A Concise Review of the Answers to Fundamental Issues of Lexical Semantics

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Abstract. There is relationship of inheritance and development between different schools of lexical semantics, which have their own emphases on dissimilar language phenomena and try to solve distinct problems of lexical semantics. The understanding of this relationship helps make explicit the drawbacks of existent study and future tendency, which is conducive to the development of natural language processing.

Keywords: lexical semantics (LS), LS schools, fundamental problems, natural language processing (NLP).

1   Introduction –Fundamental Problems of LS

LS flourishes with related subjects such as NLP, etc. LS acts as the base for many applications, such as second language acquisition and learning, dictionary compiling, and computational linguistics[1].

According to the requirements of related subjects, Paradis points out that there are five questions (or issues) that are of central importance to any theory of lexical semantics that makes claims to be a coherent framework within which lexical meanings can be described and explained. These five questions are:

1. What is the nature of meaning in language?
2. What is the relation between words and their meanings?
3. How are meanings of words learned and stored?
4. How are meanings of words communicated and understood by language users?
5. How and why do meanings of words change? [1]

Of these questions, questions (1) and (2) are more basic than the others. Paradis points out that:

> The answers to these five questions make up the fundamental theoretical assumptions and commitments which underlie different theories of lexical semantics, and they form the basis for their various methodological priorities and explanations for word meanings in language. [1]

In the following section, a concise review is offered about how different schools of LS have tried to answer these questions, which is expected to be helpful in making clear what have been done about these five issues and what should be done in the future, especially for application studies, such as NLP, etc.

2   Answers of Different LS Schools to the Five Issues of LS

According to time and relationship of inheritance between different LS Schools, Geeraerts[2] divides LS into five schools: historical-philological semantics, structuralist semantics, generativist semantics, and Neo-structuralist semantics, cognitive semantics. These schools places distinct importance on and offers diverse answers to the five issues, as is to be discussed separately in this section.

2.1   Nature of Meaning in Language

In historical-philological semantics, meaning is a psychological type of entity and a kind of thought; and meaning changes result from psychological processes [2]. Structuralist semantics emasculates psychology from historical-philological semantics and thought that the nature of meaning lies in the relationship between language units and the main clue of all of its theories focuses on the description of relations. Generativist semantics renews the mental reality of historical-philological semantics[2], adopting a meaning viewpoint of mentalism. Neo-structuralist semantics, while inheriting main viewpoints and methods of structuralist semantics, considers the psychological adequacy of meaning.

None of the above explanations about the nature of meaning are satisfactory. Cognitive semantics, which inherits and develops the cognitive and psychological orientation of historical-philological semantics, provides the most rich and systematic explanation about the nature of meaning.

Cognitive semantics, a subfield of cognitive linguistics, shares these two slogans:
（1）Meanings are based on the bodily experience；
（2）Meanings are in the head.

This kind of semantic view explains the nature and source of meaning, implying that meaning is embodied and creative[3], and categories and concepts are formed based on human's experience of the outside and inner worlds, and finally words are created to express these categories or concepts. While experiencing the world to form concepts, the following processes are undergone: perception, presentation, categorization and conceptualization, etc. Conceptualization is the last and key stage of the formation of concepts. Meaning, based on perception, presentation, and categorization, is the result of conceptualization[4][5]. In cognitive linguistics, presentation is expressed with image schemata.

Wang Yin points out that conceptualization involves many cognitive styles and cognitive structures. These cognitive styles include embodiment, categorization, metonymy, metaphor, and construal, activation, relevance, conceptual blending, etc., and cognitive structures includes all kinds of image schemata[3].Cognitive styles and

cognitive structures exist side by side and promote each other. Cognitive structures come from cognitive styles and once formed, they act as the base for cognitive styles, which means that meaning is established on world knowledge and there is no clearcut boundary between language knowledge and world knowledge[6].

According to cognitive semantics, word meaning is not the mirror image of the outside world; and the formation and understanding of word meaning involves all the cognitive styles touched upon in the process of conceptualization; and the presentation of word meaning can not do without image schemata; and the generative mechanism trying to explain polysemy can not avoid metonymy, metaphor and construal, concept blending, etc.[7].

Cognitive subjects, with different natural or cultural backgrounds, may own different cognitive styles which may lead to diverse conceptualizations and meanings for the same entity or event. Wang Yin proves with many examples that during the process of categorization and conceptualization, people may understand the same entity or event from different angles, paying attention to different characteristics or parts of it and lexicalize it[3]. And thus the same entity or event might be endowed with different meanings in different languages or cultures.

The understanding of the nature of meaning determines the ways of how to represent the meaning of a word and the meaning generation mechanism based on the representation, which in turn influences the understanding of word meaning(s) in contexts. The question of the nature of meaning is the most basic and it is the starting point of rational explanation and correct understanding of word meaning(s), which is crucial to many applications such as word sense disambiguity (WSD) in NLP because the understanding of the nature of meaning determines the principle, methods, and even the effect of WSD.

Main contents of this section is shown in table 1.

Table 1. Studies or views about the nature of meaning

LS schools	Studies or views.
historical-philological semantics	Psychological entity, a kind of thought.
Structuralist semantics	Relations between language units.
Generativist semantics	Psychological entity (a mentalism view of meaning).
Neo-structuralist semantics	Extended relations between language units and psychological entity.
Cognitive semantics	Meanings are based on the bodily experience; meanings are in the head.

2.2   Relations between Words and Their Meanings

Three LS schools have comparatively rich studies on this issue, of which structuralist semantics and Neo-structuralist semantics focuses on syntagmatic and paradigmatic relations between words, while cognitive semantics emphasizes senses of the same word (form).

Structuralist semantics has three theoretical clues: lexical field theory, componential analysis, and relational semantics. Structuralist semantics observes that the nature of meaning lies in relations between language units and all its main theoretical clues are description of relations.

Structuralist semantics offers such word relations as synonymy, hyponymy, antonymy, and partonymy (meronymy), homonymy, polysemy, etc. Relational semantics of structuralist semantics emphasizes description of synchronic semantic relations, observing that meaning is expression network with all kinds of semantic relations. It can be said that componential analysis is the method of lexical fields and word relations are the content of lexical fields. A clear understanding of word relations is conducive to discovering the distinctive features of a lexical field, which is the base for determining word semantic features.

Some branches of Neo-structuralist semantics, including WordNet project, Mel'čuk's lexical function theory (1982), and distributional corpus analysis, develop relational semantics.

WordNet offers such word relations such as *troponymy* and *entailment*. Troponymy is dedicated to expressing special way(s) of doing an action. E.g. to *sleepwalk*, *stride*, *shuffle*, *stroll*, *slouch*, etc. are particular ways of walking and these verbs are troponyms of *walk*. E*ntailment* refer in particular to certain relations between verbs, e.g. *to snore* entails *to sleep*.

Word relations mentioned above are restricted to limited metalinguistic paradigmatic relations. In Mel'čuk's Meaning-Text Theory, more relations between words and expressions are discerned and expressed with lexical functions. As a result, paradigmatic relations are expanded greatly and syntagmatic relations are also expressed richly. Lexical functions convey both semantic and grammatical relations. For detail, we can refer to Mel'čuk[8]. Lexical functions are universal, usable in all languages.

Lexical functions provide abundant, multidimensional structures for lexical description. From the perspective of practice, an Explanatory Combinatorial Dictionary (ECD)(the main contents of which are lexical functions) constructs more information sources than WordNet do for a word form and has aroused strong interest in lexicographers and computational linguists. However, because it is very time-consuming to construct an ECD, the quantity of vocabulary of existing ECDs and number of languages which has established an ECD are much less, which restricts the application of ECD.

Syntagmatic relations expressed by lexical functions are not deep or complete enough because of lexical functions' lack of extensive distributional basis, which can be remedied by distributional corpus analysis. Distributional corpus analysis, because of its continuous renovation and dynamicity, has been the absolute dominant method in NLP.

The main developments of distributional methods of LS came from the application of distributional thought in large-scale corpus, which leads to the appearance of distributional corpus analysis. According to Geeraerts, distributional corpus analysis takes a radical usage-based rather than system-based approach: it considers the analysis of actual linguistic behaviour to be the ultimate methodological foundation of linguistics[2].

Distributional corpus analysis disambiguates word senses according to collocation and it digresses from the mainstream of structuralist semantics as collocation is in essence contextual. Combined with statistical methods, distributional corpus analysis overcomes many weaknesses of rule-based methods, such as:1) so far, no suitable system of semantic primitives has been demarcated or established ; 2) there has been no way of differentiating linguistic knowledge from extralinguistic knowledge.

The biggest disadvantage of distributional corpus analysis is that its theoretical backgrounds are not always clear and extralinguistic knowledge is usually not considered by it.

Cognitive semantics remedies these disadvantages of distributional corpus analysis, offering many related methods to explain word sense relations and these methods include the prototype theory, metaphor and metonymy, idealized cognitive models, image schemata, etc. While explaining word sense relations, image schemata are the bases, metaphor and metonymy are the cognitive mechanisms concerned, and prototype effect and polysemy are the phenomena or results to be explained.

Cognitive semantics observes that cognitive models are in the form of image schemata but not propositions, and operations of metaphor and metonymy are based on image schemata[9][10]. In virtue of the operations of metonymy and metaphor based on image schemata , more categories and concepts, especially abstract ones, are formed, which in turn result in more image schemata, and during this process human being develops their abstract thinking and inferring ability, complex concepts are formed from simple ones, and all kinds of conceptual structures are also produced. Thus we have prototypical models of categorical structures and the phenomenon of polysemy.

Thus, image schemata, metaphor and metonymy, prototype effect, polysemy are in fact unified and they form a series with immanent logical relations：

　　　Image schemata＞metonymy and metaphor＞prototype effect≥polysemy

'＞' stands for 'appear or exist prior to' which means that the appearance or existence of the former is a prerequisite for the latter to appear and the former can be used to explain the latter. E.g. image schemata, metonymy and metaphor, prototype effect can be used to explain polysemy, while image schemata can be used to explain the mechanism of metonymy and metaphor. No wonder, Lakoff points out that *idealized cognitive models* (equivalent to *image schemata* in this paper) are the source of categorical structures and prototype effect [11].

Production of prototype effect involves both metonymy and metaphor, with metonymy being the more fundamental mechanism, as metaphor is often based on metonymy. There are two kinds of prototype effect:

(1) The structure represented by a sense with certain denotation embodies prototype effect. E.g. when the word *fruit* is understood as 'something which grows on a tree or bush and which contains seeds or a stone covered by a substance that you can eat', its denotation unanimously includes *apple*, *cherry*, *pear*,etc. However, such things as *cucumber, tomato, bitter gourd* may or may not be included as *fruit* according to such factors as culture, regions and eating habits. In this situation, different degrees of prototypicality of these members of *fruit* embody prototype effect.

(2) Structure formed by the senses of the same word (form) can also embodies prototype effect. E.g. the original sense of the word *fruit* is 'something which grows on a tree or

bush and which contains seeds or a stone covered by a substance that you can eat' and this sense is expanded to mean 'result', 'achievement', 'production' , etc., which have only different degrees of meaning overlap with the original meaning of *fruit* .

In short, good solution of the question of the relations between words and their senses is one of the keys to reasonable explanation of language phenomena, understanding language, and constructing language resources. Frequently-used resources in NLP such as linguistic ontologies, WordNet, FrameNet, etc. all have rich studies about relations between words and their meanings, however, there is still deficiency which is remedied by lexical functions of Meaning-Text Theory to a great degree. Applied fully, lexical functions can not only express more relations between words and their meanings but also substitute a lot of work previously done by syntactic transformation to save much time and labor, which is meaningful for many NLP applications as textual entailment recognition.

Main studies or views of different LS schools about relations between words and their meanings are summarized and shown in table 2 below.

Table 2. Relations between words and their meanings

LS schools	Studies or views
historical-philol-ogical semantics	Relations between word meanings: semasiological change--chain change of word meaning.
Structuralist semantics	Lexical field theory, componential analysis and relational semantics (limited number of meta-linguistic paradigmatic relations.
Generativist semantics	Katz semantics: inheritance of semantic feature.
Neo-structuralist semantics	Related contents of structuralist semantics are expanded, e.g. lexical functions:paradigmatic relations are expanded greatly and syntagmatic relations are also conveyed sufficiently.
Cognitive semantics	Explanatory adequacy: relations between words and their senses are produced through all kinds of cognitive styles--image schemata are the basis, metonymy and metaphor are mechanism, and prototype effect and polysemy the results.

2.3 Acquisition and Storage of Word Meanings

Though historical-philological semantics adopts methods of cognition, psychology and explanation while studying meanings, its emphasis is placed on explaining the psychological factors involved in understanding meanings in contexts. Though it points out that word meanings are stored in mental structures, it offers no concrete studies.

Structuralist semantics treats language as an isolated, automatic system and basically does not discuss the acquisition or storage of word meanings. However, from the study of structuralist semantics it can be inferred that relations between words (and even language units) can be seen as means of storing word meanings.

Adopting the related viewpoints of historical-philological semantics, generativist semantics offers concrete mental structures for storing the meanings of words.

Neo-structuralist semantics, inheriting many viewpoints and some methods of structuralist semantics, studies meaning in an extensive cognitive context and offers many ways for storing word meanings. E.g. Jackendoff's Conceptual Semantics, Bierwisch's Two-Level Semantics, and Pustejovsky's Generative Lexicon all touch upon word meaning storage because of their formalized representations of word meanings.

Conceptual Semantics considers the combination of linguistic and extra-linguistic knowledge and offers methods to distinguish the two kinds of knowledge. Conceptual Semantics observes that: (1) there is no need to express all the information about the usage of language in word presentation and part of the task (e.g. visual memory, perceptual knowledge, etc.) can be expressed by other cognitive models; (2) formalized representation of word meanings do not need to include all the information related to explaining the conceptual ability of language users; (3) information of word meanings should be put in the level of 'conceptual structure' in which linguistic and extra-linguistic knowledge (e.g. perceptual knowledge and motor schemata, etc.) can interact with each other and word meaning no longer owns a privileged position[12]. Conceptual structure constructs an interface between linguistic and extra-linguistic knowledge, and the interface's function can be embodied by an entry as follows:
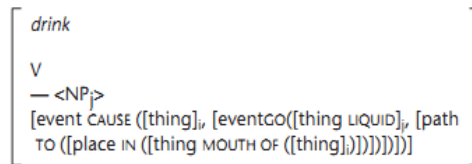
$$
\left[\begin{array}{l} drink \\[4pt] V \\ -\ \langle NP_j \rangle \\ [event\ \text{CAUSE}\ ([thing]_i,\ [event \text{GO}([thing\ \text{LIQUID}]_j,\ [path \\ \quad \text{TO}\ ([place\ \text{IN}\ ([thing\ \text{MOUTH OF}\ ([thing]_i)])])])])] \end{array} \right]
$$

Fig. 1. The conceptual structure of the word *drink*[13]

Conceptual Semantics' differentiation between linguistic and extra-linguistic knowledge is static, ignoring the dynamic interaction between the two kinds of knowledge in concrete contexts. Two-Level Semantics tries to deal with this kind of interaction. Like Conceptual Semantics, Two-Level Semantics also adopts a modular view of cognition, observing that:

> Cognitive behaviour is determined by the interaction of systems and subsystems that operate as largely autonomous modules of the mind. In particular, polysemy in natural language may be adequately described by distinguishing between two levels of knowledge representation: semantic form and conceptual structure[2].

According to Geeraerts, 'Semantic form' and 'Conceptual structure' express linguistic and extra-linguistic knowledge respectively[2]. A semantic form expresses only one sense of a word (form), however, the interaction between a semantic form and a conceptual structure in certain contexts can produce a series of explanations, which means that Two-Level Semantics emphasizes dynamic relations between words and meaning changes. E.g., $\lambda x[\text{PURPOSE}[x\ w]]$ is a abstract logical expression and words with the semantic feature PURPOSE can substitute x to get a comparatively concrete expression. If the word *university* is understood as 'a institution providing advanced study and teaching', it has the semantic feature PURPOSE and can substitute x to get this expression:

λx [PURPOSE[x w] & advanced study and teaching [w]]

This can be understood as: there is an x (*university*) which owns a semantic feature PURPOSE that exists in a (mental) space (marked as 'w') independent of language as the schema 'advanced study and teaching'-a kind of conceptual structure. The two levels of knowledge is related to each other in the space w. If we want to express another semantic feature 'the place or buildings where a university lies' of the word *university*, this expression can be used: λx [building [x] & purpose [x w]].

According to Geeraerts, the most elaborate formalized componential model in contemporary semantics is the Generative Lexicon defined by Pustejovsky (1995a)[2], which uses word sense presentation structure as in F.g. 2 to store word meanings and grammatical information.
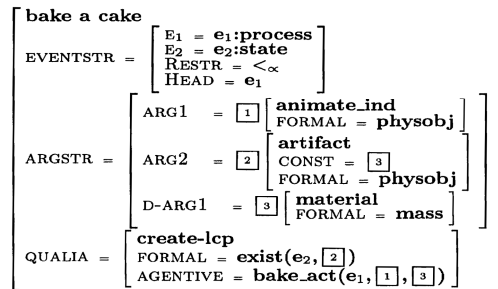
$$
\begin{bmatrix}
\text{bake a cake} \\
\text{EVENTSTR} = \begin{bmatrix} E_1 = e_1\text{:process} \\ E_2 = e_2\text{:state} \\ \text{RESTR} = <_\propto \\ \text{HEAD} = e_1 \end{bmatrix} \\
\text{ARGSTR} = \begin{bmatrix} \text{ARG1} = \boxed{1}\begin{bmatrix} \text{animate\_ind} \\ \text{FORMAL} = \text{physobj} \end{bmatrix} \\ \text{ARG2} = \boxed{2}\begin{bmatrix} \text{artifact} \\ \text{CONST} = \boxed{3} \\ \text{FORMAL} = \text{physobj} \end{bmatrix} \\ \text{D-ARG1} = \boxed{3}\begin{bmatrix} \text{material} \\ \text{FORMAL} = \text{mass} \end{bmatrix} \end{bmatrix} \\
\text{QUALIA} = \begin{bmatrix} \text{create-lcp} \\ \text{FORMAL} = \text{exist}(e_2, \boxed{2}) \\ \text{AGENTIVE} = \text{bake\_act}(e_1, \boxed{1}, \boxed{3}) \end{bmatrix}
\end{bmatrix}
$$

Fig. 2. Semantic representation of verb phrase '*bake a cake*' [14]

All image schemata, including idealized cognitive models, frames and scripts, from cognitive semantics are word meaning storage means. Frames are the most fundamental and can be integrated with other image schemata in application studies. LS shools prior to cognitive semantics lack studies in the origin of meanings, which is remedied by cognitive semantics based on Embodied Philosophy. It is pointed out that:

Embodied Philosophy observes that the combination of body experience and mental ability produces concepts and meanings; language comes from practice and is closely related to conceptual structures and cognitive styles; and linguistic forms and concepts are interdependent and there is large quantity of instances of iconicity[3].

Wang Yin explains in detail the origin of words and their meanings from two aspects:

(1) Lexical construction (including origin of lexicon, embodied categorization, conceptualization, lexicalization, and embodied metaphor, embodied metal lexicon, spatialized compound words and affixes);

(2) the embodiment of lexical categories (including the division of parts of speech, conversion of parts of speech, and gender, number and case of nouns, time, aspect and voice of verbs)[3].

Embodied Philosophy describes the formation of language and meaning from the level of all human languages. To an individual human being, embodiment and mentality are both essential factors in acquiring a language. The study of Littlemore[15] offers good evidence for the importance of embodiment in language and meaning formation. Main contents of this section is summarized in table 3.

Table 3. Studies or views about acquisition and storage of word meaning

LS schools	Studies or views.
historical-philological semantics	Meanings are the results of mental processes (acquisition) and represented with mental structures (storage).
Structuralist semantics	Word meanings are stored in language system, especially in word relations.
Generativist semantics	Recovers and develops historical-philological semantics, offering concrete mental structures to represent word meanings.
Neo-structuralist semantics	Formalized conceptual structures from Jackendoff's Conceptual Semantics, Bierwisch's Two-Level Semantics, and Pustejovsky's Generative Lexicon (meaning storage).
Cognitive semantics	Embodied Philosophy.

2.4   Communication and Understanding of Word Meanings

This issue is closely related to the previous issue. Word meaning storage means represent abstract, static meanings, while ostensive utterances express concrete, dynamic meanings. The understanding of word meanings involves many factors: ostensive utterances, word meaning storage means such as image schemata triggered by these utterances, and the current contexts (including time, space, relations between communicators,etc.), all kinds of cognitive ability and styles, and so on.

Table 4. Studies or views about communication and understanding of word meanings

LS schools	Studies or views
historical-philological semantics	Explaining meaning changes in contexts: differentiation between 'usual meaning' and 'occasional meaning'--the basis of meaning changes is to regulate 'usual meaning' into 'occasional meaning'.
Structuralist semantics	Semanteme (from lexical field theory and componential analysis), word relations and distribution.
Generativist semantics	Projection rules based on a tree diagram way of word meaning representation.
Neo-structuralist semantics	Conceptual semantics：conceptual structure (static). Two-Level Semantics：interaction between two levels of knowledge representation--*semantic form* and *conceptual structure* of autonomous modules of the mind. The Generative Lexicon：semantic generation mechanisms based word representation.
Cognitive semantics	Image schemata and semantic generation mechanisms based on them (including metonymy, metaphor, and conceptual blending theory, etc.)

Studies about communication and understanding of word meanings comes mainly from two LS schools--Neo-structuralist semantics and cognitive semantics. The Generative Lexicon of Neo-structuralist semantics not only offers elaborate word meaning representation mechanisms but also semantic generation mechanisms based on the presentation mechanisms.

Two of the core tasks of cognitive semantics are word meaning representation mechanisms and corresponding semantic generation mechanisms. Idealized cognitive models, frames and scripts are all word meaning representation mechanisms; and metonymy, and metaphor are the semantic generation mechanisms based on these image schemata. The answers of different LS to the issues discussed in this section is shown in table 4 in a nutshell.

2.5   Ways and Reasons for Word Meaning Changes

Historical-philological semantics thinks that meaning changes are the results of mental processes; and the change mechanisms which can be established through studying historical classification of words, correspond to human's mode of thinking; and metonymy and metaphor are considered not only as linguistic notions but also as human's cognitive ability[2].

Historical-philological semantics's fundamental method is to explain meaning changes in contexts and it develops a kind of pragmatic, usage-based meaning change theory based on the differentiation between 'usual meaning' and 'occasional meaning':

> The basis of meaning changes is to regulate 'usual meaning' into 'occasional meaning'; meaning changes are important objects of study, the focal point of which is *semasiological change* (the phenomenon of adding new senses to an existing word) but not onomasiological change (the phenomenon of expressing a new sense with a coined word) .

Semasiological change is first divided into connotational change and denotational changes. Denotational change is further divided into analogical change and non-analogical change. Analogical change is the process of copying the polysemy of another word, which may takes place in one language or between different languages. Non-analogical change involves four mechanisms: specialization ('narrowing' of meaning), generalization ('expansion', 'extension', or 'broadening' of meaning), metonymy, and metaphor. Denotational change alters only attributes (usually concomitant meanings, such as social meanings or emotional meanings) of a word[2]. Structuralist semantics are not interested in meaning changes, especially diachronic meaning changes. Generativist semantics is interested in only synchronic meaning changes. Neither generativist semantics nor Neo-structuralist semantics is interested in diachronic meaning changes.

Cognitive semantics pay attentions both to diachronic and synchronic meaning changes and its methods for explaining prototype effect and polysemy can in fact be used to explain meaning changes. There is large quantity of this kind of studies, such as Wang Yin[3]. The main contents of this section is shown in table 5.

Table 5. Studies or views about the ways and reasons for word meaning changes

LS schools	Studies or views
historical-philological semantics	semasiological changes; meaning changes are also the results of mental process and change mechanisms correspond to human's mode of thinking.
Generativist semantics	Tries to use tree diagrams to analyze words and *projection rules* are used to finish analysis of synchronic meaning changes.
Neo-structuralist semantics	Carries out exploration into synchronic meaning changes in virtue of word representations, e.g., the Generative Lexicon offers systematic semantic generation mechanisms based on word sense representations.
Cognitive semantics	Is interested in both diachronic and synchronic meaning changes and offers the most elaborate ways for explaining (polysemy) and meaning changes.

3   Conclusion

When different LS schools try to answer those fundamental questions of LS, they have different emphases and advantages; and there are both conflicts and complementarity between their viewpoints and methods. All studies of these fundamental questions boil down to this issue: how to represent/store word meanings with suitable forms and how to disambiguate word senses and explain polysemy based on these representations. This is one of the core problems both for daily linguistic understanding and linguistic applications (e.g. NLP). To get more satisfactory solution to this issue, the following thing should be helpful: using cognitive semantics as the foundation, different schools of LS should learn from each other and at the same time refer to the research methods and results of related subjects such as NLP, cognitive science, and psychological linguistic, artificial intelligence, etc., which will certainly bring about breakthrough for explaining, understanding and generating word meanings and which has special significance for breaking through bottlenecks in NLP.

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