

Sentence processing in Chinese — resolving garden-path ambiguities

Summary: Syntactic garden-path ambiguity is common in Mandarin Chinese.

This article looks at the main factors that contribute to garden-path processing in Chinese, with a focus on structural principles, lexical information and contextual cues.

Indexation terms: garden-path ambiguity; structure-based parsing models; constraints satisfaction parsing models; minimal attachment; late closure

Introduction

During the process of sentence comprehension, an incremental parser constantly faces choice points at which there is more than one option for the current parse to continue. If a particular parsing decision turns out to be the incorrect one based on later linguistic input, the parser has to backtrack and revise the initial analysis. Sentences that present local ambiguities that may potentially lead the parser to the wrong parse are called garden path sentences. Some classic examples of garden path sentences are given in (1) (examples taken from Townsend and Bever 2001)

(1). a. Main clause/reduced relative clause

The horse *raced* past the barn fell.

b. Object/sentential complement

John knew *the answer* was wrong.

c. Direct object of initial clause/subject of the second clause

While Mary was mending *the sock* fell off her lap.

d. Coordinated objects/coordinated sentences

Jacob kissed Miriam and *her sister* laughed.

In (1a), during the first parse, the verb *raced* is mostly likely to be analyzed as the matrix verb of the whole sentence, while, ultimately, the correct analysis is one in which it is a past participle that introduces a reduced relative clause. The area at which the parser is likely to be led down a “garden path” is italicized in each of the examples above.

Garden path sentences have generated a lively discussion in the last three decades. By observing how the parser fails or succeeds in resolving syntactic ambiguities in garden path sentences, we can gain insight into the parsing mechanisms that support online structure building. With regard to the architecture of such parsing mechanisms, the basic questions that different parsing models need to address are the following:

- At each choice point when there is potentially more than one syntactic parse, does the parser only pursue one particular syntactic analysis, or are multiple options being entertained at the same time? This distinction determines whether the parsing strategy is serial or parallel.

- What kind of information is available to the parser at the initial stage of processing? Does the parser rely on one primary source of information, such as syntactic information, or does information from all sources come into play at the same time, as early as possible?

The garden-path model (Frazier 1978; Frazier and Fodor 1978) falls within the category of serial parsing models on a serial-parallel continuum. Critically it holds that, at the very initial stage of parsing, the choice of a particular parse is determined solely by structural factors. Non-structural information, such as lexical preference, or referential information from the discourse, can only play a role at a later time during parsing (but see a revision of this for non-primary relations under the Construal principle, Frazier and Clifton 1996). Two main structural principles have been proposed to determine initial parsing preferences: minimal attachment and late closure (Frazier 1978). Minimal Attachment states that when attaching new input into the established structure, the parser should postulate only the simplest structure possible, i.e. the smallest number of new nodes; and Late Closure encourages the attachment of the new material onto the most recently postulated structure (Ferreira and Clifton 1986; Ferreira and Henderson 1991; Frazier and Rayner 1982). Both of these follow from the general economy principle that the parser prefers the simplest structure in order to reduce computational load (see Frazier 1987 for a review).

Other structural models, although different from the Garden-path model in important ways (Pritchett 1992; Crocker 1995; Abney 1989), mostly agree at the initial stage of parsing, structural principles help to establish one or more structural representations; and then at a later stage, non-structural principles join in to help select the final parse. In contrast to this view, constraint-satisfaction models do not assign any privileged status to structural representations. Sentence structures, rather than being built as an independent level of representation based on grammatical knowledge, actually emerge from the rich lexical information encoded in each lexical item. MacDonald, Pearlmutter and Seidenberg (1994) proposed that syntactic ambiguity resolution can be reduced to essentially the same mechanisms that account for lexical ambiguity resolution (also see Boland 1997; Boland, Tanenhaus, Garnsey and Carlson 1995; Trueswell, Tanenhaus and Kello 1993). At any given word, the parser would build a lexical representation that contains an extensive set of information, including the frequency of the lexical item, its argument structure, voice, animacy constraints, X-bar structure, phi-features, etc. Syntactic parses emerge through the massive interaction and parallel activation of all the lexical information. Multiple syntactic parses compete at the same time and the parse that has the strongest activation is chosen as the final winner. Discourse context also plays an important role for the constraint-based models. For instance, it has been experimentally demonstrated that referential contexts are particularly important when the parser decides whether modifications on a noun are

necessary (Altmann and Steedman 1988; Spivey et al. 2002; Sedivy et al. 1999; Tanenhaus et al. 1995).

When testing the strengths and weaknesses of different parsing models, a cross-linguistic investigation can provide important insight as to what should be the primitives in a parsing model and whether the proposed principles are universal across all languages or if they need to be conditioned by language-specific constraints. Sentence processing research on Mandarin Chinese is relatively sparse compared to other languages, but some pioneering work has revealed important findings, which I will turn to below.

The Basic garden-path effects in Mandarin Chinese

It is common to observe temporary syntactic ambiguities in Mandarin Chinese, due to its mixed-headedness word order and the lack of inflectional morphology that signals syntactic categories on lexical items. Lee (2006) hypothesized three types of garden-path effect in Mandarin that arise from structural ambiguity, and also three types from lexical ambiguity. One example from each category is given below (the starting point of the temporarily ambiguous region is italicized):

(2). a. Garden-path due to structural ambiguity:

verb of complement clause vs. verb of relative clause

王经理 喜欢 喝 葡萄酒 的 官员。

Wangjinli xihuan *he* putaojiu de guanyuan.

manager-Wang like *drink* wine DE employee

“Manager Wang likes employees that drink wine.”

b. Garden-path due to lexical ambiguity:

verb particle vs. verb of complement clause

这几个 年轻人 爱 上 明星 的 当。

zhejige nianqingren ai shang mingxing de dang

These young people love *resultative/fall* movie star DE trick

“These young people love (or are easy to) to fall into movie star’s traps.”

Experimentally, sentence processing in Chinese is still a largely unexplored area. Zhang, Zhang and Shu (2000) were among the first to experimentally demonstrate a robust garden effect in Chinese. The V-NP1-DE-NP2 structure is ambiguous between the following two structures:

(3). a. $[_{NP} [e_i V NP1 DE] NP2_i]$ Relative clause parse

b. $[_{VP} V [NP1 DE NP2]]$ Verb-Object parse

The parse in (3a) gives rise to a subject relative clause, in which DE marks the relativization. (3b) on the other hand, parses the same string into a VP, with a complex possessive noun phrase as the object of the verb (DE marks the possessive relation). Zhang, Zhang and Shu (2000) looked at the processing of the “balanced” V-NP1-DE-NP2 phrases; i.e., the stimuli were controlled such that the verb-object analysis and the relative clause analysis are equally likely.

These balanced phrases were embedded in a sentence context, such that the subsequent material following NP2 would disambiguate the phrase to either the verb-object or the relative clause analysis. For example, in (4a), “*quickly*” would confirm a relative clause analysis, whereas “*after*” in (4b) would confirm a verb-object analysis. Using a self-paced-reading paradigm, it was found that when the sentence is disambiguated towards a verb-object analysis, the disambiguating regions were read much more slowly than the control unambiguous conditions; on the other hand, when the sentence is disambiguated towards a relative clause analysis, there is no difference between the disambiguating regions and the corresponding unambiguous controls. Two points about this result are significant. First, the finding supports a serial model rather than a parallel one. If both structures had been entertained at the same time, since the preference for either is equal, one would have expected no “surprisal” effect at the disambiguating region no matter which direction the sentence is disambiguated towards. The fact that disambiguating towards a verb-object analysis poses problems for the parser suggests that this structure wasn’t postulated by the parser in the initial stage of parsing. Furthermore, the fact that it is the relative clause structure, rather than the verb-object structure, that was chosen as the initial analysis, supports the principle of Minimal Attachment, since at the choice point “xiaoming (肖明, N1 in the string)”, the relative clause structure is the simpler one (see 3).

(4)

- a. 撞倒 肖明 的 车子 飞速 行驶... (Relative clause)

zhuangdao xiaoming DE chezi feisu xingshi

hit xiaoming DE car quickly drive...

The car that hit xiaoming quickly drove away...

- b. 撞倒 肖明 的 车子 之后... (Verb-object)

zhuangdao Xiaoming DE chezi zhihou

hit Xiaoming DE car after

After hitting Xiaoming's car...

The effect of lexical bias

In another study, Zhang, Liu, Shu and Sun (2003) looked at whether lexical bias affects the initial stage of processing. In the examples below, the critical word 包装 (5a) or 交代 (5b) are lexically ambiguous between a noun or a verb meaning. Used as a noun, it will be analyzed as the direct object of the previous verb; this is also the simplest parse at this point, as it conforms to the Minimal Attachment principle; used as a verb, on the other hand, the critical words will introduce a relative clause, with the head noun at the very end of the sentence. Crucially, the lexical bias of the critical words was controlled so that half of them (such as 5a) have a noun bias, and the other half (such as 5b) have a verb bias. For both (5a) and (5b), the final correct parse of the critical words should be their verb meaning.

(5) a. noun biased critical words

... 他们 有权 撕开 包装 得 严严实实 的 盒子。

tamen youquan sikai *baozhuang* de yanyanshishi de hezi

they entitled open package tightly de box

“They have permission to open the boxes that are tightly packaged.”

b. verb biased critical words

... 村长 给了 冯莉 一个 交代 事件 发生 经过 的 机会。

cunzhang gei-le Fengli yige jiaodai shijian fasheng jinguo de jihui

village-head gave Fengli one describe event happen process DE chance

“The head of the village gave Fengli a chance to describe what happened.”

The RT results showed that for both conditions, regardless of whether the critical word had a verb or noun bias, the first disambiguating region in the ambiguous conditions was read significantly slower than their unambiguous controls, suggesting that the verb bias in (5b) didn't prevent participants to initially parse it as a noun and hence participants were led into a garden path. At the subsequent regions, however, although the noun biased condition (5a) is still read slower than its unambiguous control, the verb biased (5b) is not different from its control, suggesting the recovery from the garden path is affected by the lexical bias; i.e. in the verb-bias condition, it is easier for participants to shift from a verb-object analysis to a relative clause analysis. The overall result, then,

supports the hypothesis that lexical bias does not affect the initial stage of parsing, but it plays an important role in reanalysis.

Wu and Shu (2003) also studied the interaction between lexical bias and garden-path resolution. For example, a word such as “hua 花” could be used either as a noun “flower” or a verb “spend”. In the example below, the disambiguating information only comes after the ambiguous word, and the parser could potentially be garden-pathed.

(6) 她 又 开始 抱怨 儿子, 因为 花...

ta you kaishi baoyuan erzi, yinwei hua

she again start complain son, because *flower/spending*

“She started to complain about her son, because flower/spending...”

a. 不 好看。

bu haokan

not pretty

(flowers) are not pretty.

b. 了 很多 钱。

le henduo qian

perf. lots money

(he spent) lots of money.

In this example, the dominant meaning of the ambiguous word is the noun meaning, and the verb meaning is subordinate. Wu and Shu (2003) found that participants encountered difficulty (longer RT compared to unambiguous controls) at the disambiguating regions when the sentence is disambiguated towards the subordinate meaning (i.e. the verb meaning), suggesting that the parser initially adopted the noun meaning at the critical word. Since the noun meaning in this example is both the dominant meaning and also gives rise to the structure that conforms to the minimal attachment principle, this result, although consistent with the garden-path model, could not totally address the issue of whether lexical biases can alter the initial preference for simple structures. Future studies need to pit lexical bias against structural principles so that the lexically dominant meaning and the meaning that the minimal attachment principle supports compete with each other (as in (5b) above). Only under such circumstances can we find out whether lexical biases have an effect on early structural parsing.

The effect of context

Discourse context has been shown to play an important role in Chinese syntactic ambiguity resolution. Zhang et al. (2002) looked at the role of referential context in resolving the temporary ambiguity in A V1-N1-DE-N2 type of structure (see an example in (4)). They found that if the discourse context sets up two contrasting referents for N2, participants were more likely to analyze the phrase N1-DE-N2 as a relative clause, which in turn was the object of V1.

Moreover, they observed that the facilitation effect from the context kicks in even before the participants encountered the disambiguating regions, suggesting an anticipatory effect on parsing based on contextual information.

Ng and Fodor (2011) investigated the interaction between structural principles and the broad discourse context from a different angle. They noted that structural economy principles like minimal attachment could be sacrificed for interpretation purposes. In a sentence completion task, participants were given sentence fragments that contained only a verb. Given the pro-drop option in Chinese, the fragment could still be continued into a matrix clause, such that the reference of the sentence initial empty category is supplied by the discourse context. Ng and Fodor found that when no prior discourse antecedent was explicitly given, participants chose to continue the sentence with a more complex structure, i.e. they chose to treat the bare verb as the predicate embedded within a sentential subject, rather than to construct a simpler structure, i.e. treating the bare verb as the matrix verb of a pro-dropped sentence. But when a discourse referent is present for the same bare verb, participants continued with the matrix verb analysis.

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