Domain Restriction in Child Mandarin

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Abstract This study investigated four to five year old Mandarin speaking children's acquisition of the distributive operator/universal quantifier *dou* (roughly correspond to *all* in English). We are concerned that whether children's problem of quantifier interpretation, namely quantifier spreading, is because of their incompetence with distributive computation, or because of different strategies of domain restriction. The two experiments we presented were designed from a perspective of domain selection, in conditions where there are two potential candidates for the domain of a distributive operator. In the first experiment, we investigated whether adults and children are capable of selecting the proper restrictor from two candidates that occurred to *dou*'s left; in the second experiment, we looked at subjects' selection of NPs as the restrictors when the two NPs are separated into both sides of *dou*. We found that four to five year old children are capable of distributive computation, but because they are flexible in domain restriction, they may choose different candidates for the domain of distributive operators than adults. As a result, they display non-adult interpretations toward sentences with distributive operators.

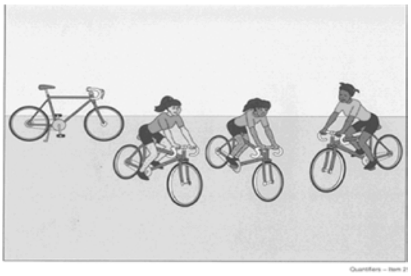
Key words: language acquisition, distributive operator, universal quantifier, domain restriction, Mandarin Chinese,

Introduction

In this article we investigate four to five year old child's acquisition of distributive operator *dou* (roughly correspond to *all* in English) in Mandarin Chinese. We are concerned with children's knowledge of the constraints involved in interpretation of sentences containing *dou*. *Dou* is normally considered as a distributive operator or a universal quantifier (Cheng, 1995; Lee, 1986; Lin, 1996, 1998). Lin's 1996 dissertation and his paper published in *Natural Language Semantics* are first serious works about *dou*-distributivity under the framework of formal semantics. We adopt the idea that *dou* is a generalized distributive operator from Lin (1996, 1998)(also see Schwarzschild, 1996 for more discussion on generalized distributive operator). We will go to some details of Lin's approach in the following paragraphs.

The phenomenon we are particularly interested in is called *quantifier spreading* (Roeper & de Villiers, 1991), or *the symmetrical response* (Crain et al., 1996; Philip, 1995, 2011) or *exhaustive pairing* (Drozd, 2001), which is a problem children encounter when interpret sentences containing distributive operators or universal quantifiers. In English, the frequently used test sentence is shown in sentence (1):

Figure 1: An example of quantifier spreading (from Seymour Roeper & de Villiers, 2000).



(1) Is every girl riding a bike?
Children: No, not this bike (pointing to the unoccupied bike).

Given Figure 1, children even up to 6 or 7 years old rejected the test sentence, by pointing to the extra bike and provided a reason like "no, not this bike". On the contrary, as is expected, adults accepted the test sentence because the test sentence said nothing about the extra bike. The problem, quantifier spreading, leads to a question that is appealing to many researchers: Are 4-5 year old children competent with universal quantification/ distributive computation?

Researchers proposed several linguistic explanations to quantifier spreading. For example, Philip (1995) systematically tested sentences including *every* in English, and drew a conclusion that children's non-adult behavior is due to their different preference in processing *every*-sentences. Specifically speaking, for children, universal quantifiers such as *every* quantify over event variables rather than quantify over individual objects as adults do.

However, Crain et al. (1996) argued that children's rejection to the test sentences just mentioned does not necessarily denote that children are incompetent with universal quantification. Crain et al. claimed that the flaw in experimental design was the reason of children's poor performance in Philip (1995). With flawed design being corrected, children made much less quantificational mistakes. So in Crain and colleagues' opinion, four year old children have full grammatical competence with universal quantification.

Further, some researchers found the difference between two sorts of quantifiers, and children may have problems with the former sort while not with the latter. Brooks & Braine (1996) observed that English speaking children rarely made mistakes when interpreted sentences with universal quantifier *all*, but performed poorly when they came to sentences with distributive quantifier *each*. Then, in Drozd (2001) and Geurts (2003), weak and strong quantifiers were distinguished in order to account for children's failure on distributive computation. Weak quantifiers could draw out both distributive interpretation and non-distributive interpretation, but strong quantifiers could only draw out distributive interpretation. Children made few mistakes when dealing with weak quantifiers, but errors significantly increased with regard to strong quantifiers.

We have the following two hypotheses based on our review of the literatures:

1. Children are competent with universal quantification (Crain, et al., 1996) .
2. There may be some reasons that can account for children’s failure when interpret

sentences with distributive operator *each* and *every* (Geurts, 2003). For example, children might be different from adults in domain selection strategies.

We would like to report results from two experiments to verify these two hypotheses. We chose *dou* to verify our ideas because for Mandarin, *dou* roughly corresponds to *all*/*every* in English. It is traditionally taken as a universal quantifier (Cheng, 1995; Lee, 1986) or a floating quantifier (Chiu, 1993). But currently, Lin (1996, 1998) developed a formal theory of distributivity based on the semantic characters of *dou*. According to Lin (1996), *dou* as a generalized distributive operator[1](henceforth generalized D-operator) differs from a universal quantifier in that it distributes over a set of members rather than quantifies over variables. The difference between a generalized distributive operator and a universal quantifier is not crucial to our study, so we would not distinguish the two terms in this paper, although the fact that *dou* can only distribute over one plural NP (its restrictor) rather than quantify over all variables in its scope is explored in this study.

Dou as a generalized distributive operator carries universal force, and introduces a tripartite structure, including the restrictor, the operator and the nuclear scope (Heim, 1982; Lin, 1998). For example, *dou* in sentence (2) draws forth a tripartite structure as shown in (3). *Dou* distributes the property represented by the VP over every member of the restrictor. In the case of sentence (2), suppose that there are three tortoises in the context, each of the tortoises should have the property of planting orchids for them.

(2) Wugui dou zhong-le lanhua.
tortoise all plant-ASP orchid
'The tortoises all planted (a) orchid(s).'

(3) tortoise dou plant orchids
[restrictor] D-operator [nuclear scope/property]

But it could become much more complicated when there are two potential restrictors within the scope of *dou*. Children and adults' selection between two potential restrictors was investigated in this study and sentence (4) and (5) are the samples of target sentences in these two experiments.

(4) Exp. 1: Xiongmao zai laoying pangbian *dou* zhong-le lanhua
Panda at eagle side *all* plant-ASP orchid
a. selecting *panda* as the restrictor:
'All of the pandas planted an orchid at the sides of the mice.'
b. selecting *eagle* as the restrictor:
'Besides both mice there is an orchid which is planted by the pandas.'

[1] Lin (1998) is based on Schwarzschild (1996), if you are interested in the framework of generalized distributive operator, please referred to Schwarzschild (1996).

(5) Exp. 2: Xiaodongwu-men *dou* reng-diao-le dianshi, chuang, he bingxiang.
animal-PLU *all* chunk-away-ASP TV, bed and fridge

a. If *dou* selects *animals* as the restrictor, it derives a meaning as:
'All of the animals chunked away a TV, a bed and a fridge.'

b. If *dou* selects the complex plural NP *TV, bed and fridge* as the restrictor:
'The TV, the bed and the fridge are all chunked away by the animals.'

With regard to sentence (4), Cheng (1995) argued that because of the Principle of Economy of Derivation (Chomsky, 1991), *dou* should quantify over the closest plural NP only (*making the shortest move* in Cheng's term), i.e. *dou* could only distribute over the NP *laoying* "eagle" in sentence (4), obtaining a meaning that at the side of every eagle there is an orchid planted by pandas. As a result, the interpretation as shown in (4b) is an available interpretation of sentence (4) while (4a) is not. The interpretation shown in (4a) is derived when *dou* distributes over the NP *xiongmao* "panda" which stays farther from *dou*.

In sentence (5), *dou* can only distribute over *xiaodongwu-men*, which is within the scope of *dou*. This is because of the Leftness condition of *dou* quantification suggested by Lee (1986) and Li (1995) that *dou* can only quantify over a plural NP to its left. Therefore, according to the Leftness condition, *dou* in sentence (5) should quantify over the NP *xiaodongwumen* "animals" which is to its left, rather than the compound NP *dianshi, chuang, he bingxiang* "TV, bed and fridge" which is to its right. If *dou* quantifies over *xiaodongwumen* "animals", the corresponding logical form would be that shown in (5a'), which means "x is an animal, for every x, x throw away the TV, bed and fridge". However, if we do not comply with the Leftness condition and therefore allow *dou* to quantify over a NP to its right, taking the compound NP *dianshi, chuang, he bingxiang* "TV, bed and fridge" as the restrictor in the case of sentence (5), the meaning as shown in (5b') could be derived, which means "x is a TV or a bed or a fridge, for every x, animals throw away x". In this case, *dou* distributes the property *animals throw away something* to every member of the restrictor *TV, bed and fridge*.

(5) a'. $\forall x\ [x \in [[\text{animal}]] \rightarrow \text{x throw away the TV, bed and fridge}]$

b'. $\forall x\ [x \in [[\text{TV, bed and fridge}]] \rightarrow \text{animals throw away x}]$

In the rest part of the paper, we will present data collected from two experiments and their pretests to answer these two questions: (i) Are children competent with universal quantification, and (ii) Are there some reasons that can account for children’s failure when interpret sentences with distributive operator *each* and *every.*

Pretests and two previous studies

The pretests were conducted to explore the first question and two experiments were designed to investigate the second one. We also want to finger out the exact reason that leads to children's failure in distributive computation.

Both of our two experiments have pretests, and we would like to show the pretests together to get a preliminary conclusion of children's knowledge of distributive operator *dou*.

As you can see in Table 1, there are four items in the first experiment and one in the second experiment. The pretests served both as preliminary tests on children's knowledge of *dou* and as practices for participants to familiarize the tasks of the experiments. Subjects are expected to correctly give the answers and adjust to the task during the pretests. For example, the experimenter should assure that subjects are engaged in the experiments, or are not too shy to give their judgments, and do not have other problems which prevented them from giving their genuine ideas and judgments, such as the yes-bias problem. Otherwise, they should be excluded from the following experiments. A typical example of sentences and corresponding pictures used in the pretests is shown as in sentence (6) and Figure 2.

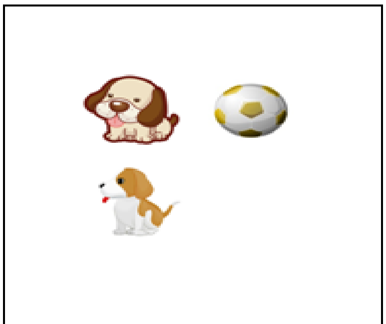
Table 1: The pretests of the two experiments

Functions	**Pretests in Exp. 1**	**Pretests in Exp. 2**
Verifying children's knowledge of *dou*	Pretest 1 and 3 (Without and with *dou*)	Pretest 1 (With *dou*)
Practice	Pretest 2 and 4	None

The pretests used to test children's knowledge of *dou* included the sentences with *dou* and those without *dou*. This allows us to clearly identify children's interpretation of *dou* by comparing their responses to these two types of sentences. The first experiment contains pretests of both types, while the second experiment only contains the sentences with *dou*.

Chinese does not have plural suffix as in English, so xiaogou "dog" in sentence (6a) could either refer to a single dog or many dogs. However, when the NP is quantified by *dou* as in sentence (6b), it must refer to all the dogs in the context, that is, the two dogs in Figure 2.

Figure 2: an example of pretests in two experiments.



(6) a. Without *dou*: Xiaogou zhaodao-le zuqiu.
dog find-ASP football
'Dog(s) found (a) football(s).'

b. With *dou*: Xiaogou dou zhaodao-le zuqiu.
dog *dou* found-ASP football
'Dogs all found (a) football(s).'

Results of the pretests showed that 4 year old children accepted the sentences without *dou* 91.7% of the time, while they accepted the sentences with *dou* extremely low to 0% of the time[2]. This is similar to adults, who accepted the statements without *dou* up to 87%, and accepted those with *dou* by 0%. The results invite us to conclude that four to five year old children know that *dou* is a universal quantifier or a distributive operator taking universal force.

In addition, in the literature there are at least two studies tested children's knowledge of *dou*. Zhou & Crain (2011) found that 4-5 year old children have the knowledge of *dou*'s universal quantification over wh-phrases. The experimenter told subjects a story in which all of the three dogs in the context have climbed up a small tree, but only one of them have climbed up a big three. Then either a statement (7a, for example) or a question (as shown in 7b) was presented, asking the subjects to judge whether it is true or false according to the story if it is a statement, while provide an answer if it is a question. The intonation effect on subjects' judgment was controlled by producing these two groups of target sentences in the same intonation pattern. Children, like adults, rejected sentence (7a) 95% of the time, and they provided correct answers such as "Tow dogs didn't" to (7b) 96% of the time. It seems that they knew that *dou* is a universal quantifier which could quantify over wh-phrases, resulting in a exhaustive interpretation of wh-phrases. Therefore, when *dou* is absent, they identified the sentence correctly as a question rather than a statement.

(7) a. shei dou meiyou pa-shang dashu.
who all not climb-up big tree
'Everyone didn't climb up the big tree.'
b. shei meiyou pa-shang dashu?
who not climb-up big tree

Another study was carried out in Lee (1986). Lee found that children as young as four to five year old knew the meaning of the sentences containing *dou*-quantification as shown in (8), by choosing the picture in the underside of Figure 3 91% of the time. It was a right choice since all of the pandas in this underside of the picture slept, while this is not the case in the upside picture.

Figure 3: Test children's understanding of *dou*, an example from Lee (1986)

(8) Test sentence: Xiongmao *dou* shuijiao le.
Panda *all* sleep Particle
'Pandas all fell into sleep.'

Task: Picture identification.

[2] The subjects in the first experiment are 25 children (mean age 4;10) and 41 adults, and those in Exp.2 are 12 children (mean age 4; 11) and 18 adults.

In summary, the results revealed in Zhou & Crain (2011) and Lee (1986) are in accordance to those of our pretests. So it is safe for us to say that four to five year old children do not have any problem with the core operation in *dou* quantification or distributive computation: they have the knowledge that dou distributes the property denoted by a VP to every member of its restrictor. Therefore, we have answered our first question about children's competence toward universal quantification or distributive computation. However, the target sentences used in the tests just mentioned are very simple, since there is only one prominent plural NP as the candidate for the domain of *dou*. In our experiments, we want to see whether children interprete the sentences like adults when there are two potential restrictors available to *dou*.

Experiments:

We would like to present data from two experiments to answer our second question: what are the reasons which could explain children's failure in distributive computation in some conditions? Both of the two experiments have two candidates for *dou* to be selected as the restrictor of *dou*.

Experiment 1:
Purpose:

This experiment is dedicated to explore children's selection of restrictor when there are two NPs available for the restrictor of *dou*. These two NPs are occurred to *dou*'s left.

Method and Procedure:

For children, we use a variant of Truth Value Judgment Task (Crain & Thornton, 1998). The task involved two experimenters. One acted out stories using pictures, and the other played the role of a puppet who watched the stories alongside the participant. After each the story, the puppet attempted to tell the participant what he thought had happened in the story using a test sentence. Participants' task was to judge whether or not the puppet was correct. For adults, we use a questionnaire that includes the same materials.

Participants:

Twenty-five monolingual Mandarin-speaking children (mean age: 4; 10; range from 4; 01 to 5; 03) participated in this experiment. They were recruited from the kindergarten at Beijing Language and Culture University. In addition, forty-one adults who were recruited from Beijing Normal University participated in the experiment as controls. The data of one child subject and five adults were deleted because they made two or more mistakes in filler items.

Materials:

The current experiment includes twelve target trials and twelve fillers. A typical test sentence is given in (9), in which there are two NPs to the left side of *dou*: *wugui* 'tortoise' and *laoying* 'eagle'[3]. Both of the NPs can be the restrictor of *dou*. The test sentence was presented following either a scenario in Figure 4 (condition 1, corresponding to the reading in which *dou* distributes over *laoying* 'eagle') or a scenario in Figure 5 (condition 2, corresponding to the reading in which *dou* quantifies over *wugui* 'tortoise').

(9) Wugui zai laoying pangbian *dou* zhong-le lanhua.
tortoise at eagle side *dou* plant-ASP orchid
'The tortoise(s) at the eagle(s) side all plant orchid(s).

condition 1

Figure 4:

condition 2

Figure 5:

The story presented to the subjects describing Figure 4 is as follows:
Here are two tortoises and two eagles. The tortoises want to plant orchids beside the eagles. Look, at the side of this eagle (pointing to one of the eagle) there is an orchid. Who planted it? It is this tortoise or that tortoise (pointing to the tortoises)? Yes, it is the left tortoise that planted it. What about the other orchid. Hmm, it is also planted by the left tortoise. You see, the right tortoise (pointing to the tortoise on the right side) didn't plant any orchid.

A similar story was presented when the subjects were shown Figure 5.

Note that in the test sentences, in order that children's interpretations would not be influenced by the emphasis pattern, we put focused on *dou*, and leave the two NPs equally un-emphasized.

Because we found the task may be a little difficult for some children, we divided the materials into two groups. Since one child had been excluded from the experiment, the rest 24 children were divided into two groups. One group viewed only the pictures in condition one (for example, Figure 4), the other only the pictures of condition two (for example, Figure 5).

Results:

The data of five adults are not included in the analysis because they made more than two errors in fillers. Data of the rest 36 adults are analyzed. As mentioned, one child (4 yr 11m) also made more than two mistakes in the fillers and is excluded from the analysis. The results are presented in Figure 6.

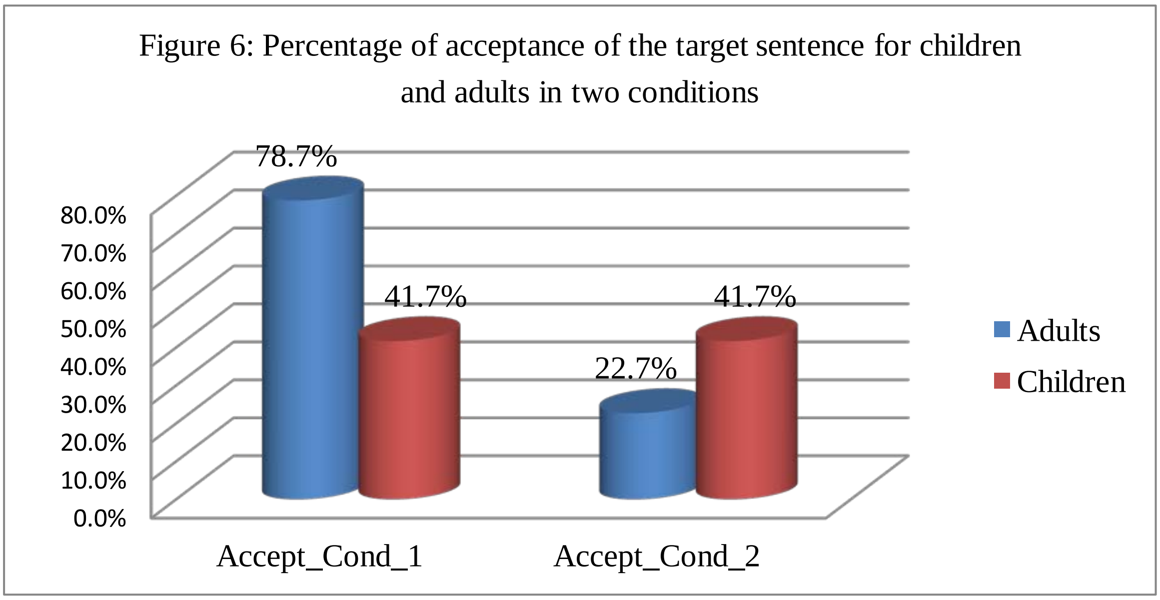
Remember that acceptance of the test sentences in condition 1 denotes that subjects have the interpretation that *dou* distributes over *laoying* "eagle" in sentence (9), which is repeated as in (10). In this case *dou* distributes over the NP closer to it.

[3] Mandarin Chinese does not have morphological distinctions between singulars and plurals, so both NPs in (1) can be interpreted either as a singular or as a plural.

On the other hand, if subjects accept the test sentences in condition two, this indicates that the participants hold the interpretation that *dou* quantifies over *wugui* "turtoise", which is farther from *dou*, comparing to the NP *laoying* "eagle".

As is revealed in Figure 6, adults prevailingly accepted the test sentences in Condition one by 78.7% while mainly rejected the test sentences in Condition 2 by 22.7%. Therefore, for adults only the closer NP could be chosen as *dou*'s restrictor. But for children, it is unascertainable that which NP they prefer to choose as the restrictor, since the acceptance rates of both conditions are of 41.7%, which is not significantly different from a random level.

Figure 6: the results of the first experiment.



(10) Wugui zai laoying pangbian dou zhong-le lanhua.
tortoise at eagle side *dou* plant-ASP orchid
'The tortoise(s) at the eagle(s) side all plant orchid(s).

The results are significant for the settlement of a traditional debate about whether *dou* is a unselective universal quantifier or a distributive operator. Suppose that adults took *dou* as a unselective universal quantifier (Lewis, 1975; Lee, 1986) and assumed that *dou* should quantifying over every variable in the scope of *dou*, it would quantify over the two indefinite NPs simultaneously, because indefinite NPs are taken as variables according to Heim (1982). Then the adults would have rejected the test sentences in both conditions in our first experiment. On the contrary, it turns out that adults accepted the test sentences in the first condition. Therefore, a distributive operator approach, which assumes that *dou* could only choose one NP as its restrictor, is more preferable.

In summary, the results show that adults had a preference that distributive operator *dou* should distribute over the NP which is closer to *dou*. Children, however, seem to be unsure about which NP to select as the restrictor of *dou*.

A problem still remains. A percentage of 41.7% does not mean that children rejected the test sentences, but rather that they were uncertain about which NP could be the restrictor of *dou*. A potential factor might make children confused in restrictor selection is the fact that the two NPs stay too close to each other and their construction NP+P+NP is a complicate syntactic structure for children.

Discussion:

It is proposed in Cheng (1995) that only the plural NP near *dou* should be selected as the restrictor, and this is because of the Principle of Economy of Derivation (Chomsky, 1991).[4] Therefore, we expect that in sentence (8), only the NP *laoying* "eagle" can be the restrictor of *dou*. For the adults in the first experiment, the prediction is definitely born out. The adults tended to reject target sentences in the condition in which *dou* quantifies over the farther NP, and accept the target sentence when *dou* distributes over the closer NP.

For children, on the other hand, it was not easy to select a suitable NP to fill in the restrictor. That they were confused is possibly due to the fact that the structure contains these two NPs is too complicated for some children. As a consequence, when they assume that one of the NPs could be the restrictor, they may find another NP is appropriate as well. In the other words, children can possibly take either NP as the restrictor, no matter the NP is far from *dou* or close to it.

If we are on the right track, a logical inference is that children do not comply seriously with the Economy of Derivation, which must be complied with for adults. This is quite striking because the Economy of Derivation is usually assumed to be part of UG and therefore is expected to be acquired at an early age. Yet before we say that children are insensitive to the Principle of Economy of Derivation, further research is needed to ascertain whether it is this principle that constrains *dou*-distributive computation.

We realize that our argument is slightly weakened since the acceptance rate for the test sentences in both two conditions is 41.7%, which is at a random level. Given that the children performed pretty well in filler items (with a correct rate of 95%), the children's hesitation of selection restrictors is possibly because of the syntactic complexity of the structure [NP [P NP], which become a disturbance to children's choice. Therefore, in order to further clarify children's flexibility of domain restriction toward the distributive operator *dou*, another experiment was conducted in which the two plural NPs are separated into two sides of *dou*. We expect when the two NPs are separated, it is easier for children to take either NP as the restrictor.

Experiment 2:

Purpose:

The second experiment was designed to investigate adults and children’s selection of NPs as the restrictors when the two candidate NPs are separated at both sides of *dou*.

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[4] Cheng (1995) assumes that *dou* adjoins to the NP which it quantifies over, and the whole complex undergoes Quantifier Raising. Therefore, the Economy of Derivation can be applied since *dou* should move in a most economy way.

Method:

Again we used a variant of Truth Value Judgment Task.

Participants:

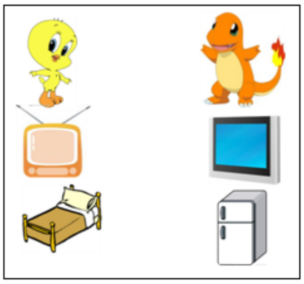
Twelve children (mean age 4; 11, range from 4;7 to 5;1) at the kindergarten of Beijing Language and Culture University participated in this experiment. Eighteen adults, all postgraduate students recruited from Beijing Normal University, served as controls, taking questionnaires with the same materials.

Materials:

Each subject received one pretest, four test items and four fillers. A typical case of the test items is shown in Figure 7 and sentence (11).

It is well-known that *dou* may only distribute over the NPs to its left, and this was stated as Leftness Condition (Lee, 1986; Li, 1995). According to the Leftness Condition, *dou* should only distribute over the NP *xiaodongwumen* "animals" to its left, and the conjunct NP *dianshi*, *chuang, he bingxiang* "TV, bed, and fridge", which stays at *dou*'s right side, is impossible to become the restrictor of *dou*. The experiment will verify whether the distributive computation of *dou* is restricted by Leftness condition.

Figure 7: a typical context of Experiment 2.



The test sentence (11) was presented following a story corresponding to Figure 7, in which one animal (the Tweety Bird) chunked a TV and a bed away, and the other (the dinosaur) chunked a TV and a fridge away.

(11) Xiaodongwu-men dou reng-diao-le dianshi, chuang, he bingxiang.
animal-PLU *dou* chunked-away-ASP TV, bed, and fridge
'The animals all chunked the TV, bed and fridge away.'

Our prediction is that if *dou* distributes over *xiaodongwu-men* "animals" in (11), the derived interpretation will be "each of the animals chunked the TV, bed, and fridge away"; if *dou* distributes over the conjunct NP *dianshi*, *chuang, he bingxiang* "TV, bed, and fridge", the meaning "for the TV, bed and fridge, each of them was chunked away by the animals" will be derived. These two interpretations can be translated as in (12) and (13), respectively.

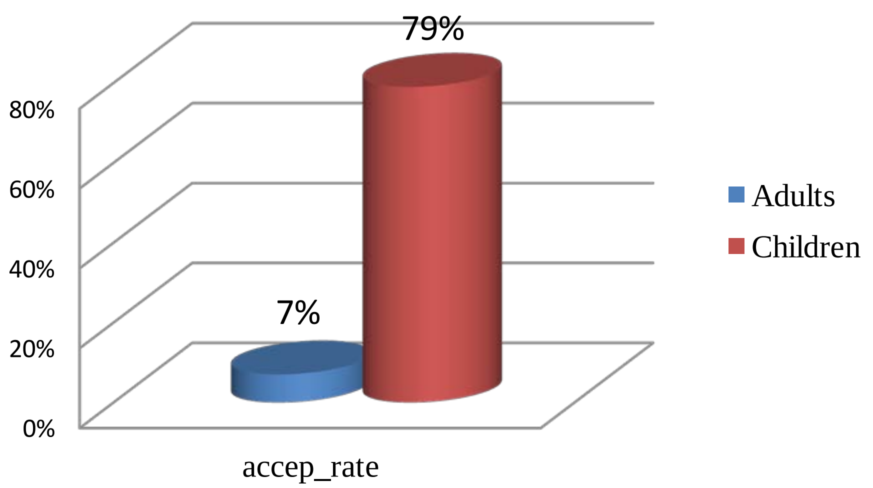
(12) $\forall x\ [x \in [[\text{animals}']] \rightarrow x$ chunk away the TV, bed, and fridge]
(13) $\forall x\ [x \in [[\text{TV-bed-and-fridge}']] \rightarrow$ animals-chunk-way x]

In addition to the test trials, each subject witnessed four fillers. Fillers were designed to verify whether children paid attention to the tasks and could provide right answers to simple statements, including offer a correct *No* to a wrong statement and *yes* to a right statement. Furthermore, we used fillers to diversify the statement patterns, in order to conceal the purpose and the inherent pattern of the target trails. A simple statement such as *Xiaoniao zhaodao le dianshi/chuang* "The Tweety Bird found the TV/bed", was used as a description of Figure 7. Children were expected to give a *No/Yes* answer. The data of those children who could not judge these fillers correctly would be excluded from the results.

Results:

All the subjects, including adults and children, accepted or rejected the filler items by a correct rate of 100%, so their data were all included in the analysis. The finding, as is shown in Figure 8, is that children accepted the test sentences 79% of the time, and rejected them only 21% of the time. Adults, on the opposite, overwhelmingly rejected the test sentence by 93%.

Figure 8: Percentage of acceptance of the target sentences and pretests in Exp. 2



Discussion:

The fact that almost all of the adults rejected the target sentences manifests a firm compliance with the Leftness Condition with regard to the distributive computation of *dou*. Adults were reluctant to select the restrictor from the NPs outside the scope of *dou*. On the other hand, 4-5 year old children showed great flexibility of domain restriction concerning distributive computation.

The results support the idea that children are more flexible than adults in restricting the domain of the distributive operator *dou*. When more than one plural NPs are present, children would take either of them to be the restrictor of *dou*, even in cases when the NPs are to *dou*'s right, namely outside the syntactic scope of *dou*.

The results also shed light on the problem raised in the first experiment. It was the syntactic complexity of the construction containing the two NPs that made the children difficult to choose any one of the NPs as the restrictor. So when the two NPs were separated, children could easily select either NP as *dou*'s restrictor.

In summary, the results of the first experiment reveal that *dou*-distribution is under the restriction of the Economy of Derivation for adults, yet children are rather free to choose a NP either far from *dou* or close to *dou* as the restrictor. The second experiment enhances the argument that children are much more flexible on domain restriction by finding that children are quite free to take a plural NP which is outside its scope as the restrictor.

General Discussion:

Comparing to adults, four to five year old children were more flexible on domain restriction, being insensitive to the Economy of Derivation and the Leftness Condition associated with *dou*-distribution. However, the non-adult behavior does not simply demonstrate that 4-5 year old children are incompetent with *dou*-distribution. Actually, the results of our pretests as well as the previous studies of Zhou & Crain (2011) and Lee (1986) reveal that 4-5 year old children have full grammatical competence with *dou*-distribution.

In order to account for children's seemly contradictory performance, an explanation that could integrate the results from the studies mentioned is much preferable. We argue that 4-year-old children are able to execute the core computational procedure of distributive operator. Children have the knowledge that a distributive operator distributes the property denoted by the VP to the restrictor. The non-adult interpretations of children can be attributed to the fact that children assign different restrictors to the distributive operator than adults do. We propose that children will become adult-like in processing distributive quantifiers once they assign the same restrictors as adults do.

Now we are ready back to the phenomenon called *quantifier spreading* mentioned in the introduction. Recall that many researchers found that children even until 7-8 year old still encounter quantifier spreading. Philip (1995) attributed quantifier spreading to children's inclination to adopt an event quantificational analysis, which is different from adults' individual quantification analysis. Crain et al. (1996) argued that children as young as 4 have full grammatical knowledge of universal quantification and meanwhile points out that quantifier spreading is because of Philip's flawed experimental design, rather than children's different analysis than that of adults. Children's performance was significantly meliorated when the experimental shortage was eliminated.

However, many further studies found that children behaved differently to *all* and *each* (Brooks & Braine, 1996), or more specifically, 4 to 10-year-old children had little difficulty restricting the quantifier *all* to the noun it modified in a task which *all* is interpreted non-distributively while only children until 9 were able to correctly select the domain of distributive *each*. The results inspired the researchers to pay attention to children's domain restriction with regard to distributive quantifiers.

Drozd (2001) and Guerts (2003) were along this path. These two studies make distinction between weak quantifiers such as *three*, *at least*, *no*, *a few* and strong quantifiers such as *most* and *each*, *every*, and they found that children are competent with the former quantifiers while frequently make mistakes with the latter ones. They supposed that children tend to treat strong quantifiers as weak ones, and as a result leave the domain of the strong quantifiers vacant. Thus, it gives place to pragmatic selection of NPs to fill the domain. For example, with the sentence *Every boy is riding an elephant* (Drozd and van Loosbroek 1999), *every* is assumed to be a weak quantifier for children, and this is because e*very*, as a strong quantifier, draws a more complicated semantic representation form comparing to weak quantifiers, which is difficult for children to process. Pragmatic factors thus affect domain selection, and some of the children will choose *elephant* which is very salient in the context as the restrictor.

What our results show is that it may be true that the knowledge of universal quantification is innate, and thus it must be acquired in an early age. But as noted by Philip (2011), children should also acquire other knowledge that apply to the universal quantifiers:

"(i) it must have a semantic restriction provided by the denotation of an NP; (ii) only one NP can have this function; and (iii) this NP must always be identified by some rule. "(Philip, 2011, p. 359)

For our experiments, we found children as young as 4 have the knowledge that *dou* should distribute over a semantic restrictor, and they were definitely capable of processing the sentence with a single NP as the restrictor of *dou* (Philip's 1st point). Furthermore, the children take only one NP as the restrictor (Philip's 2nd point), rather than quantify over every NP available, as was shown in the first experiment. However, they have problems when selecting the restrictor from two potential NP candidates, as is shown in our two experiments. The possible reason is that they are insensitive to rules used to identify the proper NP for the restrictor (Philip's 3rd point). This is exactly what Philip predicts:

"There must be some grammatical rules or other which always selects an NP in a specific syntactic position as the source of its semantic restriction. However, it is not necessary for UG to spell out exactly what the rules in question are by supplying parameters that need to be set. This is because the actual rules can straightforwardly be learned as constructions from positive evidence." (Philip, 2011, p. 360)

The results of our experiments show that the Economy of Derivation helps adults to select only the NPs that are closer to *dou*, and the Leftness Condition constrains adults to choose only the NPs that are to *dou*'s left. However, four to five year old Mandarin speaking children abide by these rules in a fairly flexible and loose way, and permit the NPs relatively far from *dou* or the NPs to *dou*'s right as the restrictors. This accounts for their non-adult performance in our experiments, and we suggest that this is also the reason of why they encounter quantifier spreading. When they hear the sentence "every girl is riding a bike", some of them may choose *a bike* as the restrictor of *every* rather than choose *girl* as adults do, while adults are strictly comply with the principle that the distributive operator *every* should combine with the NP *girl* in *every*'s local position.

The present study also deepens our understanding on the relationship between children's production and comprehension. Lee (1986, 2011) reports that children even younger than three year old produced sentences with *dou* (and *sai* in Cantonese) correctly. What's more, 4-year-old children also performed perfectly and evinced undisputed knowledge on *dou*-distribution. However, we would like to caution against rush conclusions based on limited evidence from production, that children are either competent or incompetent of *dou*-distribution, or in a boarder sense, universal quantification or distributive computation. It seems 4-5 year old children are able to produce *dou* in a restrictor-selection simple condition, and their comprehension on this kind of sentences do not encounter any problem. However, in the cases where they are facing complicated sentences which contain two potential candidates for the restrictor of *dou*, 4-5 year old children become insensitive to several domain restrictions that is abided by adults. Therefore, we argue that the production of *dou* indicates that children have the knowledge of the core computational process associated with *dou*, but their failure in our comprehension tasks reveals that they might stumble over the procedure of complicated restrictor selection.

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