A Resolution for Polysemy:  
the case of Mandarin verb ZOU (走) 

Yaling Hsu          Meichun Liu  
National Chiao Tung University  
yalings@ms38.hinet.net          mliu@mail.nctu.edu.tw

Abstract 
In this paper, we propose a procedural schema as a model of cognitive processing of word senses, which can be viewed as a derivational resolution of polysemy. Previous researches, such as Frame-Based Lexicon by Fillmore [4] and Lexical Semantics by Cruse [2], are all concerned with word senses, but what is still missing is a holistic resolution of polysemy. Therefore, in this paper, we focus on the cognitive process from word form to word senses, based on corpus-based procedural resolution. In this way, we hope to provide an overall discussion and a computerizable way of solving multiplicity of semantic usages of a single word form. A case study of the Mandarin verb ZOU (走) is presented and used as an illustration.

1   Introduction  
Since ‘two or more semantic elements may be expressed in a single monomorphemic lexical item’ (Bybee [1]), to understand the meaning of a word in a particular utterance, we need to resort to ‘cognitive structures, knowledge of which is presupposed for the concepts encoded by the words’ (Fillmore [4]). According to Fillmore [4], we know word senses are not related to each other directly, but only by way of their links to common background frames and indications of the participant roles associated with such frames (i.e., Frame elements). However, when we turn to semantic multiplicity of a single word form in Mandarin, such as ZOU (走), the highlighted core elements of frames may not be enough to help us distinguish the different meanings of the single monomorphemic lexical item. The problem can be the spelled out as follows:  
a) Different senses of a single lexical item may have similar participant roles in the general terms and similar patterns of expressing these elements. Therefore, if we only depend on the information of core frame elements, how could we tell the different senses and in what way we can tell the non-prototypical senses from the prototypical one? Since the process of sense selection is under the force of many interacting factors (Bybee [1]), a reliable source of clues is collocational patterns that reveal lexical as well as grammatical associations of words. To fully utilize corpus data, we will look at Colloconstruction (a term adopted from Stefanowitsch and Gries’ idea with some modification), i.e., clause-internal, morpho-syntactic patterning characteristic of each sense, to further distinguish semantic polysemy.  
b) With the postulation of Colloconstruction, we may still encounter ambiguous cases where two different senses may share similar frame elements and similar Colloconstructions. Thus, next in our cognitive resolution, we propose ‘Contextual Dependence’ as another disambiguation factor which depends on discourse-level patterning across sentences, and we will have a detailed discussion in the following sections.

2   Cognitive resolution  
The resolution model proposed here intends to simulate human cognitive process of detecting word senses. As Cruse [2] describes, a lexical form may well be associated with an unlimited number of possible senses, but these are not all of equal status (bold is added by us)…every lexical form has at least one relatively well-utilized sense. Our resolution is based on Cruse’s observation and the assumption made by cognitive linguists that each word has at least one cognitively most salient meaning, the prototypical sense. First, a single word form within a clause comes into our cognitive system, and then according to the salient frame-evoked elements, we might easily get one sense from the word form (as shown by the arrowed line ‘a’ in Figure 1 below.). In most cases, readers tend to start with the predominant sense with the highest frequency count (we will discuss this in the following sections). However, some words may have two different senses that share similar participant roles and surface patterns, and then we need an efficient mechanism to detect the different sense while probing into the underlining frame. In these cases, we need to go through the next step—identifying Colloconstruction (as shown in the following) to get more information to help delimit the different senses. Colloconstruction provides information regarding morpho-syntactic patterns within a particular construction which consists of frequently co-occurring leemes. Still, in some cases, Colloconstructions are not distinct enough to disambiguate. There might be another sense which requires similar core elements in a similar Colloconstruction as the more prototypical sense does. Then, we have to go into the next step - finding ‘[Contextual Dependence’, i.e., discourse-pragmatic variables commonly associated with a given sense. The resolution formula is schematically...
represented in Figure 1 below. Assuming that the most prototypical and thus more frequently used sense is easier to detect, the process starts with checking the highlighted frame elements and the high frequencies used for identifying the prototypical sense. As shown in Figure 1, the path with the arrowed line ‘a’ represents this shortest route – frame element checking. The paths with the arrowed lines ‘b’ and ‘c’ represent the additional efforts required for identifying less prototypical senses.

Fig. 1. Cognitive resolution

3 The different senses of Mandarin verb ZOU(走):

In this paper, we use the Mandarin verb ZOU(走) to test and illustrate our cognitive resolution. First, we will distinguish the different senses of the verb by frame conceptions (adopting the frame definitions in FrameNet II with little modifications), as shown in Table 1.

Table 1. The four main senses of Mandarin verb ZOU(走)

| Sense       | Frame      | Frame Elements                      | Frequency (Total: 200) |
|-------------|------------|------------------------------------|------------------------|
| Sense1: walk/go | Self_motion | Area, goal, path, source, self-mover, duration | 135 (67.5%) |
| Sense2: move     | Motion     | Area, goal, path, source, theme     | 10 (5%)                |
| Sense3: visit     | Arriving   | Area, goal, self-mover             | 9 (4.5%)               |
| Sense4: leave     | Path_shape | Path, path_shape, road, self-mover, duration | 46 (23%)               |

As we can see in Table 1, all the senses are in different frames with some shared core frame elements. In what way, then, can we identify these different senses by their frame elements? Besides, how do we distinguish the different senses when they are composed of the same pattern with the same instantiated frame elements? In order to provide an overall analysis of semantic polysemy, we propose fluid routes for cognitive resolution.

4 Frame-based sense distinction

As we mentioned above, the predominant sense goes through fewer steps since it is cognitively more accessible. Take the verb ZOU(走) in Chinese as an example. Among the four possible senses, sense 1 occurs most frequently (as shown in Table 1) and denotes a specific sensory motor action that is assumed to be cognitively salient and prototypical. Sense 2 can be viewed as extended from sense 1 in that the human action of moving by walking is broadened to denote the moving of entities in general. While sense 1 and sense 2 are both motional and they share a number of core frame elements, the two meanings can be easily distinguished in terms of the semantic attributes of participate roles. That is, sense 1 is associated with human or animate self-mover, and sense 2 is associated with inanimate moving entities or ‘theme’, as exemplified in the examples (1) and (2) below.

(1) Sense 1
Self-mover [animate] <*< Distance
他也不知道究竟走了多远，終於在一個荒僻的大山下面，發現了一個山洞。
\text{ta1 ye3 bu4 zhi dao4 jing4 zou3 le du4 lyuan3, zhong1 lyu2 zai 4 yi1 ge4 huang1 pi4 de}
\text{da4 shan1 xia4 mian4, fa1 xian4 le yi1 ge4 shan1 dong4}

He also not know actually walk how far, finally at one-CL desolate DE great mountain under, find LE one-CL cave

(2) Sense 2
Motion [animate] <*< Distance
他從家裡開始走了一個小時，終於在一個荒僻的大山下面，發現了一個山洞。
\text{ta1 cong1 jia4 li1 ke1 hai1 zai 4 yi1 ge4 ji4 jing4 zou3 le du4 lyuan3, zhong1 lyu2 zai 4 yi1 ge4}
\text{da4 shan1 xia4 mian4, fa1 xian4 le yi1 ge4 shan1 dong4}

He also start from home began to walk how long, finally at one-CL desolate DE great mountain under, find LE one-CL cave
He also did not know how far he walked actually, and finally under the desolate great mountain, he found a cave.

(2) Sense 2
Mover [inanimate] <*< Distance
大約130分鐘，火車走了約200公里，我們到了統一前東德的第三大都市德勒斯登。

da4yue1 130 fen1 zhong1, huo3 che1 zou3 le yue1 200 gong1 li3, wo3 men dao4 le tong3 yi1 de le4 di3 san1 da4 de4 li3 de le4 di3 san1 da4 de le4 di3 san1 da4 de4 li3 de le4 ti3 di3 du1 de le4

about 130 minutes, train walk LE about 200 kilometers, we come LE unify before east German DE third big city Deluxe

‘About 130 minutes, the train walked about 200 kilometers; we came to the third metropolis, Deluxe, of ex-east German.’

Figure 2 below is meant to capture the details of the sense derivational process of the word form ZOU(走), and we will see that sense 1 and sense 2 are distinguished in the first step. Semantic information of their frame elements is utilized to process these two senses in cognition.

5 Colloconstruction
Colloconstruction refers to a combination of lexical and grammatical collocations. It is used to identify the specific morpho-syntactic sequences of lexical items. Colloconstruction may help detect crucial collocomputational elements and constructional features when the word form is semantically compatible with the construction. When semantic information of participant roles is insufficient, word senses can only be detected with a careful examination of lexical and grammatical collocations. For example, sense 1 and sense 3 of ZOU(走) can only be distinguished when collocomputations are taken into consideration. Consider the following uses of sense 3:

(3) Self-mover <*< path
民眾欲見南仁山區的森林生態系，只消走一趟南迴公路即可。

min2 zhong4 yu4 jian4 nan2 ren2 shan1 qu1 de sen1 lin2 sheng1 tai4 xi4, zhi3 xiao1 zou3 yi4 chao1 nan2 hui2 gong1 lu4 ji2 ke3

‘If people want to take a look around the forest ecosystem of the Nan-Ren mountain area, they may have a visit of the south highway’

(4) Self-mover <*< goal
臺灣本島的小朋友來說，要看看恐龍標本，只要走一趟科博館就可以了。

tai2 wan1 ben3 dao3 de xiao3 peng2 you3 zhi3 xiao1 zou3 yi4 chao1 nan2 hui2 gong1 lu4 ji2 ke3

‘For insular kids in Taiwan, if they want to see the dinosaur specimen, they may visit of the science museum all right’
In these utterances, the delimiting phrases yitang (一趟) or yizao (一遭) combined with a Location are crucial indicators of the ‘visiting’ sense of ZOU(走). In other words, the word form ZOU(走) and the phrases yitang (一趟) or yizao (一遭) co-construct a specific sequence commonly associated with the sense of ‘visiting’. Exactly, in what way can Colloconstruction help? The answer is: when frame-based semantic roles fail to disambiguate. Let’s consider the following utterances which contain the uses of sense 1:

(6) Self-mover <*< path

接著是訓練他們走路。走斜坡，走平路，也走不平的路。

then is train them walk.  walk slope, walk even, also walk uneven road

‘Then, train them walk, walk slope, walk even road, and also walk uneven road’

(7) Self-mover <*< goal

我對她笑一笑走開了。仰頭一看, 才知道走到一排松樹下。

I to her simile walk away.  faced upward a look, just know walk to a line pine tree under

‘I gave a smile to her and walked away.  Then, I faced upward taking a look and found that I had walked under a line of pine trees.’

(8) Self-mover <*< goal

往英國花園的西南邊走，是一個舊市區（Vielle Ville），

toward British garden DE southwest side walk, is an old downtown (Vielle Ville)

‘Walk toward the southwest side of the British garden, there is an old downtown (Vielle Ville)’

As we can see, the examples (6)-(8) above contain uses of sense 1 and the core frame elements (Self-mover, Area, and Goal) are similar to those of sense 3 (examples in (3)-(4)). To detect the differences between these two senses, we need to pay attention to their collocational features. Here, the colloconstruction [ZOU(走) + yitang (一趟) / yizao (一遭)] help to identify the occurrence of sense 3. Therefore, as we proposed above, Colloconstructions might be the anchor for the derivational senses. In this case, the adjunct yitang (一趟), yizao (一遭) help to anchor sense 3 in a commonly recognized construction, taking the following NP as a destination (Goal) and then the sense ‘visit’ is derived. This resolution conforms to the perspective of Emergent Grammar, as Firth [5] contended that usage patterns of lexical forms can best be examined by looking at ‘the company’ they keep. However, given the dynamic nature of word usage, collocaional associations alone may not be flexible enough to distinguish subtle differences of the senses of a word. Therefore, we need to take another step, looking into contextual dependence to obtain the overall resolution for polysemy.

6 Contextual dependence

The word form ZOU(走) has another sense —sense 4 ‘leave’—as shown in examples (9)-(11). Initially, we take the first step and test whether sense 4 can be derived only by utilizing information of core frame elements. Let’s consider the following utterances:

(9) Self-mover <* (sense 4: leave)

於是大夥兒便分頭走了, 帶著滿腔的興奮。

hence a group of people separately walk away LE, bring full De excitement

‘Hence, the group of people walk away separately filled with excitement.’

(□□□□) Self-mover <* (sense 4: leave)

一部摩托車，沒有腿的騎士，遠颺了。

‘One motorcycle, no leged rider, far away.’
yi1bu4 mo2tuo1che1, mei2you3 tui3 de qi2shi4, yuan3yang2le…zou3le…

'A motorcycle, carrying a knight without legs, moved far away … leave …'

Self-movers* (sense 1: walk)

我在滿街水兵和軍官們中間走著，聽他們用熟悉的粗話互相笑鬧著、喧囂著，一直來到碼頭邊

wo3 zai4 man3 jie1 shui3bing1 han4 jun1guan1 men zhong1 jian1 zou3zhe, ting1 ta1men yong4

'I walk in the street full with the soldiers and the military offic erses, hearing them use the familiar obscene language, laugh to each other, make hullabaloo, and has been arriving at the wharf.'

Relying solely on core elements, it would be difficult to tell the differences between instances of sense 4 ‘leave’ (as in examples (9), (10)) and the use of sense 1 ‘walk’ (as in example (11)), because they show the same highlighted elements and the same associated constructions. At first glance, in terms of Colloconstruction, we may find an anchor for sense 4 - the verb-final ‘了’, which has quite distinct distributions with clauses containing either ‘walk’ or ‘leave’, as we can see in the statistics in Table 2:

| Sense       | ‘leave’ | ‘walk’ |
|-------------|---------|--------|
| Co-occur with verbal ‘了’ 28/42 (57.14%) | 7/33 (13.2%) |
| without verbal ‘了’ 14/42 (42.86%) | 46/53 (86.8%) |

Table 2. Collocate frequencies for the ZOU LE(走了) construction as the meaning of ‘walk’ and ‘leave’.

Although, as shown in Table 2, the possible anchor ‘了’ indeed has a higher frequency of occurrence in clauses compatible with the sense of ‘leave’, we still have to explain how people distinguish the two senses in the fewer cases where both senses have the same Colloconstruction - co-occurring with ‘了’ to form a collocation - [walk + 了 + duration] or [leave + 了 + duration] (such as examples (12)-(13)). Moreover, how can we deal with utterances with a bare ‘了’ and no other constructional anchors can be found (such as example (14))? 没有其他的结构

(12) sense 1: walk

一路跟蹤而進,有時岔路上兩邊都有腳印,只得任意選一條路。走了好半天,山洞中岔路不知凡幾

yi1lu4 gen1zong1 er2jin4, you3shi2 cha4liu4shang4 liang3bian1 dou1you3 jiao3yin4, zhi3dei3

All the way we follow the footprints and walk into the caves, sometimes bot h sides of branch road all left the footprints and we just can choose one road arbitrarily. We walked a long time, we met uncountable branch roads on our way.'

(14) sense 4: leave

我翻身坐了起來,怔了一怔,清醒了許多,問道:「走了多久?」「不知道,我下午開始陪他,後來看書看得睏了,就睡著了,起來就沒看到他了

wo3 fan1shen1 Zuo4le qi3lai2, zheng1leyi1zheng1, qing1xing3le xu3, wen4duo4:

'I turned body sit to get up, and was being stunned a while, and when I wide awoke, I asked:" How long did he leave?" 'I don't know. I started to accompany him in the afternoon, and then read the book and I felt asleep, and then imperceptibly I fall asleep; when I got up, I did not see him.'
Comparing examples (12) and (13) above, sense 1 and sense 4 are almost identical in surface structure as they share the following:

**Shared core frame elements:** path, self-mover, duration

**Shared syntactic pattern:** (CNI/self-mover) <*< duration

**Shared colloconstruction:** [* + duration] (* represents the verb)

To distinguish the two senses, additional information from the larger context is needed. Each sense is believed to display certain features of Contextual Dependence. Here, Contextual Dependence refers to both foregrounded and backgrounded factors that are contextually linked with a given sense. In other words, we derive the sense ‘leave’ or the sense ‘walk’ from contextually bounded elements across clause boundaries. We make inferences on the basis of identifiable sense relations. For example, in example (12), the preceding sequence provides a valuable clue – the mention of *jiao yin* (脚印) ‘footprint’, which helps infer to the sense of ‘walk’. A semantic link is established since the definition of ‘walk’ is ‘the act of traveling by foot’ (from WordNet). The clear mention of ‘footprint’ thus motivates a contextually appropriate reading of ZOU(*走*). In examples (13) and (14), the sense of ‘leaving’ is motivated by contextual sequences referring to ‘appearing/disappearing’, ‘seeing/not seeing’ or ‘finishing/departure’. For example, *mei kan dao ta le* (没看到他了) ‘(he) is no longer seen’, and *mian chi wan* (麵吃完) ‘finished eating the noodles’, both are related to the concept of disappearance. The semantic distance or proximity of contextual variables can be obtained if an independently motivated hierarchy of semantic categories is available. In practice, a valuable resource would be databases such as SUMO. The contextually salient features can be readily identified if a close link in the SUMO hierarchy can be established. In our proposed resolution, discourse-level factors may be utilized with a clear measure of their semantic relations. According to Hopper and Thompson [6], ‘users of a language are constantly required to design their utterances in accord with their own communicative goals and with their perception of their listeners’ needs.’ We also believe that communicative goals will often be realized with semantically coherent sequences.

7 Conclusion

In the previous sections, we present a preliminary model of the cognitive process for detecting word senses. Given the principle of economy and mechanisms in prototype theory, we assume that not all the senses of a word have equal weights and require exactly the same procedure for sense derivation. Therefore, three modules are called upon in a sequence when needed. The first module focuses on frame-based information regarding participating frame elements and their expressions. The second module identifies colloconstructions that go beyond the expression of core arguments and look for detailed lexical as well as grammatical association patterns. The last module deals with contextually dependent cues that are semantically or ontologically related to the target word. In sum, the proposed resolution schema could be viewed as the cognitive procedure drawn upon when multiple senses are present in a single word form, as illustrated with the case of Mandarin verb ZOU(*走*). For further research, an automatic procedure may be established that makes use of frame-based semantic analysis and ontological hierarchy such as Sumo. A comprehensive investigation of Mandarin lexical semantics is under way (Liu [7][8]) and a bilingual ontological wordnet (Sinica BOW) is also available (Huang et al [9]). With useful tools, the cognitive procedure may offer a workable model to develop a computer system dealing with polysemy resolution. This model aims to integrate lexical semantics, corpus-based morphosyntax, and discourse analysis to provide a procedural and holistic solution. We also hope that this resolution can be applied in languages besides Mandarin.

Notes

1. The data used in Table 1 and Table 2 in this paper is from the Sinica Corpus (http://www.sinica.edu.tw/SinicaCorpus/). And the numbers are based on the randomly 200 utterances found in the corpus. The total occurrences of ZOU(*走*) in Sinica Corpus is over 2000. The examples cited in this paper are also from Sinica Corpus.
2. The definition is adopted from WordNet 2.0
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On-line Resources
FrameNet II: http://www.icsi.berkeley.edu/~framenet/
Sinica BOW: http://BOW.sinica.edu.tw/
SUMO: http://ontology.teknowledge.com/
WordNet: http://www.cogsci.princeton.edu