Word Order Effect in Children's Garden Path of Relative Clauses[*]

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This study examines whether Chinese-speaking children use the NVN word order strategy to comprehend OO relative clauses. The results of a truth value judgment test showed that children in the older group (mean age 5;11) interpreted the test sentences correctly 93% of the time, but children in the younger group (mean age 4;9) wrongly considered the subject NP of the relative clause as the object of the main verb 46% of the time. The difference between the two age groups was significant (t(29) = 2.685, $p < 0.02$). Since Chinese-speaking children by 3 to 4 years old can produce relative clauses accurately (Su 2004), the comprehension errors from the younger children here are taken to reflect the difficulty of reanalyzing the sentences when they are led into a garden path, similar to the patterns found from adults in on-line sentence processing experiments.

Key words: mandarin chinese, relative clauses, comprehension, first language acquisition

1. Introduction

This paper aims to examine whether Chinese-speaking children use the NVN word order strategy (Bever 1970 and Townsend and Bever 2001) to comprehend object-extracted relative clauses when they are the objects of the main verbs (i.e. OO relative clauses) as in (1).

(1) nanhai qi le [papaxiong zhaodao t_i de yazi]
    boy ride ASP panda find COMP duck
    'The boy rode on the duck that the panda found.'

The organization of this paper is as follows. In section 2, we review previous studies examining children's comprehension of relative clauses. Section 3 illustrates the details of the experiment, and section 4 provides a general discussion and conclusion.

2. Previous studies on children's comprehension of relative clauses

Previous studies investigating children's comprehension of relative clauses were mostly conducted in English, and the task used was mainly an act out task in which child subjects were asked to act out the interpretation of the sentences said to them by

the experimenter using the toys and props provided in the workspace. Sheldon (1974) first used the following four types of sentences with relative clauses to test children between the ages of 3;8 to 5;5.

(2)   SS: The dog that jumps over the pig bumps into the lion.   (1.58) (78%)[1]
      SO: The lion that the horse bumps into jumps over the giraffe.   (0.52) (21%)
      OS: The pig bumps into the horse that jumps over the giraffe.   (0.88) (19%)
      OO: The dog stands on the horse that the giraffe jumps over.   (1.52) (38%)

The results from this study showed that SS and OO sentences were easier to comprehend than SO or OS sentences for child subjects in this study. The author hence proposed the parallel function hypothesis to account for the results. According to this hypothesis, for SS and OO sentences, since the grammatical role played by the head noun in the relative clause accords with its role in the matrix sentence, they are easier to process.

Tavakolian (1978) used four types of relative clauses similar to Sheldon (1974), and found that although SS was still the easiest type of sentence to comprehend for children, the accuracy for OO type of sentences was not high, and thus the prediction of the parallel function hypothesis was not supported. In addition, the ranking of accuracy for SO and OS type of sentences also differed from the results of Sheldon (1974). From the error patterns of the child subjects, Tavakolian (1978) noticed that for OS type of sentences, 63% of the children in her study and 44% in Sheldon's (1974) study interpreted the subject of the matrix sentence as the agent of the matrix verb and the verb in the relative clause. Tavakolian (1978) thus argued that children interpreted complex sentences such as sentences with relative clauses as simple conjoined clauses (i.e. the conjoined-clause hypothesis).

De Villiers et al. (1979) further examined the comprehension difficulty caused by the object of a preposition, as compared with the subject and the object of a verb in a relative clause. Nine types of sentences were employed as illustrated in the following examples.

(3)   SS: The gorilla that bumped the elephant kissed the sheep.   (3.907)[2]
      SO: The turkey that the gorilla patted pushed the pig.   (2.975)
      SP: The giraffe that the turkey yelled to pushed the zebra.   (2.469)
      OS: The kangaroo kissed the camel that shoved the elephant.   (3.897)
      OO: The turtle hit the pig that the giraffe touched.   (3.736)

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[1] The number in the first parentheses indicates the average correct interpretations out of the three test sentences in Sheldon (1974), and the one in the second parentheses is the accuracy from Tavakolian (1978).

[2] The numbers are the average correct interpretations out of six test sentences for each type.

OP: The crocodile touched the gorilla that the zebra yelled to.   (3.565)

PS: The turtle shouted to the camel that pushed the kangaroo.   (3.608)

PO: The horse spoke to the turtle that the sheep touched.   (3.433)

PP: The kangaroo whispered to the turkey that the zebra shouted to. (3.351)

The following four hypotheses were discussed with respect to their predictions of the ranking of comprehension difficulty.

(4) i. One Variable: (a) The embeddedness of the relative clause
        (OS, OO, OP, PS, PO, PP) < (SS, SO, SP)
     ii. One Variable: (b) The focus of the relative clause
        (SS, OS, PS) < (SO, OO, PO) < (SP, OP, PP)
     iii. Two Variables: (a) The parallel function hypothesis
        (SS, OO, PP) < (SO, SP, OS, OP, PS, PO)
     iv. Two Variables: (b) The processing heuristic hypothesis
        $OS \leq PS < SS < OO \leq OP \leq PO \leq PP < SO \leq SP$

The first hypothesis only considers the grammatical role played by the relative clause in the matrix sentence. Since a relative clause in the subject position of a matrix sentence will result in center-embedded construction, comprehension difficulty of these sentences will be increased. The second hypothesis is based on Keenan and Comrie's (1979) hierarchy of accessibility of noun phrases, which takes into consideration only the grammatical role played by the head noun in the relative clause, and hence predicts the ranking of comprehension difficulty to be subject-extracted, verb object-extracted, and preposition object-extracted (from the easiest to the most difficult). The third hypothesis is Sheldon's (1974) parallel function hypothesis, which considers both the relative clause and the matrix sentence, and which predicts that SS, OO, and PP types of sentences will be easier to comprehend. The fourth hypothesis is based on Bever's (1970) noun-verb-noun (NVN) sequence strategy and Smith's (1974) minimal distance principle, which states that the linear word order of the sentence will affect comprehension difficulty. The authors argued that their results were more consistent with the prediction of the fourth hypothesis. However, as pointed out by O'Grady (1997), the results of de Villiers et al. (1979) also demonstrated that for English, subject-extracted relative clauses in general were easier to comprehend.

Goodluck and Tavakolian (1982) investigated whether the animacy of arguments would influence the way children interpreted the OS type of relative clauses. They tested ten 4-year-old and 5-year-old children respectively on the following types of sentences (accuracy indicated in parentheses).

(5) OS type I: The dog kicks the horse that knocks over the sheep. (49%)

OS type II: The dog kicks the horse that knocks over the table.   (69%)

OS type III: The dog kicks the horse that hops up and down.   (76%)

The major difference among the three types of sentences is that the object of the verb in the relative clause is animate for type I sentences, whereas it is inanimate for type II sentences, and the verbs in type III sentences are intransitive. The results showed that for type I sentences, 32.5% of the children's responses took the subject of the matrix sentence as the agent of both the matrix verb and the verb in the relative clause. This error pattern amounted to 23% and 20% of the children's responses for type II and type III sentences, respectively. Therefore, the animacy of arguments has an effect on comprehension difficulty.

With respect to research methodology, Hamburger and Crain (1982) pointed out that none of the previous studies took the felicity condition on the use of relative construction into consideration. They argued that in those studies children's misunderstandings arose because the two presuppositions of the restrictive relative clause were not satisfied in the experimental context. That is to say, for a restrictive relative clause to be used felicitously, there should be at least two entities of the same type in the context, and the action described by the relative clause should take place before the action in the main clause. Based on this, Hamburger and Crain (1982) took into account the different presuppositions of relative clauses and made the apparently minor change of adding more entities to the acting out situation for the test sentences. The results of their study showed when the pragmatic condition was met, even 3-year-old children could correctly act out the OS type of sentences about 69% of the time, in contrast with the 49% accuracy in Goodluck and Tavakolian (1982).

Since the canonical word order is SVO in English, whether the findings from the afore-mentioned studies in English are applicable to other languages is not clear. Hakuta (1981) conducted a series of experiments to tackle how Japanese-speaking children interpreted relative clauses. The major finding of the study was that there was an interaction between word order and the grammatical role played by the relative clause in the matrix sentence. When the matrix sentence had SOV word order, the sentence was easier to comprehend when the relative clause was in the subject position than in the object position. However, when the word order of the matrix sentence was OSV, the sentence would be easier to interpret if the relative clause was in the object position rather than in the subject position. The pattern demonstrated that in Japanese center-embedded construction was more complex and hence more difficult to comprehend than left-branching construction. In addition, the study also found that for children acquiring Japanese, SOV was easier than OSV word order, and object-extracted relative clauses caused less difficulty than subject-extracted relative clauses. Clancy et al.'s (1986) study on Korean also found the accuracy for sentences

with canonical SOV word order was higher than that of OSV order, and there was an interaction between word order and the grammatical role played by the relative clause in the matrix sentence. Specifically, the accuracy for SS and SO types of sentences was higher in SOV than in OSV order, whereas the accuracy for OS and OO types of sentences was higher in OSV than in SOV order. However, regarding the grammatical role of the head noun in the relative clause, it was found that, unlike Hakuta (1981), when the relative clause was the object of the matrix sentence, an object-extracted relative clause was easier to comprehend, but when the relative clause was the subject of the matrix sentence, a subject-extracted relative clause caused less processing difficulty.

With respect to studies of Chinese, Chang (1984) employed an act out task to test 48 elementary school children on the following four types of relative clauses.

(6) SS: yao   gou   de   mao   zhui   laoshu
          bite   dog   COMP   cat   chase   mouse
          'The cat that bit the dog chased the mouse.'
     SO: bei   gou   yao   de   mao   zhui   laoshu
          by   dog   bite   COMP   cat   chase   mouse
          'The cat that was bitten by the dog chased the mouse.'
     OS: laoshu   zhui   yao   gou   de   mao
          mouse   chase   bite   dog   COMP   cat
          'The mouse chased the cat that bit the dog.'
     OO: laoshu   zhui   bei   gou   yao   de   mao
          mouse   chase   by   dog   bite   COMP   cat
          'The mouse chased the cat that was bitten by the dog.'

In addition to the above four types of sentences with animate arguments, Chang (1984) also included four types of sentences with inanimate arguments as shown below.

(7) SS: zhuang   gongche   de   qiche   zhui   jipuche
          bump   bus   COMP   car   chase   jeep
          'The car that bumped into the bus chased the jeep.'
     SO: bei   gongche   zhuang   de   qiche   zhui   jipuche
          by   bus   bump   COMP   car   chase   jeep
          'The car that was bumped into by the bus chased the jeep.'
     OS: gongche   zhuang   le   zhui   jipuche   de   qiche
          bus   bump   ASP   chase   jeep   COMP   car
          'The bus bumped into the car that chased the jeep.'

OO: gongche zhuang le bei jipuche zhui de qiche
bus bump ASP by jeep chase COMP car
'The bus bumped into the car that was chased by the jeep.'

The results of this study showed that the ranking of comprehension difficulty for Chinese-speaking children was SS = SO < OO = OS, regardless of the animacy of arguments. Chang (1984) discussed Sheldon's (1974) parallel function hypothesis, Bever's (1970) NVN strategy, Tavakolian's (1978) conjoined-clause analysis, and argued that none of the three hypotheses could account for the results from Chinese. Based on Slobin (1973), Chang (1984) proposed that the main factor influencing the comprehension of relative clauses in Chinese was whether the processing of relative clauses would interrupt the interpretation of matrix sentences or not. Since in Chinese relative clauses appear before the modified head noun, a relative clause which is the object of the matrix verb will cause interruption in the processing and comprehension of the matrix sentence. As for why studies in English did not show similar results, Chang (1984) conjectured that in Chinese both relative clauses and adjectives appeared before the modified nouns, whereas in English relative clauses appeared after the head nouns, but adjectives before the modified nouns, and hence the comprehension of English relative clauses would involve reorganization of word order.

The reason why Chang (1984) did not find the effect of animacy for arguments could be that in the inanimate condition, all the argument nouns were inanimate, and thus the semantic roles of agent and theme were not predictable (i.e. the thematic roles were reversible). This was different from the manipulation in Goodluck and Tavakolian (1982). Another problem with this study is that the relative clauses in SO and OO sentences (e.g. *bei gongche zhuang de qiche* 'the car that was bumped into by the bus') should be better categorized as subject-extracted rather than object-extracted due to the fact that the corresponding declarative sentence is 'the car was bumped into by the bus'. This might be the reason why Chang (1984) found SS and OO sentences displayed patterns of results similar to SO and OS, respectively. With this modification of sentence categorization, the results probably can be accounted for by Bever's (1970) word order strategy, as it predicts that the second noun phrases in OS and OO sentences will be misinterpreted as the theme as well as the object of the matrix verb.

Cheng (1995) adopted an act out task to test 36 preschool Chinese-speaking children on the comprehension of the following sentences.

(8) SS (animate) ti konglong de gougou zhui xiaoxiong
kick dinosaur COMP dog chase bear
'The dog that kicked the dinosaur chased the bear.' (0.44)

(inanimate)	yao	tangguo	de	houzi	bao	baitu		
	bite	candy	COMP	monkey	hold	rabbit		
	'The monkey that bit the candy held the rabbit.'					(0.83)		
SO (animate)	konglong	zhui	de	gougou	bao	xiaoxiong		
	dinosaur	chase	COMP	dog	hold	bear		
	'The dog that the dinosaur chased held the bear.'					(0.22)		
(inanimate)	houzi	ti	de	chezi	zhui	baitu		
	monkey	kick	COMP	car	chase	rabbit		
	'The car that the monkey kicked chased the rabbit.'					(0.50)		
OS (animate)	konglong	bao	zhui	gougou	de	xiaoxiong		
	dinosaur	hold	chase	dog	COMP	bear		
	'The dinosaur held the bear that chased the dog.'					(0.06)		
(inanimate)	houzi	ti	bao	tangguo	de	baitu		
	monkey	kick	hold	candy	COMP	rabbit		
	'The monkey kicked the rabbit that held the candy.'					(0.25)		
(intransitive)	gougou	ti	zai	tiaowu	de	xiaoxiong		
	dog	kick	BE	dance	COMP	bear		
	'The dog kicked the bear that was dancing.'					(0.94)		
(existential)	houzi	bao	you	bandian	de	gougou		
	monkey	hold	have	spot	COMP	dog		
	'The monkey held the dog that had spots.'					(0.97)		
OO (animate)	konglong	yao	gougou	bao	de	xiaoxiong		
	dinosaur	bite	dog	hold	COMP	bear		
	'The dinosaur bit the bear that the dog held.'					(0.03)		
(inanimate)	houzi	yao	baitu	ti	de	tangguo		
	monkey	bite	rabbit	kick	COMP	candy		
	'The monkey bit the candy that the rabbit kicked.'					(0.19)		

From the accuracy indicated in parentheses after each sentence, the results of this study showed that sentences with intransitive or existential verbs were the easiest to comprehend for children, and sentences with one inanimate argument were easier to comprehend than sentences with only animate arguments, which was consistent with the finding in Goodluck and Tavakolian (1982). However, regardless of the animacy of arguments, the ranking of difficulty for the four types of relative clauses was SS < SO < OS < (=) OO, which differed from Chang (1984) mainly on the comparison of SS and SO. Chang (1984) did not find any significant difference between SS and SO, whereas the results from Cheng (1995) showed SS was much easier than SO. This difference between the two studies can be attributed to the reason mentioned earlier, namely, the problematic categorization of Chang's (1984) SO and OO sentences.

Cheng (1995) discussed in detail the explanatory power of the accessibility

hierarchy strategy (Keenan and Comrie 1979), the parallel function hypothesis (Sheldon 1974), the word order strategy (Bever 1970), the anti-interruption strategy (Slobin 1970, 1973), the minimal distance principle (Smith 1974, based on C. Chomsky 1969), and the conjoined-clause hypothesis (Tavakolian 1981) toward her results. All the hypotheses predict that SS is the easiest for comprehension. With respect to the other three types of relative clauses, the accessibility hierarchy strategy (i.e. subject-extraction is less difficult than object-extraction) predicts OS type of sentences, and the parallel function hypothesis predicts OO type of sentences to be easy to comprehend, contrary to the results of this study. The author pointed out that Lee's (1992) study found the ranking of difficulty as SS < OS < SO < OO, consistent with the prediction of the accessibility hierarchy strategy. The prediction of the anti-interruption strategy (i.e. SS and SO will be easier than OS and OO) and the prediction of the word order strategy as well as the minimal distance principle (i.e. OO type of sentences will be the most difficult,[3] whereas the strategy can help children correctly interpret SO type of sentences) are compatible with the findings. Nevertheless, although Chang (1984) and Lee (1992) did not find the conjoined-clause hypothesis to influence the comprehension of Chinese relative clauses, Cheng (1995) found for SO, OS, and OO types of sentences, the conjoined-clause hypothesis can account for most of the children's errors in her study. That is to say, children consider the first noun phrase to be the subject of the two verbs, and the second as well as the third noun phrases to be the object of the two verbs, respectively. This error pattern cannot be accounted for by the word order strategy or the minimal distance principle. Therefore, Cheng (1995) concluded that the comprehension of Chinese relative clauses was mainly under the influence of the anti-interruption strategy and the conjoined-clause hypothesis.

Chiu (1996) tested 65 preschool children (age ranging from 3;2 to 6;1, divided into three age groups, with about 20 children in each group) on the following sentence types.[4]

(9) SS (animate)   bao   xiaozhu de   konglong qin   maomao
     (71%, 87%, 94%)   hold   piggy   COMP   dinosaur kiss   Maomao
                        'The dinosaur that held the piggy kissed Maomao.'
          (inanimate)   chi   caomei   de   konglong qin   maomao
     (83%, 86%, 89%)   eat   strawberry   COMP   dinosaur kiss   Maomao
                        'The dinosaur that ate the strawberry kissed Maomao.'

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[3] According to these two hypotheses, the subject of the relative clause will be misinterpreted as the object of the matrix verb.
[4] The numbers in parentheses under the categorization of sentence types indicate the average accuracy for each age group (from the youngest to the oldest).

SO (animate)   konglong bao de xiaozhu qin maomao
(83%, 94%, 95%)   dinosaur hold COMP piggy kiss Maomao
'The piggy that the dinosaur held kissed Maomao.'

OS (animate)   maomao qin bao xiaozhu de konglong
(41%, 84%, 83%)   Maomao kiss hold piggy COMP dinosaur
'Maomao kissed the dinosaur that held the piggy.'

(inanimate)   maomao qin le chi caomei de konglong
(59%, 82%, 93%)   Maomao kiss ASP eat strawberry COMP dinosaur
'Maomao kissed the dinosaur that ate the strawberry.'

OO (animate)   maomao qin konglong bao de xiaozhu
(64%, 71%, 65%)   Maomao kiss dinosaur hold COMP piggy
'Maomao kissed the piggy that the dinosaur held.'

(inanimate)   maomao chi le konglong na zhe de
(61%, 100%, 92%)   Maomao eat ASP dinosaur hold ASP COMP
caomei
strawberry
'Maomao ate the strawberry that the dinosaur was holding.'

SIO   milaoshu song yigen xiangjiao gei ta de
(64%, 77%, 94%)   Mickey give a.CL banana to him COMP
konglong qin le maomao
dinosaur kiss ASP Maomao
'The dinosaur that Mickey gave a banana to kissed Maomao.'

OIO   maomao qin le milaoshu song yigen xiangjiao
(38%, 53%, 72%)   Maomao kiss ASP Mickey give a.CL banana
gei ta de konglong
to him COMP dinosaur
'Maomao kissed the dinosaur that Mickey gave a banana to'

SP   xiaozhu gen ta jianghua de konglong qin
(74%, 87%, 94%)   piggy to him talk COMP dinosaur kiss
le maomao
ASP Maomao
'The dinosaur that the piggy talked to kissed Maomao.'

OP   maomao qin le xiaozhu gen ta jianghua
(45%, 58%, 60%)   Maomao kiss ASP piggy to him talk
de konglong
COMP dinosaur
'Maomao kissed the dinosaur that the piggy talked to.'

SG	xiaozhu	ti	le	ta	de	jiao	de	konglong
(68%, 84%, 94%)	piggy	kick	ASP	he	of	leg	COMP	dinosaur

	qin	le	maomao
	kiss	ASP	Maomao

'The dinosaur whose leg the piggy kicked kissed Maomao.'

OG	maomao	qin	le	xiaozhu	ti	le	ta	de	jiao
(44%, 48% 47%)	Maomao	kiss	ASP	piggy	kick	ASP	he	of	leg

	de	konglong
	COMP	dinosaur

'Maomao kissed the dinosaur whose leg the piggy kicked.'

In general, children's comprehension of relative clauses in this study was much better than Chang (1984) and Cheng (1995), perhaps due to the fact that this study took into consideration the felicitous condition, and provided children with two toys of the same type as did Hamburger and Crain (1982). Another two possible reasons contributing to the high accuracy in this study are that the matrix verb was the same across different types of sentences except for OO-inanimate, and that the argument other than the head noun modified by the relative clause was always Maomao, which resulted in the events being either "the dinosaur held the piggy" or "the dinosaur ate the strawberry" for SS, SO, OS, and OO types of relative clauses. The high predictability might have reduced the difficulty to a certain extent. Basically, the results of this study are similar to what was found in Chang (1984), Lee (1992) and Cheng (1995). That is, sentences with relative clauses as the subject of the matrix sentences are easier to comprehend than sentences with relative clauses as the object of the main verbs. As for the animacy of arguments, this study only found the effect in SS and OS types of sentences for the youngest group, and OO type of sentences for the middle as well as the oldest groups. Since Chiu (1996) did not analyze children's detailed error patterns, it is not clear whether there was any kind of strategy dominating children's interpretation of the test sentences.

From the above review of children's comprehension of relative clauses, the task employed by these studies was similar (i.e. an act out task), but the results were not always consistent. For the English studies, SS was always the easiest for children to comprehend, and the most difficult one was either SO or OS. For the Chinese studies, the only thing in common was that all the studies found the SS type of sentences to be the easiest, and the OO type to be the most difficult. As for the OS and SO types of sentences, the results from these studies did not agree with each other. In addition, the accuracy among these studies differed a lot. None of these studies included adults as control subjects, and Cheng (1995) and Chiu (1996) only had one test sentence for each type, and hence the sample might be too small. Regarding methodology, as O'Grady (1997) pointed out, an act out task might not be an ideal task for testing

comprehension of relative clauses, for even adults might only act out the part of the matrix clause, ignoring the relative clauses which presumably happened before the event in the matrix clause took place. In fact, that was how the older children responded in Hamburger and Crain (1982) for OS type and in Cheng (1995) for OS and OO types of sentences. As mentioned in Gordon (1998), compared with other tasks commonly used in comprehension studies (e.g. picture selection or act out), a truth value judgment task does not require much metalinguistic judgment and can minimize performance variables. Owing to these considerations, in the current study we will use a truth value judgment task (e.g. Crain and Thornton 1998) as a first step to examine whether the comprehension difficulty for the OO relative clauses experienced by Chinese-speaking children reflects the artifact of the act out task or a consequence of children's adopting an NVN word order strategy to interpret OO relative clauses.

3. Experiment

What we will investigate in the present study is whether the canonical NVN word order plays a role in leading Chinese-speaking children to misinterpret OO relative clauses, and if it does, whether there is any age effect. The rationale is that since the canonical word order in Chinese is SVO, but the head noun follows the relative clause, a parser may misinterpret the subject of the relative clause as the object of the matrix verb and hence be led to a garden-path effect. Besides, since children in general are not as capable of revising incorrect parsing commitments as adults (e.g. Trueswell et al. 1999), they may thus adopt a processing strategy such as NVN word order strategy to interpret complex sentences. Although part of the results from Chang (1984) and Cheng (1995) can be attributed to children's adopting NVN word order as a comprehension strategy, since the two studies used an act out task, which had no restriction on how a subject might interpret a sentence, it is not clear whether the strategy does influence children's comprehension, or if it is only an artifact of the task. Specifically, we will use a truth value judgment task in which stories with the NVN word order interpretation are incorporated into the scenarios, and then test sentences with the OO type of relative clauses are presented for subjects to make judgments regarding the truth value of the sentences.

3.1 Method

3.1.1 Participants

Thirty-one preschool children and twenty-nine adults participated in this experiment. The adult subjects were all undergraduate students at National Taiwan

Normal University in Taipei, and the child subjects were recruited either from the daycare center at National Taiwan University in Taipei (conducted in August, 2002) or Kai-Hsin Kindergarten in Hsin-chu, Taiwan (conducted in April, 2005). In order to examine whether there is any age effect in adopting the NVN word order strategy for comprehending the OO type of relative clauses, we further divided the child subjects into two age groups—the younger group (N = 15, from 4;2 to 5;5, mean age 4;9) and the older group (N = 16, from 5;6 to 6;9, mean age 5;11).[5]

3.1.2 Procedures

We tested the child and adult subjects using a truth value judgment task (Crain and Thornton 1998) which involved two experimenters—one acting out the stories using toys and props, and the other one playing the role of a puppet (in this study Big Bird) who watched the stories with the subject. At the end of each story, the puppet made a statement regarding what he thought happened in the story, and the subject had to decide whether the puppet's statement was 'true' and reward him with a bite of an ice cream, or 'wrong' and punish him with a bite of an onion. If the subjects thought the puppet's statement was wrong, they would have to provide an explanation to justify their answers.

Compared with other tasks usually used in comprehension studies (e.g. act out or picture selection), the truth value judgment task has several advantages. First, relevant contexts for the interpretations of the test sentence are provided in the form of a story. The subject's task is to judge whether or not the test sentences accurately depict the events that transpire in the story. Since the test sentences are presented to the child by a puppet, the child subject will not feel as though he is being tested. Instead, the task is designed to make it appear that the statements of a puppet are under investigation. When a test sentence is ambiguous, only one of its interpretations is made true in the context. The sentences are usually false in the interpretation that adults assign to them. Therefore, if children consistently judge the sentences to be false, then we are confident that they assign them the same unique interpretation as adults do. However, if children accept the test sentences, then this is taken to be evidence that children allow an interpretation that is not available to adults. In this way, the task lets us see whether children allow more readings for the test sentences than adults do. In other words, it permits us to investigate whether child subjects interpret unambiguous

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[5] One of the reviewers commented that the child subjects in the current study only covered a small age range. However, the age range (i.e. 4;2 to 6;9) of our child subjects was in fact larger than Sheldon (1974) (3;8 to 5;5), Tavakolian (1978) (3;0 to 5;6), and Goodluck and Tavakolian (1982) (4-5 years old), and comparable to Cheng (1995) (3;4 to 6;3) and Chiu (1996) (3;2 to 6;1). What is more important regarding the two age groups is that they demonstrated different patterns of results, and so to include children older than 6;9 or younger than 4;2 would still show that younger children made more errors in comprehending Chinese OO relative clauses.

sentences as ambiguous, i.e. whether the relevant semantic constraint exists in subjects' mental grammar or not. Finally, when subjects judge a sentence to be false given the context, they are asked to give an explanation regarding what really happens in the story. This provides evidence for the basis of the child's decision, so we can ensure the judgment is based on relevant events that take place in the story, and is not due to lack of attention or a bias to reward or punish the puppet.

The child subjects were tested individually in a quiet room in the daycare center. Children who were too shy to communicate with the experimenters or gave incorrect answers to the two practice stories did not complete the whole session. The adult subjects were shown a videotaped version of all the stories witnessed by the children and were given an answer sheet to indicate, for each story, whether they thought the puppet's statement was right or wrong and also to provide a justification for the answer.

3.1.3 Materials

The experiment included eight trials administered in a pseudo-random order—two practice trials, three experimental trials, and three filler trials that were items from an unrelated experiment.[6] The practice trials were made obviously false in the context of the stories so that the subjects knew the puppet could say something wrong, and only those children who correctly rejected at least one of the two practice trials and could correctly justify their answers were included in the data analysis.

Since in this experiment we were interested in scrutinizing the effect of the NVN word order strategy in children's relative clause interpretation, we incorporated the interpretation into the scenarios as the actual outcomes of the stories. Take the sentence in (10) as an example.

(10) nanhai qi   le   papaxiong zhaodao de   yazi
      boy   ride ASP   panda   find   COMP   duck
      'The boy rode the duck that the panda found.'

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[6] The three filler sentences were from another experiment examining Chinese-speaking adults and children's interpretations of ambiguous sentences with negation and a numerally quantified noun phrase (QNP) like *xiaojie meiyou mai liang-ding maozi* 'The lady didn't buy two hats.' In these stories, the main character was originally thinking about doing something to the four objects or animals, but later due to some reason, he/she only did the intended action to two of the objects / animals. Since the sentence was ambiguous, the answer could be either Yes (if the subject has access to the QNP wide scope reading) or No (if the subject only allows the QNP narrow scope reading). One of the anonymous reviewers suggested that since the correct answer for the practice trials was No, children might choose to say No when they had trouble understanding the sentences. This is not a problem for any study using a truth value judgment task, as whenever a subject rejects the test sentence, he/she has to provide an explanation to justify the answer, otherwise the data will not be included for analysis.

Since the canonical word order is SVO, but relative clauses precede the modified head noun in Mandarin Chinese, the subject in the OO type of relative clause follows the matrix verb. Therefore, according to the NVN word order strategy, the subject of the relative clause may be wrongly interpreted as the object of the matrix verb, and thus the sentence in (10) may be comprehended as the boy rode the panda, and the panda found the duck. That is to say, the original OO type of sentences may be interpreted into two parts, with the argument noun phrase preceding each verb as the agent, and the noun phrase following the verb as the theme. In the story corresponding to the sentence in (10), a panda plays hide-and-seek with two ducks—a big one and a little one, and finds the little duck that hides itself behind a tree. A boy then comes to the playground, and would like to ride the little duck because it looks cute. The little duck begs the boy not to ride it for it is still too tiny to carry the boy. At that moment, the big duck comes out to suggest the boy ride it, and the panda also asks the boy to ride it. At the end of the story, the boy rides both the big duck and the panda. Figure 1 illustrates the scenario of the sample story.

1. A panda is playing hide-and-seek with two ducks — a big one and a little one.	2. After the ducks hide themselves, the panda says "There must be someone hiding behind the tree."
3. The panda finds the little duck, and brings it to the playground.	4. A boy comes to the playground, and would like to ride the little duck. The little duck begs the boy not to ride it for it is still too tiny to carry the boy.

5. The panda suggests the boy should ride it, so the boy rides the panda.

6. The boy also rides the big duck when it comes out to the playground.
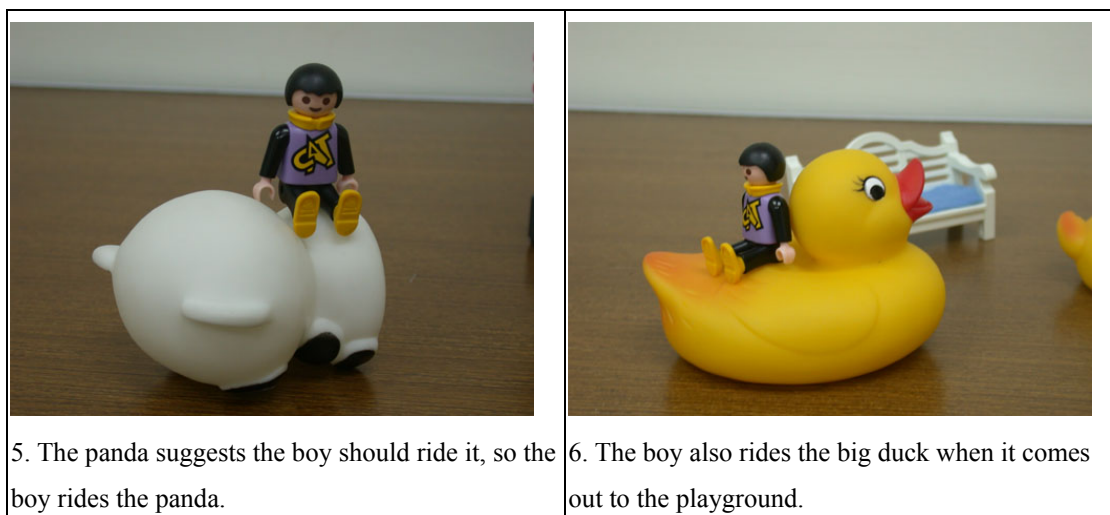
Figure 1. The scenario of the sample story

Note that in the story, the boy rides the panda and the panda finds a duck, but the duck that is ridden by the boy (i.e. the big one) is not the one found by the panda (i.e. the little one), and hence according to the correct interpretation of the sentence, subjects should reject the sentence as a description of the scenario. However, if subjects interpret the sentence using the NVN word order strategy, they may accept the sentence. The three test sentences and the two practice trials are presented in Table 1.

Table 1. Test and practice trials in the experiment

Test Trials

1. xiao xiong Weini daizou wupo bao guo de xiao gou
   little bear Winnie take witch hold ASP COMP little dog
   'Winnie the Pooh took the dog that the witch held.'

2. chuanzhang wei le Hamutailang zhui guo de mao
   captain feed ASP Hamutailang chase ASP COMP cat
   'The captain fed the cat that Hamutailang chased.'

3. nanhai qi le papaxiong zhaodao de yazi
   boy ride ASP panda find COMP duck
   'The boy rode the duck that the panda found.'

Practice Trials

1. tuzi meiyou chi xigua
   rabbit did.not eat watermelon
   'The rabbit did not eat the watermelon.'

2. xiaojie mai le quanbu de maozi
   lady buy ASP all of hat
   'The lady bought all of the hats.'

3.1.4 Results

The dependent measure used in the current study was the proportion of NO responses to the puppet's statements. The adult subjects rejected the test sentences 92% of the time (80 out of 87 trials), and children in the older group 94% of the time (45 out of 48 trials), whereas children in the younger group rejected puppet's statements only 67% of the time (30 out of 45 trials).[7] The difference between the rejection rate from adults and children in the older group was not significant, but the difference between children in the older group versus the younger group was significant, $t(29) = 2.685$, $p < 0.02$ (Figure 2).
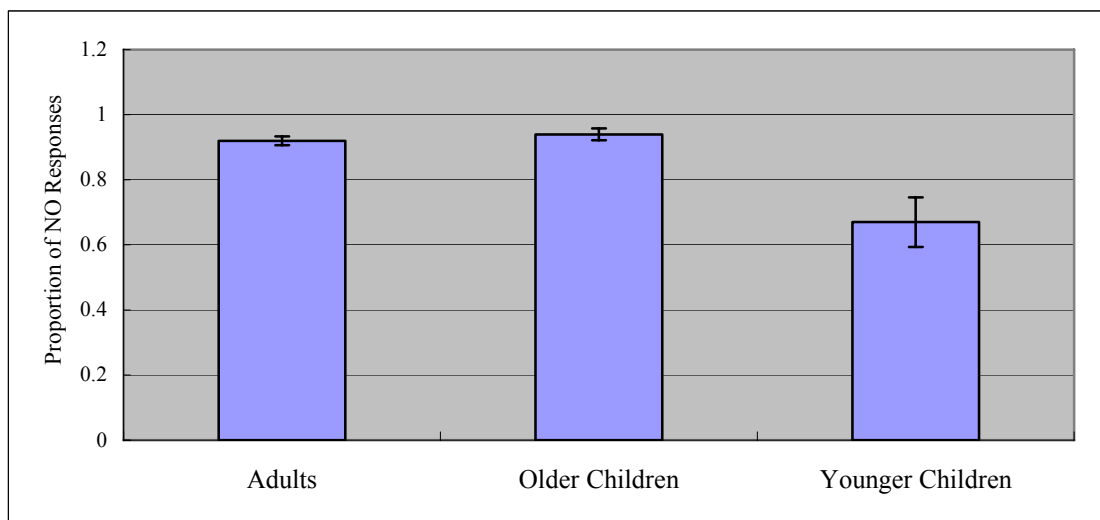
Figure 2. Proportion of NO responses to test trials for adults and the two groups of children

Among the adults, 24 out of the 29 subjects rejected all the three test sentences, and the other four subjects rejected two of the test sentences. Only one adult subject accepted all the three test sentences. For children in the older group, 14 out of the 16 children rejected all the three test sentences. One child rejected two of the statements, and the other one rejected one of the three test sentences. As for children in the

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[7] One of the reviewers considered the performance of the 4-year-old group (i.e. 67% accuracy) in this study to be comparable to Chiu's (1996) study, and suggested that very young children may not benefit from the truth value judgment task. However, as pointed out in our review, the high predictability of the events used in Chiu (1996) can be the reason why the accuracy in Chiu's (1996) study is higher than other studies (e.g. the accuracy for OO relative clauses was only 3% in Cheng 1995). In addition, in Chiu (1996), the accuracy of even the oldest group was only 65%, but in the current study older children correctly rejected the test sentences 94% of the time. The age effect was not observed by any previous studies that used an act-out task. The reason why younger children did not perform like adults was because they were led to a garden path when examining the sentence and the scenario of the story (i.e. the subject NP of the relative clause was indeed affected by the matrix verb), not because of the task. In another experiment we are currently conducting, even the younger group correctly rejected the test sentences when the subject NP of the relative clause was not affected by the matrix verb in the scenario of the stories.

younger group, 7 out of the 15 subjects rejected all the three test sentences, and 2 children rejected two of the trials. Five children in this group rejected only one of the test sentences, and the other one accepted all the three sentences. The reasons children and adults provided when rejecting the puppet's statements were either that the boy did not ride the little duck, the panda found the little duck, or that the boy rode the big duck (not the little duck). Among the children who wrongly accepted the test sentences, we further asked four of them which duck the panda found, and they could correctly point to the little duck as the answer to our question. Although we did not ask all the subjects the follow-up questions, the fact that these four children could provide correct answers to these follow-up questions suggested that at least some children who wrongly accepted the test sentences nevertheless could construct the right structure for relative clauses.

4. General discussion and conclusion

4.1 General discussion

The results of this experiment demonstrate that indeed Chinese-speaking children may adopt the NVN word order strategy to comprehend the OO type of relative clause and hence misinterpret the sentences, but the effect is mainly observable in younger children (especially 4-year-old children). Since the task used in this study (i.e. a truth value judgment task) requires less processing load than other comprehension tasks, the finding cannot be simply attributed to methodological artifacts. On the other hand, the fact that children as young as 2 years old can produce relative clauses in their spontaneous speech (Tse et al. 1991), and that 4 to 5 year-old Chinese-speaking children use gaps and resumptive pronouns in a way similar to adults (Su 2004) suggest that relevant structures and constraints governing the production of relative clauses are operative in children's mental grammar. In the rest of this section, we will argue that the non-adult interpretation found in the younger group of children does not result from any non-adultlike grammatical representation of the sentences,[8] but a garden-path effect similar to the patterns found among adults in on-line sentence processing experiments (e.g. Xiang et al. 2003). In addition, younger children have more difficulty reanalyzing their initial parsing commitments than adults or older children do (e.g. Trueswell et al. 1999 and Lidz and Musolino 2002), and hence adopt

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[8] One of the reviewers pointed out that children's accepting the test sentences does not necessarily mean they allow an interpretation that is not available to adults, especially considering that they can articulate relative clauses around two years old. This is exactly what I am trying to say in this study. The comprehension errors made by the younger children result from the garden path effect of interpreting the subject of the relative clause as the object of the matrix verb and their difficulty of revising an incorrect initial parsing, not any kind of non-adult structural representations for relative clauses.

a strategy to accommodate their parsing difficulty.

As mentioned earlier, since the canonical word order in Chinese is SVO, but a relative clause precedes the head noun it modifies, it is likely that when an object-extracted relative clause appears in the object position of the matrix verb, the subject NP of the relative clause may be initially misinterpreted as the object of the matrix verb. Although normal Chinese-speaking adults do not experience obvious garden-path effects in reading or hearing this type of sentences, the experimental results from Xiang et al. (2003) showed that in a self-paced reading task, this was exactly what happened. In the first experiment reported in Xiang et al. (2003), four types of sentences as shown in (11) were used to probe the incremental processing and interpretation by Chinese-speaking adults.

(11) a. shengzhang   BA   [shizhang   kuajiang   le   yifan   *t*   DE   jingli]
         governor   BA   mayor   compliment   ASP   once   DE   manager
         dama   le   yidun…
         scold ASP   once
         'The governor scolded the manager that the mayor complimented.'

   b. shengzhang   dama   le   yidun   [shizhang   kuajiang   le   yifan   *t*
       governor   scold ASP   once   mayor   compliment   ASP   once
       DE   jingli]…
       DE   manager
       'The governor scolded the manager that the mayor complimented.'

   c. shengzhang   BA   [shizhang   xihuan   *t*   DE   jingli]   dama   le
       governor   BA   mayor   like   DE   manager   scold ASP
       yidun
       once
       'The governor scolded the manager that the mayor liked.'

   d. shengzhang   dama   le   yidun   [shizhang   xihuan   *t*   DE   jingli]
       governor   scold ASP   once   mayor   like   DE   manager
       'The governor scolded the manager that the mayor liked.'

For (11a), the first four words form a potential clause, but the next word *DE*, as a relative clause marker, clearly shows the earlier clausal parsing is wrong, and reanalysis is required. In (11b), the first three words are a potential clause, and the next word (i.e. the verb *kuajiang* 'compliment') disambiguates it. Sentences in (11c) and (11d) are similar to (11a) and (11b) respectively, but the verb is changed from an eventive to a stative. The results showed that reading times at and beyond the verbs *kuajiang* 'compliment' and *xihuan* 'like' were longer in (11b) and (11d) than in (11a) and (11c), suggesting that at this region readers encountered some processing difficulty for the non-BA conditions in (11b) and (11d), compared to the BA

conditions in (11a) and (11c). The finding from Xiang et al. (2003) demonstrates typical garden-path effects in Chinese, and shows that subjects form a syntactic representation of a clause as soon as possible when they see a DP_1 V DP_2 or a DP_1 BA DP_2 V string. A garden path difficulty arises when more information comes in and the second DP has to be reanalyzed as the subject of a relative clause as in (11b) and (11d). Therefore, Chinese-speaking children as well as adults experience processing difficulty in interpreting OO relative clauses. Next we turn to the differences in ability to revise incorrect initial parsing between children and adults.

Trueswell et al. (1999) examined children's moment-by-moment language processing abilities by using a head-mounted eye-tracking system, which monitored eye movements as participants responded to spoken instructions. Sentences similar to the ones in (12) were used to inspect whether children coordinated multiple sources of information to interpret temporarily ambiguous sentences.

(12) a. Put the frog on the napkin in the box.   (Ambiguous)
     b. Put the frog that's on the napkin in the box.   (Unambiguous)

For (12a), the prepositional phrase *on the napkin* is temporarily ambiguous for it can indicate the Destination or be a Modifier for the preceding NP *the frog*. The sentence is disambiguated when the subject hears the following PP *in the box*. Each test sentence was presented in one of two visual contexts. One context supported the Modifier interpretation, consisting of two frogs, one of which was on a napkin, an empty napkin, and an empty box (2-referent context). The other context supported the Destination interpretation and consisted of the same scene except that the second frog was replaced with another animal such as a horse (1-referent context). The rationale was that according to the Referential Principle (Crain and Steedman 1985), upon hearing *the frog*, the subject would not know which one was being referred to in the 2-referent context, and hence should interpret the phrase *on the napkin* as a Modifier. In the 1-referent context, since there was only one frog, modification of *the frog* with *on the napkin* would be unnecessary, and hence the Destination interpretation would be assigned to the first PP. The results of this study showed that 5-year-olds were more likely to look at the incorrect destination (i.e. the empty napkin) during the ambiguous trials (70%) than during the unambiguous trials (30%), regardless of referential contexts. In addition, 5-year-olds were often unable to recover from their initial misinterpretation, resulting in actions consistent with the Destination interpretation of the ambiguous phrase (60% vs. unambiguous sentences 3%). The authors therefore concluded that unlike adults, 5-year-old children did not take into account relevant discourse principles when resolving temporary syntactic ambiguities, and showed little ability to revise initial parsing commitments.

Another study with bearing on the difference in computational resources between

children and adults is Lidz and Musolinao (2002), which examined how children and adult speakers of English and Kannada interpret scopally ambiguous sentences containing numerally quantified noun phrases and negation as shown below.

(13) a. The caveman didn't ride two horses.
    b. Anoop   eradu   kaaru   toley-al-illa
       Anoop   two   car   wash.INF.NEG
       'Anoop didn't wash two cars.'

In both English and Kannada, the numerally quantified noun phrases in (13) can take either a wide scope reading or a narrow scope reading. For (13a), the wide scope reading corresponds to a situation in which there exist two horses that the caveman does not ride, and the narrow scope reading can be paraphrased as 'It is not the case that the caveman ride two horses.' The results of this study showed that while English- and Kannada-speaking adults could easily access either scope interpretation, 4-year-old children displayed a strong preference for the narrow scope reading. For English, they further tested a group of 5-year-old children on the wide scope interpretation, and found that 5-year-olds accepted this reading significantly more often than 4-year-olds (79% vs. 33%). No significant differences were found between the acceptance rates from 5-year-olds and adults on this interpretation. The findings of Lidz and Musolino (2002) suggest that being able to entertain two possible interpretations for a given sentence requires a larger computational cost, which is what younger children lack. Since to maintain both possible structures for a temporarily ambiguous phrase also consumes more processing resources, this can result in younger children's difficulty in revising their initial incorrect interpretation as found in Trueswell et al. (1999) and our experiment.

    Another piece of evidence for our account comes from two experiments we are currently conducting. In one of the experiments, the conjoined-clause interpretation is incorporated into the scenarios of the stories. Take the sentence *nanhai qi le papaxiong zhaodao de yazi* 'The boy rode the duck that the panda found' as an example. In the story presented to subjects, the boy rode the panda and found a duck (i.e. the big buck), but the boy did not ride the duck that the panda found (i.e. the little duck). The preliminary results showed that among the 23 Chinese-speaking children (4;1 to 5;7, mean age 5;2), they rejected the sentences given the scenarios of the stories 74% of the time, which is significantly different from adults' 93% rejection rate (t(36) = 2.197, $p < 0.05$). In another experiment, we designed the scenarios of the stories in such a way that the subject NP of the relative clause was not affected by the matrix verb. That is to say, for the above test sentence, the panda found the little duck, and the boy rode the big duck, but the boy did not ride the panda or the little duck. The fifteen children who participated in the experiment (4;8 to 6;5, mean age 5;3)

correctly rejected the test sentences 93% of the time,[9] which did not differ significantly from adults' 98% rejection rate ($p > 0.05$).[10] The results of these experiments with different scenarios demonstrate that when children examine the test sentences and the scenarios of the stories, they are led to an incorrect interpretation when the subject NP of the relative clause is affected by the matrix verb. That is to say, when the subject NP is wrongly taken to be the object of the matrix verb, children will hence provide a non-adult answer to the test sentences. The fact that younger children accepted the scenarios with NVN word order strategy and the conjoined-clause strategy suggested that these children stuck to their initial parsing, and took either the subject of the matrix verb or the subject NP of the relative clause to be the agent of the second verb. This is similar to Trueswell et al. (1999), in which the incorrect actions of 5-year-old children can be categorized into four classes—(1) to ignore the second PP; (2) to put one of the animals first on the incorrect destination and then into the correct destination; (3) to place one animal on the incorrect destination and the other animal into the correct destination; and (4) to move the other animal into the correct destination. All the errors showed that these children had misinterpreted the first PP as the destination and used other strategies for accommodation when they failed to reanalyze the initial parsing.

4.2 Concluding remarks

This study takes as a first step, using a task that minimizes processing load (i.e. a truth value judgment task), to investigate whether Chinese-speaking children adopt an NVN word order strategy to comprehend an OO relative clause. The results show that while adults and older children's patterns are alike in correctly interpreting the test sentences, younger children do allow an interpretation based upon NVN word order strategy. Since children at this age produce Chinese relative clauses with characteristics similar to adults, the non-adult performance in comprehension is hence taken to reflect the difficulty of reanalyzing the sentences when they are led into a garden path, similar to the patterns found among adults in on-line sentence processing experiments. The discrepancy between children in the two age groups suggests that for younger children whose computational resources may be more restricted, the NVN

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[9] One of the anonymous reviewers commented that when using a truth value judgment task, it was difficult to rule out other possible accounts if the child failed to provide expected responses. The different patterns of responses from children in this experiment clearly demonstrate the advantage of the truth value judgment task over other tasks. That is, with careful design of experiments, one can tear apart the influence of various factors on children's responses.

[10] We are still testing more children for these two experiments. In addition, we are also conducting an experiment with the conjoined-clause interpretation in the scenarios of the stories, but add the passive morpheme BEI in between the matrix verb and the subject NP of the relative clauses to see whether children will still give non-adult responses when the subject NP's of the relative clauses are not adjacent to the matrix verb.

word order strategy may be used to accommodate their difficulties in reanalyzing the incorrect initial parsing. Further research with a task like the one used in the current study will be needed to examine whether other strategies reported in previous studies (e.g. the conjoined-clause hypothesis) indeed reflect how children interpret the OS or SO types of relative clauses, rather than a methodological artifact.

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詞序效應對兒童中文關係子句理解的影響

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　　本研究探討是否習得國語為母語的兒童運用「名詞─動詞─名詞」的詞序策略來理解 OO 類的關係子句。真假值判斷實驗的結果顯示年齡較大的兒童（平均 5 歲 11 個月）理解測驗句之正確率為 93%，而年齡較小的兒童（平均 4 歲 9 個月）有 46%會誤將關係子句的主語理解為主要動詞的賓語，且兩組兒童之間的差異顯著(t(29) = 2.685, $p <$ 0.02)。由於習得國語為母語的兒童 3、4 歲時已能正確使用關係子句（Su 2004），本研究中年齡較小之兒童的理解錯誤應視為反映出兒童在理解上需要重新分析句子結構時的困難，與成人在語句理解的電腦連線實驗中的表現模式類似。

關鍵字：國語、關係子句、理解、母語習得