A Unification-based Approach o Mandarin Questions

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This paper provides unification-based GPSG and LFG analyses of Mandarin questions. First, we briefly introduce four kinds of Mandarin question, namely, **WH-questions**, **A-not-A questions**, **disjunctive questions**, and particle questions. Their different interrogative messages are adequately encoded with different feature-value pairs. Then, the compatibility of this interrogative information in a simple sentence is investigated. Both the GPSG and LFG approaches provide a straightforward account for their mutual exclusiveness. Finally, the scope of percolation of Mandarin interrogative information is examined. It is suggested that the matrix verb of a complex sentence is responsible for the scope of interrogative information in its complement sentence. According to our observations, Mandarin verbs should be divided into at least three classes. We provide preliminary analyses of the topic. The GPSG analysis relies on the **Foot Feature Principle (FFP)** and the LFG analysis relies on **functional uncertainty**. It is shown that the transmitting of Mandarin interrogative information can be adequately accounted for in both GPSG and LFG.

**Keywords**: Mandarin questions, WH-questions, disjunctive questions, A-NOT-A questions, particle questions, unification, Generalized Phrase Structure Grammar (GPSG), Lexical Functional Grammar (LFG), Foot Feature Principle, Functional Uncertainty.

1. **INTRODUCTION**

In contrast to a purely formal concern of whether a string is generable by the grammar of a certain language, recently, an informational approach to linguistic phenomena has presented a new perspective regarding language as a system for encoding and transmitting ideas (see Kay (1986)). This approach requires grammar formalisms to represent how languages convey information. Such a requirement is accomplished by associating strings with their informational domain of well-structured sets of feature-value pairs. Grammar formalisms derived from this design choice are capable of encoding various kinds of information, which is especially important in the research community of natural language understanding and generation. Thus, in this paper we attempt to study Mandarin questions from an informational point of view.

Traditionally, Mandarin questions have been divided into four main types, namely, **WH-questions**, **A-NOT-A questions**, **disjunctive questions** and **particle questions**. Unlike

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1 This classification is adopted mainly from Tang (1981), in which tag questions are not regarded as a separate type. Discussions of tag questions can be found in Tang (1981: 20-21) and Li and Tompson (1981: 546).
English, which always involves Subject-Aux inversion or WH-word fronting in question formation, Mandarin Chinese does not have any characteristic syntactic constructions to mark interrogatives. Except for intonation\(^2\), which is beyond our syntactic consideration in this paper, declarative and interrogative counterparts in Mandarin may simply differ in the existence of a crucial element, such as a **WH-word**, an **A-NOT-A construction**, a **disjunctive conjunction**, or an **interrogative sentential clitic**. These four kinds of questions are briefly introduced below:

### 1.1 WH questions

In Mandarin, WH-questions are formed by simply replacing the elements questioned with appropriate WH-words. This is exemplified as follows\(^3\).

\[(1)\]  
\[\text{a. Daxiong pa Ji-an.} \quad \text{(declarative sentence)}\]  
\[\text{Daxiong fear Jian} \]  
\['Daxiong is afraid of Jian.'\]  

\[\text{b. Daxiong Pa Shei?} \quad \text{(WH questions)}\]  
\[\text{Daxiong fear who}\]  
\['Who is Daxiong afraid of?\]

(1) a. is a declarative sentence, while (1) b. is a WH-question. From this pair of contrasting sentences, we can find that the presence of a WH-word is the sole marker of a WH-question\(^4\).

### 1.2 Disjunctive questions

Mandarin disjunctive questions are marked by the existence of a disjunctive conjunction haishi, as exemplified below:

\[(2)\]  
\[\text{a. Daxiong pa Ji-an han Yijing.} \quad \text{(declarative sentence)}\]  
\[\text{Daxiong fear Ji-an and Yijing}\]  
\['Daxiong is afraid of Ji-an and Yijing.'\]

\[\text{b. Daxiong pa Ji-an haishi Yijing?} \quad \text{(disjunctive question)}\]  
\[\text{Daxiong fear Ji-an or Yijing}\]  
\['Is Daxiong afraid of Ji-an or Yijing?'\]

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\(^1\) It is always possible to turn a Mandarin statement into a question by imposing a rising intonation.

\(^2\) The Romanization system adopted in this paper is Mandarin Phonetic Symbols II (MPS III, which was formally adopted by the Ministry of Education, R.O.C., in 1986.

\(^3\) It is worth mentioning that Mandarin Wh-words may have non-interrogative usages, as exemplified below:

(i) \(\text{SAei ye bu-shiu he iiou.}\)  
\[\text{Who(ever) ye NEG-allow drink wine}\]  
\['Nobody is allowed to drink.'\]

(ii) \(\text{Jintian you Shei lai baifang wo ma?}\)  
\[\text{today have who(ever) come visit me MA}\]  
\['Is there anyone to visit me today?'\]

Since the discussions in this paper are focused on interrogatives, the non-interrogative usages of WH-words\(^5\) will not be pursued further. Readers are referred to Tang (1981: 250-271) for a WH-words.
These kinds of questions explicitly present the respondent with a choice of some possible answers.

1.3 A-NOT-A questions

Traditionally, a Mandarin A-NOT-A question is considered as the result of identical elements deletion from a full coordinate structure which is formed by an affirmative sentence and its negative counterpart. Thus, most linguistic studies analyze A-NOT-A questions on a par with disjunctive questions, as exemplified below:

(3)a. Daxiong pa Ji-an.  
Daxiong fear Ji-an  
'Daxiong is afraid of Ji-an.'

b. Daxiong pa Ji-an haishi Daxiong bu pa Ji-an?  
Daxiong fear Ji-an or Daxiong not fear Ji-an.  
'Is Daxiong afraid of Ji-an or is he not afraid of Ji-an?'

c. Daxiong pa-bu-pa Ji-an? 
Daxiong fear-not-fear Ji-an  
'Is Daxiong afraid of Ji-an or not?'

However, A-NOT-A questions have more restrictions on their conjuncts, e. g., the number of their conjuncts is limited to two, the syntactic category of their conjuncts must be a predicate, and the form of their conjuncts must be an affirmative predicate and its negative counterpart. But disjunctive questions do not have such restrictions on their conjuncts. So, we consider A-NOT-A questions and disjunctive questions as separate types of questions.

1.4 Particle questions

Mandarin particle questions are marked by the presence of interrogative sentential clitics. According to Lu (1984) and Shiu (1989), ma is the most typical interrogative sentential clitic, and it functions to turn a statement into a yes-no question, as exemplified below:

(4) a. Daxiong Pa Ji-an.  
Daxiong fear Ji-an  
'Daxiong is afraid of Ji-an.'

b. Daxiong Pa Jz’an ma?  
Daxiong fear Ji-an MA  
'Is Daxiong afraid of Ji-an?'

As illustrated above, Mandarin questions are marked by the existence of interrogative elements.

5 Zwicky (1985) has investigated the grammatical status of clitics and particles. It is suggested that 'clitic' is a theoretical construct which belongs to a level between 'word' and 'affix', while 'particle' is a redundant cover term which should be eliminated. Following this line of approach, Huang (1985) explicitly points out that the so-called Mandarin sentential particles are indeed sentential clitics.
According to our observation, different kinds of interrogative elements may co-occur within a sentence, and their conditions on compatibility and the environments of their co-occurrences seem rather intriguing. Taking the informational approach, we offer a systematic and straightforward solution to this problem and provide a preliminary study of the encoding and transmitting of Mandarin interrogative information. In particular, the compatibility nature and the scope of percolation of this interrogative information will be carefully investigated. Since the flow of information is much more explicitly formulated in unification-based formalisms, and Generalized Phrase Structure Grammar (GPSG) and Lexical Functional Grammar (LFG) are two of the linguistically best-established frameworks using this approach, we will adopt them in subsequent discussions. Accounts in either frameworks are independently motivated. Their mutual compatibility and validity, however, lend support to Shieber's (1986 and 1987) avocation of unification as an underlying grammar formalism.

2. THE ENCODING OF MANDARIN INTERROGATIVE INFORMATION

2.1 A GPSG analysis

As mentioned previously, Mandarin questions are marked solely by the existence of interrogative elements. In GPSG, this phenomenon may raise problems of semantic interpretation. Adopting the basic concept of Montague Grammar, syntax and semantics in GPSG are separate but parallel components, in which every syntactic structure is directly paired with a semantic interpretation supplied by a set of translation rules. Since Mandarin declaratives and interrogatives do not differ in their syntactic structures, their semantic denotations could also be indistinguishable. As a consequence, syntactic specifications which are semantically interpreted have to be introduced to encode different kinds of interrogative information. We assume Mandarin interrogative elements are listed in lexicon as follows:

(6)<shei, [N+], [V-], [QTYPE WH], …] …>
(7)(haishi, […], [QTYPE DJ], …>
(8)(pa-bu-pa, […, [QTYPE A-NOT-A], …] …>9
(9)<ma, [CLIT MA], [QTYPE YN], …] …>

The feature-value pairs [QTYPE WH], [QTYPE DJ], [QTYPE A-NOT-A], and [QTYPE YN] are postulated to encode the interrogative information of WH-words, the disjunctive conjunction, the A-NOT-A construction, and the interrogative sentential clitic, respectively.

One point worth noting is that the interrogative information is crucially related to sentence type.

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6 Readers are referred to Sells (1985) for a general overview of the GPSG and LFG frameworks, to Gazdar et al. (1985) for the most complete description of GPSG, and to Bresnan(1982) for a collection of important LFG literatures. In-depth discussion of unification can be found in Shieber (1986), Sag et al. (1986), and works cited therein.

7 However, Kaplan (1989) points out that LFG allows the addition of disjunction and negation in the description language, thus LFG is better described as an equality-based theory.

8 For a more detailed discussion on how syntax and semantics interact in GPSG, please see Gazdar et al. (1985: 182-244).

9 The morphological module in GPSG has not been well-studied. Here we simply assume that the whole A-NOT-A construction, after some kind of morphological process, encodes the specification of [QTYPE A-NOT-A].
Thus, although the interrogative specifications are encoded in the lexical entry of WH-words, they must be semantically interpreted at a sentential level. A natural solution to this problem in GPSG is to assign the feature QTYPE to the class of FOOT features. In GPSG, features, according to their percolation properties, are divided into three classes; namely, HEAD features, FOOT features, and LOCAL features. Foot feature distributions obey the Foot Feature Principle (FFP):

(10) **FOOT Feature Principle (FFP):**

The FOOT feature specifications that are instantiated on a mother category in a tree must be identical to the unification of the instantiated FOOT feature specifications in all of its daughter categories. (Gazdar et al. (1985: 82))

The basic operation underlying FFP is unification. Based on such a mechanism, specifications will be "passed up" from a phrasal daughter to a mother. Thus, interrogative information in GPSG can be locally specified by the lexical word, while being checked and percolated (if unification is successful) unbounded up the tree.

### 2.2 An LFG analysis

In LFG, since semantic interpretation is derived from the attribute-value matrix representations of f-structures, we have to properly introduce different feature-value pairs to encode interrogative information. Here, we also assume that the presence of the feature QTYPE marks a sentence as a question and the value of this feature further specifies which kind of question the sentence is. Thus, Mandarin interrogative elements are represented in the lexicon as (11)

(11) **Lexicon**

<table>
<thead>
<tr>
<th>Word</th>
<th>Feature Class</th>
<th>Feature Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>shei</td>
<td>N</td>
<td>(Body Bottom ↑) QTYPE=WH, (↑ PRED)=‘PRO’, (↑ t HUMAN)=+</td>
</tr>
<tr>
<td>haishi</td>
<td>CONJ(Body Bottom ↑)</td>
<td>QTYPE=DJ</td>
</tr>
<tr>
<td>pa-bu-pa</td>
<td>V</td>
<td>(↑ PRED)=‘FEAR &lt;(↑ SUBJ) (↑ OBJ))’, (↑ QTYPE)=A-NOT-A</td>
</tr>
<tr>
<td>ma</td>
<td>CLIT</td>
<td>(↑ LAST)=+</td>
</tr>
</tbody>
</table>

Again, this interrogative feature QTYPE should be interpreted at the matrix level in the f-structure. But, instead of general feature percolation principles as in GPSG, the LFG mechanism of functional equations explicitly specifies how the functional information contained in lexicon or on a node in c-structure participates in f-structure. That is, the flow of information in LFG is governed by independent functional equations. The WH word shei and the disjunctive conjunction haishi encode an equation (Body Bottom f) QTYPE=WH and (Body Bottom f) QTYPE= DJ, respectively. The equations encoded on both of them involve the inside-out version of functional uncertainty.

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10 In LFG, ‘↑ ’ and ‘↓ ’ are meta variables. ‘↑ ’ refers to the grammatical function represented by the mother node, and ‘↓ ’ refers to the grammatical function represented by the current node. The equal sign ‘=’ explicitly means merge or unification.
(proposed in Kaplan and Zaenen (in press)), which will be discussed in detail in section IV. The treatment of A-NOT-A construction is similar to that of GPSG. We assume that the whole A-NOT-A construction is the output of a morphological process and encodes an equation \( \uparrow \text{QTYPE} = \text{A-NOT-A} \). The lexical entry of ma has been discussed in Shiu (1989) and we assume it encodes an equation \( \uparrow \text{QTYPE} = \text{YN} \).

Given the above GPSG and LFG analyses, every kind of Mandarin interrogative information can be adequately encoded and appropriately interpreted. These analyses will be further supported in the next two sections.

### 3. THE COMPATIBILITY OF MANDARIN INTERROGATIVE INFORMATION

In this section, we will briefly discuss how the interrogative information in Mandarin interacts within simple sentences. Let us consider the following sentences:

* (12) *Daxiong pa-bu-pa shei?*
  Daxiong fear-not-fear who
  (A-NOT-A construction and WH word)

* (13) *Daxiong Pa Ji-an haishi pa shei?*
  Daxiong fear Ji-an or fear who
  (disjunctive conjunction and WH word)

* (14) *Daxiong pa-bu-pa Ji-an haishi Yi-jing?*
  Daxiong fear-not-fear Ji-an or Yi-jing
  (A-NOT-A construction and disjunctive conjunction)

* (15) *Daxiong pa shei ma?*
  Daxiong fear who MA
  (WH word and sentential clitic ma)

* (16) *Daxiong pa-bu-pa Ji-an ma?*
  Daxiong fear-not-fear Ji-an MA
  (A-NOT-A construction and sentential clitic ma)

* (17) *Daxiong pa Ji-an haishi Yi-jing ma?*
  Daxiong fear Ji-an or Yi-jing MA
  (disjunctive conjunction and sentential clitic ma)

From the above sentences, we can conclude that different kinds of interrogative elements cannot co-occur within simple sentences. Based on the analyses proposed in the previous section, we will provide adequate and straightforward accounts for this phenomenon.

### 3.1 A GPSG analysis
Notice that syntactic categories in GPSG are partial functions from features to values. Defining categories this way has a natural consequence that no well-formed syntactic category may have different specifications for the same feature. Thus, the mutual exclusiveness of different kinds of interrogative information can be accounted for in GPSG by assuming each kind of interrogative element encodes one kind of specification of the feature QTYPE. Summarizing our encoding of Mandarin interrogative information in GPSG, the feature QTYPE and the set of its possible values are indicated below:

<table>
<thead>
<tr>
<th>feature</th>
<th>value range</th>
<th>feature class</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTYPE</td>
<td>{WH, DJ, A-NOT-A, YN}</td>
<td>FOOT</td>
</tr>
</tbody>
</table>

According to this analysis, the grammaticality of (12)-(17) can be nicely captured by FFP and unification. Owing to FFP, different kinds of interrogative specifications in a sentence will all percolate up to the matrix node and result in feature clashes. Thus, all these sentences are ruled out as ungrammatical because of failure of unification.

3.2 An LFG analysis

Taking a similar approach to GPSG, we attribute all kinds of interrogative information to the feature QTYPE. The encoding of this feature in different kinds of questions is summarized below:

<table>
<thead>
<tr>
<th>Lexicon</th>
<th>QTYPE value</th>
<th>QTYPE class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shei</td>
<td>N</td>
<td>(Body Bottom $\uparrow$) QTYPE=WH</td>
</tr>
<tr>
<td>Haishi</td>
<td>CONJ</td>
<td>(Body Bottom $\uparrow$) QTYPE=DJ</td>
</tr>
<tr>
<td>pa-bu-pa</td>
<td>V</td>
<td>( $\uparrow$ QTYPE)= A-NOT-A</td>
</tr>
<tr>
<td>ma</td>
<td>CLIT</td>
<td>( $\uparrow$ QTYPE)=YN</td>
</tr>
</tbody>
</table>

The LFG account of the grammaticality of (12)-(17) is similar to that of GPSG in that they both resort to unification. In LFG, the ungrammatical sentences are ruled out by functional uniqueness because the attribute QTYPE is assigned multiple values.

Thus, it is suggested that the seemingly complicated phenomena of the compatibility of Mandarin interrogative information can be straightforwardly accounted for with our analyses in unification-based formalisms.

4. THE SCOPE OF PERCOLATION OF MANDARIN INTERROGATIVE INFORMATION

In this section, we will further examine the behavior of Mandarin interrogative information within Mandarin complex sentences.

Consider the pair of contrasting sentences below:

(20) Tamen xiwang [Daxiong pa shei]?
    they hope Daxiong fear who
    'Who do they hope Daxiong is afraid of?'

(21) Tamen taolun [Daxiong pa shei].
they discuss Daxiong fear who
'They discuss who Daxiong is afraid of.'

Although both sentences contain a WH-word shei 'who', yet (20) must be interpreted as a direct question, and (21) must be interpreted as a statement taking an indirect question. The difference between (20) and (21) reveals an interesting phenomenon concerning the scope of percolation of Mandarin interrogative information. Grimshaw (1979), based on English data, suggests that the matrix verb of a sentence is responsible for the scope of interrogative information in its complement sentence. That is, different kinds of verbs will result in different kinds of percolation of interrogative information. This idea has been widely adopted in research on interrogatives. Huang (1982a), following this line of approach, studied the scope properties of Mandarin WH-questions, cleft sentences, and A-NOT-A questions in Government-Binding Theory (GB). In this section, we will discuss the scope of percolation of all kinds of Mandarin interrogative information within the GPSG and LFG frameworks and briefly compare our analyses with those in Huang (1982a).

4.1 Linguistic facts

As mentioned earlier, different kinds of Mandarin verbs will result in different kinds of percolation of interrogative information\textsuperscript{11}. Here, we only take the verbs xiwang 'hope', taolun 'discuss' and zhidao 'know' as illustrative samples.

First, let us consider the following sentences concerning the verb xiwang:

\textit{(22) Tamen xiwang [Daxiong pa Ji'an].}
\begin{center}
They hope Daxiong fear Ji-an
\end{center}
'They hope that Daxiong is afraid of Ji-an.'

\textit{*\textit{(23) Tamen xiwang [Daxiong pa Ji-an ma].}}
\begin{center}
They hope Daxiong fear Ji-an MA
\end{center}\textsuperscript{12}'They hope whether Daxiong is afraid of Ji-an or not.'

\textit{(24) Tamen xiwang [Daxiong pa Ji-an] ma?}
\begin{center}
They hope Daxiong fear Ji-an MA
\end{center}'Do they hope that Daxiong is afraid of Ji-an?'

\textit{(25) Tamen xiwang [Daxiong pa shei]?}
\begin{center}
They hope Daxiong fear who
\end{center}'Who do they hope that Daxiong is afraid of?'

\textit{(26) Tamen xiwang [Daxiong pa Ji-an haishi pa Yijing]?}
\begin{center}
They hope Daxiong fear Ji-an or fear Yijing
\end{center}'Do they hope that Daxiong is afraid of Ji-an or afraid of Yijing?'

\textsuperscript{11} For ease of description, we use the term 'verbs' to stand for predicates in Mandarin.
\textsuperscript{12} For ease of description, we use the term 'verbs' to stand for predicates in Mandarin.
**(27)** Tamen xiwang [Daxiong **pa-bu-pa** Ji-an]?
They hope Daxiong fear-not-fear Ji-an

**(28)** Shei xiwang [Daxiong Ji-an ma]?
Who hope  Daxiong fear Ji-an MA

**(29)** Shei xiwang [Daxiong pa Ji-an haishi pa Yijing]?
Who hope  Daxiong fear Ji-an or fear Yijing

**(30)** Shei xiwang [Daxiong **pa-bu-pa** Ji-an]?
Who hope  Daxiong fear-not-fear Ji-an

(22) shows that the verb xiwang can take a statement as its complement. The contrasting pair (23) and (24) shows that the interrogative sentential clitic ma can only attach to a matrix sentence instead of an embedded sentence. (25) and (26) show that if the complement sentence of xiwang contains a WH-word or a disjunctive conjunction, the whole sentence is interpreted as a direct question. (27) shows that A-NOT-A construction can not occur in the complement sentence of Xiwang. (28) shows that if there is an interrogative element in the matrix sentence, the attachment of ma will cause the whole sentence to be ungrammatical. (29)-(30) show that if both the matrix sentence and the embedded sentence of xiwang contain an interrogative element, and they are not of the same type, the whole sentence will be ungrammatical.

Next, let us consider the sentences concerning the verb taolun:

**(31)** Tamen (zai) taolun [Daxiong pa Ji-an].
They be-Ving discuss Daxiong fear Ji-an
'*They (are) discuss (ing) that Daxiong is afraid of Ji-an.*'

**(32)** Tamen (zai) taolun [Daxiong pa Ji-anl ma?
They be-Ving discuss Daxiong fear Ji-an MA

**(33)** Tamen (zai) taolun [Daxiong pa shei].
They be-Ving discuss Daxiong fear who
'They are discuss (ing) Daxiong is afraid of whom.'

**(34)** Tamen (zai) taolun [Daxiong pa Ji-an haishi pa Yijing].
They be-Ving discuss Daxiong fear Ji-an or fear Yijing
'They (are) discuss (ing) whether Daxiong is afraid of Ji-an or afraid of Yijing.

**(35)** Tamen (zai) taulueut [Daxiong pa-bu-pa Ji-an].
They be-Ving discuss Daxiong fear-not-fear Ji-an
'They (are) discuss (ing) whether Daxiong is afraid of Ji-an or not.'

**(36)** Shei (zai) taolun [Daxiong pa Ji-an haishi pa Yijing]?
Who be-Ving discuss Daxiong fear Ji-an or fear Yijing
'Who (are) discuss (ing) whether Daxiong is afraid of Ji-an or Yijing?'
(37) Shei (zai) taolun [Daxiong pa-bu-pa Ji-an]?
  Who be-Ving discuss Daxiong fear-not-fear Ji-an
  'Who are (are) discuss (ing) whether Daxiong is afraid of Ji-an or not?'

(31)-(35) show that the verb taolun obligatorily takes a question as its complement, but the whole sentence is interpreted as a statement taking an indirect question rather than a direct question. (36)-(37) show that if both the matrix sentence and the embedded sentence of taolun contain an interrogative element, the whole sentence is still grammatical.

Finally, let us consider the sentences concerning the verb zhidao:

(38) Tamen zhidao [Daxiong pa Ji-an].
  They know Daxiong fear Ji-an
  'They know that Daxiong is afraid of Ji-an.'

(39) Tamen zhidao [Daxiong Pa shei].
  They know Daxiong fear who
  'They know Daxiong is afraid of whom.'

(40) Tamen zhidao [Daxiong pa Ji-an haishi pa Yijing].
  They know Daxiong fear Ji-an or fear Yijing
  'They know whether Daxiong is afraid of Ji-an or is afraid of Yijing.

(41) Tamen zhidao [Daxiong pa-bu-pa Ji-an].
  They know Daxiong fear-not-fear Ji-an
  'The know whether Daxiong is afraid of Ji-an or not.'

(42) Shei zhidao [Daxiong pa Ji-an haishi pa Yijing]?  
  Who know Daxiong fear Ji-an or fear Yijing
  'Who knows whether Daxiong is afraid of Ji-an or is afraid of Yijing?'

(43) Shei zhidao [Daxiong pa-bu-pa Ji-an]?
  Who know Daxiong fear-not-fear Ji-an
  'Who knows whether Daxiong is afraid of Ji-an or not?'

(38)-(41) show that the verb zhidao can take either a statement or an indirect question as its complement. If the complement sentence of zhidao is a question, the whole sentence is interpreted as a statement taking an indirect question rather than a direct question. (42)-(43) show that if both the matrix sentence and the embedded sentence of zhidao contain an interrogative element, the whole sentence is still a good sentence.

4.2 A GPSG analysis

As mentioned previously, the FFP in GPSG requires that all the FOOT feature specifications
instantiated on a daughter be instantiated on its mother in any given local tree. Since our proposed interrogative features are all FOOT features, without additional stipulations, the interrogative messages should be passed to the top matrix node, rather than be limited to the embedded clause. But this prediction is contradictory to the empirical fact, as shown in (21).

Here, we make crucial use of the feature SUBCAT in our GPSG analysis\(^\text{13}\). Three ID rules are postulated as shown in (44)\(^\text{14}\):

\[
\begin{align*}
\text{(44) a. } & \text{VP} \rightarrow \text{V}[11], \text{S-[QTYPE A-NOT-A]} \\
\text{b. } & \text{VP} \rightarrow \text{V}[12], \text{S[QTYPE]} \\
\text{c. } & \text{VP} \rightarrow \text{V}[13], \text{S([QTYPE])}
\end{align*}
\]

First, let us discuss the verb xiwang. We assume it is listed in lexicon as (45):

\[
(45) \langle \text{xiwang}, [N-], [V=], [\text{SUBCAT 11}], \ldots \rangle \text{HOPE'}
\]

Reconsider the following sentences:

\[
\begin{align*}
(22') & \text{Tamen xiwang [Daxiong pa Ji-an].} \\
& \text{They hope Daxiong fear Ji-an} \\
& \text{They hope that Daxiong is afraid of Jian.}
\end{align*}
\]

\[
\begin{align*}
(23') & \text{Tamen xiwang [Daxiong pa Ji-an ma].} \\
& \text{They hope Daxiong fear Ji-an MA} \\
& \text{[QTYPE YN]}
\end{align*}
\]

\[
\begin{align*}
(24') & \text{Tamen xiwang [Daxiong pa Ji-an] ma?} \\
& \text{They hope Daxiong fear Ji-an MA} \\
& \text{[QTYPE YN]}
\end{align*}
\]

\[
\begin{align*}
(25') & \text{Tamen xiwang [Daxiong pa shei]?} \\
& \text{They hope Daxiong fear who} \\
& \text{[QTYPE WH]}
\end{align*}
\]

\[
\begin{align*}
(26') & \text{Tamen xiwang [Daxiong pa Ji-an haishi pa Yijing]?} \\
& \text{They hope Daxiong fear Ji-an or fear Yijing} \\
& \text{[QTYPE DJ]}
\end{align*}
\]

\[
\begin{align*}
(27') & \text{Tameut xiwang [Daxiong pa-bu-pa Ji-an]?} \\
& \text{They hope Daxiong fear-not-fear Ji-an} \\
& \text{[QTYPE A-NOT-A]}
\end{align*}
\]

\[
\begin{align*}
(28') & \text{Shei xiwang [Daxiong pa Ji-an] ma?}
\end{align*}
\]

---

\(^{13}\) The use of the feature SUBCAT is an important mechanism in GPSG, whereby the relevant subclasses of a pre-terminal symbol can be matched with the ID rules that introduce it.

Who hope Daxiong fear Ji-an MA
[QTYPE WH] [QTYPE YN]

* (29') Shei xiwang [Daxiong pa Ji-an haishi pa Yijing]?
Who hope Daxiong fear Ji-an or fear Yijing
[QTYPE WH] [QTYPE DJ]

(30') Shei xiwang [Daxiong pa-bu-pa Ji-an]?
Who hope Daxiong fear-not-fear Ji-an
[QTYPE WH] [QTYPE A-NOT-A]

According to our analyses, (22') is interpreted as a statement because there is no interrogative information encoded in this sentence. The contrasting pair (23') and (24') show that the interrogative sentential clitic ma can only attach to a matrix sentence instead of an embedded sentence. This phenomenon has been discussed and accounted for in Shiu (1989: 33-41). With the GPSG analyses proposed in Shiu (1989), ma will always function to form a direct question, and the specification [QTYPE YN] will be always interpreted at the level of the matrix sentence. (25') and (26') show that although the [QTYPE WH] and [QTYPE DJ] specifications are introduced in the embedded sentences, they will percolate up to the matrix sentences by FFP, and cause the sentences to be entirely interpreted as direct questions. However, it is shown in (27') that [QTYPE A-NOT-A] cannot appear in the complement of xiwang. This fact can be nicely captured because xiwang is introduced by ID rule (44)a, in which the specification (–QTYPE A-NOT-A) is explicitly stipulated and, thus, complements containing CQTYPE A-NOT-A will be ruled out because of feature clash. (28') shows that if the matrix sentence has encoded one kind of interrogative message, the attachment of ma will cause unification of incompatible information and, thus, (28') is ungrammatical. Finally, in (29')-(30'), both the matrix sentences and embedded sentences bear some kind of interrogative information. In these cases, except for CQTYPE A-NOT-A, other interrogative specifications encoded in embedded sentences will percolate up to matrix sentences and merge with the ones encoded in matrix sentences. Since a feature can have only one value, the ungrammaticality of (29')-(30') will also be nicely accounted for.

Next, consider the verb taolun. We assume this verb is listed in lexicon as (46):

(46) <taolun, [N-], [V+], [SUBCAT 12], […] DISCUSS>

Let us reconsider the following sentences:

*(31') Tamen (zai) taolun (Daxiong pa Ji-an).

---

15 The GPSG analyses of ma proposed in Shiu (1989) are summarized below:

(i) lexicon
   <ma, [[CLIT MA], [+LAST], [QTYPE YN~, ...]])

(ii) ID rule
   S' → S, [CLIT α]*

(iii) LP statement
   x < [+LAST]
They be-Ving discuss Daxiong fear Ji-an
*They (are) discuss (ing) that Daxiong is afraid of Ji-an.

*(32') Tamen (zai) taolun [Daxiong pa Ji-an] ma?
They be-Ving discuss Daxiong fear Ji-an MA
[QTYPE YN]

(33') Tamen (zai) taolun [Daxiong pa shei].
They be-Ving discuss Daxiong fear who
[QTYPE WH]

(34') Tameut (zai) taolun [Daxiong pa Ji-an haishi pa Yijing].
They be-Ving discuss Daxiong fear Ji-an or fear Yijing
[QTYPE DJ]

(35') Tamen (zai) taolun [Daxiong pa-bu-pa Ji-an].
Who be-Ving discuss Daxiong fear-not-fear Ji-an
[QTYPE A-NOT-A]

(36') Shei (zai) taolun [Daxiong pa Ji-an haishi Pa Yijing]?
Who be-Ving discuss Daxiong fear Ji-an or fear Yijing
[QTYPE WH] [QTYPE DJ]

(37') Shei (zai) taolun [Daxiong pa-bu-pa Ji-an]?
Who be-Ving discuss Daxiong fear-not-fear Ji-an
[QTYPE WH] [QTYPE A-NOT-A]

The fact that taolun obligatorily takes a question as its complement can be determined by the 'SUBCAT feature of taolun and the ID rule in (44)b. As indicated earlier, the percolation of FOOT features in GPSG is manipulated by the FFP. Notice, however, that the FFP governs only instantiated FOOT feature specifications\(^{16}\). Since the FOOT feature QTYPE in ID rule (44)b is inherited rather than instantiated, its behavior is ~Pt regulated by the FFP. As a consequence, none of the QTYPE specifications encoded in embedded sentences will be passed up to matrix sentences, but rather be terminated within the embedded sentences. Thus, (33')-(35') are interpreted as indirect questions instead of direct questions. Further, (36')-(37') are not counterexamples to the proposals in the previous section because no interrogative information will flow up from the embedded sentences and incompatible specifications do not co-occur in any categories in matrix sentences.

Lastly, let's turn to the verb zhidao. Its lexicon is shown in (47).

(47) <zhidao, [N-], [V+], [SUBCAT 13], …) KNOW'>
We need to account for the following sentences with zhidao:

(38') Tamen jradu [Daxiong pa Ji-an].

\(^{16}\) Readers are referred to (10) for the definition of the FFP.
They know Daxiong fear Ji-an
'They know that Daxiong is afraid of Ji-an.'

(39') Tamert zhidao [Daxiong Pa shei].
They know Daxiong fear who

[QTYPE WH]

(40') Tamen zhidao [Daxiong pa Ji-an haishi pa Yijing].
They know Daxiong fear Ji-an or fear Yijing

[QTYPE DJ]

(41') Tamen zhidao [Daxiong pa-bu-pa Ji-an].
They know Daxiong fear-not-fear Ji-an

[QTYPE A-NOT-A3]

(42') Shei zhidao [Daxiong pa Ji-an haishi pa Yijing]?
Who know Daxiong fear Ji-an or fear Yijing

[QTYPE WH] [QTYPE DJ]

(43') Shei zhidao [Daxiong pa-bu-pa Ji-an]?
Who know Daxiong fear-not-fear Ji-an

[QTYPE WH] [QTYPE A-NOT-A]

The verb zhidao can take either a statement or an indirect question as its complement. Thus, we introduce it by (44)c, in which an optional QTYPE feature is specified. When zhidao takes a statement as its complement, the feature QTYPE is absent, but when it takes a question as its complement, the feature QTYPE is present. Thus, the grammaticality of (38)-(43) is accounted for in the way we just discussed with taolun.

Generally speaking, all Mandarin verbs can be divided into these three classes; therefore, the scope of percolation of Mandarin interrogative information is successfully accounted for in GPSG.

4.3 An LFG analysis

Recall the LFG treatment of interrogative markers in a previous section. We repeat the lexicon of these interrogative elements in (48):

(48) Lexicon

<table>
<thead>
<tr>
<th>shei</th>
<th>N</th>
<th>((Body Bottom ↑ ) QTYPE)=WH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(↑ PRED)=‘PRO’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(↑ HUMAN)= +</td>
</tr>
<tr>
<td>haishi</td>
<td>CONJ</td>
<td>((Body Bottom ↑ ) QTYPE)=DJ</td>
</tr>
<tr>
<td>pa-bu-pa</td>
<td>V</td>
<td>(↑ PRED)=‘FEAR&lt;(↑ SUBJ)(↑ OBJ)&gt;’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(↑ QTYPE)= A-NOT-A</td>
</tr>
<tr>
<td>ma</td>
<td>CLIT</td>
<td>(↑ LAST)= +</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(QTYPE)= YN</td>
</tr>
</tbody>
</table>
Notice that both shei and haishi lexically encode an equation with the prefix (body bottom). This equation indicates a functional uncertainty device which has recently been developed in LFG. The mechanism of functional uncertainty, as explicated in Kaplan and Zaenen (in press), was originally proposed to account for long-distance dependencies in natural languages, such as topicalization and English WH questions. The basic idea of this mechanism is that long-distance dependencies are, in fact, functionally conditioned, and this kind of relation should be captured by a direct link between functions rather than through the mediation of local dependencies.

The general rule of functional dependencies is formally expressed in Kaplan and Zaenen (in press), as shown in (70):

\[(49) S'-- \Omega \sum (\uparrow DF)\updownarrow = \updownarrow (\uparrow DF) = (\uparrow body bottom)\]

[where \(\Omega\) is a maximal phrasal category, \(\sum\) is some sentential category, \(DF\) is taken from the set of discourse functions (TOPIC, FOCUS, etc.), and body must be a regular expression].

The equation \((t DF)=(t body bottom)\) in (49) is a functional uncertainty path in which any language can impose its own specific conditions on the functions of the body and the bottom only if the body is a regular expression.

This approach to long-distance dependencies is well-supported by the study of Icelandic, English, and Japanese data. Huang et al. (1989), based on Mandarin topicalization and relative clauses, also suggests that functional uncertainty can provide an elegant solution to long-distance dependencies in Mandarin. In this paper, we use a reverse kind of functional uncertainty in resolving the percolation of interrogative information.

Mandarin interrogatives, in fact, do not involve overt long-distance dependencies. Unlike English WH questions, no gap-filler pairs can be found in any type of Mandarin question. However, as pointed out earlier, in some cases the existence of an interrogative element will turn the whole sentence into a direct question, regardless of how deeply embedded the bearer of interrogation is. Thus, some bearers of interrogation should be able to link to an f-structure many layers up and, theoretically, there is no limit to the distance of such linking. In LFG, functional uncertainty is the mechanism to capture this kind of unbounded relation. Notice, however, that there are two basic differences between the ordinary long-distance dependencies, such as topicalization, and the dependencies discussed in this section. First, as we have pointed out, Mandarin questions do not involve the so-called gap-filler relations; thus, the functional uncertainty equations for them are not to specify the associations between the gap functions and the filler functions, but to ensure the interrogative feature QTYPE is interpreted at the right places in the f-structure. Second, Mandarin questions are characterized by the existence of bearers of interrogation, but these interrogative elements do not occupy a specific position at surface structure, such as the sentence initial, clause-external position for topic; therefore, it is not appropriate to encode the functional uncertainty equations at c-structure rules such as (49). On the contrary, intuitively, the functional uncertainty
equations for Mandarin questions should be encoded in the lexicon of interrogative markers. Since the interrogative sentential clitic ma never occurs in embedded sentences, no functional uncertainty path should be imposed on it. As for the A-NOT-A construction, since it is always attached to a matrix sentence, there is no higher sentence where its interrogative information can percolate up to, so no functional uncertainty path on this construction is necessary. However, WH questions and disjunctive questions are not interpreted entirely locally. For example, consider the following sentences:

(50) Shiau-mei jiuede [tamen xiwang [Daxiong pa shei]]?
    Shiau-mei feel    they  hope   Daxiong fear who
    'Who does Shiau-mei think they want Daxiong to be afraid of?'
(51) Shiau-mei jiuede [tamen xiwang [Daxiong pa Ji-an haishi pa Yijing]]?
    Shiau-mei feel    they  hope Daxiong fear Ji-an or    fear Yijing
    'Does Shiau-mei think they want Daxiong to be afraid of Ji-an or is afraid of Yijing?'

Though the WH word shei and the disjunctive conjunction haishi are encoded in embedded sentences, they turn the whole matrix sentences into direct questions. This phenomenon prompts us to adopt the inside-out version of the functional uncertainty equation (Halvorsen and Kaplan to appear, and Dalrymple et al. in preparation) which is encoded in the lexicon of WH words and haishi, and can characterize the unbounded upward association between interrogative specifications. The general form of such equations is given in (52), where bottom is a grammatical function:

(52)((body bottom ŵ) \(\text{QTYPE}\))=DJ or WH

The observation is that although the category and the in-clause argument relation of a WH-question or a disjoint question is locally encoded by the interrogative marker (WH-word or A-not-A), two pieces of information must be 'percolated up' to an appropriate level. They are because the sentence is interrogative and because the focus of interrogation is indicated by the marker. Our claim is that both pieces of information can be encoded with the feature QTYPE. The presence of the attribute indicates interrogation and its value specifies the type of information sought by the question.

Strictly speaking, the linking of the QTYPE attribute to an appropriate f-structure level is not a syntactic operation per se, it can best be regarded as a step in semantic interpretation. In other words, the lexically encoded attribute plays a crucial role in, semantically interpreting the sentence as a question and in locating the interrogative information, but it has no place in determining either the predicate-argument structure of the sentence or the grammatical relation of the constituent. Employing the mechanism of inside-out functional certainty is thus well-motivated. Halvorsen and Kaplan (to appear) first introduce the idea to account for the scopes of quantifier phrases, and Dalrymple et al. (in preparation) extends the application to interpretative constraints of anaphora. Both are clear cases of semantic interpretation.

The inside-out functional uncertainty equation given as part of the lexicon in (11) and (48), and repeated here as (52) is spelled out as (53)a and (53)b.

(53) a. ((body COMP/XCOMP ŵ) \(\text{QTYPE}\))=DJ

An apparent exception concerns a particular set of verbs, such as 'tsai 'guess', and shiang 'think', etc. Tang (1981, 1983) calls them "the semantically bleached verbs". These verbs cannot form A--to-T-A constructions, but if their complement sentences contain A-NOT-A constructions, the whole sentence are interpreted as direct questions. However, this type of verb exhibits several other syntactic idiosyncrasies, such as non-co-occurrence with aspect markers, inability to construct condensed answers by itself, etc. Since properties of this kind of verb are not clear to us at this moment, we do not analyze them in this paper.
Recall that up and down arrows (↑ and ↓) are meta variables standing for f-structures in LFG. The up arrows (↑) in the uncertainty equations above stand for the f-structure where the interrogative information is physically represented, and the QTYPE attribute will be the outside-in path as termed in Dalrymple et al. (in preparation). Body, like in outside-in uncertainty (Kaplan and Zaenen in press, and Huang et al. 1989), represents the iterating part of the path. Discussion sketched in this section and in more details in Huang and Shiu (in preparation) will show how the body will be constrained by lexically encoded conditions, such as (55)-(57). The additional specification introduced in (53) involves restricting the set of bottom for each type of question. For disjoint questions, which semantically require propositions as its focus, the minimal f-structure containing the interrogative information must be a COMP or XCOMP. For WH-questions, the minimal f-structure is the one represented by the WH-word. Explications and arguments for this account will be taken up in Huang and Shiu (in preparation).

Using this approach of Mandarin interrogative information, the WH question in (50) and the disjunctive question in (51) will have correct c-structure and f-structure pairs as shown in (54) and (55), respectively.

We could follow Dalrymple et al. (in preparation) and mnemonically mark the up arrow ↑ with a subscript, such as their Œ for the f-structure where an anaphor appears. This possibility will be taken up in Huang and Shiu (in preparation).
Shiau-mei jiuede tamen xiwang Daxiong pa shei

b. f-structure
(54)(for (50))

a. c-structure

```
S'
   |
   ↑=↓
S

(↑SUBJ)= ↓ ↑=↓
NP  VP

↑=↓  (↑COMP)= ↓
(↑COMP LAST)= -

V

S'
   |
   ↑=↓
S

(↑SUBJ)= ↓ ↑=↓
NP  VP

↑=↓  (↑COMP)= ↓
(↑COMP LAST)= -

V

S

(↑SUBJ)= ↓ ↑=↓
NP  VP

↑=↓  (↑OBJ)= ↓
(↑OBJ)= ↓

Shiau-mei
jiuede
```
However, the LFG analysis of Mandarin interrogative information above might appear to still be too general. As mentioned earlier, Mandarin verbs may impose their specific requirements on the sentence types of their complement sentences. Thus, the unbounded linking we proposed in (52) should be subject to the conditions encoded on verbs. Based on the same data as presented in section 4.1, we assume the verbs xiwang, taolun, and zhidao encode different kinds of constraints as shown below:

(55) xiwang-- ([ ^COMP QTYPE])
(56) taolun ([ ^COMP QTYPE])
(57) zhidao ([ ^COMP QTYPE])

(55) states that the feature QTYPE cannot be specified in the complement function of the verb xiwang. Thus, the interrogative specifications encoded in embedded sentences must be linked to higher f-structures. On the other hand, the verb taolun encodes an existential constraint which will ensure the presence of the feature QTYPE at the function of its complement sentence. Thus, taolun must take a question as its complement, and this question is an indirect question because the feature QTYPE is only interpreted at the embedded level. As for the verb zhidao, it can take either a
statement or an indirect question as a complement. Hence, an optional constraint is imposed on it.

In conclusion, we have successfully shown that the scope of interrogative information can also be adequately managed in LFG.

4.4 A comparison with the generalization in C.-T. J. Huang (1982a)

Despite taking rather dissimilar approaches, C.-T.J. Huang's (1982a) and subsequent studies of Mandarin WH-questions, cleft sentences, and A-NOT-A questions arrive at conclusions rather similar to ours. Adopting the transformational theory of GB, C.-T. J. Huang (1982a) argues that their scope phenomena can be adequately accounted for if one assumes that there are abstract movements in Logic Form (LF) and regards Mandarin WH-words, shr-Focus, and A-NOT-A elements as LF quantifiers. The arguments in C.-T.J. Huang (1982a) have been carefully discussed in Tang (1984) and C.-R. Huang (1987: 156-166). Here, we just briefly mention a discrepancy in our accounts and a major difference in the implications of our approaches.

Consider sentence (58):

(58) Jangshan zhidao shei mai-le shu
 Jangshan know who bought book

(a) 'Who does Jangshan know bought books?'
(b) 'Jangshan knows who bought books.'

C.-T. J. Huang (1982a) claims that (58) has two possible readings, as indicated in (a) and (b). But, as pointed out in Tang (1984) and C.-R. Huang (1987), most native speakers only accept reading (b), that is, they interpret (58) only as an indirect question. Our analyses are in accord with the latter judgement. On the other hand, the grammatical judgement C.-T.J. Huang (1982a) based on forced him to propose some ad hoc stipulations, such as the arbitrary distinction between objectual and non-objectual WH-words, and the complicated conditions on the LF rule of Absorption. In contrast, the unification-based analyses proposed in this paper may provide a more satisfactory and straightforward account for Mandarin questions.

In terms of theoretical implications, C.-T. J. Huang's (1982a) abstract LF movement account, like ours, is an effort to differentiate the (semantic) interpretation procedure of questions on Mandarin form other syntactic relations which involve non-canonical structural positions (i.e., permutations in transformational terms). In his approach, all grammatical relations are taken to be structural and transformational. Semantic interpretation employ the same tree structure and movement mechanisms, with the crucial difference in that the movement has no effect on the actual surface strings and the movements take place at a separate level of representation. Thus, movement at LF is proposed not only for WH-questions but for other scoping relations such as cleft sentences. One obvious drawback of the structural approach is that the resulted LF tree still has to be semantically interpreted and it is yet to be explicated how the interpretation can be done methodologically. On the other hand, the unification-based accounts in either GPSG or LFG proposed in this paper make no pretense that semantic interpretations are structural in nature. The feature percolation account of GPSG and the functional uncertainty account of LFG are both part of the attested semantic interpretation procedure of the theories, as formal interpretation rules of

21 It is argued in Huang (1982a) that the non-objectual WH-words, i.e., weishenme 'why' and tzeme 'how', are subject to Wh-island constraint, while objectual WH-words, i.e. other WH-words, are not.
features or attributes in f-structures have both been explicitly articulated (Gazdar et al. 1985 and Halvorsen 1982 respectively). Hence we are dealing with three potential types of theories for semantic interpretation: a theory where in situ question elements are interpreted as such, a theory where they undergo abstract movement before being interpreted, and a theory where they are interpreted by a procedure which involves abstract movements. The latter two differ in how the abstract movements are treated. The three theories may not make substantially different predictions with regard to the grammaticality of the sentences. However, assuming that they all make identical predictions, invoking Ockham's razor would exclude movements at an abstract level.

5. CONCLUSION

The paper investigates the interrogative information of Mandarin questions. It suggests that the compatibility and the scope of percolation of different kinds of interrogative information can be adequately and straightforwardly accounted for in GPSG and LFG. The GPSG analysis relies on the Foot Feature Principle (FFP) and the LFG analysis on functional uncertainty. However, from the comparative study we have presented in this paper, readers may have noticed that the analyses in GPSG and LFG are quite similar. One important reason for their similarity is that they are both unification-based formalisms. They agree with each other in taking feature-value pairs as their basic linguistic objects and in adopting unification as their basic operation. Owing to their similarity, we are able to extract and compare their main concepts. Further, it is also easier to adopt ideas from the other theories to solve one's own problems. These merits of unification-based grammar formalisms have led many researchers to adopt this approach in their theoretical models as well as in their computational implementations. Owing to the brevity of this paper, we simply provide a preliminary unification-based study for Mandarin questions, but promising results on this topic can be expected along this line of research.

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