A description of Chinese NPs using Head-Driven Phrase Structure Grammar

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Abstract

In Chinese, as well as in Japanese and Korean, nouns and classifiers share the co-occurrence restrictions, which are known as the noun-classifier matching. (Levy and Oshima, 2003) And this kind of agreement is the most salient feature of noun phrases, which presents a challenge for linguistic description and formalization.

In this paper, we propose an analysis of Chinese NPs in the framework of HPSG, especially focusing on the noun-classifier matching. Also, with the implementation in the LKB system, we could figure out the pros and cons of the analysis.

1. Introduction

Concerning the noun-classifier matching, we give the examples as follows:[1]

（1）a. yì běn shū
one CL_bound book
'a book'

b. *yì taí shū
one CL_machine book

c. yì taí diànnǎo
one CL_machine computer
'a computer'

In (1a), the noun *shū* could be modified by the classifier *běn*, but not *taí* (as example (1b) shows). In contrast, the classifier *taí* could modify another noun *diànnǎo* instead. (See (1c)) Thus, these facts of match and mismatch show the co-occurrence restrictions of nouns and classifiers.

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[1] CL is the abbreviation of classifiers.

The paper is organized as follows: in section 2, we provide a general description of Chinese NPs and introduce the statistic results based on real data. Section 3 compares the three main articles concerning the Chinese NPs in the framework of HPSG. In Section 4, a deep analysis on classifiers is given. Section 5 proposes our analysis of Chinese NPs, which consists of the syntactic structures, the type hierarchies and the semantic features of Chinese NPs. Section 5 shows the results of the implementation in the LKB system. The conclusion remarks are several new ideas and the unsolved problems.

2. A General Description of Chinese NPs

Noun phrase refers to a group of words with a noun or pronoun as the main part (the HEAD) (Jack C. Richards, 2000:315). In the same way, Chinese NPs are generally constructed with nouns and other constituents. And they could also be formed by bare nouns without any functional elements such as determiners, classifiers, or number morphemes. (Rullmann and You, 2003) But, when nouns in Chinese are quantified, the numeral necessarily co-occurs with an appropriate noun-specific classifier. (Ng, 1997)

Further, we need to note that most of the attributes precede the head noun in Chinese NPs. Zhu (1982:151) has concluded that the linear sequence of Chinese NPs is like the following: possessives, demonstratives, quantities (numerals and classifiers), adjectives and nouns. This is only the basic structure of NPs without the particle *de*. In this section, we will describe the basic and complex structures of Chinese NPs, as well as the statistical data.

2.1 The basic structures of Chinese NPs

（2）a. zhè běn shū
this CL book
‘this book’
b. yì běn shū
one CL book
‘a book’
c. zhè liǎng běn shū
this two CL book
‘these two books’

As the example (2a), (2b) and (2c) shown above, we find out that they all include classifiers and nouns, but the numerals and the determiners are selected to construct different structures. Obviously, we formalize these structures as follows: “Dem + CL + N”, “Num + CL + N” and “Dem +Num+ CL + N”.[2]

2.2 The complex structures of Chinese NPs

In other cases, NPs are more complex due to the particle *de* that functions as a marker of attributes. (Bloomfield, 1980)

（3）a. tā sònggěi wǒ de nà běn shū
he give me particle that CL book
‘that book which he gives it to me’

b. nà běn tā sònggěi wǒ de shū
that CL he give me particle book
‘that book which he gives it to me’

The examples above show the complex structures of Chinese NPs. In this case, nouns are modified with possessives or relative clauses. The particle *de* is used after the adjuncts and before the nouns. Then we formalize the complex structures as follows: “PossP/RC * (*de*) + Dem + (Num) + CL + N” and “Dem + (Num) + CL + PossP/RC* (*de*) + N”.[3]

Moreover, there are certain adjectives that can modify classifiers, such as dà (big), xiǎo (small), hòu (thick), báo (thin) etc. (Ding, 1961) Just as the example (4) illustrates:

（4） yì dà běn shū
one big CL book
‘a big book’

2.3 Data

We have used the CCRL to collect the data from *People’s Daily* (2000). From the selected data of 292,352 words, we identified the four basic structures of Chinese NPs.[4]

---

[2] Dem, Num and N separately refer to demonstratives, numerals and nouns.

[3] PossP and RC refer to possessive phrase and relative clause. Also, * means the constituents could be repetitive.

[4] CCRL is the abbreviation of the Chinese Corpus Retriever for Linguistic Attributes. And the results are analyzed by Antconc 3.0.

Types of NPs	Frequency	Examples
Dem + CL + N	158	zhè běn shū 'this book'
Num + CL + N	93	yì běn shū 'a book'
Dem +Num+ CL + N	19	zhè liăng běn shū 'these two books'
Num/Dem + CL + A+ N	18	shí běn xiăo shū 'ten small books'

Table 1 The basic types of NPs

As it is shown in the Table 1, the structure of "Dem + CL + N" is most frequently used, and then the sequence of "Num + CL + N" follows, while the other three structures are not used so frequently. With these statistical results, we could point out that the "Dem + CL + N" and "Num + CL + N" are two of the most important structures of Chinese NPs. Therefore we take these two types as the object of our study. In the next section, we will review the three articles on Chinese NPs.

3. Previous Studies

Gao (1994), Xue and McFetridge (1995) and Ng (1997) have analyzed Chinese NPs in the framework of HPSG. To compare the ideas in the articles, three main issues have been discussed. The first one is the head of the noun phrase, and the second issue is about the role of demonstratives in the "Dem-CLP-N" structure. Then the last one goes to the co-occurrence between nouns and classifiers. Therefore, in this section, we will focus on these three issues.

3.1 Gao's analysis

Gao assumes the Demonstratives and the CLP together constitute the DemP. And the DemP functions as the Specifier of the head noun.[5] (Just as the figure below shows)

[5] CLP refers to classifier phrases and DemP refers to demonstrative phrase.

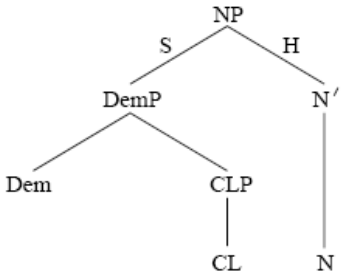

Figure 1 The syntactic structure of NP (Gao, 1994)

Following the analysis of Xue and McFetridge (1995), as well as Ng (1997), we could firstly figure that the construction of DemP is not convincing. Xue and McFetridge (1995) have presented a simple example as the following shows.

（5） nà sān wǎn fàn hé yì wǎn tāng
That three CL rice and one CL soup
'that three bowl of rice and one bowl of soup'

The phrase in (5) is ambiguous, because the demonstrative *nà* could refer to "the three bowls of rice" or "three bowls of rice and one bowl of soup". But according to Gao's analysis, *nà* only denotes "three bowls of rice" (As the Figure 2 shows). Actually, *nà* could also refer to "three bowls of rice and one bowl of soup".

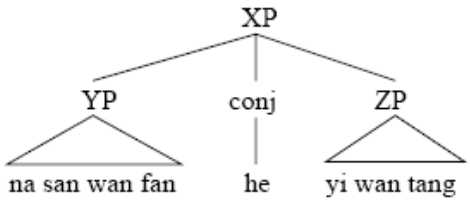

Figure 2 The analysis of *nà sān wǎn fàn hé yì wǎn tāng*

Next, as Ng (1997) has suggested, to specify that the SPEC value of the specifier is an N' with the value sing (see Figure 3) is fundamentally flawed, since nouns in Chinese are indistinguishable with respect to number.

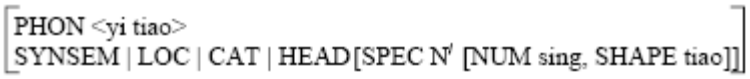

Figure 3 The feature structure of the classifier *yì tiáo*

3.2 Xue and McFetridge's analysis

First of all, their ideas are based on the DP hypothesis, so Xue and McFetridge assume that Dem is the head of DP and selects NP as its complement. And this NP consists of CLP and nouns. (As the Figure 4 shows)

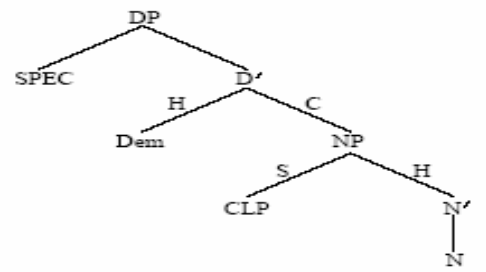

Figure 4 The syntactic structure of NP (Xue and McFetridge, 1995)

However, if we analyze the noun phrase in a broader scope, such as the sentence, we suggest that it is nouns that have relation to the other constituents. Take the sentence below as example, it is the noun *shū* that behaves as the object of the verb *mǎi*.

（6） tā mǎi le yì běn shū
He buy particle one CL book
'He bought a book'

Moreover, as Ng points out, if the demonstrative is not filled, this will lead to empty categories which current HPSG attempts to avoid. And since NP is as the sub structure of DP, this makes the analysis more complex.

Finally, in dealing with the noun-classifier matching, they only add one feature SHAPE to entail a list of words that could match. (As the figure 5 shows) This seems easy to present the matching facts, but the set of classifiers is an open one, we can not list all the words.

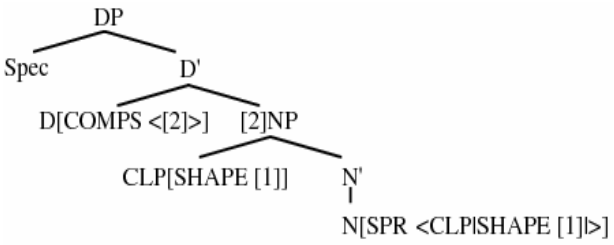

Figure 5 The noun-classifier matching (Xue and McFetridge, 1995)

3.3 Ng's analysis

Using the framework of X-bar theory, Ng suggests a double-specifier analysis of the structure 'Dem-CLP-N'. That is to say, both the Dem and the CLP are analyzed as specifiers of the head noun within an NP. (As the figure 6 shows)

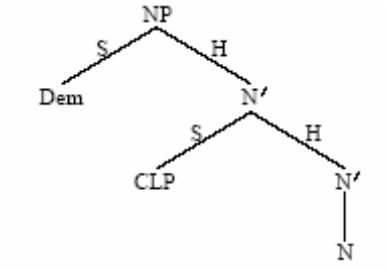

Figure 6 The syntactic structure of NP (Ng, 1997)

In detail, several reasons might account for this conclusion. The most crucial one lies in the argument of head. In contrast to Xue and McFetridge (1995), Ng (1997) claims that even with demonstratives, the head of Chinese NPs should also be noun. Further, Comparing with the analysis of Gao (1994), Ng also make a change in explaining the syntactic role of demonstratives, that is both demonstrative and classifier phrases are specifiers of the head noun.

Moreover, giving a deeper analysis to the internal structure of CLP, Ng finds out that certain adjectives could intervene into the "Num-CL" sequence, in the condition that nouns should own a feature of group. Thus, Ng suggests that there is number agreement between classifiers and nouns.

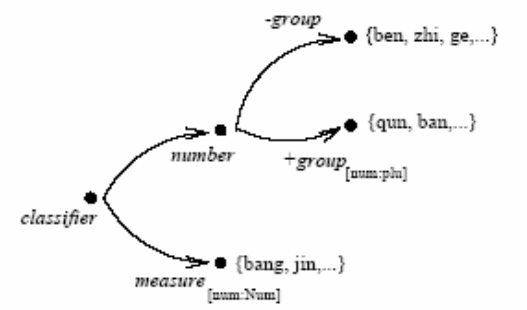

Figure 7 Number agreement between classifiers and nouns (Ng, 1997)

From the figure 7 above, we can see that nouns are classified into group nouns or non-group nouns, which can have different classifiers to be modified. To realize this constraint, Ng assigns a specifier-head relation between numerals and classifiers. We think this makes sense, because the sequence of "CL-N" is not allowed. There must be other constitutes proceed CL. Finally, all analyze above have been tested computationally through an implementation in ALE.[6]

To conclude, we prefer nouns as the head of noun and then considering the role of demonstratives in the "Dem-CLP-N" structure, we prefer a double-specifier account of Chinese NPs. While for the noun-classifier matching problem, their ideas are not sufficient to solve it. Then, in the next section, we need a deeper analysis on the co-occurrence restrictions between classifiers and nouns.

4. Classifiers

Noun classifiers characterize the noun and co-occur with it in a noun phrase. In Mandarin, this kind of agreement is determined by lexical selection, rather than matching any inflectional properties. (Aikhenvald, 2000) Then, to describe this lexical selection, we need to analyze the common features of nouns and classifiers. In the section, we thus concentrate on two aspects, one is the general classification of nouns and classifiers and the other is the semantic feature.

[6] ALE is short for the Attribute Logic Engine. See Penn and Carpenter (1999) for more information.

4.1 The classification

Wang (2004) has classified classifiers and nouns as the table below:[7]

	Indivi-diual	Subs-tance	Group	Abs-tract	Proper	Event	None
Individual	+	-	-	-	+	-	-
Measure	+	+	+	+	-	-	-
Container	+	+	+	-	-	-	-
Group	+	+	+	-	-	-	-
Kind	+	+	+	+	-	-	-
Shape	+	+	-	+	-	-	-
Indefinite	+	+	+	+	-	-	-
Time	-	-	-	-	-	+	-
Verbal	-	-	-	-	-	+	-

Table 2 The classification of classifiers and nouns

From the table above, we know that one classifier may match with different kinds of nouns. Like the group classifier *tào*, may modify individual nouns *shū* (book), group nouns *yīfú* (cloths), or even abstract nouns *zǔzhī* (organization).

Also, we notice that time and verbal classifiers are different from noun classifiers. They could only modify the event nouns. Moreover, we need to point out that their syntactic functions vary dramatically. For noun classifiers as we mentioned in Section 2, they function as modifiers of nouns. While for verbal classifiers, they play as complements of the verbs. Nevertheless, we focus on the function of noun classifiers, so the time and verbal classifiers are not discussed in this paper.

4.2 Individual classifiers

Further, the matching between individual classifiers and individual nouns are more complex. Zhu (1982:49) has pointed out that this kind of coercion is idiosyncratic, and thus need to be noted in the dictionary. And Chao

[7] The words in the vertical column are classifiers and the ones in the horizontal column are nouns.

(1979:234) holds the same idea. It is easy to make a list of the classifiers, but nouns are more productive, which makes it difficult to make a complete list.

Further, in a historical point of view, some classifiers come from nouns. To take *zhī* for example, which originally means a kind of bird, while now is used as a classifier to modify certain kind of animals and other things (Wang, 1980:236). Such analysis presents a clue of the inherent semantic relations between nouns and classifiers.

4.3 Semantic features

Huang (2003) has pointed out that it is the classifier that selects the relevant properties of the noun and coerces the appropriate meaning. Also, Tai (1990: 312) points out: "A classifier categorizes a class of nouns by picking out some salient perceptual properties, whether physically or functionally based, which are permanently associated with the entities named by the class of nouns."

What's more, many nouns have several meanings, and different meaning may need different classifiers. Levy and Oshima (2003) suggest that each class should be a set of semantic properties. And in order to make a selection between nouns and classifiers, we need to judge whether there is an intersection between them. Inevitably, it is not easy to make a unified criterion to define these semantic features. And a list of these features would be endless.

In sum, the noun-classifier matching is based on the classification and the shared features. Then in the next section, we will propose an analysis in the framework of HPSG.

5. Proposed Analysis of Chinese NPs

We suggest three ways to describe Chinese NPs: (1) to propose a model of the syntactic trees of Chinese NPs, including the basic and complex structures; (2) to construct the type hierarchy of Chinese nouns and classifiers; (3) to define new features describing the semantic properties of nouns and classifiers. And at the end of this section, we propose an overall account of the syntactic and semantic analysis of Chinese NPs.

5.1 Syntactic structure

Based on the language facts in section 2, we infer that Chinese NPs could be simply divided into two groups: one is the group which consists of bare nouns and noun phrases without classifiers, and the other with classifiers. Further, this group can be distributed as basic structure and complex structure. In basic ones, NPs are constituted by "CL-N" which proceeded by either "Dem", or "Num", or even "Dem and Num". And the complex ones include more attributives, such as possessives or relative clauses, which might be followed by a particle *de*.

5.1.1 The basic and complex structures

In section 3, we have discussed three crucial issues on the relations of these constituents. The first issue is about the head of NP, we prefer nouns as the head rather than demonstratives. The second one is a debate on the role of demonstratives, we agree with Xue and McFetridge (1995) that demonstratives should not be combined with CLP, and then following the analysis of Ng (1997), we prefer a double-specifier account, that is to say, demonstratives also play a specifier role. The final one is the noun-classifier matching, we propose a specifier relation between them. Then following Ng (1997), we present a specifier-head relation between numerals and classifiers. And the head of CLP is classifiers. Other relations are obvious, for instance, the possessives and relative clauses are modifiers of nouns. Hence, we can display these analyses as the following two figures.

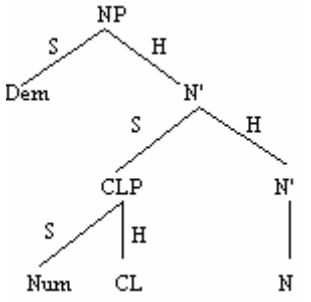

Figure 8: basic structure

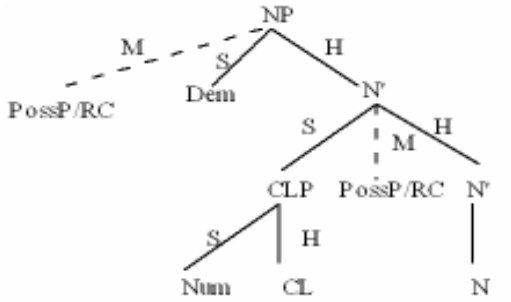

Figure 9: complex structure

5.1.2 Double-Specifier Rule

Since we refer the double specifier account (Ng, 1997) to analyze the structure of NPs with demonstratives and classifiers, we need to modify the

head-specifier rule as follows.

$$\mathrm{X}\left[\mathrm{SPR}\ \boxed{1}\right] \rightarrow \boxed{2}\left[\mathrm{SPEC}\ \boxed{3}\right],\ \boxed{3}\,\mathrm{X}\left[\mathrm{SPR}\ \boxed{1} + \left\langle \boxed{2} \right\rangle\right]$$

Figure 10: Double-Specifier Rule

5.2 Type hierarchy of Nouns and Classifiers

In HPSG, the lexicon itself can be treated of a type hierarchy. (Sag and Wasow, 2003) Therefore, concerning the classification in Section 4, we construct the type hierarchy of Chinese nouns and classifiers.

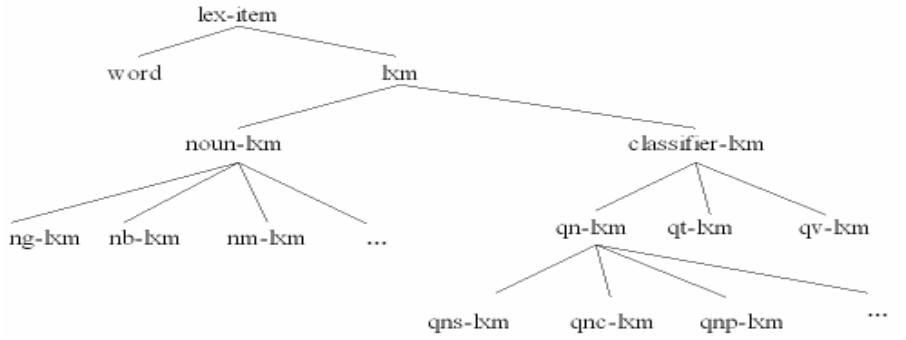

Figure 11 Type Hierarchy of Nouns and Classifiers

As the figure 11 shows, the classifiers are first divided into noun, time and verbal classifiers, and then it is noun classifiers that have sub-types of classifiers, such as individual classifiers which are represented as “qns-lxm”.

5.3 Semantic features

Following the analysis in section 4, we will focus on the coercion between nouns and classifiers. While dealing with this problem, we need to settle two basic questions first. One is that classifiers do not simply agree with noun word, but instead coerce a particular meaning from it. (Huang, 2003) The other one is to determine the basic meanings of nouns and classifiers.

Following Pustejovsky (1995), a book, for example, is constituted by “content”, its formal appearance is “bound”, and it is used to be “read”. As the nouns are constituted by multiple meanings, thus we could make a list of these meanings as [+content, +bound, +read]. Considering the classifiers, the semantic properties of individual classifiers varies, for example, *běn* modifies things which are bound as a common feature. Hence, we could predict that

běn and *shū* could match because of the common feature [+bound]. Then, we introduce another feature CLS to represent the semantic properties just as the figure 12 shows.

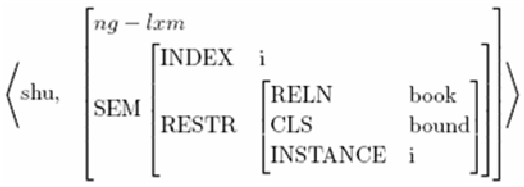

Figure 12: The lexical entry of *shū* (book)

5.4 The analysis of NPs

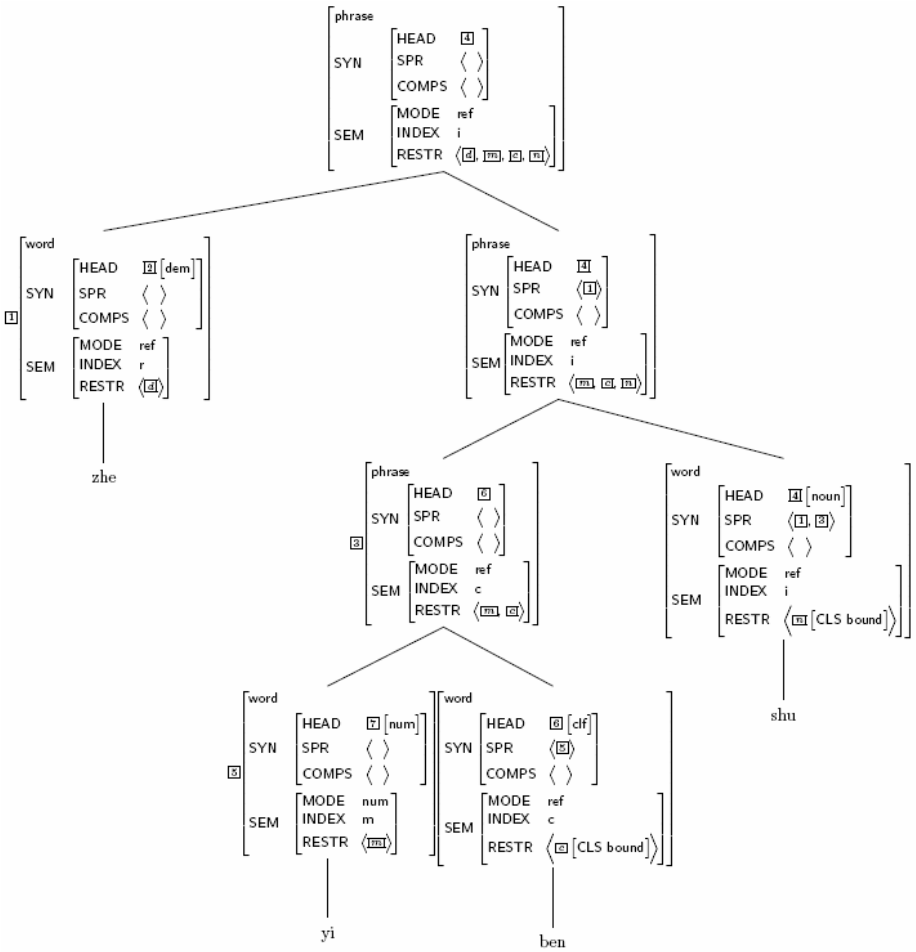

Figure 13: Complete analysis of "*zhè yì běn shū*" (this book)

As the figure above shows, the noun phrase "*zhè yì běn shū*", which is constructed as "Dem+Num+CL+N", obeys Double-Specifier Rule. We begin with the lexical SD of the head noun *shū*.[8] Note that, just as the tag [4] shows, the HEAD value of the word *shū* and that of the noun phrase are identified via the Head Feature Principle. And in the list of the SPR value of the head noun, there are nodes labeled [1] and [3], which separately refers to the demonstrative *zhè* and the classifier *běn*. Then, we could see that, the head noun selects the demonstrative and the classifier as specifiers by the Double-Specifier Rule.

Next, concerning the noun-classifier matching, the head noun and the classifier share the same RESTR value as "bound", which is constrained by the feature CLS. Further, with the Semantic Compositionality Principle, we could see that the RESTR value of the mother is the sum of the four daughters' RESTR lists.[9]

6. Implementing in the LKB system

The LKB system (the Linguistic Knowledge Building system) is a grammar and lexicon development environment for typed feature structures (Copestake, 2002: 6). Since it has been most extensively tested with grammars based on Head-Driven Phrase Structure Grammar (Pollard and Sag, 1987, 1994), we, in this section, implement our analyses in LKB system, and try to figure out the pros and cons of the ideas proposed above.

6.1 Proposed grammar rules, types and lexicon

In Section 5, we modify the Specifier-Head Rule and present a double specifier rule, thus in the grammar file, we need to add this rule as follows:

```
specifier-head-rule-1 := binary-head-final &
    [   SPR #rest,
        COMPS #comps,
        ARGS < #1,    [ SPR [FIRST #1, REST #rest] , COMPS #comps ] > ].
```

Figure 14: Modified Head-Specifier Rule

[8] SD is the abbreviation of structural description. See Sag and Wasow (2003).
[9] The rules and principles mentioned in this section are based on Sag and Wasow (2003).

Then, concerning the noun-classifier matching in Section 4, we also add a feature CLS in the semantic representations. In Section 5, we add this feature in the RESTR, while in the LKB system, the feature is constrained in INDEX. This seems a contradiction. So we present the problem here that is not solved when implementing in the LKB system. Below are the types of nouns preceded by classifiers:

```
noun-lxm-clf := noun-lxm &
[     SPR < phrase &
            [ HEAD clf,
              SPR <>,
              SEM.INDEX #1 ] >,
      SEM.INDEX object & #1 ].
```

Figure 15: Nouns preceded by classifiers

Moreover, concerning the lexicon related to nouns and classifiers, we add the CLS feature at this level. For example,

```
shu := noun-lxm-clf &
[     ORTH <! "shu" !>,
      SEM.KEY.PRED "shu_rel",
      SEM.INDEX.CLS "bound" ].
```

Figure 16: The lexical description of *shū* (book)

6.2 The results

With the grammar we built in the LKB system, we could parse the basic types of Chinese NPs, such as "Num + CL + N", "Dem + CL + N" and "Dem +Num+ CL + N". Take *yì běn shū* as example, we enter "yi ben shu" to parse. After the grammar has been loaded, we get the tree diagram as figure 17 shows.[10]

[10] In this figure, there are two NUM and two CL nodes. This is due to the inull-rull and the rule from the lexicon to the tree that we used in our grammar.

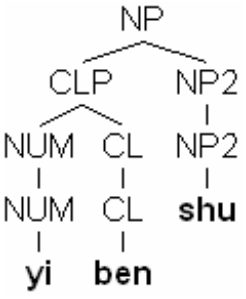

Figure 17: The tree diagram

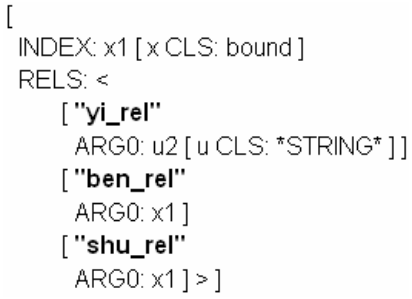

Figure 18: the MRS

In the LKB system, the tree diagram clearly shows the syntactic structure of this noun phrase. However, the syntactic relations between these constituents will be shown in the chart below.[11]

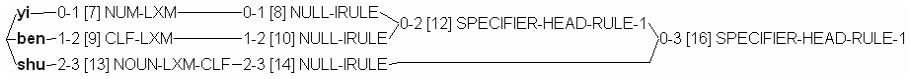

Figure 19: Parsing chart for 'yi ben shu'

Also, if we check the MRS option in the LKB system, Figure 18 just presents the MRS representation for "yi ben shu".[12] In this figure, we could find out that the semantic features for *běn* and *shū* are labeled for the same node "x1", because they are given the same feature as "bound". While concerning the numeral *yī*, the feature for CLS is an empty string, which is not well formed, since numerals do not need this CLS feature.

Finally, if we input "yi tai shu", there will be "No parses found", because tai does not match with *shū* in Chinese, we could see the grammar well solve the noun-classifier matching phenomena.

So far, we built a small grammar of Chinese NPs in the LKB system and successfully test the matching problem between nouns and classifiers. Still, some problems are not solved and new problems arise. For instance, concerning the MRS value, it remains a question that if we need to add the feature CLS in INDEX or RESTR.

[11] The inull-rull here represents the non-morphology changes in Chinese.

[12] MRS refers to the Minimal Recursive Semantics. See more information at Copestake, Ann, Pollard, Carl J. and Sag, Ivan A. (2001) and Flikinger, Dan, Bender, Emily M. and Oepen, Stephan (2003).

7. Concluding remarks

In summary, we analyze the syntactic structures and semantic constrains of Chinese NPs in the frame work of HPSG. Focusing on the noun-classifier matching problem, we suggest a new feature to solve it. For proving our proposal, we implement our ideas in the LKB system and find out the questions of MRS representation.

We also find two questions: (1) For Chinese HPSG processing, we need a further study of the multiple matching and the semantic constraints between nouns and classifiers of classifiers; (2) The problem when implementing the MRS representation in the LKB system should be studied completely. Further researchers include the multiple matching problems and implementations in other systems, like TRALE and the Matrix.[13]

References

Aikhenvald, A. 2000. *Classifiers: a Typology of Noun Categorization Devices*. CUP.

Chao, Y. R. 1979. *A Grammar of Spoken Chinese*. Beijing: The Commercial Press.

Copestake, Ann. 2002. *Implementing Typed Feature Structure Grammars*. CSLI.

Copestake, Ann, Pollard, Carl J. and Sag, Ivan A. 2001. *Minimal Recursion Semantics: An Introduction*. (1):1-47.

Ding, Shengshu and etc. 1961. *Xiàndài Hànyǔ Yǔfǎ Jiǎnghuà*. Beijing: The Commercial Press.

Emily M. Bender, Melanie Siegel. 2004. *Implementing the Syntax of Japanese Numeral Classifiers*. In Proceedings of the First International Conference on Natural Language. Processing. Hainan, China.

Flikinger, Dan, Bender, Emily M. and Oepen, Stephan. 2003. *MRS in the LinGO Grammar Matrix: A Practical User's Guide*. 12.

Gao, Q. 1994. *Chinese NP Structure*. Linguistics 22, 475–510.

[13] TRALE is a grammar implementation platform specifically for the implementation of theoretical HPSG grammars. (Nurit Melnik, 2005) And the Matrix is a framework for the development of broad-coverage, precision, implemented HPSG grammars for diverse languages. (http://www.delph-in.net/matrix/)

Huang, Churen and Ahrens, Kathleen. 2003. *Individuals, kinds and events: classifier coercion of nouns*. Language Sciences 25, 353–373.

Levy, Roger and Oshima, David. 2003. *Non-transitive information flow in Japanese noun-classifier matching*. In proceedings of HPSG 2003. CSLI.

Melnik, Nurit. 2005. F*rom "Hand-written" to Computationally Implemented HPSG Theories*. In proceedings of HPSG 2005. CSLI.

Ng, Say Kiat. 1997. *A DoubleSpecifier Account of Chinese NPs using Head-Driven Phrase Structure Grammar*. University of Edinburgh. (Msc thesis)

Penn, Gerald and Carpenter, Bob. 1999. *{ALE} for Speech: a Translation Prototype*. Budapest: Proceedings of the 6th Conference on Speech Communication and Technology.

Pollard, Carl J. and Sag, Ivan A. 1994. *Head-Driven Phrase Structure Grammar*. Chincago: University of Chicago Press.

Pustejovsky, J. 1995. *The Generative Lexicon*. Cambridge: MIT Press.

Richards, Jack C., Platt J. and Platt, H. 2000. *Longman Dictionary of Language Teaching and Applied Linguistics*. Beijing: Foreign Language Teaching and Research Press.

Rullmann, Hotze and You, Aili. 2003. *General Number and the Semantics and Pragmatics of Indefinite Bare Nouns in Mandarin Chinese*. Paris: the Fifth Syntax and Semantics Conference.

Sag, Ivan A. andWasow, Thomas. 1999. *Syntactic Theory: A Formal Introduction*. Stanford: Center for the Study of Language and Information.

Tai, J.H.-Y. 1990. *Variation in classifier systems across Chinese dialects: towards a cognition-based semantic approach*. In Proceedings of the First International Symposium on Chinese Languages and Linguistic pages 308–322.

Wang, H. 2004. *A syntagmatic study of noun senses in contemporary Chinese*. Beijing: Peking University Press.

Wang, Li. 1980. *Hànyǔ Shǐ Gǎo*. Beijing: Zhōng Huá Book Company.

Xue, P. and McFetridge, P. 1995. *DP structure, HPSG and the Chinese NP*. In Proceedings of the 14th Annual Conference of Canadian Linguistics Association (CLA '95).

Zhu, Dexi. 1982. *Yǔfǎ Jiǎngyì*. Beijing: The Commercial Press.