

Predicting Processing Difficulty in Chinese Syntactic Ambiguity Resolution:
A Parallel Approach

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Revising a misanalysis of a syntactic ambiguity elicits greater processing difficulty in some cases than in others. What factors contribute to processing difficulty at disambiguation when the dispreferred structure is required? Both serial and parallel syntactic processing theories have been proposed, which differ in how the parser responds to syntactic ambiguity. We define a serial parser as one that is committed to a single structure at each word position in an ambiguous sentence, even if multiple structural alternatives are considered initially. On the other hand, a parallel parser maintains multiple alternative structures of an ambiguity across several words.

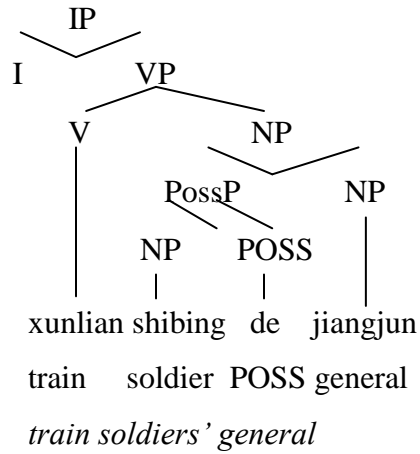
A serial parser has to reparse or repair the initial parse when the existing structure proves to be incompatible with the input string. The more recent repair accounts (e.g. Fodor & Inoue, 1994; Lewis, 1998) are cue-driven and suggest that repairing an incorrect parse is easy if the syntactic disambiguation effectively signals the local parsing error. In contrast, under a limited, ranked parallel account, such as that proposed by Gibson (1991), multiple structural analyses are ranked based on the preferences of the available constraints, and re-ranking occurs when the highly ranked structure is inconsistent with the disambiguating material. Gibson (1991) maintains that the strength of all possible analyses are computed and compared at each word position, with the one that receives most support ranked highest. It is worth noting that only a limited number of structures are retained during the ambiguous region due to memory constraints.

Unlike the serial models in which processing difficulty is determined by the efficacy of the disambiguating cue and the scope of structural repair, a limited, ranked parallel parser attributes processing difficulty to structural re-ranking. The critical factor that affects misanalysis difficulty is the relative activation strength of the candidate analyses. Like other constraint-satisfaction models, a limited, ranked parallel version would allow all sources of information to have an immediate and direct effect on the activation strength of the candidate analyses at a syntactic ambiguity. Crucially, the cost of promoting a dispreferred structure should escalate if the initially preferred analysis receives more support during the ambiguous region while the dispreferred alternative becomes less accessible due to lack of support.

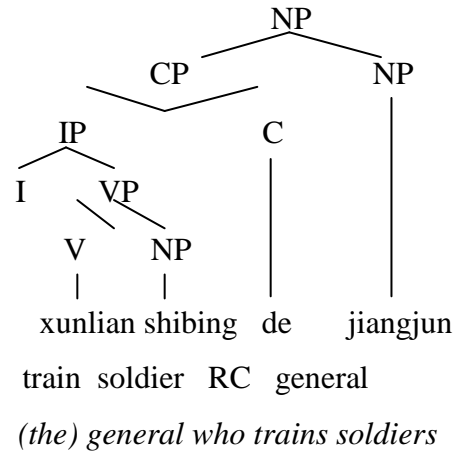
Two eye-tracking experiments were conducted to evaluate a limited, ranked parallel account in which multiple syntactic alternatives can be maintained for several words if each alternative receives support from relevant constraints (e.g. Gibson, 1991). We manipulated the strength of support for the complement clause (CC) analysis and the relative clause (RC) analysis of the Chinese ambiguous construction *Verb NP₁ de NP₂*, which was then disambiguated to the dispreferred CC interpretation at the following conjunction.

As shown in Figure 1, the ambiguity hinges upon the lexical ambiguity of the homograph *de*. For example, the first four words of (1a) could mean either *the general who trains soldiers* (RC) with *de* serving as a RC marker, or *to train the soldiers' general* (CC) with *de* being a genitive marker. Crucially, the RC was the preferred analysis, based on structural simplicity, semantic completeness, corpus statistics, and sentence completion data (Hsieh et al., 2009).

(1a) complement clause (CC)



(1b) relative clause (RC)



An example of the experimental materials is provided in (1) and (2) below. The ambiguous sentences (1a) and (2a) contained the construction *Verb NP₁ de NP₂* in the first four words, which is temporarily ambiguous between a CC structure and a RC structure. The sentences were disambiguated as the dispreferred CC analysis at word 5, the conjunction (*before/after/while*). Each of the ambiguous conditions was compared to an unambiguous control, such as (1b) and (2b), in where *NP₁* was replaced by an adjective.

1.

(a) *Strong RC-bias Ambiguous*

[xunlian shibing de jiangjun] zhihou, zongsiling fabiao le jianduan yanshuo
[train soldier POSS general] after, commander give PERF short speech
After [training the soldiers' general], the commander gave a short speech.

(b) *Strong Unambiguous*

[xunlian nianqing de jiangjun] zhihou, zongsiling fabiao le jianduan yanshuo
[train young ATT general] after, commander give PERF short speech
After [training the young general], the commander gave a short speech.

2.

(a) *Weak RC-bias Ambiguous*

[anwei bingren de jiashu] zhihou, nage hushi likai le bingfang
[comfort patient POSS relative] after, that nurse leave PERF ward
After [comforting the patient's relative], the nurse left the ward.

(b) *Weak Unambiguous*

[anwei beishang de jiashu] zhihou, nage hushi likai le bingfang
[comfort sad ATT relative] after, that nurse leave PERF ward
After [comforting the sad relative], the nurse left the ward.

While the syntactic constraint always favored the RC analysis, we manipulated the degree of semantic support for the RC and the CC structures during the ambiguous region, such that the semantic constraint provided stronger support for the RC reading in (1a) than in (2a). In (1a), the Strong RC-bias Ambiguous condition, the semantic evidence strongly favored the RC interpretation: it is much more plausible that a general trains soldiers (RC) than soldiers' general

is to be trained (CC). In (2a), the Weak RC-bias Ambiguous condition, the two readings were semantically and pragmatically more balanced: it is almost equally plausible that a family member comforts a patient (RC) and that a patient's family.

As shown in Figure 2 & 3, both the Strong RC-bias Ambiguous and the Weak RC-bias Ambiguous conditions exhibited a garden-path effect, reflected in increased reading times and more regressive eye movements at word 5 (i.e. the disambiguating conjunction) in comparison with the unambiguous controls. Crucially, processing costs were higher in the Strong RC-bias Ambiguous condition than in the Weak RC-bias Ambiguous condition when the dispreferred CC analysis was required at disambiguation. The findings are consistent with a limited, ranked parallel account, such as the Gibson (1991) model or the SOPARSE model (Tabor & Hutchins, 2004), which predicts that processing difficulty arises when a structure of low availability has to be elevated to the top-ranked status. Re-ranking was more costly in the Strong RC-bias Ambiguous condition because the required CC interpretation received little support from the syntactic and the semantic constraints and thus became relatively inaccessible. On the other hand, the CC structure, although lower-ranked, remained relatively active in the Weak RC-bias Ambiguous condition given the balanced semantic information.

We argued that both the RC and the CC analyses were retained up to disambiguation and were ranked based on the supporting evidence from the relevant constraints. The activation level of structural alternatives varies as a function of the strength of support from the relevant constraints (e.g. McRae et al., 1998). Even though the RC and the CC analyses were maintained for the same number of words (i.e. up to the disambiguation at word 5), the difference in activation between the two alternatives was exaggerated in the Strong RC-bias Ambiguous sentences as the RC structure received overwhelming support from the available constraints. On the other hand, the strengths of the higher- and lower-ranked readings were closer in the Weak RC-bias Ambiguous items. A parallel parser that adjusts the activation of alternative structures based on the support from the input constraints provides a unifying mechanism to account for differential processing difficulty.

Serial parsing systems such as the Diagnosis model and SNIP cannot account for the differential processing cost in the Strong and the Weak RC-bias Ambiguous sentences, although the models correctly predict that the non-local structural revision would induce difficulty in both conditions. The serial repair models assume that a repair process is triggered by structural inconsistency and is performed through detaching and reattaching constituents. Meanwhile, the cost of structural repair is determined by how detectable the misanalysis is (Fodor & Inoue, 1994) or how effective the syntactic cue is in signaling the misanalysis (Lewis, 1998). This cannot explain the differential processing difficulty in the Strong and the Weak RC-bias Ambiguous sentences because the structural disambiguation (i.e. the conjunction at word 5) was consistent across the two conditions, and the misanalysis in the initial parse (i.e. *de* being erroneously analyzed as a RC maker) should be equally visible or invisible.

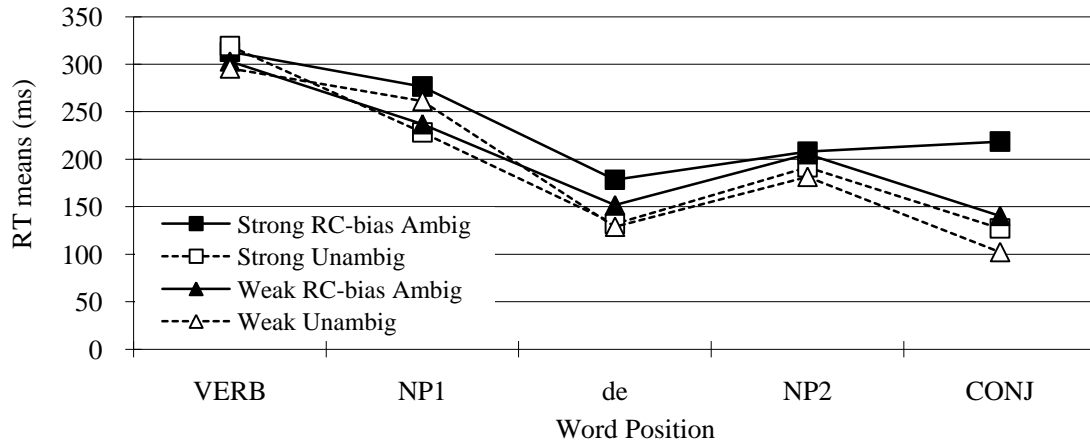


Figure 2. Means for first-fixation durations for each condition at each word position.

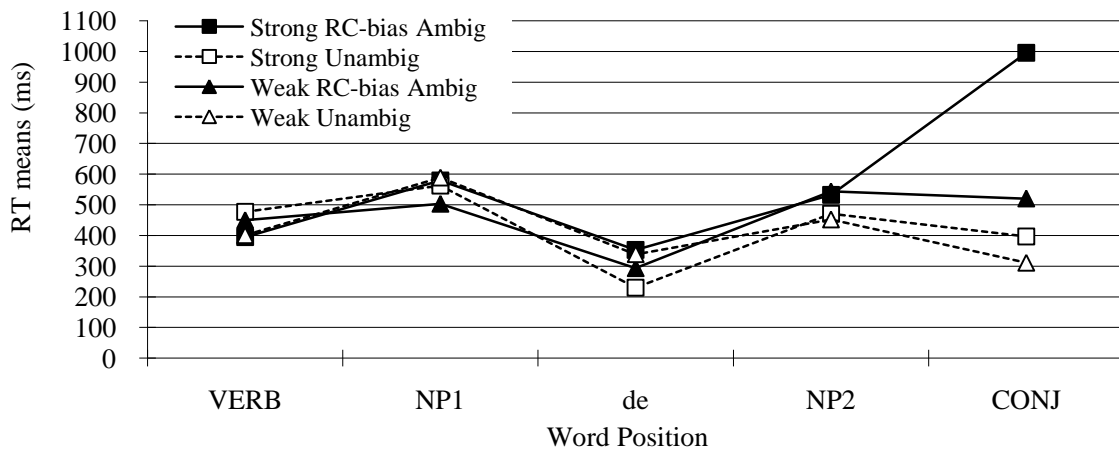


Figure 3. Means for regression-path durations for each condition at each word position.

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