A Descriptive Framework for Cognitive Lexicology*. Berlin & New York: Mouton de Gruyter.

Geiger, Odie, & Lawrence M. Ward. 1999. Metaphors and the mental lexicon. *Brain and Language* 68.1–2:192–198.

Gelman, Andrew, Jennifer Hill, & Masanao Yajima. 2012. Why we (usually) don't have to worry about multiple comparisons. *Journal of Research on Educational Effectiveness* 5.2:189–211.

Gernsbacher, Morton Ann. 1984. Resolving 20 years of inconsistent interactions between lexical familiarity and orthography, concreteness, and polysemy. *Journal of Experimental Psychology: General* 113.2:256–281.

Gilquin, Gaëtanelle, & Stefan Th. Gries. 2009. Corpora and experimental methods: a state-of-the-art review. *Corpus Linguistics and Linguistic Theory* 5.1:1–26.

Giora, Rachel. 2003. *On Our Mind: Salience, Context, and Figurative Language*. Oxford & New York: Oxford University Press.

Gries, Stefan Th, Beate Hampe, & Doris Schönefeld. 2005. Converging evidence: bringing together experimental and corpus data on the association of verbs and constructions. *Cognitive Linguistics* 16.4:635–676.

Gries, Stefan Th, Beate Hampe, & Doris Schönefeld. 2010. Converging evidence II: more on the association of verbs and constructions. *Empirical and Experimental Methods in Cognitive/Functional Research*, ed. by Sally Rice & John Newman, 59–72. Stanford: CSLI.

Grondin, Ray, Stephen J. Lupker, & Ken McRae. 2009. Shared features dominate semantic richness effects for concrete concepts. *Journal of Memory and Language* 60.1:1–19.

Hino, Yasushi, Stephen J. Lupker, & Chris R. Sears. 1997. The effects of word association and meaning frequency in a cross-modal lexical decision task: is the priming due to 'semantic' activation? *Canadian Journal of Experimental Psychology* 51.3:195–211.

Hirshman, Elliot, & Richard Durante. 1992. Prime identification and semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 18.2:255–265.

Huang, Chu-Ren, Kathleen Ahrens, Li-Li Chang, Keh-Jiann Chen, Mei-Chun Liu, & Mei-Chih Tsai. 2000. The module-attribute representation of verbal semantics: from semantic to argument structure. *Computational Linguistics and Chinese Language Processing* 5.1:19–46.

Hutchison, Keith A. 2003. Is semantic priming due to association strength or feature overlap? A microanalytic review. *Psychonomic Bulletin & Review* 10.4:785–813.

Jones, Machael N., Walter Kintsch, & Douglas J. K. Mewhort. 2006. High-dimensional semantic space accounts of priming. *Journal of Memory and Language* 55.4:534–552.

Joordens, Steve, & Suzanna Becker. 1997. The long and short of semantic priming effects in lexical decision. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23.5:1083–1105.

Kawamoto, Alan H. 1993. Nonlinear dynamics in the resolution of lexical ambiguity: a parallel distributed-processing account. *Journal of Memory and Language* 32.4:474–516.

Kintsch, Walter, & Ernest F. Mross. 1985. Context effects in word identification. *Journal of Memory and Language* 24.3:336–349.

Klein, Devorah E., & Gregory L. Murphy. 2001. The representation of polysemous words. *Journal of Memory and Language* 45.2:259–282.

Klepousniotou, Ekaterini. 2002. The processing of lexical ambiguity: homonymy and polysemy in the mental lexicon. *Brain and Language* 81.1–3:205–223.

Klepousniotou, Ekaterini, & Shari R. Baum. 2005a. Processing homonymy and polysemy: effects of sentential context and time-course following unilateral brain damage. *Brain and Language* 95.3:365–382.

Klepousniotou, Ekaterini, & Shari R. Baum. 2005b. Unilateral brain damage effects on processing homonymous and polysemous words. *Brain and Language* 93.3:308–326.

Klepousniotou, Ekaterini, & Shari R. Baum. 2007. Disambiguating the ambiguity advantage effect in word recognition: an advantage for polysemous but not homonymous words. *Journal of Neurolinguistics* 20.1:1–24.

Klepousniotou, Ekaterini, G. Bruce Pike, Karsten Steinhauer, & Vincent Gracco. 2012. Not all ambiguous words are created equal: an EEG investigation of homonymy and polysemy. *Brain and Language* 123.1:11–21.

Klepousniotou, Ekaterini, Debra Titone, & Carolina Romero. 2008. Making sense of word senses: the comprehension of polysemy depends on sense overlap. *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 34.6:1534–1543.

Kuznetsova, Alexandra, Per Bruun Brockhoff, & Rune Haubo Bojesen Christensen. 2014. lmerTest: tests in linear mixed effects models (R package version 2.0-20). http://CRAN.R-project.org/package=lmerTest.

Lakoff, George. 1993. The contemporary theory of metaphor. *Metaphor and Thought* (2nd edition), ed. by Andrew Ortony, 202–251. Cambridge & New York: Cambridge University Press.

Lin, Chien-Jer Charles, & Kathleen Ahrens. 2010. Ambiguity advantage revisited: two meanings are better than one when accessing Chinese nouns. *Journal of Psycholinguistic Research* 39.1:1–19.

Locker, Lawrence, Lesa Hoffman, & James A. Bovaird. 2007. On the use of multilevel modeling as an alternative to items analysis in psycholinguistic research. *Behavior Research Methods* 39.4:723–730.

Love, Tracy, & David A. Swinney. 1996. Coreference processing and levels of analysis in object-relative constructions: demonstration of antecedent reactivation with the cross-modal priming paradigm. *Journal of Psycholinguistic Research* 25.1:5–24.

Lucas, Margery. 2000. Semantic priming without association: a meta-analytic review. *Psychonomic Bulletin & Review* 7.4:618–630.

Lupker, Stephen J. 1984. Semantic priming without association: a second look. *Journal of Verbal Learning and Verbal Behavior* 23.6:709–733.

McClelland, James L., & David E. Rumelhart. 1981. An interactive activation model of context effects in letter perception: I. An account of basic findings. *Psychological Review* 88.5:375–407.

McKoon, Gail, & Roger Ratcliff. 1994. Sentential context and on-line lexical decision. *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 20.5:1239–1243.

McRae, Ken, & Stephen Boisvert. 1998. Automatic semantic similarity priming. *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 24.3:558–572.

Moseley, Rachel L., & Friedemann Pulvermüller. 2014. Nouns, verbs, objects, actions, and abstractions: local fMRI activity indexes semantics, not lexical categories. *Brain and Language* 132:28–42.

National Languages Committee. (eds.) 1994. *Revised Dictionary of Mandarin Chinese*. Taipei: Ministry of Education.

Nelson, Douglas L., Cathy L. McEvoy, & Simon Dennis. 2000. What is free association and what does it measure? *Memory & Cognition* 28.6:887–899.

Nelson, Douglas L., Cathy L. McEvoy, & Thomas A. Schreiber. 2004. The University of South Florida free association, rhyme, and word fragment norms. *Behavior Research Methods*, *Instruments*, *& Computers* 36.3:402–407.

Nicol, Janet L., Janet Dean Fodor, & David A. Swinney. 1994. Using cross-modal lexical decision tasks to investigate sentence processing. *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 20.5:1229–1238.

Nicol, Janet L., David A. Swinney, Tracy Love, & Lea Hald. 2006. The on-line study of sentence comprehension: an examination of dual task paradigms. *Journal of Psycholinguistic Research* 35.3:215–231.

Nunberg, Geoffrey, Ivan A. Sag, & Thomas Wasow. 1994. Idioms. *Language* 70.3:491–538.

Onifer, William, & David A. Swinney. 1981. Accessing lexical ambiguities during sentence comprehension: effects of frequency of meaning and contextual bias. *Memory & Cognition* 9.3: 225–236.

Ortony, Andrew, Richard J. Vondruska, Mark A. Foss, & Lawrence E. Jones. 1985. Salience, similes, and the asymmetry of similarity. *Journal of Memory and Language* 24.5:569–594.

Peleg, Orna, Rachel Giora, & Ofer Fein. 2001. Salience and context effects: two are better than one. *Metaphor and Symbol* 16.3–4:173–192.

Peleg, Orna, Rachel Giora, & Ofer Fein. 2008. Resisting contextual information: you can't put a salient meaning down. *Lodz Papers in Pragmatics* 4.1:13–44.

Perea, Manuel, & Eva Rosa. 2002. The effects of associative and semantic priming in the lexical decision task. *Psychological Research* 66.3:180–194.

Raaijmakers, Jeroen G. W. 2003. A further look at the 'language-as-fixed-effect fallacy'. *Canadian Journal of Experimental Psychology* 57.3:141–151.

Raaijmakers, Jeroen G. W., Joseph M. C. Schrijnemakers, & Frans Gremmen. 1999. How to deal with 'the language-as-fixed-effect fallacy': common misconceptions and alternative solutions. *Journal of Memory and Language* 41.3:416–426.

Rodd, Jennifer, M. Gareth Gaskell, & William Marslen-Wilson. 2002. Making sense of semantic ambiguity: semantic competition in lexical access. *Journal of Memory and Language* 46.2: 245–266.

Rosch, Eleanor H. 1973. On the internal structure of perceptual and semantic categories. *Cognitive Development and the Acquisition of Language*, ed. by Timothy E. Moore, 111–144. New York: Academic Press.

Rubenstein, Herbert, Lonnie Garfield, & Jane A. Millikan. 1970. Homographic entries in internal lexicon. *Journal of Verbal Learning and Verbal Behavior* 9.5:487–494.

Schmid, Hans-Jörg. 2000. *English Abstract Nouns as Conceptual Shells: From Corpus to Cognition.* Berlin & New York: Mouton de Gruyter.

Schmid, Hans-Jörg. 2007. Entrenchment, salience, and basic levels. *The Oxford Handbook of Cognitive Linguistics*, ed. by Dirk Geeraerts & Hubert Cuyckens, 117–138. Oxford & New York: Oxford University Press.

Schmid, Hans-Jörg. 2010. Does frequency in text instantiate entrenchment in the cognitive system? *Quantitative Methods in Cognitive Semantics: Corpus-driven Approaches*, ed. by Dylan Glynn & Kerstin Fischer, 101–133. Berlin & New York: De Gruyter Mouton.

Schmid, Hans-Jörg. 2014. Lexico-grammatical patterns, pragmatic associations and discourse frequency. *Constructions Collocations Patterns*, ed. by Thomas Herbst, Hans-Jörg Schmid & Susen Faulhaber, 239–293. Berlin & Boston: De Gruyter Mouton.

Schmid, Hans-Jörg. (forthcoming). Introduction: a framework for understanding linguistic entrenchment and its psychological foundations in memory and automatization. *Entrenchment*, *Memory and Automaticity: The Psychology of Linguistic Knowledge and Language Learning*, ed. by Hans-Jörg Schmid, 1–24. Boston: APA/Walter de Gruyter.

Seidenberg, Mark S., Michael K. Tanenhaus, James M. Leiman, & Marie Bienkowski. 1982. Automatic access of the meanings of ambiguous words in context: some limitations of knowledge-based processing. *Cognitive Psychology* 14.4:489–537.

Shelton, Jennifer R., & Randi C. Martin. 1992. How semantic is automatic semantic priming? *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 18.6:1191–1210.
Simpson, Greg B. 1981. Meaning dominance and semantic context in the processing of lexical ambiguity. *Journal of Verbal Learning and Verbal Behavior* 20.1:120–136.
Simpson, Greg B., & Curt Burgess. 1985. Activation and selection processes in the recognition of ambiguous words. *Journal of Experimental Psychology: Human Perception and Performance* 11.1:28–39.
Stringaris, Argyris K., Nicholas C. Medford, Vincent Giampietro, Michael J. Brammer, & Anthony S. David. 2007. Deriving meaning: distinct neural mechanisms for metaphoric, literal, and non-meaningful sentences. *Brain and Language* 100.2:150–162.
Svanlund, Jan. 2007. Metaphor and convention. *Cognitive Linguistics* 18.1:47–89.
Swinney, David A. 1979. Lexical access during sentence comprehension: (re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior* 18.6:645–660.
Swinney, David A., William Onifer, Penny Prather, & Max Hirshkowitz. 1979. Semantic facilitation across sensory modalities in the processing of individual words and sentences. *Memory & Cognition* 7.3:159–165.
Tabossi, Patrizia. 1988. Accessing lexical ambiguity in different types of sentential contexts. *Journal of Memory and Language* 27.3:324–340.
Tabossi, Patrizia, & Francesco Zardon. 1993. Processing ambiguous words in context. *Journal of Memory and Language* 32.3:359–372.
Taler, Vanessa, Ekaterini Klepousniotou, & Natalie A. Phillips. 2009. Comprehension of lexical ambiguity in healthy aging, mild cognitive impairment, and mild Alzheimer's disease. *Neuropsychologia* 47.5:1332–1343.
Tanenhaus, Michael K., James M. Leiman, & Mark S. Seidenberg. 1979. Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. *Journal of Verbal Learning and Verbal Behavior* 18.4:427–440.
Traxler, Matthew J., & Kristen M. Tooley. 2007. Lexical mediation and context effects in sentence processing. *Brain Research* 1146:59–74.
Tyler, Andrea, & Vyvyan Evans. 2001. Reconsidering prepositional polysemy networks: the case of over. *Language* 77.4:724–765.
Vigliocco, Gabriella, & David P. Vinson. 2007. Semantic representation. *The Oxford Handbook of Psycholinguistics*, ed. by M. Gareth Gaskell, 195–215. Oxford & New York: Oxford University Press.
Vitevitch, Michael S. 2002. The influence of phonological similarity neighborhoods on speech production. *Journal of Experimental Psychology: Learning*, *Memory*, *and Cognition* 28.4:735–747.
Wike, Edward L., & James D. Church. 1976. Comments on Clark's 'the language-as-fixed-effect fallacy'. *Journal of Verbal Learning and Verbal Behavior* 15.3:249–255.
Williams, John N. 1992. Processing polysemous words in context: evidence for interrelated meanings. *Journal of Psycholinguistic Research* 21.3:193–218.
Williams, John N. 1996. Is automatic priming semantic? *European Journal of Cognitive Psychology* 8.2:113–161.

[Received 1 July 2014; revised 31 December 2014; accepted 2 February 2015]

Yuchun Chang (corresponding author)
Graduate School Language & Literature Munich - Class of Language
Ludwig-Maximilians-Universität München
Schellingstr. 10, 80799 München, Deutschland
Y.Chang@lipp.lmu.de

詞義的約定俗成與隱喻性：以跨模式詞彙促發作業探討隱喻多義詞之心理處理歷程

張有鈞[1]　林千哲[2]　安可思[3]

慕尼黑大學[1]
印第安那大學布魯明頓校區[2]
香港浸會大學[3]

已往的詞彙歧義研究雖常探討詞義的相對頻率對其在偏向語境中解歧的影響，但卻較少注意不同類型歧義詞之區分或詞義本身語意性質（如：字面義或隱喻義）與其約定俗成程度的影響；過去實驗中大多使用以具體意義爲主要意義的實驗材料，忽略了以抽象意義爲主要意義的詞彙。本研究聚焦於中文裡同時具字面義與隱喻義的多義詞，藉由線上跨模式詞彙促發作業，檢驗字面義強勢詞彙（即含有強勢字面詞義與次要隱喻詞義的多義詞，如「廢物」：‘失去原有使用價值的東西；比喻沒有用的人’）與隱喻義強勢詞彙（即含有強勢隱喻詞義與次要字面詞義的多義詞，如「角度」：‘兩直線或平面相交所形成的空間；比喻觀察特定事件的觀點’）在偏向字面義、偏向隱喻義及中性語境中的意義激發模式。結果發現，字面義強勢詞彙的兩詞義無論語境偏向爲何皆被激發，而隱喻義強勢詞彙只有隱喻義在相容語境中被激發。本文於是就字面義與隱喻義約定俗成程度之不同，以及此二類詞彙意義激發的時間進程，討論實驗結果。

關鍵詞：語境效應，約定俗成，詞彙歧義，隱喻多義詞，詞義頻率