Development of Syntax-Discourse Interface Knowledge in 3- to 6-Year-Old Mandarin Chinese Speaking Children

Yuan Xie, Sergey Avrutin, and Peter Coopmans

1. Introduction

Bridging refers a discourse operation that allows speakers to use a definite DP without previous mention of a corresponding indefinite (e.g., in the sequence "*A ship* is on the river. *The flag* is blue.", *the flag* can be bridged to *a ship*). Children's ability to build such bridges between a definite DP and a preceding indefinite one has mainly been explored in Indo-European languages (Avrutin & Coopmans, 2000; Van Hout, De Ree & De Ree, 2008). Results showed that children were unable to successfully build such a bridge at age 3 (no difference from chance level performance). It was only after the age of 4 that they began to demonstrate the knowledge of bridging. The mistakes that very young children make in this bridging task have been explained as resulting from their inability to appreciate the addressee's perspective (Van Hout, De Ree & De Ree, 2008), from having a wider implicit common ground than adults ('Concept of Non-Shared Assumption', Schaeffer & Matthewson, 2005), from over-evaluating the information status of the definite DPs (De Cat, 2013) or from insufficient processing resources (Avrutin & Coopmans, 2000).

The plausibility of these explanatory accounts may gain further support by evidence from other than Indo-European languages. To our knowledge, Mandarin Chinese children's ability to build bridges has not been explored yet.[1] Yet, this language presents an interesting case study due to the absence of morphological marking of definiteness. Chinese does not have overt articles, by which such properties as definiteness can be expressed, and instead can use word order to do so (e.g. preverbal position).

The bridging mechanism may also be seen to underlie linking constructions involving the reflexive pronoun. Schumacher et al (2010) has shown how the connection between a SELF morpheme in a complex reflexive like *himself* and its antecedent can be viewed in this way. This is so because the SELF morpheme

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[1] In this paper our further use of the term "Chinese" refers to Mandarin Chinese.

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typically represents an instance of inalienable possession and the connection with its antecedent can be viewed as a case of metonymy: a part representing the whole, e.g. a rib, soul, nose or belly (Yu, 2000). It is most likely this property of the SELF morpheme that provides the possibility for the so-called logophoric uses of reflexives.[2]

When we turn to the study of reflexive elements in child language, specifically children's understanding or their interpretations in a variety of constructions, we observe that most studies of children's knowledge of reflexives have focused on their non-logophoric use (starting with one of the earliest studies by Chien & Wexler, 1990) with the exception of a few studies that investigated children's interpretation of logophoric reflexives (e.g. Avrutin & Coopmans, 2000; Coopmans, et al, 2004; Sigurjónsdóttir & Hyams, 1992). To the best of our knowledge, no research on the comprehension of logophoric reflexives in Chinese has been carried out yet.

The goal of this paper therefore is to answer the following two questions:

(1) how do Chinese children build a bridge between a definite DP and an indefinite one?
(2) how do Chinese children build a bridge between a reflexive and its antecedent in both logophoric as well as non-logophoric constructions?

We will begin by introducing a syntax-discourse model for the representation and interpretation of bridging. We will then report the results of two experiments that tested Mandarin Chinese children's ability to build bridges (e.g. a definite DP—an indefinite one; a reflexive—its antecedent), and briefly discuss how these results can be interpreted in relation to the proposed model.

2. A syntax-discourse processing model

2.1. From file change semantics to a syntax-discourse interface model

The Syntax-Discourse-Processing (S-D-P) model proposed here is an extension of the Syntax-Discourse Interface Model (Avrutin, 1999; Schumacher et al, 2010), which in turn is an extension of the File Change Semantics (FCS) proposal by Heim (1982). The basic idea of the Syntax-Discourse Interface model is that dependent elements (such as definite DPs, reflexives etc.) and their antecedents are DPs that can be represented by file cards which are composed of a *frame* (projected by the functional category D) and a *heading* (projected by the lexical category NP):

[2] Sells (1987) has argued that the logophoric dependency established between a reflexive and its antecedent is regulated by discourse information, such as the perspective or mental attitudes of the speaker. Here we will adopt the view that the logophoric nature of the reflexive itself originates with the morpheme SELF.

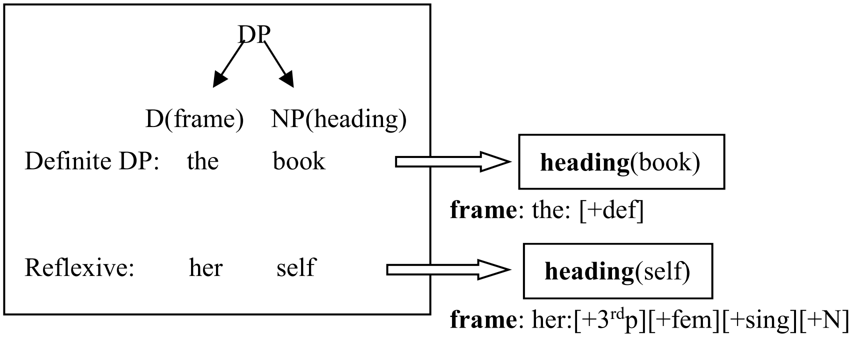

Figure 1. From DPs to File Cards

Frames and headings are feature bundles. Since a frame is projected by the functional category D, the features of a frame refer to its functional make-up, including phi-features and definiteness. The features of a heading refer to the lexical meaning (contents).

A dependent file card is uninterpretable by itself, so it must be connected with its antecedent card in order to be interpreted. Bridging takes place when such links are possible—a dependent card will bridge to its antecedent card if the features of frames and headings are matched (e.g. person, gender, number, definiteness, categorial feature). For example, in the sentence *John was holding a book behind himself,* the frame features of the file card introduced by *himself* (him: 3rd person, male, singular) match with those of its antecedent card *John.* The heading of the card *himself* (self: body part) also has a hidden connection with that of the antecedent card *John*.

In the sequence "*A ship is on the river. The flag is blue.*"*,* the frame features of the file card introduced by the DP *the flag* (+ definite) match with that of *a ship* (+ indefinite).[3] The heading of *the flag* (flag) is linked with that of *a ship* (ship) because of the hidden semantic connection between *flag* and *ship* (there is usually a flag on a ship).

2.2. File cards and the strength of memory traces

The concept of file cards can be connected with the strength of memory traces through a processing mechanism.[4] File cards are feature bundles. The

[3] The feature of definiteness can be interpreted only when it is connected with an indefiniteness feature. Therefore, feature matching between a definite DP and an indefinite one is to be understood as [+definite] -- [+indefinite].

[4] Memory trace is defined as a by-product of perceptual processing (perception here includes both sensory and semantic processing). It also has its neurological foundation, which represents a pattern of neural network connections in different brain areas.

more features a file card has, the more effort is needed to process them, leaving a stronger memory trace. This is in line with the theory of Depth of Processing (Craik & Lockhart, 1972), which holds that “greater ‘depth’ implies a greater degree of semantic or cognitive analysis” and “with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces.” (p.675).

Thus, the strength of a file card (and hence its activation) in turn depends on the morphosyntactic properties of a lexical item. For example, the file card introduced by *himself/herself* (features: person, gender, number, categorial feature) is stronger than the card introduced by Chinese reflexive *ziji,* whose person, gender, and number features are underspecified (Huang & Tang, 1991). The strength of memory trace left by processing the file card *himself/herself* is therefore stronger than that left by *ziji*. On the other hand, the strength of memory trace left by processing the file card *the flag* is stronger than that of the Chinese counterpart of *the flag,* i.e., *qizi,* because of the presence of the morphosyntactic marker *the.*

2.3. The strength of file cards and information

The strength of file cards can be interpreted in terms of information. “Information” here means uncertainty/surprisal (Shannon, 1948), which can be calculated by the logarithm of the probability of the event. The idea is that the higher the probability of occurrence of an event, the more certain it is, and the lower information it has. Although the concept of information is related to frequency/probability, we suggest that the strength of file cards can be viewed as an index of information. Specifically, if the strength of the file card is weak, it means that the neural network connection is relatively loose and the item (here: the file card) is less activated (Anderson, 2010: 161), making it more uncertain, hence the information is correspondingly higher.

The distribution of information, however, follows a hypothesis of Uniform Information Density (UID) (Jaeger & Levy, 2007). These authors argue that at any level of linguistic communication the information should be uniformly distributed. Taking phonology as an example, if a speaker would like to produce a word that has a complex phonological structure, they will probably produce it slowly in order to let the addressee fully understand it.

We suggest that the UID hypothesis can be extended to account for the distribution of referentially dependent elements. That is, if the information of a reflexive/definite DP is high (less certain), then the information of its antecedent is expected to be low (more certain, highly activated). For example, since the information of *himself/herself* is lower than that of *ziji* (the strength of the file card *himself/herself* is stronger than that of *ziji*), it is predicted that the information of the antecedent card of *himself/herself* is higher (less activated) than of the antecedent of *ziji* (more activated). Likewise, since the information of the file card introduced by a definite DP (e.g. *the dog*) in English is lower than that in Chinese (the strength of the file card *the dog* is stronger than that of *gou* (dog)), the information of the antecedent card introduced by an English DP is then higher (less activated) than that introduced by the corresponding DP in Chinese (higher activated).

Importantly, we take the established referential link between an antecedent and a referentially dependent element as a linguistic object that obeys the requirements imposed by the UID. That is, it is this object as a whole that should have a balanced distribution of information. It is not the case that both antecedent and the dependent element are at the same level of information, rather the opposite.

3. Experiments

3.1. Experiment 1: bridging between a definite DP and an indefinite DP

In our first experiment, we tested whether Chinese children can build a bridge between a definite DP and an indefinite one. The method we adopted was a modified Truth Value Judgement Task with bright and colorful photoshopped electronic pictures shown on a computer screen to better attract the attention of the young children.

91 monolingual Chinese children aged 3 to 6 years from a local kindergarten in Hunan Province participated in this experiment. They were divided into three age groups (3-4, 4-5 and 5-6 years), with approximately 30 children per age group. All children showed normal hearing and speech abilities and were very happy to participate in the experiment. In addition, 20 adult participants, undergraduate students in a local university (aged 18 to 21), were recruited as a reference group in the experiment.

The test materials consisted of 8 test pictures, 4 fillers and 3 practice trials. Of the 8 test pictures, 4 represented the true condition and 4 represented the false condition, as illustrated in (1) and (2) respectively. In both conditions, the pictures used contained two (indefinite) DPs which could in principle function as antecedents, one of which would enter into a proper form of bridging. So, in the examples below there would be two types of door (1), a yellow one in a bus, the other, non-yellow, in a house (True), and similarly for two sets of tires (2), with a truck having green tires and a bike having non-green tires (False).

(1) You liang qiche zai malu shang. Men shi huangse de. (True)
Have CL bus Prep road on. Door BE yellow DE
"There is a bus is on the road. The door is yellow."

(2) You liang zixingche zai caodishang. Luntai shi lanse de. (False)
Have CL bike prep grassland. Tire BE blue DE.
"There is a bike is on the playground. The tires are green."

Each picture was presented to the participating subjects one at a time. Such a set-up was similar to the one in the Avrutin & Coopmans (2000) study.

The experiment involved an experimenter, a handpuppet (enacted by a student assistant) and the child subject who sat next to the experimenter. The whole process took the form of a guessing game: the experimenter told stories to the child supported by pictures on the computer screen and at the end of each story there was a specific scenario for the puppet to make a guess about, which was also the scenario to elicit the test sentence. Then the handpuppet would guess by uttering the test sentence whose truth value the child would pass a judgment on. The child could directly say yes or no (true/false) to the puppet's guessing. For the very introvert child it was also possible to respond in an alternative way, such as by touching the handpuppet's head (correct) or patting the handpuppet's hand gently (incorrect). Before the actual testing, there were three practice trials for the child to become familiarized with the guessing game and also for the experimenter to see whether the child could in fact make judgements or not. The experimental data of those who had passed all three practice trials were collected in the final data analysis. Of those who failed in the practice session or did not finish the entire task, the data were excluded. The experiment was conducted in a specific classroom in a local kindergarten.

Table 1. Accuracy Rates in Bridging Experiment 1

	True	**False**
group1 (3-to-4) (30)	75.83%	63.33%
group2 (4-to-5) (30)	89.17%	84.17%
group3 (5-to-6) (31)	92.74%	83.87%
all children (91)	85.91%	77.12%
Adults (20)	98.75%	92.50%

Results. Table 1 shows the accuracy rates of Chinese children's performance in both the true and false conditions. These accuracy rates for groups 2 and 3 were very high (>80%) in both true and false conditions. The lowest accuracy rate was 63.33% (group 1) in the false condition. This percentage, however, was significantly above chance level ($t\ (29) = 2.15$, $p = 0.02$). This indicates that the Chinese children began to show the ability to build a bridge from 3 years onward (although the percentages are still not very high).

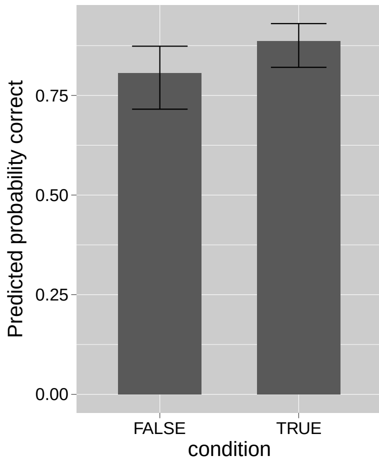

Figure 2. Probability of Correctness in Different Conditions

Figure 2 shows that the difference between false and true conditions is not significant (z = -1.80, p = 0.07).

This first experiment was aimed at testing Chinese children's ability to build a bridge between a definite DP and an indefinite DP, such as illustrated in examples (1) and (2). The main finding of this experiment is that Chinese children from 3 years onward know how to build such a connection between an indefinite DP and a definite one, and will often do so if the possibility arises. The accuracy rate in the false condition - rejecting the handpuppet's guess that such a link can be established - by the youngest age group of Chinese children was above chance level. This score turned out to be higher than that of a group of similarly aged Dutch children (46% accuracy score in a parallel study conducted by Avrutin & Coopmans, 2000), who showed around or below chance level performance (Dutch: t (11) = 0.5, p = 0.63).

According to the S-D-P model, the frame of a file card introduced by a DP in Chinese is weaker (higher information, less activated) than that in Dutch, so the antecedent card of a Chinese DP should have lower information (highly activated), facilitating the bridging process and possibly resulting in higher accuracy rates. Thus the lack of overt articles in Chinese in fact turns out to facilitate the process of anaphora resolution for small children since the information of the antecedent is lower and therefore requires less processing resources for establishing a link with a referentially dependent element, when we compare the Chinese situation to Dutch or English.

Finally, the difference between the true and false conditions is non-significant, which we interpret to mean that Chinese children are firmer in their yes/no responses, i.e. they appear to show less "guessing" behavior.

3.2. Experiment 2: bridging a reflexive to its antecedent

In our second experiment, we tested Chinese children's ability to build bridges between a reflexive and its antecedent in both logophoric and nonlogophoric constructions.

The experimental method adopted, the child participants for this test and the adult controls, as well as the test procedure were the same as those described for the first experiment. Here too, the test materials were test sentences following story-based scenarios which needed to be judged as correct or incorrect guesses. The stimuli included 16 test stories (half of which as instantiations of the true condition, the other half for the false condition), 8 fillers and 3 practice trials. In the nonlogophoric (anaphoric) condition, the reflexive *ziji* and its antecedent are co-arguments (ex 3.). In the logophoric condition, the reflexive *ziji* and its antecedent are not co-arguments (ex 4.).[5]

(3) **Nonlogophoric (co-argument) - False**
Xiaogou de baba qingqing de pai-le ziji.
Little dog DE father gentle DE pat-LE self-N
"The little dog's father is patting himself gently."

(4) **Logophoric (non co-argument) - True**
Xiaoxiang de nainai ba san da zai le ziji toushang.
Little elephant DE grandma BA umbrella hold prep LE self-N head-above
"The little elephant's grandma is holding the umbrella above herself."

In the case of example (3) the scenario is one where the father is patting the little dog - False. In the corresponding nonlogophoric-True counterpart the agent is performing such act on herself. In example (4) the scenario is that the grandma is holding the umbrella above herself - True. In the False counterpart condition the action is directed at the other character. There are all together 2 (logophoric/nonlogophoric)*2 (True/False) conditions. The experimental setup with 4 (Logo/non-Logo * True/False) conditions invited the children to either approve or disapprove of the handpuppet's guesses. Such a setup is similar to that in Coopmans, et al (2004).

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[5] The difference between co-arguments and non co-arguments can be illustrated by the following examples:

(i) John patted himself.
(ii) John was holding an umbrella above himself.

In (i), *John* and *himself* are co-arguments of the predicate *pat*. In (b) *John* and *himself* do not share the same predicate *hold*, - *himself* is an argument of the locative preposition *above* -, hence they are not co-arguments.

Results. Table 2 shows the accuracy rates of the Chinese children's performance in the four experimental conditions:

Table 2. Accuracy Rates of Chinese Children

	Nonlogophoric		**Logophoric**	
	True	**False**	**True**	**False**
Group1 (30)	82.50%	76.67%	80.83%	83.33%
Group2 (30)	95.83%	90.83%	97.50%	94.17%
Group3 (31)	98.39%	99.19%	94.35%	97.58%
All children (91)	92.24%	88.89%	90.89%	91.69%
Adults (20)	98.75%	98.75%	100%	100%

As can be seen here, the Chinese children from 4 years old onwards showed ceiling effect accuracy rates (above 90%) in all conditions. The lowest accuracy rate, 76.67% (youngest age group in the nonlogophoric false condition), was above chance level, statistically significant ($t(29) = 2.15$, $p < 0.001$). This shows that even the youngest Chinese children already began to demonstrate knowledge of logophoricity. In addition, the accuracy rates between the nonlogophoric and logophoric uses of *ziji* for children as a whole did not differ greatly from each other ($z=-1.81$, $p= 0.07$). Posthoc pairwise comparisons showed that the differences between logophoric and nonlogophoric condition were not significant either in the false condition ($z=0.21$, $p=0.83$) or in the true condition ($z=-1.18$, $p=0.24$).

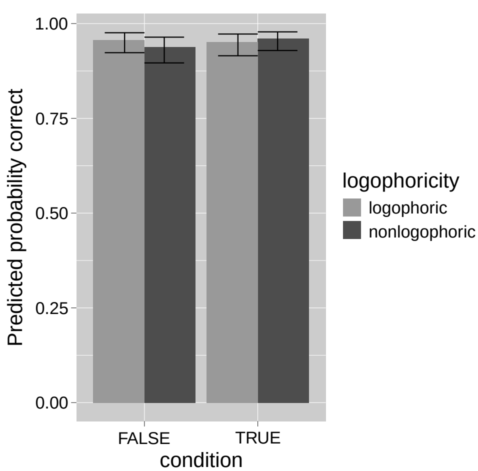

Figure 3. Probability of Correctness in Different Conditions

In our second experiment, we were primarily interested in finding out whether Chinese children display the knowledge needed for building a logophoric bridge. And indeed, the main finding of this experiment was that Chinese children in the youngest age group already began to demonstrate such knowledge and that overall there was no significant difference in their non-logophoric and logophoric uses of *ziji*. This pattern is different from what was found with Dutch speaking children in a parallel study carried out by Coopmans et al (2004). In that study the younger age group (whose mean age 4;11 was much higher than that of the youngest age group tested here) did show a significant difference between the two constructions, with the children performing less well on the logophoric-false condition (69%) than the nonlogophoric-false condition (94%).

This different result found for Chinese may be related to the fact that *ziji* has a large amount of logophoric uses, as it can occur in different syntactic positions (e.g. subject, object, adjunct), violate syntactic constraints such as c-command and locality, or refer to an antecedent across sentence boundaries. Chinese children, therefore, may also be much more frequently exposed to the input of logophorically used *ziji*. This frequent exposure to logophoric constructions may potentially decrease processing difficulties (e.g. reduce the uncertainty/information), resulting in good performance on this task.

4. Conclusion

In this paper, we tested Chinese children's performance in two bridging tasks against the background of the of S-D-P model briefly outlined here. The experimental results show that Chinese children are able to build such bridges from 3 years onward, about a year earlier than their Dutch counterparts. Such results can be captured in our S-D-P model, which allows us to express the view that the processing of dependent relations (bridging) is modulated by the morphosyntactic features, discourse properties and working memory. Relying on basic concepts of syntactic, discourse and information theories, we argue that the processing of referential dependencies between reflexives/definite DPs and their antecedents should be modeled as a relation between discourse entities (file cards). During processing, these entities have different degrees of strength, as a function of their morphosyntactic composition. Furthermore, in line with the Uniform Information Density hypothesis (UID) of Jaeger and Levy (2007), we propose that bridging reflects information balancing: when the information of the antecedent card is low, the information of the dependent card is high. In this way, our acquisition study extends the application of the UID as an explanatory mechanism for establishing referential dependencies and provides a coherent account of previously observed and newly obtained experimental results.

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