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No ‘‘Chinese-speaking phase’’ in Chinese Children’s Early Grammar – A Study of the Scope between Negation and Universal Quantification in Mandarin Chinese☆

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Abstract

Based on the naturalistic data from four children (aged from 00;10 to 02;06) and experimental data from 60 children (aged from four to eight years old) and 15 adults, the study proposes that Mandarin speakers’ judgment about the scope assignment between negation and universal quantification is attributed to the interplay of several influential factors: word order, lexical semantics of logical expressions, structural complexity, conversational implicature, and felicity in the use of negation. Knowledge about the vital importance of word order in the grammar of Mandarin-speaking adults is not initially present in the grammar of children, but is gradually acquired. They initially rely excessively on lexical semantics in interpreting scope, sometimes leading to non-adult interpretations. Full mastery of scope knowledge comes when they become fully aware of the prominent role of isomorphism, at age 6 or 7.

Keywords: Scope; Negation; Universal quantification; Child language acquisition; Mandarin

1. Research background

Plato’s Problem is a puzzle about the mysterious gap between what we experience and what we know, which can be clearly observed in children when they attempt to acquire their first language. A reflection on this problem can be more tangible when it is presented as a discussion about scope assignment between negation and its clausemate, universal quantification. This matter involves considerable complexity because children’s command of scope knowledge presupposes their full knowledge of the lexical semantics of the two different logical expressions, as well as of some syntactic and pragmatic factors actively involved in deciding relative scope, such as word order, structural complexity, felicity in the use of negation, and triggers of conversational implicature. Such sophisticated knowledge is difficult to teach; indeed, it is never actually taught. All the same, faced with such an intricate, multi-level task, young preschoolers, without much formal instruction to rely on, eventually acquire the ability to interpret scope the way adults do. How can they achieve this?

As mentioned earlier, scope assignment between logical expressions is sensitive to a number of factors, such that a change in one of them will result in a change in the final interpretation of a sentence. Metaphorically speaking, examining the issue of scope is like looking through a kaleidoscope, seeing how many pieces of colored glass (factors working as the

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determinants of scope interpretations) there are, how they are arranged (hierarchies of the factors in terms of their importance), and what patterns they can possibly form (scope interpretations). By posing questions, we may be able to gain a better insight into cross-linguistic universals and differences.

Among a host of studies on children's early acquisition of the scope between negation and universal quantification, Musolino's dissertation in 1998 was a pioneer, one that influenced a number of subsequent studies conducted on the basis of cross-linguistic data. Using the Truth-Value Judgment Task (TVJT), he tested three- to seven-year-old English-speaking children and English-speaking adults to investigate their interpretations of constructions with the word *every* in the subject position (e.g., (1)) and the object position (e.g., (2)).

(1) Subject QP
Every horse didn't jump over the fence.
a. ∀(x) [horse(x) → ¬ Jump over the fence(x)]
b. ¬∀(x) [horse(x) → Jump over the fence(x)]

(2) Object QP
The Smurf didn't buy every orange.
a. ¬∀(x) [orange(x) → The Smurf bought(x)]
b. * ∀(x) [orange(x) → ¬ The Smurf bought(x)]

When tested in the subject situation, children (4;0–7;3, mean 5;11) rejected the narrow scope interpretation of *Every N* (the ''some'' reading) 92.5% of the time (74/80). Specifically, 18 children rejected the ''some'' reading 100% of the time and two children (aged 6;11–7;3) accepted it 75% of the time. Conversely, all 20 tested adults accepted the ''some'' reading 100% of the time. The proportions of YES responses given by children (6.5%) and adults (100%) were found to be significantly different ($z = 8.34$, $p < 0.05$). Musolino concluded that, until the age of about seven, children do not know that negation can take scope over a universally quantified expression in the subject position. In the case of the word *every* in the object position, where the adults chose the ''some'' reading, the children (3;11–6;0, mean 4;10) accepted this reading 85% of the time (68/80). It should be noted that, out of his 20 children, 18 accepted the ''some'' reading 94% of the time (68/72). Two children rejected this interpretation in all the trials. This observation leads us to the conclusion that young English-speaking children (mean 4;10) can correctly interpret the word *every* in the object position with respect to negation the way adults do. In summary, given the two conditions, the children were more inclined toward the surface scope reading than the adults.

Musolino (1998) believes that Universal Grammar governs the process of early language acquisition and that the children's non-adult interpretations are therefore systematic, that is, governed by a particular principle, which he generalizes as the observation of isomorphism (the OI).

(3) The Observation of Isomorphism
Unlike adults, young children systematically interpret negation and quantified NPs on the basis of their position in overt syntax. (Musolinoet al., 2000: 14)

The OI works well to explain why English-speaking children initially interpret the scope in sentences such as (1) and (2) isomorphically. Musolino (1998: 149, 2011: 325) defines the nature of the OI as ''an epiphenomenon, derived from the interplay between a universally encoded dichotomy splitting the class of QNPs and learnability considerations,'' and not as a principle.

In fact, the OI does not bring an end to this interesting story because observations on some non-isomorphic cross-linguistic data from early child grammar have ignited doubts and disputes. Gualmini et al. (2005), Musolino and Lidz (2006), and Zhou and Crain (2009) have reported that contextual manipulations can make non-isomorphic readings more accessible. Furthermore, according to Crain et al. (2013) and Moscati and Crain (2014), the non-isomorphic reading can gain the upper hand over the isomorphic reading if the role of information strength is made clear. Gualmini (2004, 2008) even argued forcefully that ''the Observation of Isomorphism has no place in our theory of child language.''

Isomorphic or non-isomorphic? Given the lack of universal agreement in the current accounts of children's non-adult scope judgment, we believe that a study on data from diverse languages such as Mandarin Chinese, which normally regards the surface word order as a pivotal factor in interpreting sentences, can greatly assist in clarifying some hazy notions about this subject. Therefore, my goal is to show that the ''Chinese-speaking phase,'' which Musolino (2011) assumes to be a phase initially experienced by English-speaking preschoolers in the process of language development, interestingly, does not exist in the early grammar of Chinese children.

Table 1
Percentage of YES responses from children and adults.

Linear orderings	Scope readings	Children	Adults
every. . .not	every > neg	100%	100%
	neg > every	47%	0%
not. . .every	every > neg	53%	5%
	neg > every	100%	100%

Source: Zhou and Crain (2009: 982)

2. Literature review: Zhou and Crain (2009)

2.1. Overview: what has been done

Among previous related literature, Zhou and Crain's (2009) article is one of the most elaborate studies on Mandarin children's knowledge about the scopal interaction between negation and universal quantification. We will review their study not only because it inspired us to carry on the discussion on the same issue, but also because it left several important problems insufficiently answered or not settled.

Zhou and Crain (2009) report the results from two experiments that were conducted with the TVJT. In their first experiment, they recruited 20 Mandarin-speaking children (3;4–5;11, mean 4;3) and 20 Mandarin-speaking adults to judge alternative interpretations of test sentences containing negation and the universal quantifier *mei* (*every*), positioned in different orders in the surface structure. In their design of test materials, they paid special attention to the pragmatic constraint on the use of negation by using two clauses in each sentence (as in (4) and (5)), the first one encouraging the listener to expect what was going to happen and the second expressing what really happened. The actual event was completely different from what was expected, which, in the view of Zhou & Crain, meets the condition that the use of negation should be associated with failing expectations.

(4) The ''every. . .not'' ordering
Mei-ge nühai dou chi-le bingjiling, danshi mei-ge nühai dou meiyou chi yao.
Every-CL girl all eat-ASP ice cream but every-CL girl all not eat pill
''Every girl ate an ice cream, but every girl didn't take pills.''

(5) The ''not. . .every'' ordering
Mei-pi ma dou tiaoguo-le liba, danshi bushi mei-pi ma dou taioguo-le fangzi.
Every-CL horse all jump-over-ASP fence, but not-be every-CL horse all jump-over-ASP house
''Every horse jumped over the fence, but not every horse jumped over the house.''
(From Zhou and Crain, 2009: 981)

They first discussed the children's responses. Their results showed that young children (mean age: 4;3) were very sensitive to the linear ordering of negation and universal quantification, always preferring the linear scope reading. When the inverse scope reading was tested, children and adults produced significantly different judgment: in the ''some'' scenario, the acceptance rate of the ''every. . .not'' sentences by the children was remarkably higher than that of the adults (47% vs. 0%, $z = 3.68$, $p < 0.001$). Likewise, in the ''none'' scenario, the ''not. . .every'' sentences were accepted by the children far more often than by the adults (53% vs. 5%, $z = 3.38$, $p < 0.001$).

The adult subjects in this study performed in the way we would expect according to the principle of linearity. Concerning the performance of the children, the OI in (3) was clearly insufficient to explain their non-adult judgment, for in the two different surface ordering conditions, approximately half of them accepted the inverse scope reading.

Recognizing the fact that the responses of children varied greatly by age, Zhou and Crain (2009) then reanalyzed the responses from the 19 children in the first experiment, the youngest nine of which formed one group (3;4–4;3) and the older ten the other group (4;5–5;11). These results are presented in Table 2.

When *mei* (*every)* preceded negation in the linear ordering, children and adults unanimously assessed the ''none'' reading positively. A closer look revealed greater similarity between the older children and the adults: the younger children (3;4–4;3) showed a stronger inclination toward the inverse interpretation, that is, the ''some'' reading, than the older children (4;5–5;11) (specifically, 89% vs. 10%, $z = 3.56$, $p < 0.001$). The older children (4;5–5;11) performed similarly to the adults (10% vs. 0%, $z = 1.41$, $p = 0.33$). When the order of *every* and negation was reversed to form the ''not. . .every''

Table 2
Percentage of YES responses from younger children, older children, and adults.

Linear orderings	Scope readings	Younger children (3;4–4;3)	Older children (4;5–5;11)	Adults
every. . .not	every > neg	100%	100%	100%
	neg > every	89%	10%	0%
not. . .every	every > neg	100%	10%	5%
	neg > every	100%	100%	100%

Source: Zhou and Crain (2009: 982).

sentences, all the children and adults accepted the linear scope reading (the ''some'' reading). In this condition, clear differences were again easily noticed between the younger children and older children, as well as between the younger children and adults, in their acceptance rates of the inverse scope reading (the ''none'' reading) (for the former, 100% vs. 10%, $z = 4.06$, $p < 0.001$; for the latter, 100% vs. 5%, $z = 4.96$, $p < 0.001$).

We interpret their results as follows: in the first instance, in the context of the Mandarin language, the adults, but not the children, were inclined to adhere to the principle of linearity. This observation amounts to a challenge to the OI. Secondly, a developmental process was apparent from the children's responses: the older the child was, the more likely he or she was to favor a linear scope reading. In other words, a tendency toward isomorphism is not a natural inclination, but is nurtured as the child grows.

Another interesting phenomenon demands our close attention: in the two conditions, the younger children's responses remained almost the same regardless of the word order or the reading presented to them. In the opinion of the authors, an extreme case occurred in their judgments about the ''not. . .every'' sentences (100% vs. 100%, in Table 2). Is the option the children chose the same as what they thought correct? In order to clarify the picture, Zhou & Crain went on to test the nine younger children from the first experiment with a preference test, in which both the ''every. . .not'' and the ''not. . .every'' sentences were produced by puppets in a ''none'' scenario. The children were asked to decide whether the two puppets said the right thing and, if they did, which one said it better. In this way, children were urged to report their preferences. Some examples follow.

(6) Mei-zhi xiaomao dou mai-le binggan, danshi mei-zhi xiaomao dou meiyou mai yu.
Every-CL cat all buy-ASP biscuit but every-CL cat all not buy fish
''Every cat bought biscuits, but every cat didn't buy fish.''

(7) Mei-zhi xiaomao dou mai-le binggan, danshi bushi mei-zhi xiaomao dou mai-le yu.
Every-CL cat all buy-ASP biscuit but not-be every-CL cat all buy-ASP fish
''Every cat bought biscuits, but not every cat bought fish.''

For (6) and (7), the ''none'' scenario that was provided to the children was that ''the cats bought some biscuits, but none of them bought fish, for the fish were not as fresh as expected.'' Their test hypothesis was that, if the children were incapable of computing conversational implicature, they would decide that (6) and (7) are both true, and equally so. Conversely, if the children were adept at computing conversational implicature, when the alternative was directly given in a preference test between (6) and (7), (7) would be assessed to be true and better stated if its inverse scope reading was available to the children (Zhou and Crain, 2009: 986). Out of nine children, eight consistently favored (6); the remaining child did not report any preference.

In summary, the information from Zhou and Crain (2009) provides the following observations. First, there is ambiguity on the part of Mandarin-speaking children on how to interpret sentences containing *mei* (every) and negation. Young children (3;4–4;3) did not report any preference, accepting the ''some'' and the ''none'' readings equally, which does not conform to the route prescribed by the Subset Principle or its extensions. It was only when the young children were asked to make a choice between the alternative interpretations in a particular scenario, which could accommodate only one interpretation, that they could state a preference. Regarding this phenomenon, Zhou and Crain (2009: 987) state that ''the results showed that Mandarin-speaking children, like their English-speaking counterparts, are able to compute conversational implicature, but only when the alternative representations are provided overtly.''

Second, the analysis of sentences such as (4) and (5), as carried out by Zhou & Crain, requires more introspection, which will be discussed in the next section. It should be pointed out that both types of sentence are free from ambiguity. Zhou & Crain propose that the scope rigidity in this case should be attributed to the use of the focus-sensitive property of *dou (all)* (as in (4)) and *shi (be)* (as in (5)). Therefore, in their account, in order to access adult interpretations of these sentences, children first have to acquire the focus-sensitive property of *dou (all)* and *shi (be)*.

Finally, as pointed out earlier, aside from a flawed match between Zhou & Crain's data and a subset reading-oriented account, there is no agreement between their data and the assumption of the OI.

2.2. Comments: what has not been done

Several issues remain unclear about Zhou and Crain (2009), ranging from their analysis of the facts about Mandarin-speaking children's acquisition of scope to their test design.

First, their (2009) account of the scope phenomenon in sentences such as (4) and (5) is open to further discussion. Before addressing the scope fact in the two sentences, we review some previous studies in order to establish the background for our discussion.

Scope is not a new topic in Mandarin-related studies. There have been a number of studies, such as those by Aoun and Li (1989, 1993), Huang (1982, 1983), Huang (1981), Lee (1986, 1991, 1993, 1996), Liu (1990, 1997), and Wu (1992), with the objective to identify factors involved in determining scope readings in Mandarin, primarily focusing on lexical differences, word order, syntactic relations, thematic roles, and topicalization. Since Mandarin is not a language characterized by rich morphological inflections, word order plays a crucial role in syntactic and semantic realization. Just for this reason, among the many factors mentioned just now, linear precedence in the surface structure is commonly believed to be the ultimate determinant in the assignment of wide scope reading (Huang, 1981, 1982; Kuno et al., 1999; Lee, 1986). Huang (1982: 119) discusses this scope feature of Mandarin as follows: ''A more convincing argument is available, however, from languages like Chinese, where ambiguities of the sort seen in English are entirely lacking, and the only available reading in each sentence is the one in which scope order corresponds to surface order.''

According to these previous studies, it is the principle of linear precedence that results in scope rigidity in Mandarin. Zhou and Crain's (2009: 977) proposition about linearity is relevant, but it is not identical to the proposition put forward in Huang (1981) and the other above-mentioned studies. In Zhou & Crain's account, the focus-sensitivity markers *dou (all)* (as in (8)) and *shi (be)* (as in (9)) contribute to a considerable extent to scope rigidity in their test structures, which they interpret as follows:

(8) Mei-pi ma dou meiyou tiaoguo liba.
Every-CL horse all not-have jump-over fence
''It was every horse that didn't jump over the fence.''
$\exists x$ [horse' (x) $\wedge \neg$ Jump over the fence'(x)] $\wedge \forall x$ [horse'(x) $\rightarrow \neg$ Jump over the fence'(x)]

(9) Bushi mei-pi ma dou tiaoguo-le liba
Not-be every-CL horse all jump-over-ASP fence
''It wasn't every horse that jumped over the fence.''
$\exists x$ [horse' (x) $\wedge$ Jump over the fence'(x)] $\wedge \neg \forall x$ [horse'(x) $\rightarrow$ Jump over the fence'(x)]

In their analysis, (8) is the same as a cleft sentence in English, which we would challenge. We introduce (10) into the discussion. Due to the overt presence of the focus-marker *shi (be)*, this is a prototypical cleft sentence, a counterpart of an ''It is. . .that. . .'' sentence in English.

(10) Shi mei-pi ma dou meiyou tiaoguo liba.
Be every-CL horse all not-have jump-over fence
''It was every horse that didn't jump over the fence.''

If (8) were analyzed correctly by Zhou & Crain, (8) and (10) should be equivalent sentences. However, our intuition does not match this assumption at all. Sentences (8) and (10) are different in their focus. In (8), the focused expression can be *meiyou (not-have*), *tiaoguo (jump-over)*, or *liba (fence)*. On the other hand, in (10), the focus lies solely on *mei-pi ma (every-CL horse)*. The difference in placing a clear focus leads to the difference in the implicatures with which the two sentences are associated. Sentence (10) implies that ''it was every horse, not other animals, that did not jump over the fence.'' That is to say, when a speaker utters (10), he intends to exclude other animals from the set of entities that can make the proposition ''x didn't jump over the fence'' true. From this perspective, (10) is associated with an implication of exclusivity, whereas (8) is not. As a result, if we add to (10) two clauses, one positive and one negative (as in (11) and (12)), the narrative in (11) is valid but the one in (12) is not.

(11) Shi mei-pi ma dou meiyou tiaoguo liba, er qitade dongwu dou tiaoguo le
Be every-CL horse all not-have jump-over fence however other animal all jump-over ASP
''It is every horse that didn't jump over the fence. However, other animals all jumped over it.''

(12) Shi mei-pi ma dou meiyou tiaoguo liba, er qitade dongwu ye dou meiyou tiaoguo
Be every-CL horse all not-have jump-over fence and other animal also all not-have jump-over
''It is every horse that didn't jump over the fence and other animals didn't jump over it either.''

Applying the addition test to (8), we find (13) and (14) both acceptable.

(13) Mei-pi ma dou meiyou tiaoguo liba, er qitade dongwu dou tiaoguo le
Every-CL horse all not-have jump-over fence however other animal all jump-over ASP
''Every horse didn't jump over the fence. However, other animals did.''

(14) Mei-pi ma dou meiyou tiaoguo liba, er qitade dongwu ye dou meiyou tiaoguo
Every-CL horse all not-have jump-over fence and other animal also all not-have jump-over
''Every horse didn't jump over the fence and other animals didn't either.''

This comparison supports my contention that Zhou & Crain's analysis of sentences such as (8) is not completely correct.

This aside, their analysis of sentences such as (7) and (9) also warrants a second thought. A positive lead-in part is added before (9), as it is in (7), which increases the accessibility of the linear scope reading, that is, the ''some'' reading. Zhou & Crain carried out a survey of 15 Mandarin adults with (15), a sentence consisting of two clauses conjoined with *shijishang (in reality)*. Their reasoning was that, if the lack of the inverse scope reading ''none of the horses jumped over the fence'' for a sentence such as (9) is due to an implicature, then the additional comment *shijishang, meiyou ma tiaoguo le liba (in fact, none of them did)* should cancel the implicature without contradiction. However, if adults do not accept the truth condition for the inverse interpretation, they will not tolerate a contradiction in (15). To put it another way, if the subjects do not work out the ''none'' reading from (9), they must judge (15) negatively. Zhou and Crain (2009: 978) reported that 10 of the 15 adults (67%) in their survey judged (15) to be unacceptable.

(15) Bushi mei-pi ma dou tiaoguo le zhalan, shijishang, meiyou (yi-pi) ma tiaoguo le zhalan.
Not-be every-CL horse all jump-over ASP fence in-reality not-have (one-CL) horse jump-over ASP fence

Based on this result, they continued their survey with (16), which was formed by removing *dou (all)* from (15), to investigate what the deciding factor in the adults' interpretation of sentences, such as (9), was, *dou (all)* or *shi (be)*.

(16) Bushi mei-pi ma tiaoguo le zhalan, shijishang, meiyou (yi-pi) ma tiaoguo le zhalan.
Not-be every-CL horse jump-over ASP fence in-reality not-have (one-CL) horse jump-over ASP fence

All 10 tested adults judged the initial part of (16), but not all of (16), to be acceptable, although five adults also commented that the lack of *dou (all)* produced an unnatural sentence. Based on the perception of these adults, Zhou and Crain (2009: 978) arrived at the conclusion that the lack of an inverse scope interpretation for sentences such as (9) is not due to a pragmatic implicature, but due to language-internal properties, in this case the occurrence of the focus marker *shi (be)*.

At present, we wonder whether it is really impossible for sentences such as (7) to produce the inverse scope reading (the ''none'' reading) and, if so, why the inverse scope reading has disappeared. I used (15) to test 24 Mandarin-speaking adults by distributing a questionnaire on the internet. My subjects were asked to judge the sentence as: (a) ''a good sentence, which can be said and understood''; (b) ''not a very good sentence, which is not often used in this way and cannot be entirely understood''; or (c) ''a bad sentence, which is never said and cannot be understood at all.'' Out of 24 adults, ten (42%) favored the sentence, seven (29%) considered the sentence ''not very good,'' and seven (29%) rejected the sentence completely. Their responses clearly reveal the existence of scope ambiguity in sentences such as (15), whose optimal interpretation is the ''some'' reading because of the use of the focus-marker *shi*, but the ''none'' reading is also possible. Even in their experiment, Zhou & Crain encountered adults who were in favor of the inverse scope reading of (5), as shown in Table 1. In my experiment, there were more adults who preferred the inverse scope reading of sentences such as (9), which we will return to in section 4.

At this point, an interim summary of my comments on Zhou & Crain's analysis of scope factors will be useful. In my opinion, their treatment of the second clause in sentences (4) and (6) as cleft sentences is actually incorrect. Moreover, their prediction that sentences such as the second clause in (5) and (7) are entirely free from ambiguity and not open to an inverse scope reading is problematic.

Additionally, I have my doubts about their account of the non-adult scope judgment of young children, which they attributed to children's insufficient knowledge of the focus-markers *dou (all)* and *shi (be)* in sentences (4), (5), (6), and (7).

Although the contribution of focus-sensitive markers to the interpretations of target constructions is a part of the core issue being discussed, it is quite possible that a full knowledge of *dou (all)* and *shi (be)* cannot guarantee a proper scopal interpretation of sentences containing those markers. The reason for this lies in the common phenomenon that the meaning of a sentence often cannot be derived compositionally from the meanings of its constituents. Longitudinal data, which we will present below, show that Mandarin-speaking children acquire the quantificational adverb *dou (all)* before the quantificational determiners *mei (every)* and *suoyou (all)*. Given this, if we follow Zhou & Crain's logic in claiming that young children's non-adult scope interpretation is mainly caused by lexical difficulty, it is reasonable to assume that the trouble that Mandarin-speaking children have in interpreting the sentences under discussion is also caused by their immature knowledge of *mei (every)* and *suoyou (all)*.

Finally, it should be acknowledged that, in their test design, Zhou & Crain encourage us to think more clearly about the felicity condition on the use of negation[1] (as proposed by Gualmini, 2006; Gualmini et al., 2005; Musolino et al., 2000, etc.). Musolino and Lidz (2002, 2006) found that a positive lead-in clause, as in (17), can make the inverse scope reading of (18) more accessible to children. A positive lead-in part triggers an expectation such as ''Every horse jumped over the rock, and then every horse was expected to jump over the fence.'' But, in fact, ''some horses failed to jump over the fence.'' In this way, negation is used felicitously to express the failing of the expectation. Following in Musolino & Lidz's steps, Zhou and Crain (2009) adopted the same strategy in their test sentences, like (4) and (5).

(17) Every horse jumped over the rock, but every horse didn't jump over the fence.

(18) Every horse didn't run into the fence.

Although such test sentences are indeed better in terms of pragmatic felicity, their length will probably create a processing pressure in subjects, especially in young children. Therefore, we have to ponder whether such long sentences are necessary. My experimental results presented below show that, even when a positive lead-in clause is not used, adults and children alike can access both the linear scope reading and the inverse scope reading, grammar permitting.

3. Longitudinal study

A better understanding of children's initial knowledge about the scope assignment between negation and universal quantification in sentences such as (4) and (5) can be gained if we can track down the first records of children's production of these linguistic items, which my study of naturalistic data can help with (Table 3).

3.1. Corpus

The longitudinal data in my study were retrieved from the CELA corpus,[2] which recorded the natural conversations of four children, born and brought up in Beijing, with adults and other children around them. Table 4 provides information about the subjects and the number of records used in this study.

3.2. Onset of children's production of negation, universal quantification, and the copular verb shi (be)

3.2.1. Negation in the early language of Mandarin-speaking children

After analyzing the set of negative utterances by children described in Table 5, Lee and Fan (2009) outlined the earliest development of the Mandarin negative markers *bu (not)* and *mei (not-have)* in their grammar. As shown in Table 6, 01;04–02;05 is a crucial period in which Mandarin-speaking children start to acquire knowledge of negation. Their spontaneous data demonstrate that, by 02;05, Mandarin-speaking children have acquired the ability to use negative markers freely in simple and complex sentences, and that, from 02;05 to 03;00, negation is a very productive category in their language.

3.2.2. Universal quantification in the early language of Mandarin-speaking children

In the earliest elaborate studies on the acquisition of scope knowledge by Mandarin-speaking children, Lee (1986, 1991) reported that children aged 03;06;00 had acquired the meaning of ''exhaustiveness'' encoded by these words, and children aged between 3 and 8 years comprehended the relative scope of QNPs in the subject and object positions.

[1] Negation is used to ''point out a discrepancy between what was expected to happen and what usually happened'' (De Villiers and Tager-Flusberg 1975; Givon, 1978; Wason, 1965).

[2] CELA (Chinese Early Language Acquisition) is a corpus established under the leadership of Prof. Hun-tak Lee at the Chinese University of Hong Kong.

Table 3
Percentage rates of children's (3;4–4;3) preference rates for the two types of sentences in the ''none'' scenario.

Preference rates	Every. . .not	Not. . .every	No preference
	89%	0%	11%

Source: Zhou and Crain (2009: 986).

Table 4
Subjects' information in longitudinal corpus.

Child	Age of observation	Total no. of sessions
CY	00;10;15–02;04;31	66
SJQ	01;02;06–01;11;29	28
ZHZ	01;04;19–02;05;22	49
ZTX	00;11;18–02;06;02	52
Total		95

Note: One ''session'' refers to the data collected from one visit, which lasts approximately one hour if there was no unexpected interruption in the process of recording.

Table 5
Children's negative utterances.

Child	Total No. of negative utterances	
	Total No. of utterances containing *bu*	Total No. of utterances containing *mei*
CY	601	211
SJQ	473	259
ZHZ	731	270
ZTX	914	674
Total	2718	1414

Table 6
Onset of spontaneous use of negative markers for various semantic types by children.

Child	CY		SJQ		ZHZ		ZTX	
Semantic types	Negative markers							
	Bu	*Mei*	*Bu*	*Mei*	*Bu*	*Mei*	*Bu*	*Mei*
Negative volition	01;04;30		01;05;28		01;07;19		01;08;04	
Negative imperative	01;09;14		01;08;13		02;02;17		01;09;15	
Nonexistence of object or human being		01;08;03		01;08;21		01;08;21		01;06;22
Nonexistence of attribute	01;10;11		01;08;21		01;10;06		01;08;24	
Denial of present (or future) event/state	01;11;30	02;03;06	01;08;13	01;10;09	01;08;30	02;00;15	01;07;28	01;10;20
Denial of past event/state		01;10;18		01;08;13		02;01;05		01;07;21
Denial of possession	02;04;21	01;09;14		01;09;04		02;02;24		01;09;15
Inability	01;10;18		01;08;27		01;09;27		01;09;29	
Denial of assertion					02;03;27			
Rhetorical use					02;03;27			

Note: The age represents the time at which three spontaneous tokens have occurred in three linguistic environments in utterances by children. A ''spontaneous token'' should meet the following conditions: (a) it should be spontaneously produced by the child, not a repeated form of utterances by adults within a 3-line context; (b) it should not be a reply to an ''A-not-A'', ''not-A'', ''A-not'' or a rhetorical question from an adult; (c) it should not be the words in a rhyme, song or poem. By ''linguistic environments'', we largely mean that a negative marker is used in the combinations with different verbs.

Table 7
Onset of spontaneous use of *dou (all)*, *mei (every)*, and *suoyou (all)* by children.

Child (Age)	Quantifier		
	Dou	*Mei*	*Suoyou*
CY (00;10;15–02;04;31)	01;10;18	*(not spontaneous use)	×
SJQ (01;02;06–01;11;29)	01;08;27	×	×
ZTX (01;04;19–02;05;22)	02;00;15	×	×
ZHZ (00;11;18–02;06;02)	01;09;29	*(use in a rhyme)	×

Note: With age we mean the age at which a child has used a target expression spontaneously in three different syntactic frames. ''*'' indicates that a target expression has occurred in the utterance of a child, but has not been used spontaneously in three different syntactic frames. '' × '' indicates that the construction has not been used at all by a child.

Considering the data we have obtained and presented in Table 7, we assume that complete knowledge about the scope relation between negation and universal quantifier determiners on the part of Mandarin-speaking children should begin to take shape after 03;00. The youngest subjects in my experiment are four-year-old children, who I believe can demonstrate the initial state of the knowledge under discussion.

Investigating scope facts, we find that, when *dou (all)* meets negation in the same Mandarin clause, their mutual linear ordering is directly relevant to scope assignment. For example:

(19) NP *dou bu/mei* VP.
NP *all not* VP
e.g. Xuesheng-men dou mei lai
Student-PLURAL all not come
''Students all didn't come.''

(20) NP *bu dou/mei* VP.
NP *not all* VP
e.g. Xuesheng-men mei dou lai
Student-PLURAL not all come
''Not all students came.''

We tested 15 Mandarin-speaking adults in Beijing, China, who reported that (19) produced only the ''none'' reading, while (20) allowed both the ''some'' reading and the ''none'' reading, where the latter was perceived as a marginal reading (only accepted about 30% of the time).

The longitudinal data in Table 8 reveals the phenomenon that Mandarin-speaking children start to produce the *dou bu/mei (all not)* combination spontaneously in circumstances that validate the ''none'' reading since around 02;05, which proves that children begin to have access to the proper reading of *dou* and the rule governing scope assignment in the *dou bu/mei (all not)* combination from a very young age. Besides, their early spontaneous use is quite suggestive of the fact that *dou bu/mei (all not)*, as opposed to *bu/mei dou (not all)*, is an unmarked syntactic combination, associated with

Table 8
Number of spontaneous uses of *bu* (not) and *mei* (not) in combination with *dou* (all) by children.

Subjects (Age)	Constructions			
	Bu (not)		Mei (not)	
	dou-bu (all-neg)	*bu-dou* (neg-all)	*dou-mei* (all-neg)	*mei-dou* (neg-all)
CY (00;10;15–02;04;31)	*	×	1	×
SJQ (01;02;06–01;11;29)	*	×	*	×
ZHZ (01;04;19–02;05;22)	6	×	3	×
ZTX (00;11;18–02;06;02)	2	×	4	×

Source: Lee and Fan (2009).
Note: ''*'' indicates that the construction has occurred in the utterance of the child, but has not been used spontaneously in three different syntactic frames. ''×'' indicates that the construction has not been used at all by the child.

a lighter work load of processing information for language users, which will be discussed in section 5.2.3. Some examples of children's early production are provided in (21) and (22).

(21) a. ZHZ02;05;01
CHI: xxx zhe shi mama shu xxx 这是妈妈书.
xxx this BE Mom book ''Those are Mom's books.''
%exp:child goes to the bed.
CHI: Dou bu neng kan la 都不能看啦.
All not can read sfp ''All can't be read.''

b. ZTX02;03;08
FAT: Ni zenme ba na mantou reng dao na litou qu le
You why BA that steamed-bun throw arrive that inside go sfp
你怎么把那馒头扔到那里头去了?
''Why did you throw that steamed-bun into that?''
FAT: A 啊?
Interj. (A sound is used to ask for an answer.)
CHI: Dou bu neng chi le bei 都不能吃了呗.
All not can eat sfp sfp
''All can't be edible.''

(22) a. CY01;11;23
(CHI found there wasn't any apple in a box.)
%exp: child looks into a box.
GMM: Mei le 没了.
Not sfp
''There isn't anything.''
CHI: Quan quan dou mei le <全>[/]全都没了.
All all all not sfp
''All are gone.''
GMM: Pingguo dou rang ni chi le 苹果都让你吃了.
Apple all let you eat sfp
''All the apples were eaten by you.''

b. ZTX01;08;18
INH: Shu xiamian 树[!]下面.
Tree under
''Under the tree.''
CHI: Qiche mei le 汽车没了.
Car not sfp
''The cars are not there.''
CHI: Dou mei le ma 都没了吗?
All not sfp sfp
''All the cars are not there?''
FAT: Shenme mei le 什么没了?
What not sfp
''What isn't there?''
CHI: Qiche mei le 汽车没了.
Car not sfp
''The cars are not there.''

4. Experimental study

4.1. Experimental design

4.1.1. Subjects

I tested 60 Mandarin-speaking children aged between 04;02;00 and 08;01;00 in one kindergarten and two primary schools in Beijing. In addition, my test involved 15 Mandarin-speaking adults who were undergraduate students from a university in Beijing, without any training in linguistics (Table 9).

Table 9
Child subjects' information in the experiments.

Age group	Age	Mean age	No. of subjects
4–5 Group	04;02–04;11	04;05	15
5–6 Group	05;03–05;11	05;05	15
6–7 Group	06;00–06;09	06;06	15
7–8 Group	07;00–08;01	07;07	15

4.1.2. Test methods, test procedure, and statistical method

In the literature on the language acquisition of scope readings in Mandarin, two kinds of experimental stimuli are primarily employed: the use of pictures (e.g., in Lee, 1986) and the use of stories told on the spot (e.g., in Zhou and Crain, 2009). In my experiment, I used both in order to validate my prediction that language users' judgments about basic scope facts do not change with the test methods employed if their related knowledge has been well established. In section 5, I carry out a comparison of the test results obtained with both methods.

Using the method of picture identification in sections 1 and 2 in my experiment, the investigator told the subjects that they would first be presented with a picture and then hear a sentence from a tape recorder. If the sentence that they heard could describe the picture they saw exactly, they would be expected to give a positive answer to the investigator's question ''Is the sentence right?'' by answering ''Yes.'' Otherwise, they were to answer ''No.''

Telling stories fluently and displaying plots with toys at the same time is such a challenging task that it can be easily affected by a number of non-linguistic factors, such as the reaction of the subjects, the physical conditions of the investigator, or environmental disturbances. If it cannot be entirely ascertained that each subject has been given the same amount of information about the same test item in the same way, it would not be proper to value their judgment equally. Considering this, in section 3 of my experiment, I opted for videoed test stories and then played them on a laptop when the tests took place. After watching a story, the subjects were asked to judge a sentence about the story spoken by a puppet. If a sentence described exactly what had happened in a story, I expected a ''Yes'' response from the subjects. Otherwise, a ''No'' response was expected.

Three pretest items in section 1 and two pretest items in section 2 were used to guarantee that all the subjects would understand what they were expected to do. Young children who failed to finish the pretest items properly did not proceed to the test sections.

The three sections were carried out following different procedures according to age groups. In the adult group, sections 1 and 3 were conducted at the same time, while section 2 was done on another day. The same investigators carried out the tests in the three sections. In the child groups, the three sections were conducted separately and in sequence, 1 through 3, with a couple of days between each section. The six investigators were divided into three groups, each of which was in charge of one section. This arrangement was done with the intention to avoid any possible interference with the young children's judgment.

The ways the subjects participated in the tests also varied across age groups. The children met an investigator and an assistant in a quiet classroom and answered test questions orally. For each of their answers, they were asked to give a reason. As an example, picture (23a) was tested in scenarios (23b). If a subject assigned the linear scope reading to (23a), which has the universal quantifier outscoping negation, he was expected to answer ''NO'' by pointing out that two clowns on the picture were blowing bubbles. In contrast, if he interpreted (23a) with negation outscoping the universal quantifier, he was expected to answer ''YES'' by reporting what one of the clowns did not do or what the others did. All the tests were recorded with a tape recorder. In the adult group, the subjects finished all the tests in a written form together in a quiet classroom.

(23) a. **Mei ge xiaochou dou bu zai chui paopao.**
Every (Cl.) kid all NEG –ing blow bubble
Every clown is not blowing bubbles.

b. **Scenario description**: Some of the entities involved undertook the action described by the VP in the sentence, but not all.

The test results in my study were analyzed with the Mann–Whitney *U* test.

Table 10
Test constructions.

Type of test construction	Linear ordering	Test structure
∀...¬	*Mei*...NEG	*Mei* (Cl.) N *dou bu/mei* VP.
	(Every...NEG)	Every (Cl.) N all not VP
	Suoyou...NEG	*Suoyoude* N *dou bu/mei* VP.
	(All...NEG)	All N all not VP
¬...∀	NEG...*Mei*	*Bu shi Mei* (Cl.) N *dou* VP.
	(NEG...every)	Not BE every (Cl.) N all VP
	NEG...*suoyou*	*Bu shi suoyoude* N *dou* VP.
	(NEG...all)	Not BE all N all VP
	NEG...*suoyou*	NP *bu/mei* V *suoyoude* N.
	(NEG...all)	NP not V all N

Note: ''Mei'' stands for ''every'', ''suoyou(de)'' for ''all'' (used before a noun), ''dou'' for ''all'' (adverb) ''bu'' and ''mei'' for the negators and ''shi'' for the copula verb ''be'' in Mandarin.

4.1.3. Test material

We tested two possible orderings of negation and universally quantifying expressions. In the first ordering, an expression in the subject position, quantified by *mei (every)* or *suoyou (all)*, precedes negation. In the second ordering, three kinds of construction with different syntactic arrangements were presented: the expressions in the subject position were quantified by either *mei (every)* or *suoyou (all)*, and the expressions in the object position were quantified by *suoyou (all)*. I did not test sentences with *mei (every)* in the object position, for such a syntactic arrangement is commonly considered less acceptable in Mandarin. The reasons for this arrangement will be discussed later.

One point needs further explanation: as illustrated in Table 10, in the condition of the ''not...every'' ordering, I designed two ways to form a negative sentence to see if scope assignment is only affected by linear ordering in the surface structure, or if the use of a cleft sentence affects the scope assignment.

In general, we can assume two possible logical readings when negation and universal quantification meet in a structure. For each reading per structure, I carried out three trials in the form of three different sentences, distributed over three sections. In total, I tested two types of orderings, five types of test structures, and 30 trials. All the trials were ordered automatically with a randomizer. The sentences used to test the construction ''*mei (every)* (+Cl.) N *dou (all)* NEG VP'' are presented in Table 11 in order to illustrate how the tests fared.

As an example, my test hypothesis was that in a scenario that only permitted the ''none'' reading, if a subject had access only to the linear scope reading of sentences of this type, the subject would say ''Yes'' when he was given pictures or stories like the ones in the left column of Table 11; otherwise, the subject would say ''No,'' when he was given those in the right column of Table 11.

4.2. Scope relation between negation and universal quantification in the grammar of Mandarin speakers

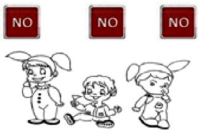
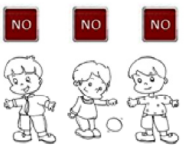
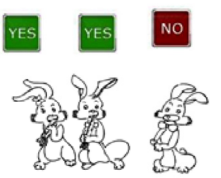
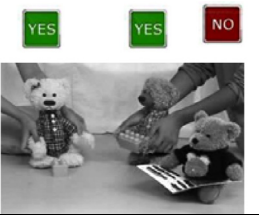
4.2.1. Experimental data of the ''∀...¬'' construction

As illustrated by Tables 12 and 13, when given sentences in which a universally quantified phrase occupied the subject position in circumstances where the ''none'' reading was valid, 15 adults and 60 children in the case of *mei (every)* and almost all the children and adults in the case of *suoyou (all)* consistently gave ''Yes'' responses.

In contrast, when hearing sentences composed according to the same ordering pattern in scenarios which only allowed the ''some'' reading, a large number of the responses of children from the 4–5 and 5–6 age groups were not adult-like, which led to a significant difference between the two groups of children and the adult group (e.g., in the case of *mei (every)*, the difference between the responses of 5- and 6-year-old children and those of adults was 13.33% vs. 0%, $z = 2.52$, $p < 0.05$; in the case of *suoyou (all)*, the difference was 24.44% vs. 0%, $z = 3.52$, $p < 0.01$) (as illustrated in Table 12). Considering the consistency of the responses, we found that, with *mei (every)*, only one child from the 4–5 age group and one from the 5–6 age group consistently accepted the three sentences in the ''some'' reading and, more importantly, seven children from the 4–5 age group and 12 from the 5–6 age group consistently rejected the sentences in the same scenario. With *suoyou (all)*, three children from the 4–5 age group and two children from the 5–6 age group invariably assessed the acceptability of the three test sentences positively, while seven children from the 4–5 age group and eight children from the 5–6 age group invariably rejected the three test sentences (as illustrated in Table 13).

The data given above bring us to a summary of my results. First, when universal quantification preceded negation in the surface structure, the linear scope interpretation (the ''none'' reading) was the only reading to which the adults had access. In the perception of children, the linear ''none'' reading absolutely overrode the inverse ''some'' reading, although

Table 11
Examples of test sentences.

Test construction	***Mei* (-Cl.) N *dou* NEG VP. *Every*-CL N *all* NEG VP**	
Types of reading	**The "none" reading(∀>¬ reading)** (Scenario description: none of the entities involved undertook the action described by the VP in the sentence.)	**The "some" reading (¬ >∀ reading)** (Scenario description: some of the entities involved undertook the action described by the VP in the sentence, but not all.)
Examples of test sentences	**In Section 1 (Picture)** **Mei ge xiaopengyou dou bu zai chi pingguo.** Every (Cl.) kid all NEG –ing eat apple Every kid is not eating apples. 	**In Section 1 (Picture)** **Mei ge xiaochou dou bu zai chui paopao.** Every (Cl.) clown all NEG –ing blow bubble Every clown is not making bubbles. 
	In Section 2 (Picture) **Mei ge xiaonanhai dou bu zai kan shu.** Every (Cl.) boy all NEG –ing read book Every boy is not reading books. 	**In Section 2 (Picture)** **Mei zhi xiaotuzi dou bu zai chi huluobo** Every (Cl.) rabbit all NEG –ing eat carrot Every rabbit is not eating carrots. 
	In Section 3 (Videoed story) **Mei zhi xiaoxiong dou bu zai shuijiao.**	**In Section 3 (Videoed story)** **Mei zhi xiaoxiong dou bu zai wan wanju**
	Every (Cl.) bear all NEG –ing sleep Every bear is not sleeping. 	Every (Cl.) bear all NEG –ing play toy Every bear is not playing with toys. 

Note: The sign ''YES'' indicates the entity involved undertook the action stated by the VP in a sentence and the sign ''NO'' indicates the opposite.

a few of the 4- and 5-year-old children considered both acceptable. If the consistency of their responses is taken into account, the inverse interpretation turns out to be quite marginal.

Second, children less than six years old were significantly different from adults in the way they evaluated the inverse scope interpretation, which shows that Mandarin-speaking children require a gradual process in order to obtain full command of the importance of linear precedence in scope assignment.

Third, the change in the type of universal quantifier from *mei (every)* to *suoyou (all)* did not create any noticeable difference in the judgment of my subjects. In this case, the effect of lexical difference is on the wane.

Table 12
YES responses from children and adults.

Linear ordering	Sentence type	Scope reading	4–5 Group	5–6 Group	6–7 Group	7–8 Group	Adult group
Every. . .not	1	every > neg	100% (45/45)	100% (45/45)	100% (45/45)	100% (45/45)	100% (45/45)
		neg > every	26.67% (12/45)	13.33% (6/45)	0% (0/45)	0% (0/45)	0% (0/45)
All. . .not	2	all > neg	97.78% (44/45)	97.78% (44/45)	100% (45/45)	100% (45/45)	100% (45/45)
		neg > all	33.33% (15/45)	24.44% (11/45)	2.22% (1/45)	0% (0/45)	0% (0/45)

Note Sentence type 1 Mei (Cl.) N dou bu/mei VP.
Every (Cl.) N all not VP
Sentence type 2 Suoyoude N dou bu/mei VP.
All N all not VP

Table 13
Percentage of subjects consistently accepting or rejecting the same readings (the "∀. . .¬" construction).

Linear ordering	Sentence type	Scope reading	Scope judgment	4–5 Group	5–6 Group	6–7 Group	7–8 Group	Adult group
Every. . .not	1	every > neg	YES	100% (15/15)	100% (15/15)	100% (15/15)	100% (15/15)	100% (15/15)
			NO	0% (0/15)	0% (0/15)	0% (0/15)	0% (0/15)	0% (0/15)
		neg > every	YES	6.67% (1/15)	6.67% (1/15)	0% (0/15)	0% (0/15)	0% (0/15)
			NO	46.67% (7/15)	80% (12/15)	100% (15/15)	100% (15/15)	100% (15/15)
All. . .not	2	all > neg	YES	93.33% (14/15)	93.33% (14/15)	100% (15/15)	100% (15/15)	100% (15/15)
			NO	0% (0/15)	0% (0/15)	0% (0/15)	0% (0/15)	0% (0/15)
		neg > all	YES	20% (3/15)	13.33% (2/15)	0% (0/15)	0% (0/15)	0% (0/15)
			NO	46.67% (7/15)	53.33% (8/15)	100% (15/15)	100% (15/15)	100% (15/15)

Note: YES indicates positive responses to the readings involved while NO indicates the opposite.

4.2.2. *Experimental data of the "¬. . .∀" construction*

As Tables 14 and 15 demonstrate, when the ordering of negation and universal quantification is reversed, the deviation in judgment on the part of children from that of adults reflects the challenge the "¬. . .∀" construction poses for young children. When the m*ei (every)* sentences were heard in the scenario of the linear scope reading (the "some" reading), the young children from the 6–7 age group evaluated the sentences positively in a significantly different way from adults (in the case of *mei (every)* and *suoyou (all)*, 84.44% vs. 100%, $z = 2.74$, $p < 0.01$) (as illustrated in Table 14). The number of subjects who consistently accepted the sentences in the scenario of the "some" reading steadily increased with age: for example, in the sentences containing *mei (every)*, the number grew from six in the 4–5 age group, to seven in the 5–6 age group, to 10 in the 6–7 age group, to 12 in the 7–8 age group, and finally to 15 subjects in the adult group (as illustrated in Table 15). The number of subjects who favored the linear "some" reading grew in tandem with their age.

Table 14
YES responses from children and adults in the situation of the "¬. . .∀" construction (with universal quantifier in the subject and object position).

Linear ordering	Sentence type	Scope reading	4–5 Group	5–6 Group	6–7 Group	7–8 Group	Adult group
Not . . .every	3	every > neg	86.67% (39/45)	66.67% (30/45)	53.33% (24/45)	57.78% (26/45)	37.78% (17/45)
		neg > every	66.67% (30/45)	71.11% (32/45)	84.44% (38/45)	93.33% (42/45)	100% (45/45)
Not. . .all (subj.)	4	every > neg	82.22% (37/45)	66.67% (30/45)	55.56% (25/45)	51.11% (23/45)	40% (18/45)
		neg > every	57.78% (26/45)	66.67% (30/45)	84.44% (38/45)	93.33% (42/45)	100% (45/45)
Not. . .all (obj.)	5	every > neg	91.11% (41/45)	93.33% (42/45)	100% (45/45)	93.33% (42/45)	51.11% (23/45)
		neg > every	66.67% (30/45)	62.22% (28/45)	46.67% (21/45)	68.89% (31/45)	100% (45/45)

Note: Sentence type 3 Bu shi Mei (Cl.) N dou VP.
Not BE every (Cl.) N all VP
Sentence type 4 Bu shi Suoyou (Cl.) N dou VP.
Not BE all (Cl.) N all VP
Sentence type 5 NP bu/mei V suoyoude N.
NP not V all N

Table 15
Percentage of subjects consistently accepting or rejecting the same readings (the "¬. . .∀" construction) (with universal quantifier in the subject and object position).

Linear ordering	Sentence type	Scope reading	Scope judgment	4–5 Group	5–6 Group	6–7 Group	7–8 Group	Adult group
Not. . .every	3	every > neg	YES	73.33% (11/15)	40% (6/15)	26.67% (4/15)	26.67% (4/15)	26.67% (4/15)
			NO	0% (0/15)	13.33% (2/15)	20% (3/15)	0% (0/15)	46.67% (7/15)
		neg > every	YES	40% (6/15)	46.67% (7/15)	66.67% (10/15)	80% (12/15)	100% (15/15)
			NO	6.67% (1/15)	6.67% (1/15)	0% (0/15)	0% (0/15)	0% (0/15)
Not. . .all(subj.)	4	every > neg	YES	60% (9/15)	40% (6/15)	26.67% (4/15)	26.67% (4/15)	20% (3/15)
			NO	0% (0/15)	6.67% (1/15)	20% (3/15)	13.33% (2/15)	40% (6/15)
		neg > every	YES	20% (3/15)	53.33% (8/15)	73.33% (11/15)	80% (12/15)	100% (15/15)
			NO	6.67% (1/15)	13.33% (2/15)	0% (0/15)	0% (0/15)	0% (0/15)
Not. . .all(obj.)	5	every > neg	YES	80% (12/15)	86.67% (13/15)	100% (15/15)	100% (13/15)	33.33% (5/15)
			NO	0% (0/15)	0% (0/15)	0% (0/15)	0% (0/15)	20% (3/15)
		neg > every	YES	46.67% (7/15)	20% (3/15)	20% (3/15)	20% (3/15)	100% (15/15)
			No	0% (0/15)	0% (0/15)	33.33% (5/15)	6.67% (1/15)	0% (0/15)

Regarding the acceptance of the test sentences in circumstances where only the inverse scope reading (the "none" reading) is eligible, a significant difference was found between 5- or 6-year-old children and adults (66.67% vs. 37.78%, $z = 2.728$, $p < 0.01$) with *mei (every)*, and between 5- or 6-year-olds and adults (66.67% vs. 40%, $z = 2.521$, $p < 0.05$) with *suoyou (all)* (as illustrated in Table 14). Regarding the consistency of the responses in the condition which allowed the inverse scope reading, the tendency changed similarly across groups in both kinds of construction. For example, with *mei (every)*, eleven children from the 4–5 age group, six children from the 5–6 age group, four children from the 6–7 and 7–8 age groups, and four adults accepted the sentences, while two children from the 5–6 age group, three children from the 6–7 age group, and seven adults rejected the sentences (as illustrated in Table 15).

In Sentence type 5, the phrase *suoyoude n. (all n.)* was placed in the object position. Such a construction is always considered acceptable, but is marked compared to the construction with *suoyou (all)* in the subject position. Concerning the naturalness of sentences such as (24), we conducted a survey on the internet to consult twenty Mandarin-speaking adults, eighteen of whom judged it to be acceptable, and only two considered it less acceptable.

(24) Ma meiyou tiaoguo suoyoude zhalan.
Horse not-have jump-over all fence
"The horse didn't jump over all the fences."

As shown in Tables 14 and 15 and in Fig. 3, the general tendency of my subjects' performance in tests using sentence types 3 and 4 can also be observed in the results from this type of sentence; that is, the rates of acceptance of the linear scope reading of the sentences grew across the groups of children, while those of the inverse scope reading declined. One point needs special attention: in circumstances where either the "some" or the "none" reading can be true, even the responses from the 7- or 8-year-old children were significantly different from those of the adults (in the condition of the "some" reading, 68.89% vs. 100%, $z = 4.049$, $p < 0.01$; in the condition of the "none" reading, 93.33% vs. 51.11%, $z = 4.447$, $p < 0.01$) (as illustrated in Table 14). We assume that that difficulty is to a great extent associated with the markedness of the syntactic arrangement of having *suoyoude n. (all. . .n.)* in the object position.

In summary, all the results from the "¬. . .∀" constructions add more insight to these findings. In the first instance, the adults perceived the linear "some" reading to be optimal, but the inverse "none" reading was also accepted by many adults (the adults' rates of acceptance of the inverse "none" reading increased from 37.78% (17/45) to 51.11% (23/45) in the three types of test sentences).

Second, sentences of this type do pose a challenge to children when it comes to scope. From my results, it seems that the young children were less rigid than the adults, for more than half of them considered both alternative readings acceptable. Young Chinese children opted for the "none" reading as their favorite, the same as in the test of the "∀. . .¬" ordering. As the subjects' age increased, more and more children rejected the "none" reading (the inverse scope reading), from which we see the development of valuing linear precedence in children. While interpreting sentence types 3 and 4 (with the universal quantifier in the subject position following *bu shi (not be)*), the 7- and 8-year-old children were no longer significantly different from the adults in their perception of scope. In tests of sentence type 5 (with *suoyou (all)* in the object position), it seems to take time even for older children to interpret scope the way adults do, that is, even 7- or 8-year-old children responded in a non-adult way, preferring the "none" reading to the "some"

reading. This difficulty very probably exists because universal quantification seldom occurs as an object NP in Mandarin. Another piece of related strong evidence is that a noun phrase quantified by *mei (every)* is entirely excluded from being in the object position. This special constraint on universal quantifiers in Mandarin can be accounted for by the scope rigidity of the language, which is largely a result of the principle of linear precedence, in combination with the strong nature of distributivity that universal quantifiers inherently have. If a universal quantifier occupies the object position, it will be in the unenviable position of taking scope over any other logical operator preceding it in the surface structure. Hence, it seldom occurs.

Ultimately, it appears that, by the age of 6 or 7, Mandarin-speaking children have started to show a clear preference for isomorphic readings.

4.3. A summary of experimental results

Our test results present us with a broad overview of Mandarin-speaking children's scope judgment between negation and universal quantification. Invariably, they initially prefer the "none" reading, with a universal quantifier outscoping negation regardless of their ordering in the surface structure. While appraising the inverse scope reading, young Mandarin-speaking children appear to be less confined to the constraint of scope rigidity in Mandarin than Mandarin-speaking adults. Especially where the "∀. . .¬" ordering is concerned, they are more likely to interpret test sentences with ambiguity. Their knowledge about the dominance of linear precedence in scope assignment needs time to mature. As the children's age increases, they are more and more inclined toward the linear scope reading. A breakthrough usually comes at age 6 or 7, when, with some instruction on the importance of linear precedence, their judgment of scope converges with that of adults.

5. General discussion

5.1. A comparative study of Mandarin studies

We will now compare the test results from Zhou and Crain (2009) with those of my study. The test methods used in the two studies differ in two aspects. First, I used both pictures and stories to present test stimuli, while Zhou & Crain only chose stories. Second, I played videoed stories in our tests on a laptop, while Zhou & Crain used live performance. Considering the difference, I believe it is very important to verify that the performance of my subjects did not fluctuate with the changes in my test methods. As the table in the Appendix shows, considerable stability was observed in the judgment of my subjects, given that the number of subjects favoring a particular reading did not change significantly.

In the following, we summarize the differences between the findings of Zhou and Crain (2009) and those of my study, primarily based on Tables 1–3, 12, 14 and 15, as well as Figs. 1–3, as in Table 16.

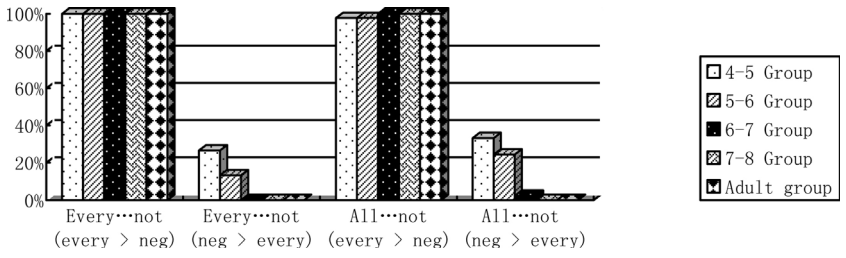


Fig. 1. YES responses from children and adults.

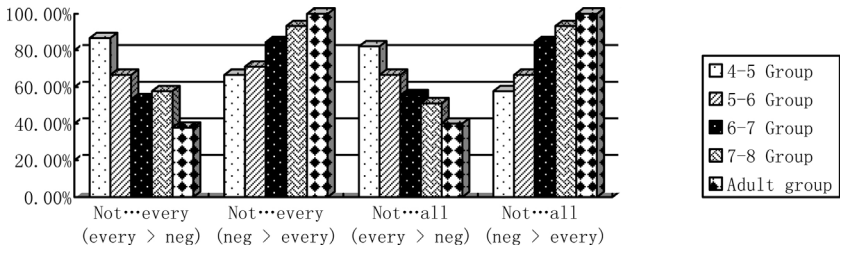


Fig. 2. YES responses from children and adults in the situation of the "¬. . .∀" construction (with universal quantifier in the subject position).

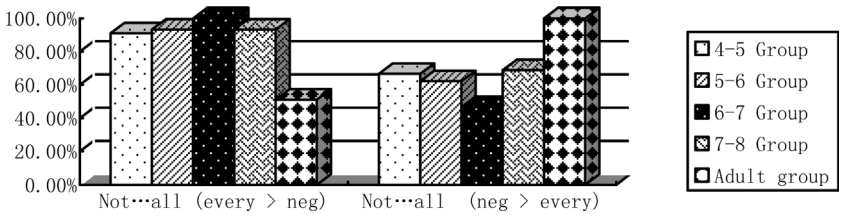


Fig. 3. YES responses from children and adults in the situation of the "¬. . .∀" construction (with universal quantifier in the object position).

Table 16
Comparison of the experiments on scope assignment in Mandarin.

Studies	Linear orderings of operators in surface structure	Children	Adults	Age at which children acquire the reading(s) consistent with adult grammar
Zhou and Crain (2009)	∀. . .¬	(Mean: 4;3) Every > Neg (Neg > Every)	Every > Neg	
	¬. . .∀	(Mean: 4;3) Every > Neg =Neg > Every	Neg > Every (??Every > Neg)	
The present study	∀. . .¬	(Mean: 4;5) Every > Neg (Neg > Every)	Every > Neg	Around the age of 6–7
	¬. . .∀	(Mean: 4;5) Every > Neg (Neg > Every)	Neg > Every (Every > Neg)	Around the age of 7–8

Note: The ranking of two readings is made according to the speakers' judgments in the experiments. "=" represents "is equivalent to" in terms of acceptability. Readings within the brackets are comparatively marked in terms of acceptability.

The first difference concerns the degrees of sensitivity in young children to the effect of word order on semantic interpretation. In Zhou & Crain's test, 4- to 5-year-old children seem to have developed some sensitivity to the linear ordering of universal quantification and negation. In both of the cases, they had greater and easier access to the linear scope reading than my subjects of a similar age. In my experiment, the 4- to 5-year-old children always favored the "none" reading, no matter how the two logical expressions were arranged.

The second difference concerns the young children's perception of the interpretation of the "not. . .every" construction in the "none" scenario. In Zhou & Crain's experiment, the subjects (4;5–5;1) assessed the "some" reading for the "not. . .every" ordering as preferable to the "none" reading (as illustrated in Table 1). However, the exact opposite is true of the responses of my 4- and 5-year-olds (as illustrated in Tables 14 and 15). The younger children (3;4–4;3) in Zhou & Crain's experiment provided responses that showed no bias toward one of the readings (as illustrated in Table 2), which differs from the responses of my subjects (mean age: 4;5), who showed a very noticeable preference for the "none" reading of the "every. . .not" construction (as illustrated in Tables 14 and 15).

These differences aside, significant commonalities can be found. Both studies shed light on the fact that Mandarin-speaking children aged around 4 have the ability to interpret a sentence ambiguously. In addition, both studies report the phenomenon that, compared to the "every. . .not" construction, the "not. . .every" construction is much more challenging to young children. A natural question arises: what causes the trouble?

5.2. Factors affecting scope assignment in the grammar of Mandarin-speaking children

5.2.1. Scope interaction between negation and universal quantification: a syntactic issue?

Is the scope interaction between negation and universal quantification a syntactic issue? In some sense, Musolino and his collaborators (Musolino, 1998, 2011: 324; Musolino et al., 2000) answer the question affirmatively, since isomorphism is the core concept in their account.

Musolino (1998: 149, 2011: 325) defines the nature of the OI as follows: "My contention, therefore, is that isomorphism in the acquisition of QNP-Neg interaction is *epiphenomenal* [my emphasis]. It should be regarded as an *emergent property* [my emphasis] arising from the interplay between properties of QNPs and learnability considerations." He (2011: 330) asserts the privilege of the isomorphic reading in this way: "Regarding the special status of surface scope, the

evidence available points to the conclusion that isomorphic interpretations of sentences containing multiple quantified expressions are theoretically, psychologically, and statistically privileged.''

The OI has considerable empirical evidence supporting it. Above all, in terms of the work load of sentence processing, the surface scope reading has a privileged status in that it tends to be initially favored by the parser. This claim is empirically supported by Anderson's (2004) study, based on three questionnaires and five self-paced reading experiments. He, too, affirms the claim that ''inverse-scope interpretations are dispreferred by the processor and that assigning inverse scope consumes more processing resources than assigning surface scope does'' (Anderson, 2004: iii).

Additionally, distributional properties should be considered a significant factor in activating children's parsers for alternative interpretations of ambiguous sentences. Gennari and MacDonald (2005/2006: 162) propose that an ambiguity process in children is one in which ''interpretations are activated as a function of distributional properties of their input, which strengthened the pairing of one interpretation with the experimental context but disfavored the alternative one.'' A statistical difference in input leads to a real difference in the production of children. In terms of distributional frequency, as Fitzgibbons (2014: 99) observes by saying that ''the surface scope reading is available to some speakers of each language and is, moreover, the only one available for Polish and Russian speakers,'' the linear scope reading must take precedence over the inverse scope reading in a number of languages. Mandarin is typical among these languages, allowing children to be exposed to a rich input of sentences with an isomorphic scope reading.

However, the OI has ''bugs'' that invite controversy. The strongest dissenting voice in the debate about its effectiveness comes from Gualmini (2004, 2008: 1158), who straightforwardly expresses his opposition by saying: ''We argue that the Observation of Isomorphism has no place in our theory of child language. In particular, we highlight the theoretical and empirical shortcomings of current theories that attribute a privileged role to surface scope in children's parsing (e.g., Musolino and Lidz, 2006). Furthermore, we show that the Observation of Isomorphism cannot even be invoked to describe children's non-adult behavior, by reviewing existing experimental findings showing that children may in fact select inverse scope interpretations for sentences that adults consistently interpret on surface scope (Krämer, 2000; Hulsey et al., 2004).'' Musolino's (2011) counter-arguments range from pointing out flaws in Gualmini's argumentation to noting the difference in the ages of subjects and the voices in the test materials used in the two studies. Complementing the OI, Musolino (2011: 326) further hypothesizes that English-speaking preschoolers go through a ''Chinese-speaking phase,'' during which they initially treat sentences as unambiguous and assign them only an isomorphic interpretation.

More interestingly, there is no trace of such a ''Chinese-speaking phase'' in the grammar of young Chinese children, as much empirical data has shown. As far as the scope interaction between negation and universal quantification is concerned, the findings of both Zhou & Crain's and my study disagree with the OI because a large number of young children were initially found to interpret scope non-isomorphically. Isomorphism is therefore not the default principle, requiring children to spend several years acquiring it. It is roughly by the age of 6 or 7 that Mandarin-speaking children have a good command of the linear principle and begin to interpret scope as Mandarin-speaking adults do.

The absence of the ''Chinese-speaking phase'' in early Mandarin grammar is also evident from a number of studies on the scope interaction between quantified NPs (e.g., Chien and Wexler, 1989; Lee, 1991). For example, Lee observes that, unlike adults, children initially do not seem to map scope relations isomorphically with the surface positions of QNPs. Therefore, he (1991: 204) concludes that ''quantifier order is distinguished by Chinese children by age 6 and that the linearity principle for scope interpretation is firmly established by age 7.''

Mandarin Chinese is a language with restricted scope ambiguity because speakers are strongly inclined to interpret scope isomorphically. Even living in this kind of speech environment, young Mandarin preschoolers, especially those 4 and 5 years old, are found to ignore the linearity principle while interpreting scope. This phenomenon leads us to a new perspective from which the OI can be revisited.

If we look at the importance of the linear ordering of logical expressions in terms of distributional characteristics, we are reminded of another interesting issue about the correlation between the distributional frequency in the input by adults and the initial scope judgment by children. Considering the fact that Chinese children acquire universal adverbs early, as illustrated in Tables 7 and 8, we focus on universal adverbs and their co-occurrence with negation in adults' speech, as shown in Table 17.

In the adults' verbal communication with a child aged around 02;05, the *all-not* combination appears much more frequently than the *not-all* combination. Such frequently occurring input has its echo in children's early spontaneous output. From my longitudinal data in Tables 7 and 8, we see that children start to spontaneously produce the *dou* (all) *not* combination, with *dou* outscoping its clausemate negation, since around 02;05. We interpret this phenomenon by assigning the feature of ''unmarkedness'' to this syntactic combination. When we consider a lack of natural conditions, likely arising from the use of a universally quantified NP in the object position, we are more convinced of this claim. The two logically possible syntactic orderings differ in terms of markedness, which can contribute to the explanation of the difficulty children encountered when they handled sentence types 3, 4, and 5.

Table 17
Number of utterances containing negation and universal adverbs by Mandarin-speaking adults.

Orderings	Adverbs	Constructions		CY	SJQ	ZHZ	ZTX
Adv-neg	*Dou* *(all)*	*dou*-neg *(all-not)*	*dou-bu*	74	28	63	104
			dou-mei	67	21	28	47
	Quan *(all)*	*quan*-neg *(all-not)*	*quan-bu*	0	0	0	0
			quan-mei	4	0	1	0
Neg-adv	*Dou* *(all)*	neg-*dou* *(not-all)*	*bu-dou*	14	3	3	2
			mei-dou	0	0	0	0
	Quan *(all)*	neg-*quan* *(not-all)*	*bu-quan*	0	0	0	0
			mei-quan	0	0	0	0

All the same, it is not right to assert that isomorphism is completely futile. Even when the "¬. . .∀" sentences are involved, it can still provide young children useful clues for choosing the linear scope reading. As Tables 14 and 15 display, more than half of the response of 4- and 5-year-old children were in favor of the linear scope reading in this type of construction.

Aware of the disagreement between his hypothesis and Mandarin data from Lee (1996), Musolino (1998) stresses his claim that there is no so-called "principle of isomorphism," only an epiphenomenon of some more profound principles. My empirical data brings us to a similar conclusion, that is, that there is no principle of isomorphism in early Mandarin child grammar. Regarding any "more profound principles" that give rise to an "epiphenomenon," as Musolino puts it, we do not have a clear mind of his real message, at very least, up to now.

5.2.2. Scope interaction between universal quantification and negation: a lexical-semantic issue?

In the literature about the scope of quantified NPs, lexical difference is commonly regarded as one factor affecting scope assignment (Beghelli, 1997; Beghelli and Stowell, 1997; Cruse, 2000; Ioup, 1975; VanLehn, 1978). In the context of Mandarin, as in Kuno et al. (1999), Lee et al. (1998), and Wu (1992), the lexical factor is taken to be one of the decisive effects on scope assignment.

Universal quantificational determiners in Mandarin, especially *mei (every)*, are characterized by the distinctive property of activating a distributive reading, and they therefore take wide scope (Wu, 1992; Kuno et al., 1999). This is because, in Mandarin, syntactic position always has an overriding effect on scope assignment, so the object position is certainly a marked syntactic position for a quantifier. When discussing my test sentences of type 5, Mandarin speakers tended to be reluctant to use *suoyou (all)* to quantify the object NP in a sentence, saying that the result would be unnatural.

In my test constructions, we can see that the strong feature of distributivity inherently attached to *mei (every)* and *dou (all)* makes the "∀. . .¬" sentences associated with the surface scope reading, in which the universal quantifier determiners outscope negation. This feature makes even the "¬. . .∀" sentences very likely to invite the inverse scope interpretation, with the same scope assignment. Hornstein (1995) classifies QNPs in terms of their possible interpretations relative to negation (as in (25)). In his terminology, *mei (every)* and *suoyou (all)* belong to Type 2.

(25) Type 1 QNPs
The quantifiers that are always interpreted isomorphically with respect to negation. (E.g., an object QNP of Type 1 will always be interpreted within the scope of negation because AgrO, the position to which it would move, is hierarchically lower than NegP.)
Type 2 QNPs
The quantifiers that are interpreted in positions that are different from their surface syntactic position, i.e., non-isomorphically, by a mechanism that does not yield the typical signature of syntactic movement (e.g., locality effects).

Universal quantificational determiners in the subject position are always accompanied by *dou (all)* in Mandarin, as in my test sentences, which further increases the possibility that universal quantifiers can take wide scope over other logical expressions. The discussion on the nature of *dou (all)* can be traced back to some classic studies early in the last century, in which it was analyzed as an adverb that expresses the idea that all entities in a speech domain are included (Ding et al., 1961: 183; Li, 1998 (1924): 188; Lu and Ma, 1985: 98; Lü, 1996 (1980): 153; Wang, 1985: 133; Zhu, 1997 (1982): 196). At first, the "inclusion over entities" view possibly matches our general intuition about the meaning of *dou (all)* well, but in

reality it has its flaws. For example, it does not work sufficiently well to account for the reason why (27) sounds good, but (26) does not.

(26) ? Women dou ba Zhangsan tui dao le.
We all cause Zhangsan pull fall asp-marker
''We all pushed Zhangsan and he fell.''

(27) Women dou ba Zhangsan tui dao guo.
We all cause Zhangsan pull fall asp-marker
''We all have pushed Zhangsan and he fell.''
(Examples taken from Wu, 1992: 320)

With the aim to improve the ''inclusion over entities'' explanation, Huang (1996: 84, 161) suggests the ''a sum operator over minimum events'' idea, which defines *dou (all)* as ''a sum operator that unions the minimum events into a plural event, and these minimum events have to be presupposed rather than presented when *dou (all)* is used.'' In this case, *dou (all)* does not quantify entities, but sub-events.

The concept of distributivity opens up another path to the nature of *dou (all)*. Lee (1986: 30) proposes the view that ''*dou* clearly exhibits the properties of an unselective universal quantifier,'' which has a distributive interpretation. He (1986: 58, 177) provides examples containing *dou (all)* that can only be grammatically correct when it is interpreted distributively.

(28) a. Zhangsan he Mali mingtian jiehun
Zhangsan and Mali tomorrow marry
''Zhangsan and Mary will marry tomorrow.''
b. Zhangsan he Mali dou mingtian jiehun
Zhangsan and ali all tomorrow marry
''Zhangsan and Mary will both marry (with someone else) tomorrow.''

(29) a. Women heyong yi-ge chufang
We share one-CL kitchen
''We share a kitchen.''
b. Women dou heyong yi-ge chufang
We all share one-CL kitchen
''We each share a kitchen (with someone else).''

Mei (every) requires the co-occurrence of *dou (all)*, which has been discussed in studies by Cheng (1995, 2009), Huang (1996), Lee (1986), Lin (1998), and Liu (1990). Cheng (2009: 12) points out that ''*mei* plus *dou* yields an interpretation comparable to *every* in English, an interpretation with distributivity.'' We conducted a survey on the acceptability of sentences containing universal quantifier determiners without *dou (all)* among 39 college students by asking them to assess the acceptability of sentences (30) and (31), which they read in a questionnaire, on a five-score scale with 5 (very good), 4 (good), 3 (acceptable), 2 (not very acceptable), and 1 (very bad). The average score for sentence (30) was 1.74, and that for sentence (31) was 2.64, which validates the proposition in earlier literature that the co-occurrence of universal quantifier determiners and *dou (all)* is obligatory.

(30) Mei-ge xiaopengyou bu chi pingguo
Every-CL child not eat apple
''Every child doesn't eat apples.''

(31) Suoyoude xiaopengyou mei na qiqiu
All child not take balloon
''All children didn't take balloons.''

The lexical nature of *mei (every)*, *suoyou (all)*, and *dou (all)* naturally empowers them to gain an advantage over other logical expressions in the competition for wide scope. However, the lexical factor does not always operate in isolation. Its effect may be curbed by other, more important factors, the most important being the linear ordering of logical expressions. Linear ordering and lexical properties can be friends and foes: in the ''$\forall \ldots \neg$'' sentences, both guide us to the same reading, but in the ''$\neg \ldots \forall$'' sentences, they are in conflict, taking us to different readings. In the second situation, as Table 14 and Figs. 2 and 3 show, the judgment of 4- and 5-year-old children deviated from that of adults, for they initially relied on the lexical property of universal quantification as a dominant rule to interpret scope, rather than the principle of linear precedence to which the adults adhered. The perception of the prominent power of linear precedence in Mandarin is the prerequisite that

guides young children to think like adults when they attempt to do scope interpretation. Additionally, some pragmatic knowledge about conversational implicature and the proper use of negation can accelerate the pace of acquisition.

5.2.3. Scope interaction between negation and universal quantification: a semantic–pragmatic issue?

In actual communication, a proposition is sometimes heavily loaded with multiple implied meanings that are strongly context- and speaker-dependent. They are often so elusive that it is usually not easy to capture them under the rubric of semantics itself. Büring's (1997) alternative semantics provides a workspace in which we can analyze the formal relationship between a proposition's logical semantic meaning and alternative pragmatically implied meanings. Following in his steps, we first suppose (32) to be ambiguous, with the ''none'' reading logically interpreted in (33) and the ''some'' reading in (34).

(32) Ma meiyou tiaoguo suoyoude zhalan.
Horse not-have jump-over all fence
''The horse didn't jump over all the fences.''

(33) The LF of the ''none'' reading
a. [[(1)]]*o* = All fences were such that the horse didn't jump over
b. [[(1)]]*f* = {all fences were jumped over, all fences were s.t. the horse didn't jump over}
c. [[(1)]]*t* = {{all fences were jumped over, all fences were s.t. the horse didn't jump over},
{most fences were jumped over, most fences were s.t. the horse didn't jump over},
{some fences were jumped over, some fences were s.t. the horse didn't jump over},
{one fence was jumped over, one fence was s.t. the horse didn't jump over}}

Once ''All fences are such that the horse didn't jump over'' is asserted, all the alternative propositions in (33c) are entailed by this assertion and are, as a result, true. Since none of the alternatives are disputable, conversational implicature cannot be yielded. It is clear that the computation task for children is relatively easy, for they only need to map the first propositions in (33c) onto the circumstances they are provided in order to decide on the truth of (32).

(34) The LF of the ''some'' reading
a. [[(2)]]*o* = It is not that all fences were jumped over
b. [[(2)]]*f* = {all fences were jumped over, it is not that all fences were jumped over}
c. [[(2]]*t* = {{all fences were jumped over, it is not that all fences were jumped over},
{most fences were jumped over, it is not that most fences were jumped over},
{some fences were jumped over, it is not that some fences were jumped over},
{one fence was jumped over, it is not that one fence was jumped over},
{no fence was jumped over, it is not that no fence was jumped over}}

When the ''some'' reading is involved, none of the alternative propositions in (34c) except the first one is entailed or contradicted by the assertion ''It is not that all fences were jumped over.'' Hence, a disputable conversational implicature comes into being. In the situation of the ''some'' reading, children have a heavy workload. They have to process the logical reading first and then the alternative conversational implicatures in (34c) one by one before they can assign a proper truth value to (32). A series of natural questions that they face in this complex situation can be: ''Were there all fences that were jumped over at all? And if so, how many? Or were there not any?'' Assessing scalar implicatures such as those in (34c) is always costly. Precisely for this reason, the ''none'' reading (the entire negation), compared to the ''some'' reading (the partial negation), is acquired by Mandarin-speaking children earlier. (A similar case is that the structure of *dou-bu/mei (not-all)* and its ''none'' reading is acquired by Chinese children by age 2;5.)

The alternative semantics-based account also enables us to answer a logical question: why can the ''none'' reading also be acceptable in circumstances that make the ''some'' reading true? The answer lies in the last implied proposition in (34c). The truth conditions that make the ''none'' reading true constitute a subset of the truth conditions that make the ''some'' reading true. As a result, the ''none'' reading and the ''some'' reading are not contradicted, although it is incorrect to say the ''none'' reading is always true when the ''some'' reading is true.

Büring's (1997) alternative semantics helps demonstrate the computational complexity of the ''some'' reading. An in-depth discussion about the pragmatic constraint on the use of negation can uncover another trigger for a salient leap in children's knowledge about scope interpretation. The use of negation can be guaranteed to be felicitous only if it is used to state a discrepancy between what was expected to happen and what usually did happen (De Villiers and Tager-Flusberg, 1975; Givon, 1978; Wason, 1965). Regarding scope, if a speaker wants to express the ''none'' reading in Mandarin, a language that highly values word order, he or she will be more likely to adopt the *mei (every)/suoyou (all)*. . .*not* ordering, as in sentence types 1 and 2. This is because such an ordering only results in a surface scope reading, easily processed

and not leaving room for vagueness. Besides, such an ordering is used by adults more frequently than *not. . .mei (every)/ suoyou (all)* (as verified by the input of adults in my longitudinal data). Conversely, if a speaker speaks a *not. . .mei (every)/ suoyou (all)* sentence as in types 3–5, he or she is less likely to communicate the ''none'' reading. He or she must intend to stress a real situation in opposition to what is communicated, like the information expressed by the underlined part in (35). The intended message can be paraphrased as ''it is commonly believed that all the horses jumped over the fence, but this is not the case,'' which implies that ''some horse(s) didn't jump over the fence.'' In other words, a *not. . .mei (every)/suoyou (all)* sentence has the ''some'' reading as its optimal reading, which is asserted by the felicitous use of negation and the characteristics of different linear arrangements. All pragmatic knowledge involved here requires a high order of delicacy in the use of a language system, which we assume comes late in the grammar of children.

(35) Bushi **mei-pi ma dou tiaoguo le zhalan.**
Not-be every-CL horse all jump-over Asp fence
''It is not the case that every horse jumped over the fence.''

Scope assignment is very sensitive to changes in a sentence's focus. We also observed that there were more adult subjects who abandoned the inverse ''none'' reading in sentence types 3 and 4 than in sentence type 5, which suggests that the use of a cleft construction has an effect on adults' perception. As to its effect on children, my data has not yet shown any clear signs. We went through 199 children's utterances containing the copular verb *shi (be)* from CY (00;10;15–02;04;31), none of which were a cleft sentence. Its late development suggests that the use of a cleft sentence in sentence types 3 and 4 presents an additional difficulty for young children to overcome.

5.2.4. Scope interaction between negation and universal quantification: a problem of learnability

There are diverse co-existing models that provide alternative accounts for children's initial preference in scope assignment. The Semantic Subset Principle and its later forms have been gaining a very prominent position in the literature. Manzini and Wexler (1987: 425) first proposed the Subset Principle, which claims that ''the learner selects the grammar that generates the smallest possible language that is compatible with the data.'' A modified version for semantic interpretation, the Semantic Subset Principle, was proposed by Crain (1992, 1993), Crain et al. (1994), Crain and Philip (1993), and Crain and Thornton (1998), and further developed into the Semantic Subset Maxim by Notley et al. (2012). The SSM claims that, if two readings of a scopally ambiguous sentence constitute a subset–superset relationship, the reading that makes the sentence true in the narrowest range of circumstances is the one initially favored by children.

In my study, a sentence containing negation and universal quantification has two logically possible interpretations, the ''none'' reading and the ''some'' reading, between which there exists an entailing relation, as discussed in 5.2.3. My data portray two possible situations that Mandarin-speaking children experience.

In the first situation, when the universal quantifier precedes negation in the surface structure, influenced by the lexical property of universally quantified expressions, 4- and 5-year-old children initially select the ''none'' reading, as predicted by the SSM. Furthermore, this reading is the surface scope reading, which agrees with the principle of linear precedence in Mandarin. As a result, children do not need to spend much time working out the readings. However, that children under 6 or 7 do as adults do does not mean that they think as adults think. They have a non-adult mechanism to rely on.

In contrast, in the second situation, where negation precedes universal quantification, relying on lexical properties and linear ordering, 4- and 5-year-old children continue favoring the ''none'' reading and simultaneously also accept the ''some'' reading. Such a preference in child grammar can also be explained by the SSM. There is a difference of more than 40% between the responses of children and adults concerning both readings (as illustrated in Table 14). As children grow up, they gradually encounter adults using the *not. . .mei (every)/suoyou (all)* sentences more often in circumstances where only the ''some'' reading can be true. They then move on to a state of adult knowledge about scope by drawing reasonable inferences about the dominant role of the linearity principle and consequently acting on it. The principle of linear precedence can be firmly established in the grammar of children at age 6 or 7. It is at this point of time in their life that their scope knowledge completely converges with that of adults. In this developmental process, the ''not. . .every/all'' sentences, rather than the ''every/all. . .not'' sentences, provide optimal instructions to Mandarin-speaking children on how to interpret scope the way adults do.

The Question-Answer Requirement model (Hulsey et al., 2004; Gualmini et al., 2008) is also influential in this area, pointing out the possibility that children's initial preference in scope assignment is based on the conversational principle of clarity, rather than the SSM or the Principle of Isomorphism. According to this model, children initially prefer the scope reading that provides a good answer to the salient ''question-under-discussion'' (QUD) in their context. Notley et al. (2015) provide an argument against the Question–Answer Requirement model by reporting children's preference for the strong reading even in a task designed to make the weak reading a good true answer to the question under discussion. Regarding the conversational factor that Hulsey et al. claim to be relevant to determining scope readings, my study in its current form cannot make any conclusions, but it will be considered in future studies.

6. Conclusion

In conclusion, the judgment of Mandarin speakers about the scope assignment between negation and universal quantification is attributed to the interplay of several influential factors: word order, lexical semantics of logical expressions, structural complexity, conversational implicature, and felicity in the use of negation. This proposal that syntactic, semantic, and contextual factors are jointly in effect is also supported by Su (2001, 2008), who studied the relative scope between negation and numerally quantified NPs in Mandarin.

Tracing the development of scope knowledge to its origin, we found that it is an overemphasis on the lexical feature of universal quantifiers that is responsible for children's non-adult interpretations at the initial stage of language development. Mandarin-speaking children initially show a preference for the ''none'' reading in a sentence containing negation and a universal quantifier, in accordance with the prediction of the SSM. The test results of my study match the SSM's predictions much better than the results of Zhou and Crain (2009), presented in Table 2, given that the young children (3;4–4;3) were not forced to state a preference. My study suggests that children's knowledge about scope at the initial stages of learning to speak can be successfully explained by lexical semantics, without resorting to the subset–superset relation between logical readings. Examining the intermediate stage in child grammar development, we see that the process by which Mandarin-speaking children acquire adult knowledge about scope involves accepting the vital importance of the linearity principle in their mother tongue.

Thus, the ''Chinese-speaking phase'' in Musolino's hypothesis does not exist in the early grammar of Chinese children, but of course has a concrete manifestation in the grammar of Mandarin-speaking adults.

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Appendix. Comparison of test results in different sessions

Test structure	Reading	Test group	Section 1 (picture)	Section 2 (picture)	Section 3 (videoed story)
Mei (Cl.) N *dou bu/mei VP.*	every > neg	4–5 Group	100% (15/15)	100% (15/15)	100% (15/15)
(Every (Cl.) N *all not* VP)		5–6 Group	100% (15/15)	100% (15/15)	100% (15/15)
		6–7 Group	100% (15/15)	100% (15/15)	100% (15/15)
		7–8 Group	100% (15/15)	100% (15/15)	100% (15/15)
		Adult group	100% (15/15)	100% (15/15)	100% (15/15)
	neg > every	4–5 Group	26.67% (4/15)	26.67% (4/15)	26.67% (4/15)
		5–6 Group	13.33% (2/15)	13.33% (2/15)	13.33% (2/15)
		6–7 Group	0% (0/15)	0% (0/15)	0% (0/15)
		7–8 Group	0% (0/15)	0% (0/15)	0% (0/15)
		Adult group	0% (0/15)	0% (0/15)	0% (0/15)
Suoyoude N *dou bu/mei* VP.	all > neg	4–5 Group	100% (15/15)	93.33% (14/15)	100% (15/15)
(All N *all not* VP)		5–6 Group	100% (15/15)	93.33% (14/15)	100% (15/15)
		6–7 Group	100% (15/15)	100% (15/15)	100% (15/15)
		7–8 Group	100% (15/15)	100% (15/15)	100% (15/15)
		Adult group	100% (15/15)	100% (15/15)	100% (15/15)
	neg > all	4–5 Group	26.67% (4/15)	33.33% (5/15)	40% (6/15)
		5–6 Group	13.33% (2/15)	40% (6/15)	20% (3/15)
		6–7 Group	0% (0/15)	0% (0/15)	6.67% (1/15)
		7–8 Group	0% (0/15)	0% (0/15)	0% (0/15)
		Adult group	0% (0/15)	0% (0/15)	0% (0/15)
Bu shi mei (Cl.) N *dou* VP.	every > neg	4–5 Group	80% (12/15)	93.33% (14/15)	86.67% (13/15)
(Not BE *every* (Cl.) N *all* VP)		5–6 Group	46.67% (7/15)	73.33% (11/15)	80% (12/15)
		6–7 Group	46.67% (7/15)	53.33% (8/15)	60% (9/15)
		7–8 Group	46.67%(7/15)	60% (9/15)	66.67% (10/15)
		Adult group	46.67% (7/15)	26.67% (4/15)	40% (6/15)

Appendix (*Continued*)

Test structure	Reading	Test group	Section 1 (picture)	Section 2 (picture)	Section 3 (videoed story)
	neg > every	4–5 Group	73.33% (11/15)	73.33% (11/15)	53.33% (8/15)
		5–6 Group	73.33% (11/15)	93.33% (14/15)	46.67% (7/15)
		6–7 Group	86.67% (13/15)	80% (12/15)	86.67% (13/15)
		7–8 Group	86.67% (13/15)	100% (15/15)	93.33% (14/15)
		Adult group	100% (15/15)	100% (15/15)	100% (15/15)
Bu shi suoyoude N *dou* VP.	all > neg	4–5 Group	66.67% (10/15)	86.67% (13/15)	93.33% (14/15)
(*Not* BE *all* N *all* VP)		5–6 Group	60% (9/15)	66.67% (10/15)	73.33% (11/15)
		6–7 Group	53.33% (8/15)	46.67% (7/15)	66.67% (10/15)
		7–8 Group	46.67% (7/15)	46.67% (7/15)	60% (9/15)
		Adult group	53.33% (8/15)	40% (6/15)	26.67% (4/15)
	neg > all	4–5 Group	80% (12/15)	33.33% (5/15)	60% (9/15)
		5–6 Group	66.67% (10/15)	86.67% (13/15)	46.67% (7/15)
		6–7 Group	80% (12/15)	86.67% (13/15)	86.67% (13/15)
		7–8 Group	86.67% (13/15)	100% (15/15)	93.33% (14/15)
		Adult group	100% (15/15)	100% (15/15)	100% (15/15)
NP *bu/mei* V *suoyoude* N.	all > neg	4–5 Group	86.67% (13/15)	86.67% (13/15)	100% (15/15)
(NP *not* V *all* N)		5–6 Group	86.67% (13/15)	93.33% (14/15)	100% (15/15)
		6–7 Group	100% (15/15)	100% (15/15)	100% (15/15)
		7–8 Group	93.33% (14/15)	93.33% (14/15)	93.33% (14/15)
		Adult group	46.67% (7/15)	66.67% (10/15)	40% (6/15)
	neg > all	4–5 Group	86.67% (13/15)	66.67% (10/15)	46.67% (7/15)
		5–6 Group	66.67% (10/15)	100% (15/15)	20% (3/15)
		6–7 Group	53.33% (8/15)	66.67% (10/15)	20% (3/15)
		7–8 Group	73.33% (11/15)	93.33% (14/15)	40% (6/15)
		Adult group	100% (15/15)	100% (15/15)	100% (15/15)

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