1. Introduction
It is well known that English sentences such as (1-2) show garden path effects. Scanning from left to right, the sentence is structurally ambiguous up to a certain point. While more than one representation can be assigned to the sentence, the language processor favors only one of these possible representations, which ultimately turns out to be incompatible with the rest of the sentence.1

(1) #The horse raced past the barn fell.
(2) #Without her contributions failed to appear.

For example, in parsing (1) from left to right, the processor favors a main clause analysis which will run into problems when one reaches the second verb 'fell', since the clausal representation will not have a subject. Similarly, in parsing (2) from left to right, the processor will favor grouping 'contributions' with 'her' as object of the preposition 'without'. This representation will, however, be disrupted when one encounters the verb 'failed', as the sentence on that analysis will be left without a subject.

What kinds of sentences count as garden path sentences in Chinese? This is a question that has not received a satisfactory answer in the psycholinguistics literature. In the last two and a half decades, a number of syntactic studies have investigated the contexts that give rise to syntactic ambiguity in Chinese (Xu 1979, Huang 1985, Feng 1995). The seminal study of Xu (1979) has observed the ambiguity of structures such as (3-6), all of which involve the nominalizer 'de'.2 Each of these phrases can be

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1 I will use the symbol '#' to indicate that the sentence that follows will produce a garden path effect when processed. Other examples of garden path sentences similar to (1-2) are sentences such as (i-ii) below.

(i) #The boat floated down the river sank.
(ii) #Since she jogs a mile seems light work.

2 Xu (1979) used different symbols to represent the phrasal categories, but my representation of Xu's views is faithful to the content of his paper. Examples of (3-6) are given in (3') to (6') below. The sentence in (3') can be understood as either "love people's premier" or "premier who loves the people". The example in (4') can be interpreted as 'prepared food enough for two years' or 'prepared food for two years', corresponding to (4a) and (4b) respectively. Sentence (5') can be read as "great writings of Stalin" or "writings of the great Stalin", corresponding to (5a) and (5b) respectively. The two readings of (6') are "toward her boundless affections" and "boundless affections toward her".

(3') Rea renmin de zongli
  Love people nom premier

(4') Zhubei le liannian de shiwu
  Prepare asp two-year nom food

(5') Weida de Sidalin de zhuzuo
  Great nom Stalin nom writing

(6') Dui ta de wuxian shenqing
  Toward her nom boundless affection
given the pair of structural groupings indicated in the corresponding (a) and (b) items.

(3) V N de N
(3a) V [N de N]
(3b) [V N] de N
(4) V Num CL de N
(4a) V [Num CL de N]
(4b) [V Num CL] de N
(5) Adj N de N
(5a) Adj [N de N]
(5b) [Adj N] de N
(6) P N de N
(6a) [P [N de N]]
(6b) [P N] de N

The insightful study of Huang (1985) has identified a wide range of other syntactically ambiguous contexts, including those given in (7-9), as well as instances of ambiguity due to scope of adverbial modification and focus, and thematic role assignment. The cause of syntactic ambiguity has been analyzed from a typological perspective by Liu (1999), who attributes certain types of syntactic ambiguity to a lack of cross-category harmony in word order.

(7) V V/Adj de N
(7a) V [V/Adj de N]
(7b) [V V/Adj] de N
(8) yi CL neg V de N
(8a) [yi CL neg V] de N
(8b) yi CL [neg V de N]
(9) V N1 N2 VP
(9a) V N1 [N2 VP]
(9b) V [N1 N2 VP]

I am citing the results of Huang (1985) using a terminology that is not exactly the one he used, but I believe my representation of his analyses is essentially accurate. Illustrations of (7-9), taken from Huang (1985), are given below. In (7'), the second verbal element (verb or adjective) can combine with the first verb to form a verb-complement structure, or serve as modifier to the following noun. It could mean "like clean children" or "children who like to be clean". In (8'), the negator-verb sequence can combine with the numeral 'yi' ("one") and the fuzzy classifier 'dian' ("bit") to signify universal quantification, or it can serve as a relative clause modifying the head noun. The sentence could be understood as "medicine that is not a bit useful" or "a bit of medicine that is of no use". The type of ambiguity exemplified by (9') stems from the possibility of null arguments in the language. The second post-verbal noun phrase in the example can be taken as an object of the matrix verb or the subject of the embedded clause. Thus the sentence could mean either "He asked me what time to leave" or "He asked (someone) at what time I will leave".

(7') Xihuan ganjing de xiaohai
Like   clean nom child

(8') Yi dian meiyou yong de  yao
One bit not-have use nom medicine

(9') Ta wen wo shenme shihou zou
He ask me/I what  time  leave

An instructive example given in Liu (1999) is the ambiguity of prepositional phrases such as that in (i), which can be understood as "at the primary schools of poverty counties" or "primary schools that are at the poverty counties". The two readings can be expressed unambiguously if one uses post-positions rather than prepositions, as in (ii) and (iii). This illustrates the incongruity resulting from having head-initial structures (i.e. prepositional phrases) in a largely head-final language.

(i) Zai pinkun xian de xiaoxue
At poverty county nom primary-school

(ii) Pinkun xian de xiaoxue li
Poverty county nom primary-school-in

(iii) Pinkun xian li de xiaoxue
Poverty county-in nom primary-school
While psycholinguists have explored how lexical ambiguity is resolved in the processing of Chinese sentences, in light of the high degree of homophony in the language (Ahrens 2002, Li et al 2002), relatively little work has been done on syntactic processing in Chinese. In an early theoretical study on processing load, Wu (1989) argues that the processing of Chinese complex sentences lends support to the 'Two-Tree Hypothesis', which states that the human parser can hold at most two unconnected trees in processing a sentence. A number of recent empirical investigations have examined how relative clauses are processed in Chinese, with respect to whether differences can be found between subject-extracted relatives and object-extracted relatives (Hsiao and Gibson 2003, Lin, Fong and Bever 2005). In a pioneering event-related potential (ERP) study, Tien, Tzeng and Hung (2003) scrutinized the parsing of syntactically ambiguous structures akin to (7) as well as ambiguous sentences involving coordinate structure, addressing the issue of modularity of mind.

Despite the above studies of syntactic ambiguity in Chinese and the various investigations of sentence processing in Chinese, scholars have not arrived at a consensus on what should be considered as garden path sentences in the language, though interesting observations have been made by Gorrell (1991). The term 'garden path sentence' can be interpreted in two ways. As observed by Gorrell (1995:106), on one usage, it refers to sentences containing local ambiguity which involve conscious restructuring when processed. On the other hand, one may also use the term to refer to syntactically ambiguous sentences in which the reanalysis of structures may be conscious or unconscious. To elucidate the concept of 'garden path sentence', it would seem useful not to take it as being synonymous with 'syntactically ambiguous sentence'. While garden path sentences always involve syntactic ambiguity, not all cases of syntactic ambiguity lead to processing failure. Many syntactically ambiguous sentences do not create parsing difficulty in a given context, because multiple

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5 As discussed in Wu (1989: 36), a contrast can be found between the following sentences. While sentence (i) involves at most two unconnected clausal trees in the parsing process, (ii) will involve more than two unconnected trees when the parser analyzes the third verb 'tou' ("steal"). Hence, whereas (i) can be understood without difficulty, (ii) fails to be processed.

(i) Zhuazhu tou shu de xuesheng de jiaoshou zou le
catch steal book nom student nom professor leave asp
"The professor that caught the student that stole the books has left"
(ii) Wo renshi zhuazhu tou shu de xuesheng de jiaoshou
I know catch steal books nom student nom professor
"I know the professor that caught the student that stole the books"

6 Wu's idea is consonant with the more elaborate formulation of Stabler (1994), who proposes the hypothesis that the acceptability of a structure degrades quickly when more than one relation of any given type connects a (partial) constituent X (or any element of X) to any constituent external to X.

7 The syntactically ambiguous sentences used by Tien et al (2003) are illustrated by (i-iii) below. The verb 'zhaogu' ("look-after") can be processed as a complement to the verb 'wangji' ("forget") or combine with the following NP to function as a relative clause modifying a head noun, as in (i) and (ii), or as a VP containing a coordinate nominal, as in (iii).

(i) Minghui wangji zhaogu Jiawen de yisheng
   Minghui forget look-after Jiawen nom doctor
(ii) Minghui wangji zhaogu Jiawen de taoshu
    Minghui forget look-after Jiawen nom peach-tree
(iii) Minghui wangji zhaogu Jiawen he Junpei
    Minghui forget look-after Jiawen and Junpei

8 As cited in Pritchett (1992:149), Gorrell (1991) considers a sentence such as (i) as a Chinese garden path sentence. In this example, the second NP 'shu' ("book") can function as the object of the verb of the subordinate clause or as the subject of the main clause that follows. The sentence may produce a garden path effect if 'shu' ("book") is combined with the first verb, since on this analysis, the second verb 'diao' ("fall") will seemingly lack an overt subject. However, it should be noted that as Chinese is a pro-drop language, the sentence can be interpreted as "As soon as Zhangsan read the book, (he) fell", in which case one should not predict a garden path effect.

(i) Zhangsan yi du shu jiu diao le
   Zhangsan as-soon-as read book then fall asp

8 The study of Tien et al (2003) seems to use 'garden path' in the second sense indicated here.
interpretations of the sentence can be structurally represented without a need for syntactic re-analysis, as in the classic examples of 'Visiting relatives can be a nuisance' or 'The boy shot the man with the gun' (Pritchett 1992: 5). In this paper, a garden path sentence is therefore taken to be one whose processing results in conscious reanalysis and some degree of parsing difficulty. I will outline a number of locally ambiguity structures in Chinese which give rise to garden path effects. Secondly, two non-pragmatic approaches to garden path sentences will be compared to see the kinds of problems these approaches will face when applied to Chinese data. I will observe that certain structural ambiguities related to lexical compounding lead to strong garden path effects, which cannot be completely accounted for by principles of thematic role assignment.

2. Non-pragmatic approaches to garden path sentences

In the literature, there have been two non-pragmatic approaches to the analysis of garden path phenomena.9 One type of approach, represented by the work of Frazier and her colleagues (Frazier 1979, Frazier and Rayner 1982, Frazier, Clifton and Randall 1983, Frazier and Clifton 1996), attributes processing failure to certain syntactically-based parsing principles, such as the well-known principles of Minimal Attachment and Late Closure, given in (10) and (11).

(10) Minimal Attachment (Frazier 1979)

"Attach incoming material into the phrase marker being constructed using the fewest nodes consistent with the well-formedness rules of the language"

(11) Late Closure

"When possible, attach incoming material into the clause or phrase currently being parsed."

These processing principles have a syntactic character as they make crucial reference to nodes in a phrase marker. Frazier's model is a serial processing model, in that the parser will select the tree in accordance with principles such as Minimal Attachment and Late Closure, and will only maintain that tree in the memory store. Reanalysis will be carried out when processing breaks down.

Given the two possible tree representations after inputting the first three words of sentence (1), Minimal Attachment will predict that the main clause analysis (12a) will be adopted, since it consists of only six nodes, whereas the reduced relative analysis in (12b) entails at least eleven nodes. A similar analysis can be extended to the example in (2). After considering the first three words of sentence (2), one may have either a representation such as (13a) or one like (13b). In terms of the number of nodes, they are the same. The principle of Late Closure, however, favors the tree in (13a). Since the phrase being parsed at the third word is NP, 'contributions' should attach to that phrase instead of the following IP. Grouping the noun 'contributions' in the same NP as 'her' will involve less cost than grouping the word with the IP that follows.

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9 I am leaving aside accounts that view garden path effects such as those in (1) as accommodations of presuppositional failures, such as Crain and Steedman (1985) and Ni and Crain (1990).
An alternative approach to garden path phenomena, which crucially appeals to thematic roles, can be found in the works of Pritchett (1988) and Gibson (1991). Pritchett uses principles such as (14) and (15) to account for the same sentences.

(14) Theta Attachment (Pritchett 1988, 1992:12)

"The theta criterion attempts to apply at every point during processing given the maximal theta grid."

(15) Theta Reanalysis Constraint (Pritchett 1988, 1992:15)

"Syntactic reanalysis which reinterprets a theta-marked constituent as outside of its current theta domain is costly."

The theta domain of a theta-marked constituent is defined as follows: "α is in the γ-theta domain of β iff α receives the γ theta role from β or α is dominated by a constituent that receives the γ theta role from β."

Intuitively, one could see how Pritchett’s theory can apply to sentences (1) and (2). In 'The horse raced past the barn fell', the main clause analysis is favored because it satisfies the theta grid of 'raced' maximally. 'The horse' will then be in the theme-theta domain of 'raced'. But when the processor reaches the verb 'fell', reanalysis will entail...
taking 'the horse' out of the theme-theta domain of 'raced', and placing it into the theme-theta domain of 'fell'. This reanalysis will break down, as it violates the Theta Reanalysis Constraint. Similarly, in 'without her contributions failed to appear', 'contributions' will go with 'her', to satisfy the theta grid of the preposition 'without' maximally. Subsequently, reanalyzing 'contributions' as the subject of 'failed' will remove it from the theta domain of 'without', placing it in the theta domain of 'failed'. Pritchett's analysis resembles Frazier's in making crucial reference to syntactic trees. It also assumes a serial processing model, in that the processor just holds one tree in the memory store at a time, and reanalysis will be needed to consider another tree. However, Pritchett's approach differs from Frazier's in locating the cause of processing difficulty not in syntax per se, but in the maximal satisfaction of the predicate's theta grid, and also in the way theta role configurations constrain reanalysis.

Gibson (1991) presents a parallel processing account based on thematic roles as well as phrase structure. This model assumes that the parser considers all possible representations, and evaluates them with respect to certain principles. Each representation will be associated with a processing load weight. If the difference in processing load between two representations exceeds a certain threshold, only the less costly representation will be retained. As observed by various scholars (Frazier and Clifton 1996:5; Lewis 1998, Nakayama 1999), parallel parsing imposes unrealistic memory demands on the human parser, given that all analyses are held in parallel in the memory store. Further, parallel processing theories should not predict garden path effects at all since all analyses of sentences are entertained by the parser. Parallel models are thus on the surface incompatible with the disruptions in processing often observed at points of disambiguation in a sentence. Despite the disadvantages of parallel processing models, the model of Gibson (1991) has plausibility as it is a memory-limited parallel model (Lewis 1998), or in the terminology of Gorrell (1995:84), a ranked parallelism model. In this kind of model, representations that incur high processing cost will be pruned. The strength of Gibson's model lies in its empirical coverage and in its unified account of processing overload and garden path phenomena.

The principles used by Gibson (1991) include those given in (16-18).

16) The Property of Thematic Reception (Gibson 1991)
"Associate a load of x PLUs (processing load unit) to each confirmed constituent that is in a position that can receive a thematic role but whose theta assigner is not unambiguously identifiable in the structure in question."

17) The Property of Lexical Requirement
"Associate a load of x PLUs to each lexical requirement that is obligatory, but is satisfied by a constituent that contains no thematic elements in the structure in question."

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10 It should be noted that the later formulations of Gibson (1998, 2000) differ significantly from those of Gibson (1991) in assigning prominence to the role of discourse referents and pronouns in sentence processing, and in the metrics for calculating integration cost and memory cost. The later model, called the Syntactic Prediction Locality Theory or the Dependency Locality Theory, succeeds in accounting for processing differences between subject-extracted relative clauses vs. object-extracted relative clauses, as well as the greater complexity of embedding a relative clause in a sentential complement than embedding a sentential complement inside a relative clause. The present paper makes use of Gibson's earlier proposal, which is more transparent in how it can be applied to the analysis of garden path sentences.
In essence, the Property of Thematic Reception derives from the Theta Criterion of Chomsky (1981), which requires each argument to bear exactly one theta role, and each theta role to be assigned to exactly one argument. According to the Property of Thematic Reception, a processing cost will result if an NP is in a theta position and the theta role is not yet identified. The Property of Lexical Requirement derives from the Projection Principle. According to this property, a processing cost will be incurred if a verb assigns a theta role that is not yet discharged. To illustrate how these principles can be applied, consider the trees in (12a-b). At the word 'raced', the processing costs associated with the structure in (12a) will be zero. 'The horse' is in a theta position, and has been assigned a theta role. 'Raced' satisfies lexical requirement, since it can be intransitive, and its theta role has been discharged. On the other hand, the structure in (12b) will have two processing load units. The phrase 'the horse' has not been assigned a thematic role. Nor is the empty operator in C assigned a thematic role, since the chain linking it to a gap is not fully identified. This will incur two PLUs due to violation of Thematic Reception. Gibson argues that a difference of two PLUs (either due to Thematic Reception or Lexical Requirement) is sufficient to cause the parser to drop the more costly analysis, hence the garden path effect.

Sentence (2) can be analyzed along the lines of Gibson (1991) in a similar fashion. In the structure (13a), at the word 'contributions', the processing load cost will be zero, since the NP 'her contributions' is in a theta position, and has received a theta role. The lexical requirement of the preposition 'without' is also fulfilled, as its theta role has been assigned. On the other hand, the structure in (13b) will bear at least one PLU due to Thematic Reception. The phrase 'contributions' is in a theta position, but has not received a theta role. To account for the garden path effect of (2), one will need to invoke a third principle of Gibson's, namely the Property of Recency Preference.

(18) The Property of Recency Preference

“The load associated with the structure resulting from attachment involving a (thematic, arbitrary) H-node H on the stack= (number of more recent words that are associated with a matching (thematic, arbitrary) H node) *x_{RP} PLUs.”

To illustrate the recency principle with respect to sentences such as 'Bill thought John died yesterday', if ‘yesterday’ attaches to the VP node for ‘died’, then the load will be zero x_{RP} PLU, since there is no other more recent verb than ‘died’. On the other hand, if ‘yesterday’ attaches to the VP for ‘thought’, then the load will be 1 x_{RP} PLU, as there is one more recent word associated with a matching H-node, i.e. ‘died’. In the representation (13b) of sentence (2), given that ‘her’ and ‘contributions’ are of matching nodes, there will be one processing load due to recency preference. Taking into account the processing load unit due to Thematic Reception discussed above, we can see that the (13b) is more complex than (13a) by two PLUs. Hence the former representation will be abandoned, leading to garden path effects.

Gibson's analysis implies that if two trees differ in processing cost by less than two processing load units, then the local ambiguity will not cause parsing failure. This can be illustrated with the examples in (19-20). By the Property of Thematic Reception and the Property of Lexical Requirement, a load of two PLUs should be associated with the reduced relative clause analysis of (19) at the word 'found'. The NP 'the bird'
has not received a theta role. The empty operator in C of the relative clause CP is not linked to any gap position as yet; its theta role is therefore not identified. If one adopts a main clause analysis, the same principles will yield a processing cost of one PLU at the word 'found', according to the Property of Lexical Requirement. At this position, 'the bird' has been assigned a theta role. However, the verb 'found', which has at least two arguments, is yet to discharge its theme theta role. The processing costs of the two analyses of the sentence thus differ by only one PLU, and no garden path effect is experienced.

(19) The bird found in the room was dead.
(20) Bill knew John liked Mary.

With regard to (20), two structural analyses are available when the parser scans the NP 'John', which can be taken as the direct object of the main verb 'knew' or as the subject of the verb 'liked' in the embedded clause. On the former analysis, the processing cost should be zero at the word 'John', as the theta roles of the two NPs have been clarified, and the two arguments of the verb 'knew' have been satisfied. On the latter analysis, the lexical requirement of 'knew' is also satisfied, since the agent role has been assigned to 'Bill' and the theme role is borne by the clausal complement containing the NP 'John'. The only processing cost is incurred by the embedded subject 'John', which has not received a theta role from the embedded verb. The difference of processing cost between the two analyses is therefore one PLU, an amount that does not reach the threshold for processing breakdown.

3. Chinese garden path sentences
In the remainder of the paper, I will examine six types of local ambiguity in Chinese that will lead to garden path effects. The data are based on my own intuitions, as well as informal elicitations carried out with eight adult Chinese speakers. For each type of ambiguity, I will examine how a Frazier-type analysis based on parsing principles such as Minimal Attachment and Late Closure might differ from the approaches of Pritchett's or Gibson's, which are based on fulfillment of thematic requirements. As will be seen, the Chinese data pose problems for the latter type of analysis. The garden path sentences can be divided broadly into two types, those due to ambiguity in structural groupings, and those arising from lexical ambiguity.

3.1 Garden path effects due to structural ambiguity
The following three types of sentences give rise to garden path effects, due to ambiguity in structural groupings.

Type I ambiguity: object of PP adjunct vs. subject of main clause
Type I ambiguity is illustrated by sentences such as (21a) and (22a), in which a noun phrase can be interpreted either as part of the object of a preceding preposition, or as the subject of the following main clause. It should be clear that these ambiguous sentences are similar to the corresponding garden path sentences in English illustrated in (2), and the garden path effect can be explained in the same way. To illustrate, in (21a), the noun phrase ‘yundong’ (‘campaign’) can form a compound with the preceding word ‘huanbao’, meaning “environmental protection”, or it may function as the subject of the following predicate ‘shenhua’ (‘deepen’). Speakers will prefer the object-of-preposition reading to the subject-of-main-clause analysis, for the same reasons as those given for the English sentence (2) above.
As discussed in Section 2, the garden path effect of sentence (2) is attributed to Late Closure on Frazier's analysis. An analogous analysis can be extended to the Chinese example (21a). On the other hand, Pritchett relates the processing failure of (2) to the Theta Attachment and the Theta Reanalysis Constraint. When applied to (21a), Theta Attachment will favor the grouping of the NP 'yundong' ("campaign") as part of the object of the preposition 'weile' ("for"), so that the Theta Criterion can be satisfied maximally. If 'yundong' is reanalyzed as the subject of the main clause, it will need to be taken out of the theta domain of the preposition. This move is prohibited by the Theta Reanalysis Constraint, hence the garden path effect. On Gibson's analysis of (21a) for the object-of-preposition reading, the thematic role of 'weile' ("for") will have been discharged at the word 'yundong' ("campaign"), as the word 'huanbao yundong' ("environmental protection campaign") has received a thematic role. On the other hand, if one adopts the subject-of-main-clause analysis, the word 'yundong' will incur a cost of one processing load unit according to the Property of Thematic Reception. Further, there will be a processing load unit associated with recency effects, since 'huanbao' is a matching category preceding 'yundong', both being nouns. Thus, a garden path effect is predicted for (21a). The control sentences with no garden path effects are given in (21b) and (22b) respectively. It is clear that Chinese garden path sentences such as (21a) and (22a) do not distinguish the two kinds of approaches discussed in Section 2 above.

(21a) # Weile huanbao       yundong bixu shenhua
         for environment-protection campaign must deepen
        "#For the sake of the environmental protection campaign, must deepen"
        "For the sake of environmental protection, the campaign must deepen"
(21b) Weile huanbao         yundong bixu choukuan
For environment-protection campaign must fund-raise
        "For the sake of the environmental protection campaign, (we) must fundraise."
(22a) # Zai shoudu jichang yijing guanbi le
      At capital airport already closed asp
        "#At the capital airport, already closed"
        "At the capital, the airport is already closed"
(22b) Zai shoudu jichang yijing guanbi le paodao
      At capital airport already closed asp runway
        "At the capital airport, the runway has closed"

Type II ambiguity: verb of complement clause vs. verb of relative clause
The second type of structural ambiguity which results in a weak garden path effect involves the possibility of a verb being analyzed either as the verb of a complement clause or as the verb in a relative clause. Type II ambiguity is illustrated by (23-24).

(23a) # Wang jingli xihuan he  Faguo putaojiu de guyuan
      Wang manager like drink French wine nom employee
        "#Manager Wang likes to drink French wine's employees"
        "Manager Wang likes employees that drink French wine"
(23b) Wang jingli xihuan he  Faguo putaojiu de weidao
      Wang manager like drink French wine nom taste
        "Manager Wang likes to drink (for) the French wine's taste"
(24a) # Jingji chuanhu yisheng lai  jiu Mali de diannao  chengxu, Urgently page  doctor come rescue Mary nom computer program, shi hen zhongyao de be very important sfp
"#To urgently page the doctor to come to rescue Mary's computer program is very important"
"The computer program that urgently pages the doctor to come to rescue Mary is very important"
(24b) Jingji chuanhu yisheng lai  jiu Mali de  chusheng ying-er, Urgently page doctor come rescue Mary nom newborn infant, shi hen zhongyao de be very important sfp
"To urgently page the doctor to rescue Mary's newborn infant is very important"

Consider sentence (23a). One can assign two structures to it at the word 'he' ("drink"), as given in (25a-b). In (25a), the verb 'he' ("drink") is analyzed as the verb of the clausal complement to the matrix verb 'xihuan' ("like"). In (25b), on the other hand, the same verb 'he' is seen as the verb of the relative clause modifying the head noun 'guyuan' ("employee"). A Frazier-type analysis can account for the preference for the structure in (25a) over that in (25b), since the former contains seven nodes whereas the latter consists of ten. Minimal Attachment will explain the garden path effect.

(25)

On the other hand, Pritchett's analysis will encounter difficulty in differentiating the two representations in (25). This is because in both trees, Theta Attachment can be said to be satisfied. In (25a), the principle is observed as the theta roles of 'xihuan' ("like") have been assigned, the experiencer role to the subject of 'xihuan', and the theme role to the clausal complement containing the verb 'he' ("drink"). The principle is also observed in (25b), in which the theme theta role has been assigned to the object NP containing 'he' ("drink") inside its relative clause modifier. It is conceivable to revise the conditions for satisfying Theta Attachment so that configurations such as (25b) will not count as satisfying the principle, for example, by requiring the receiver of a theta role to be the head of a phrase, instead of other constituents such as modifiers or parts of modifiers. On this revised analysis in the spirit of Pritchett (1988), the parser will favor (25a). However, in such a situation, re-attaching 'he' ("drink"), originally attached as part of the clausal complement, as part of the
complex NP does not seem to require moving the verb out of the theta domain of 'xihuan' ('like'). In both trees, the verb 'he' ('drink') falls within the theta domain of the main verb 'xihuan' ('like'). Thus, the reanalysis should not be costly, contrary to fact.

Likewise, the approach of Gibson’s will run into problems. The processing cost associated with (25a) should be only one PLU. The lexical requirement of the higher verb 'xihuan' ('like') is satisfied, since the complement clause has thematic material in it already. However, the lexical requirement of the embedded verb 'he' ('drink') is not yet fulfilled, since the theme theta role has not been discharged. Therefore only one PLU is incurred. In the structure (25b), the processing cost should be the same, as one of the theta roles of 'he' ('drink') is not discharged. As the difference in processing cost between the two trees is less than two PLUs, garden path effects are not predicted, unless we assign some cost to the processing of gaps like the subject of 'he'. The empty category representing the subject of the relative clause has a theta role assigned by 'he' ('drink'), so thematic reception is not violated. The second type of Chinese garden path sentence reflects an inadequacy in the thematic-based approaches of Pritchett and Gibson.

Type III ambiguity: object of verb in preceding subordinate clause vs. subject of main clause

In the third type of structural ambiguity that leads to garden path effects, a noun phrase may be analyzed as the object of a preceding subordinate clause, or it may be regarded as the subject of the following main clause, as illustrated in (26). The configuration involves a sequence of 'NP₁, NP₂ V₁ ( ) NP₃ (adverb) V₂...' in which NP₁ is a topic NP, which can be linked to a gap immediately following the first verb (in the subordinate clause). Thus NP₃ may be analyzed as the direct object of the first verb, eliminating the potential trace of the topic NP, or it may be understood as the subject of the second verb in the main clause. The sentence in (27a) illustrates a variant configuration consisting of a sequence 'NP₁ V₀ NP₂ V₁ ( ) NP₃ (adverb) V₂...'. Here, NP₃ may be analyzed as the direct object of V₁ or the subject of V₂. In the former attachment, the empty category projected by V₁ will be obliterated; in the latter representation, it will be bound by NP₂, which is the object of V₀.

(26a) # Zhe jibaige gongren, jingli jueding jieping gongsi
    This several-hundred worker, manager decide fire company
gupiao jiu dadie le.
    stocks then fall asp.
    "#As for these several hundred workers, (once) the manager decided to fire
    company stocks, (something) fell"
    "As for these several hundred workers, (once) the manager decided to fire
    (them), the company stocks fell (in prices)"

(26b) Zhe jibaige gongren, jingli jueding jieping wushiming
    This several-hundred worker, manager decide fire fifty
    gongsi gupiao jiu dadie le.
    company stocks then fall asp.

(27a) Zhe jibaige        gongren, jingli  jueding jieping wushiming
gongsi gupiao jiu dadie le.
    company stocks then fall asp.
    "As for these several hundred workers, (once) the manager decided to fire
    company stocks, (something) fell"
    "As for these several hundred workers, (once) the manager decided to fire
    (them), the company stocks fell (in prices)"

11 In English, configurations such as (25b) are not encountered since relative clauses follow rather than precede the head noun, and typically the antecedent of the gap, i.e. the head noun, will appear before the gap.
12 The topic NP can be a base-generated topic or linked to a gap position in the remainder of the sentence. If NP₃ becomes the direct object of V₁, as in (26b), then the topic NP will be a base-generated one.
"As for these several hundred workers, (once) the manager decided to fire fifty (of them), the company stocks fell (in prices)".

(27a) #Women duo mai yixie shucai chi changwei
We more buy some vegetable eat intestines
cai hui juede shufu
then will feel comfortable
"(If) we buy some more vegetables to eat intestines, then (we) will feel comfortable"
"(If) we buy some more vegetables to eat, (our) intestines will feel comfortable."

(27b) Women duo mai yixie shucai chi shuiguo
We more buy some vegetable eat fruit
changwei cai hui juede shufu intestines then will feel comfortable
"(If) we buy some more vegetables and eat fruits, then (our) intestines will feel comfortable"

The third type of structural ambiguity can be explained by either a syntactically-based or a thematic-based account. The structure in (28a) will be favored over that in (28b), according to the principle of Late Closure, since the noun phrase 'gongsi gupiao' ("company stocks") in (28a) will complete the object NP being analyzed. On the approach of Pritchett, Theta Attachment will favor the representation in (28a). Reanalysis of the NP 'gongsi gupiao' ("company stocks") as subject of the main predicate will entail moving it out of the theta domain of the verb complex 'jueding jieping' ("decide to fire"), in violation of the Theta Reanalysis Constraint. Thus a garden path effect is predicted. In the framework of Gibson's, one can see a difference of at least two PLUs between the two structures, a difference adequate for abandoning the more costly structure. In (28b), the NP 'gongsi gupiao' ("company stocks") should incur one PLU as it has not been assigned a theta role. There will also be one PLU due to recency preference. An additional processing load cost may be included if one considers the identification of the object trace of the first verb 'jueding jieping' ("decide-to-fire") with the topic of the sentence. Therefore, the parser will not consider (28b) at all, and processing difficulty results. Like the first type of garden path sentences, Type III does not distinguish between the two types of approaches being considered.

(28a)
3.2 Garden path effects due to lexical ambiguity
Three other types of local ambiguity which give rise to garden path effects hinge on the homophony and categorical ambiguity of words.

Type IV ambiguity: verb particle vs. verb of complement clause
The first type of such lexical ambiguity, which we call Type IV ambiguity, can be seen from sentences like (29-30). The partial tree representations of (29) after the word 'shang' are given in (31a-b). The morpheme 'shang' literally means "up". It could be a resultative complement, in which case 'ai shang' would mean "fall in love with". On the other hand, it could be a main verb meaning "experience". Now the intuition is that the preference is for us to group 'shang' with the preceding verb to form a verb compound, rather than combine it with the following constituent to form a complement clause to the matrix verb 'ai' ("love").

(29a) # Zhe jige nianqingren ai shang
This few young people love RESULT/experience
mingxing de dang
movie-star nom trick
"#These several young people fell in love with movie stars' tricks"
"These several young people loved to experience movie stars' tricks"

(29b) Zhe jige nianqingren ai shang
This few young people love RESULT
mingxing de rongmao
movie-star nom appearance
"These several young people fell in love with the movie stars' looks"

(30a) # Jinnian dakao, wuli laoshi xiang chu
This-year exam, physics teacher think not out/set
diaoan de timu, yi baozheng daduoshu ren jige
hard NOM questions, to guarantee most people pass
"#In this year's exam, the physics teachers could not think of hard questions to ensure most people will pass"
"In this year's exam, the physics teachers intend not to set hard questions, to guarantee most people will pass"

(30b) Jinnian dakao, wuli laoshi xiang bu chu lai
This-year exam, physics teacher think not out come
In this year's exam, the physics teacher could not think of hard questions, and therefore many people got an A.

Frazier's Minimal Attachment principle can predict the preference for (31a) over (31b), since fewer nodes are found in the former than in the latter. However, the two trees may not be distinguishable on either Pritchett's method of analysis or on Gibson's. Following Pritchett's approach, at the word 'shang', the verb compound 'ai-shang' ("fall in love with") in (31a) still has to discharge its theme theta role. In (31b) the theta roles of 'ai' ("love") have been satisfied; however, the object theta role of 'shang' ("experience") has not been assigned. Thus, neither (31a) nor (31b) have satisfied the Theta Attachment Principle. If one considers the representations at the word 'mingxing' ("movie star"), both trees will satisfy Theta Attachment. There will then be no need to carry out a reanalysis.

If one analyzes the two representations in terms of the thematic requirements of Gibson's method, the tree in (31a) should have only one processing unit cost at the point of 'shang', since the lexical requirement of 'ai shang' is not yet fulfilled, its object theta role not yet discharged. In (31b) the lexical requirement of the matrix verb 'ai' ("love") is fulfilled by the complement clause which already contains lexical material. The only lexical requirement that remains unfulfilled is the object theta role of the verb 'shang' ("experience"). The two trees should not differ in processing cost, contrary to fact. Even if we consider additional processing cost to be associated with recency effect in (31b), the difference between the two structures will not exceed two units. It would seem that one will have to assign cost to the identification of PRO in addition to postulating a recency effect to arrive at a threshold difference between the two structures. Thus, the preference for the verb compound analysis in Type IV structures remains a puzzle on either Pritchett's or Gibson's analysis.

**Type V ambiguity: verb particle vs. adjective in NP specifier**

The second type of garden path sentences involving lexical ambiguity, Type V ambiguity, is a variation of Type IV ambiguity, illustrated by (32). The morpheme 'hao' ("good") can be a resultantive complement or an adjective. The preference is to favor the reading in which the morpheme is part of a verb-resultative compound over the reading in which it serves as an adjective modifying a following noun phrase. That is, the interpretation "only if the sponsors thought of all ways to organize the students of the class well will the quality of the weekend party be guaranteed" is preferred to the reading "only if the sponsors thought of all ways to organize the students of the good class will the quality of the weekend party be guaranteed".
garden path effect is strengthened by the fact that the phrase 'ban de tongxue' ("class's students") is odd for phonological reasons.\(^{13}\) The tree representations are given in (33a-b).

Frazier's Minimal Attachment explains the preference for the resultative verb reading, since fewer nodes are involved in (33a) than in (33b). It would be difficult to predict the right result if one were to follow the approach of Pritchett. At the point of 'hao' ("RESULT"), the verb compound in (33a) still needs to assign its theme theta role. The verb 'zuzhi' ("organize") in (33b), however, has assigned its theme role to the NP containing the adjectival modifier 'hao' ("good"). This analysis will favor (33b) over (33a), which runs counter to fact. If one considers the two trees at the word 'ban' ("class"), both representations will observe Theta Attachment, as the theta roles of 'zuzhi-hao' ("organize-well") or 'zuzhi' ("organize") will have been assigned. No reanalysis will be needed in such a situation, and processing difficulty is not predicted.

The representations in (33) will likewise pose problems for Gibson's analysis, which will consider (33b) to be easier than (33a) at the point of 'hao', as the lexical requirement of 'zuzhi' ("organize") in (33b) is fulfilled, with the object of the verb already identified by the adjective modifier contained in the object NP. One may attribute a processing load unit to recency preference in (33b), as the adjective 'hao' can potentially combine with the verb 'zuzhi' ("organize"). However, the processing cost should not be so strong as to cause one to abandon the analysis of (33b).

(32a) # Zhubanren xiangjin banfa
Sponsor think-all ways
zuzhi hao ban de tongxue,
organize RESULT/good class nom student,
zhoumo wanhui zhiliang cai you baozheng
weekend party quality then have guarantee.
"Only if the sponsors thought of all ways to organize the students of the class well will the quality of the weekend party be guaranteed"
"Only if the sponsors thought of all ways to organize the students of the good class will the quality of the weekend party be guaranteed".

(32b) Zhubanren xiangjin banfa
Sponsor think-all ways
zuzhi hao gao nianji de tongxue,
organize-RESULT upper year nom student,
wanhui zhiliang cai you baozheng
party quality then have guarantee.
"Only if the sponsors thought of all ways to organize upper year students will the quality of the party be guaranteed"

\(^{13}\) The phrase ‘ban de tongxue’ would be odd because of the preference for nouns such as ‘ban’ ("class") to appear in disyllabic form, 'ban' being a bound form.
Type VI ambiguity: Locative particle vs. verb of main clause

The third type of lexical ambiguity that leads to garden effects, Type VI ambiguity, arises because of the possibility of some morphemes to act either as a functional morpheme (e.g. a locative particle or a conjunction) or as part of a main verb. This phenomenon is illustrated in sentences (34-35). In (34), the locative particle 'mian' ("face/side") can combine with 'xia' ("down/under") to form the localizer 'xiamian' meaning more or less "below". It may also combine with the following morpheme 'xiang' ("toward") to form a compound verb 'mian-xiang' ("face-toward"). The garden path effect shows that a preference for the localizer analysis. In (35), the morpheme 'qian' ("before/front") can serve as a conjunction, meaning "before". It may also combine with a verb like 'jin' ("forward") to form a verb compound 'qianjin' ("progress"). The processing facts favor the conjunction interpretation of 'qian'. The relevant trees are given in (36).

On the syntactic analysis of Frazier, Minimal Attachment will not differentiate the two trees in (36), as both contain eleven nodes at the point of 'xiang' ("face/toward"). Late closure will, however, favor (36a) over (36b), since it would be easier to incorporate 'mian' ("face/side") into the N node containing 'xia' ("below").
analyses of Pritchett and Gibson will nonetheless face problems, however. In the tree in (36a), both the subject NP 'women' ("we") and the prepositional object 'bieshu' ("villa") have been assigned theta roles, the former by the verb 'xiang' ("face/toward") and the latter by the preposition 'zai' ("at"). However, the verb 'xiang' ("face/toward") has not discharged its goal theta role. Thus, one processing unit cost due to lexical requirement should result. Structure (36b) should involve the same amount of processing cost, as in that structure, the subject NP receives a thematic role from 'mian-xiang' ("face-toward") being analyzed as the main verb, and the NP 'bieshu' ("villa") bears a theta role assigned by the preposition 'zai' ("at"). The main verb 'mianxiang' ("face-toward"), however, has not assigned its goal theta role. Even if one includes a PLU due to recency preference for (36b), the difference in processing cost between the two representations should not lead us to abandon one for the other.

(36)

\[
\begin{array}{c}
\text{NP} \\
\text{Women} \\
\text{"We"} \\
\text{PP} \\
\text{zai} \\
\text{bieshu} \\
\text{"below"} \\
\text{IP} \\
\text{NP} \\
\text{V} \\
\text{xiang} \\
\text{NP} \\
\text{VP} \\
\end{array}
\quad
\begin{array}{c}
\text{NP} \\
\text{Women} \\
\text{"We"} \\
\text{PP} \\
\text{zai} \\
\text{bieshu} \\
\text{"below"} \\
\text{IP} \\
\text{NP} \\
\text{V} \\
\text{mianxiang} \\
\text{NP} \\
\text{VP} \\
\end{array}
\]

The kinds of garden path sentences in Chinese that are due to lexical ambiguity, given as Type IV, V and VI above, all involve a morpheme that may be considered as part of a verb compound or as a separate word or part of another word. We have shown that the garden path effects of these structures can be accounted for by Minimal Attachment and Late Closure, but pose problems for principles that rely crucially on thematic attachment and lexical requirement, such as those of Pritchett (1988, 1992) and Gibson (1991). It is surprising that the thematic accounts are found to be inadequate, since they are considered to cover a wider range of empirical facts than the purely syntactically-based approach of Frazier (1979). For example, as noted by Gibson (1991), examples such as (19) and (20) above will pose problems for Frazier's theory, which will wrongly predict garden path effects for these sentences taking into account only the number of nodes in the trees concerned.

It should be pointed out that both Pritchett and Gibson have considered cases of processing effects due to lexical ambiguity, and have accounted for them in terms of their principles. Pritchett (1992: 123) regards the example in (37) as a garden path sentence, and attributes the processing effect to a revised version of the Theta Reanalysis Constraint.14 Gibson (1991) shows that the garden path characteristics of examples like (38) can be successfully explained by the principles of Thematic Reception and Lexical Requirement, as the tree representation for the modifier reading of 'Russian' will be less costly than the head-noun interpretation of 'Russian'.

14 The revised constraint is called 'On-Line Locality Constraint' (OLLCC), and is stated as follows (Pritchett 1992: 101): "The target position (if any) assumed by a constituent must be governed or dominated by the source position (if any), otherwise attachment is impossible for the automatic Human Sentence Processor."
by three processing load units.

(37) #The old train the young.\(^{15}\)
(38) #The Russian women loved died.

The Chinese examples of lexical ambiguity such as (29-31) seem to suggest that once a form is lexically specified as part of a compound, principles of lexical integrity will not allow it to be moved out of the compound to be reanalyzed as a constituent of another structure. In articulating a diagnostic model of garden path sentences which accounts for garden path effects in terms of the difficulty of diagnosing one's parsing error and repairing it, Fodor and Inoue (1998:111) have remarked that "lexical specifications are non-negotiable; revision attempts are stopped short by contrary lexical facts". These scholars account for the strong garden path effects of sentences like (39) by noting that revision will not be successful when clashes of lexical specification are involved. In (39), if one has decided on 'daughter' as the head noun of the first NP, its feature will be specified as \([-\text{masc}].\) This will conflict with the \([+\text{masc}]\) requirement of the reflexive 'himself'.

(39) #The daughter of the king's son admires himself.

The difficulty of reanalyzing an element that is incorporated as part of a verb compound may be another piece of evidence in support of the lexical factor in sentence reanalysis noted by Fodor and Inoue.\(^{16}\) Such kinds of lexical/syntactic ambiguity are highly visible in a language like Chinese, which has SVO order and productive verb compounding mechanisms.

4. Conclusions

In this discussion on garden path sentences, we have identified six types of garden path environments in Chinese. Three of these arise from structural ambiguity, while the remaining three are due to homonymy and categorial ambiguity. The Chinese data are used to test two different types of analyses of garden path phenomena in the literature, that of Frazier (1979), which is based on syntactic parsing principles, and those of Pritchett (1988, 1992) and Gibson (1991), which rely heavily on the idea that changing thematic attachments may exact a processing cost, or the conception that unfulfilled thematic requirements incur processing cost. We have shown that certain types of local ambiguity, in particular Types II, IV, V and VI, pose problems for the latter type of theory, but can be accounted for by means of Minimal Attachment and Late Closure. It should be noted that these sentences involve the attachment of a morpheme following another verb. In some cases, as in Type II ambiguity, the morpheme may be analyzed as the verb of a complement clause or that of a relative clause. In other cases, as in Type IV ambiguity, the morpheme at issue may be seen as a resultative complement in a verb compound or as the verb of a complement clause. These types of local ambiguity are found in Chinese because of the co-existence of an

\[^{15}\text{It should be noted that (37), unlike (38), will not be taken as a garden path sentence by Gibson (1991), since the alternative representations will not differ by two or more PLUs.}\]

\[^{16}\text{As noted by Yamashita, Stowe and Nakayama (1993) and Nakayama (1999), constant revision is necessary in the processing of Japanese sentences. When encountering an initial sequence of 'NP; NP; V' in Japanese, one will not be able to decide whether it is a main clause or a relative clause until one encounters the head noun. It would seem that constant revision would also be required for processing sequences such as 'NP; V; NP; V' or 'NP; V; V' in Chinese. With respect to the former sequence, the second NP could be object of the verb or an NP within a relative clause. As for the latter sequence, the second verb may be part of the clausal complement to the first verb, or part of a relative clause. As we have seen, the second verb may also form a compound with the first verb.}\]
SVO order, the positioning of relative clauses before the head noun, and productive verb compounding.

References


Huang, Guoying (1985) "Xiandai Hanyu de qi yi duanyu (Ambiguity phrases in Modern Chinese)," Yuyan Yanjiu (Language Research) No. 8: 69-89.


Lin, C., S. Fong and T. Bever (2005), "Constructing filler-gap dependencies in Chinese possessor relative clauses," Proceedings of PACLIC 19, the 19th


Tien, Yi-Min, O. Tzeng and D. Hung (2003) "Yuyan nengli yu biaoxian: naobo huodong xingtai xianshi Zhongwen jufa chuli de duanju celue (Competence versus performance: brain potentials reveal the effects of parsing strategy on syntactic processing of Chinese sentences)," ms. National Chung Cheng University, National Yang-Ming University and Academia Sinica, Taiwan, R.O.C.


Xu, Zhonghua (1979) "Hanyu shumian yuyan qiyi xianxiang juli (Cases of ambiguity phenomena in written Chinese)," Zhongguo Yiwun (Chinese Language), 1979, No. 5: 339-343.