Sentence processing in Chinese — long distance dependencies

Summary: Long distance dependencies in Chinese challenge the parser with its mixed-headedness structures and covert wh-dependencies. Research on processing Chinese long distance dependencies provides cross-linguistic insight on the general mechanism of structural building.

Indexation terms: long distance dependencies; head-final relative clauses; wh-in-situ questions; topicalization; filler-gap dependencies; memory retrieval

To understand the architecture of human sentence comprehension, one needs empirical evidence to address at least two issues. First, what are the necessary linguistic representations built in real time in order for sentence comprehension to happen? And second, what are the control structures that impose processing operations and constraints on such representations? Filler-gap dependencies form an ideal testing ground for this investigation. Sentences as simple as "which movie do you think John will like?" have attracted attention of both theoretical linguists and psycholinguists for decades, exactly because the non-local relation between the wh-element (e.g. "what", the "filler") and its original canonical position (e.g. the position after "likes", the "gap") brings up important questions as to what kind of syntactic/semantic representations should be constructed and how our memory structure supports such long distance relations in real time.

With respect to the processing constraints imposed on processing long distance dependencies, two very robust findings have been observed in the literature. The first one is the "active filler strategy" of the parser (Stowe 1986; Frazier and D'Arcais 1989; Fodor 1995). This refers to the observation that, while reading a sentence starting with a filler—for instance, a wh-question word—the parser actively looks for a gap and establishes a long distance filler-gap relation whenever possible, rather than waiting to verify the correct position of the gap by accumulating evidence from bottom-up information. This strategy is taken even though it may potentially lead to parsing errors. For instance, Stowe (1986) reported that a sentence like "*My brother wanted to know who my brother will bring us home to at Christmas*" generally creates more processing difficulty, and hence longer reading time, at the word "us", since the preceding verb "bring" provokes the expectation of a direct object gap corresponding to the wh-filler "who", leading to an incorrect parse. The second robust finding in the literature is the effect of distance. At the gap position, in order to establish a dependency, the parser needs to retrieve the filler that was previously processed from working memory. The distance between the filler and the gap affects retrieval of the filler and the subsequent integration process (Gibson 1998; Warren & Gibson 2002; Van Dyke & Lewis 2003; Lewis et al. 2006).

Mandarin Chinese has some interesting properties that make it a good testing ground for the cross-linguistic investigation of filler-gap dependencies. Chinese word order is normally head-initial. But within noun phrases, it is strictly head-final. Therefore, although it is regularly SVO at the clause level, any

modification on the noun head is pre-nominal. The mixed-headedness creates local syntactic ambiguities that interact with the processing of long distance dependencies, especially in the domain of relative clauses. The regular SVO order can also be altered via topicalization, which creates a long dependency that looks like the regular filler-gap dependencies studied in other languages. Chinese wh-questions are strictly in-situ, such that the wh-elements are not dislocated from their base position. This is very different from any of the wh-dependencies that have been investigated in the literature. Wh-in-situ questions pose questions about whether covert dependencies are constructed in real time, and if they are, what are the processing differences between constructing covert and overt dependencies.

Head-final relative clauses

Head-final relative clauses in Chinese present a gap-first dependency to the parser (as will be shown by the examples later). Hsu and Bruening (2003) showed that in such "gap-filler" dependencies, the active filler strategy is still at work. They compared sentence pairs like the ones below:

(1) a. 那位　老太太　昨天　　编织了 一件毛衣　　送给　她儿子。

　　nawei laotaitai zuotian　bianzhile yijian maoyi songgei taerzi

　　that　old-lady yesterday knitted a-CL sweater give-to her son

　　"That old lady yesterday knitted a sweater to give to her son."

　b. 那位　昨天　　编织了　一件毛衣　　送给　　她儿子 的　老太太　生病了

nawei zuotian bianzhile yijian maoyi songgei taerzi   DE laotaitai shengbingle

that   yesterday knitted   a-CL-sweater give-to her-son DE old-lady get-sick

"The old lady that yesterday knitted a sweater to give to her son got sick."

In the relative clause (1b), if the parser actively tried to link the initial gap with a downstream filler, the first position it could do so grammatically is after the word "sweater". Had the head noun "old lady" appeared after the word "sweater", it would have formed a relative clause "that old lady who knitted a sweater yesterday". Driven under such expectations, the parser would be "surprised" at the region "give to her son". This is exactly what the authors found. The RT on the "give to her son" region is longer than its counterpart in the control condition (1a), which is not a relative clause.

Using a plausibility manipulation, Ng (2008) also observed a similar "gap-filler" effect. In the example below, in (2a), the subject gap within the subject relative clause can be immediately linked to the later filler "child", but in (2b) an immediate association between the gap and filler "kindergarten" is implausible.

(2) a. Plausible

[e$_i$ 弄坏了   几个 玩具] 并未使   小孩子   的 保姆 更小心。

[e$_i$ nonghuaile jige wanju] bingweishi xiaohaizi de baomu$_i$ gengxiaoxin

[e$_i$ broke   a-few toy] not-CAU   *child*   DE nanny$_i$ more-careful

"Having broken a few toys did not make the child's nanny more careful."

b. Implausible

[e_i 弄坏了　几个 玩具] 并未使　*幼儿园*　的 保姆 更小心。

[e_i nonghuaile jige wanju] bingweishi youeryuan　de baomu_i gengxiaoxin

[e_i broke　a-few toy] not-CAU *kindergarten* DE nanny_i more-careful

"Having broken a few toys did not make the kindergarten's nanny more careful."

Ng (2008) found a reading time slow-down for the implausible "kindergarten" condition compared to the plausible "child" condition, although only at the spill over region "DE", still suggesting the parser has attempted to associate the gap with a filler as soon as possible, hence an (im)plausibility effect. Moreover, at the real head noun "nanny" and after, there is a trend for a slow-down of the plausible condition (2a), possibly due to a reanalysis in (2a), in which "child" has been taken as a filler at the earlier step.

Since Mandarin allows pro-drop, the filler of a gap could potentially be found in the discourse context rather than the current sentence. Mixed headedness coupled with the presence of discourse-related empty categories creates more online ambiguities as to where to locate the potential fillers. Ng and Fodor (2011) discussed a case in which the parser seems to have adopted a ranked strategy: when the closest filler in the current sentence is also a plausible one, the parser favors that analysis; but when the closest filler isn't plausible, the parser anticipates a structurally more complex analysis that contains a plausible filler downstairs, rather than opting for a structurally simpler analysis that leaves the exact interpretation of the empty category open to the discourse.

In-situ questions

Chinese wh-questions have a different word order from their English counterpart in that they are wh-in-situ. Namely, the wh-word stays in its canonical argument position, rather than moving to the edge of the clause. A regular English question *What did John buy?* would be expressed literally as *John bought what?* in Mandarin Chinese.

Generally speaking, there are two broad classes of analyses for Chinese wh-in-situ questions: the *LF movement* approach and the operator-binding approach. The LF-movement analysis (Huang 1982) assimilates wh-in-situ questions to their overtly moved counterpart in English, and argues for a movement of the wh-word to the [Spec, CP] position at Logical Form (LF). The unselective binding approach (Aoun & Li 1993; Tsai 1994; also see Reinhart 1997, 1998), advocates for a parsimonious relationship between LF and surface word order. Under this account, wh-words do not move at either LF or surface structure. Instead, they are bound by an interrogative operator that scopes over the entire sentence (see Cheng 2003 for a review of competing theoretical analyses). Although different in many important ways, both analyses on Chinese wh-in-situ questions assume a long distance dependency between the [Spec, CP] position and the wh-item, even though such a dependency is not overtly marked by any morpho-syntactic cues.

Wh-in-situ questions, therefore, raise the question as to how covert non-local dependencies are established in real-time processing, and whether this process is similar or different from processing overt dependencies. Covert dependencies have

been postulated in generative syntax to explain a range of different syntactic phenomena, including scope ambiguities and antecedent contained deletion, but the real-time processing reflex of covert representations still awaits more investigation (see Chen and Hale 2010; Frazier 1999; Frazier and Clifton 2000; Lidz and Musolino 2002). The relationship between the parsing steps taken to resolve in-situ wh-phrases versus overtly fronted wh-phrases potentially can provide valuable insights into the parsing mechanisms that operate on covert dependencies. On the one hand, overt and covert dependencies plausibly have core abstract similarities in their syntactic and semantic representations. On the other hand, the distribution of surface cues to the dependency is quite different. In covert dependencies, there is no direct perceptual evidence for the existence of a dependency, whereas in overt dependencies, the perceptual evidence, namely, the encountering of an explicit wh-phrase, unambiguously signals to the aprser to prepare for a dependency.

There has been no prior research on whether a "filler-gap" strategy exists for processing in-situ wh-questions, but one can make some predictions based on the following thought experiment. Although usually there are no perceptual cues on the surface to indicate the presence of an in-situ wh-dependency until the actual wh-element, in some cases the lexical information on the verb can still cue the parser into an expectation for a filler-gap dependency. For instance, verbs like "xiangzhidao (wonder)", which obligatorily takes an embedded wh-clause complement, unambiguously supports a structure of an embedded wh-question. The wh-feature on such verbs then, could potentially have an effect on the parser as any overt

"filler" would. Namely, the parser might actively engage in looking for a position that can successfully "absorb" such a feature.

The exact processing mechanism that contributes to the construction of a covert wh-dependency is largely unknown. Xiang et al. (2011a) argued that the parser undergoes very similar processes for establishing covert and overt dependencies. Using the Speed-accuracy-tradeoff (SAT) paradigm, Xiang et al. (2011a) found that processing an in-situ wh-question in Mandarin is different from processing a regular declarative sentence in two critical aspects, although the two constructions on the surface share similar word orders. First, wh-in-situ questions are always more costly than their declarative counterparts. Second, a longer wh-in-situ question affects the rate parameter of the SAT function, but not the final accuracy, indicating the processes of a content-addressable retrieval process, as have been documented for English overt dependencies (McElree et al. 2003); but for declarative sentences, length of the sentence does not have an effect on either the retrieval speed or the comprehension accuracy. The contrast between wh-in-situ questions and their declarative counterparts suggests that there is indeed a dependency being constructed between the [Spec,CP] and the in-situ wh-element, which is supported by similar mechanisms that underline overt dependencies in other languages. Comparable findings are also reported in Xiang et al. (2011b), using ERP recordings.

Topicalization

Topicalization in Mandarin alters the regular word order and creates a dependency that looks like an overt filler-gap dependency in English. For example, in the example below, the regular SVO order becomes OSV when the object is topicalized.

(3). a. regular SVO word order

约翰　很　喜欢　那辆车

Yuehan hen xihuan naliangche

John　very like　that-CL-car

"John likes that car."

b. topicalization of the object

那辆车，　约翰　很　喜欢

naliangche , Yuehan hen xihuan

that-CL-car, John　very like

"That car, John likes very much."

The standard filler-gap strategy was observed for topicalization constructions in Huang and Kaiser (2008). Manipulating the plausibility on the first downstairs verb that can take the topicalized DP as its object, Huang and Kaiser (2008) found longer RT on the implausible verb, which suggests the parser attempted to fill the gap with the topicalized DP at the verb position. More interestingly, the plausibility effect was found on verbs embedded within an adverbial clause, which normally is not a legitimate site to host the base position of a topicalized element. Huang and Kaiser

argued that the parser filled the gap within an "adverbial-island" only under circumstances in which another gap in the matrix clause is permissible, parallel to the parsing sensitivity to parasitic gaps found for English in Phillips (2006).

Although topicalization constructions are subject to the same "active filler-gap" strategy observed for other chains formed by A'-movement, the exact nature of the dependency between the topicalized element and its base position is still under debate. The movement analysis argues that the topicalized element undergoes A'-movement from the base position to its surface position (Shi 1992, 2000; Shyu 1995), and the base-generation analysis treats the topicalized element as being base-generated at its surface position (Li and Thompson 1981; Tsao 1990; Ning 1993). Furthermore, topicalization evokes certain discourse constraints on the entities that are topicalized. Namely, the NP that is topicalized should represent a discourse-old entity (Prince 1981, Hankamer 1971, Kuno 1972). The discourse constraints imposed on topicalization implie extra processing cost on dependencies formed by topicalization, compared to other long distance dependences (e.g. Bader and Frazier 2005 for discussion on German). Few studies have directly compared topicalization with other types of dependencies, with the exception of Felser, Clahsen and Münte (2003), who compared topicalization and wh-questions in German and actually found a larger P600 at the gap-verb for wh-questions. In Chinese, it is not easy to directly compare topicalization constructions with other A'-movements, such as wh-in-situ questions or relative clauses, because of the word order differences among these structures. Some innovative experimentation would be required in order to address all the relevant issues.

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