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Children's knowledge of double negative structures in Mandarin Chinese

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Abstract This study investigated children's knowledge of double negation in Mandarin Chinese. Double negation is a phenomenon where two negatives cancel each other out, thereby yielding a positive meaning. Previous research found that children did not have knowledge of double negation until the age of seven or later. We argue that the observed difficulty of children in previous research is due to an artifact of the experimental task where the target structure was presented without the support of an appropriate context. To see whether preschool children have knowledge of double negation, we used experimental tasks which presented the structure in a plausible context. The results show that 5-year-olds already know that two negatives cancel each other out. By age 6 children are even able to produce double negation in an adult-like manner. This is evidence that double negation does not pose significant difficulty for young children if a plausible context is provided.

Keywords Double negation · Logic · Plausible contexts · Child language · Mandarin Chinese

1 Introduction

In logic, negation is a simple notion. Adding negation to a formula reverses its truth value (e.g., if a statement *p* is true, then *not-p* is false, and vice versa). There is only one negation operator in logic, and it can be applied iteratively. In logic, therefore, two negatives cancel each other out (e.g., *not-not-p* is equivalent to *p*). In contrast, negation in natural language is a complex phenomenon. Its effects go well beyond a simple change in truth value. Consider English. Negation can be marked by words

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like *not* (e.g., He did *not* go to the party), *no* (e.g., I have *no* doubt), and *never* (e.g., She *never* loved me), and by prefixes such as *un-* (e.g., *un*happy), *in-* (e.g., *in*active) and *dis-* (e.g., *dis*honest). Negation also interacts with quantifiers. For example, English speakers interpret the sentence *All vegetarians do not eat meat* as having the meaning that no vegetarian eats meat, yet the same speaker would interpret the sentence *All planes do not carry pets* as meaning that some, but not all planes, carry pets (e.g., Hintikka 2002). This difference in interpretation is often referred to as a 'scope phenomenon.' In the first example, the 'none' meaning arises because the universal quantifier *all* takes scope over the negation marker *not* (*all* > *not*). In the second example, the 'not all' meaning arises, because the negation marker *not* takes scope over the universal quantifier *all* (*not* > *all*). In addition, when two negatives occur in the same sentence, there is a subtle change in meaning between the double negative structure in (2) and its affirmative counterpart in (1). Although the two negatives in (2) cancel each other out, they produce a weakened affirmative, as compared to (1) (Horn 1989). To further complicate matters, in some languages like French and Italian, two negatives do not cancel each other out. For instance, in the Italian example (3), instead of cancelling each other out the two negatives equal a single semantic negation. So, (3) means that Gianni didn't eat anything. This phenomenon is referred to as Negative Concord (see Zeijlstra 2004 for a detailed discussion).

(1) It was possible that John failed the exam.
(2) It was not impossible that John failed the exam.
(3) Gianni non ha mangiato niente
Gianni not has eaten nothing
'Gianni didn't eat anything.'
(4) I didn't drive to work today.

In natural language the use of negation is always subject to pragmatic constraints. Negative statements are generally used to point out discrepancies between a presumed expectation and the facts (Givón 1978, 1993; Glenberg et al. 1999; Horn 1989; Wason 1965, 1971). For example, when hearing the negative sentence in (4), the listener would assume that the speaker normally drives to work. The sentence would sound awkward if it were uttered by someone who the listeners know normally commutes by train. We will refer to the pragmatic constraints as the felicity conditions on the use of negation. In natural language, the felicity conditions play a crucial role in the use of negative sentences, as we discuss below.

The asymmetry between negation in logic and in natural language has been an important area of inquiry in both linguistics and psychology, since it provides insights into the relationship between logic and language. In particular, research has focused on children's knowledge of negation, since it is there that light is shed on the development of our logical abilities. However, our current understanding of children's knowledge of negation comes mainly from studies using a single negation. Few studies have looked at children's knowledge of double negation. The present study investigates children's comprehension and production of double negation in Mandarin Chinese. The purpose of the study is twofold: first, to

determine the age at which children have mastered the law of double negation in logic, according to which two negatives yield a positive meaning and, second, to determine the age at which children first correctly apply negative markers iteratively to produce double negative structures. The paper is structured as follows. First we discuss the role of felicity conditions in processing negative sentences. Then we introduce the double negation phenomenon in Mandarin Chinese and review previous research on children's understanding of double negation. We argue that children's difficulty in processing double negative sentences, found in previous research, is minimized or eliminated altogether by providing appropriate contexts. Finally, we present two experiments investigating Mandarin-speaking children's comprehension and production of double negative sentences.

2 The felicity conditions on the use of negation

Negative sentences are generally presumed to be harder to process than their affirmative counterparts, resulting in longer response times and higher error rates (e.g., Carpenter et al. 1999; Sherman 1976; Wason 1959). However, research has also shown that for both adults and children negation does not pose significant processing demands when the felicity conditions associated with it are satisfied (e.g., de Villiers and Tager Flusberg 1975; Glenberg et al. 1999; Kaup et al. 2006, 2007; Lüdtke and Kaup 2006; Staab 2007; Wason 1965, 1971). A number of experimental studies have found that the processing difficulty associated with negation can be alleviated or even eliminated if the experimental situation allows for the appropriate use of negative sentences.

For example, Wason (1971) found that a negative sentence like (5) was more difficult for adults to process than a positive sentence like (6) even though (5) and (6) express the same proposition. However, the difficulty associated with negation was considerably mitigated when sentence (5) was preceded by a positive statement like *4 is an even number*, as indicated in (7).

(5) 5 is not an even number.
(6) 5 is an odd number.
(7) a. 4 is an even number, but 5 is not an even number.
    b. 4 is an even number, and 5 is not an even number.

Similar findings were presented in Glenberg et al. (1999). These researchers conducted a series of experiments investigating adults' processing of negative sentences, and they found that negative sentences were processed as fast as their positive counterparts when presented in appropriate contexts. For example, in one of their experiments, participants were asked to read both positive (e.g., (9a)) and negative sentences (e.g., (9b)) following either supportive contexts (e.g., context (8a) established an expectation that the couch might be black), or non-supportive contexts (e.g., context (8b) didn't establish the expectation that the couch might be black). Participants' reading times were then recorded.

(8) a. She wasn't sure if a darkly colored couch would look the best or a lighter color.
She finally picked one out and had it delivered to her home.
b. She wasn't sure what kind of material she wanted the couch to be made of.
She finally picked one out and had it delivered to her home.
(9) a. The couch was black.
b. The couch wasn't black.

The results showed that negative sentences like (9b) were read as fast as positive sentences like (9a) when the negative sentences were preceded by supportive contexts (e.g., (8a)). On the basis of these findings, Glenberg and colleagues concluded that negative sentences are not necessarily harder to process than positive sentences if they are used in an appropriate context, and the processing difficulty associated with negation found in some previous studies might be due to an experimental artifact that negative sentences were presented outside of an appropriate context.

The importance of an appropriate context in the use of negation has also been confirmed in children's comprehension of negative sentences (e.g., de Villiers and Tager Flusberg 1975; Gualmini 2004). For example, de Villiers and Tager Flusberg (1975) investigated two- to five-year-old English-speaking children's interpretation of negative sentences using a sentence completion task. In the task, seven or eight objects (or drawings) were placed in front of a child. Among these objects (or drawings), six or seven were similar and one was different (e.g., seven cars and one baby's bottle). The experimenter then pointed to one of the objects and asked "This is a __?" or "This is not a __?", thus eliciting true affirmatives or true negatives. In this task, answering a negative probe for the exceptional item (e.g., the baby's bottle) is more plausible than answering a negative probe for one of the similar items (e.g., one of the seven cars). Therefore, children were expected to respond to negative sentences like "This is not a __?" faster and more accurately when the experimenter pointed to the exceptional item than when the experimenter pointed to one of the similar items. This hypothesis was confirmed in the study. It was found that only the implausible negative sentences were associated with longer response times and higher error rates. If the negative sentences were presented in a plausible context (i.e., when the experimenter pointed to the exceptional item), four-year-old English-speaking children showed no differences in the interpretation of the affirmative sentences and the corresponding negative sentences. Based on the findings, de Villiers and Tager Flusberg concluded that negation does not pose significant processing demands for children if appropriate contexts are provided. By 4 years of age, plausible negatives are no more difficult than affirmatives.

Taken together, previous research suggests that the difficulty of processing negative sentences can be mitigated if appropriate contexts are provided to satisfy the felicity conditions associated with negation. The nature of the processing difficulty associated with negation, as Horn (1989) argued, is not a property of negation per se, but rather reflects a consequence of the way negative sentences are used in natural language. For the purpose of the present study, we propose that the same argument applies to children's interpretation of double negation. More

specifically, we want to argue that the difficulty associated with double negation, observed in previous studies, can be greatly minimized by providing an appropriate context. We present two experiments investigating how Mandarin-speaking children comprehend and produce double negative sentences. Before reporting the experiments, we will briefly introduce double negative structures in Mandarin Chinese, and review previous studies on children's interpretation of double negative sentences.

3 Double negative structures in Mandarin Chinese

Mandarin Chinese is a typical double negative language (Cheng and Li 1991; Ding 1961; Lü 1985). There are two primary negation markers in Mandarin Chinese: *bu* and *mei(you)*[1] (both are translated as English *not*). The two negation markers can be combined iteratively to form a double negative structure. The following examples illustrate.

(10) Ta **bu** hui **bu** lai. (*bu* + *bu*)
he not will not come
'He won't not come.'

(11) **Mei**(you)-ren **mei** lai. (*mei* + *mei*)
not(have)-person not come
'Nobody did not come.'[2]

(12) Wo **mei**(you) **bu** xihuan xiandai yinyue. (*mei* + *bu*)
I not(have) not like modern music
'It is not the case that I don't like modern music.

In all the three examples, the two negatives cancel each other out, thereby yielding a positive meaning. So sentence (10) means *he will come*, sentence (11) means *everybody came*, and sentence (12) means *I like modern music*.

4 Double negation in child language

Previous research on children's understanding of negative sentences mainly focused on children's knowledge of single negation (e.g., de Villiers and Tager Flusberg 1975; Fan 2007; Gualmini 2004; Lee and Fan 2009; Pea 1980; Zhang et al. 2006; Zhou 2002). Most of these studies have found that two- to three-year-old children already know that negation reverses the truth value of a statement, and they use negation to deny statements. Studies on Mandarin-speaking children's acquisition of negation have shown that Mandarin-speaking children have mastered the basic

[1] In Mandarin Chinese the morpheme *-you* is often omitted in the negation marker *mei(you)*. So, throughout the text *mei* and *mei(you)* refer to the same negation marker.

[2] A double negative structure like *nobody did not come* might sound unnatural in English, but the corresponding structure, as in (11), is perfectly natural in Mandarin Chinese.

semantics of the two primary negation markers *bu* and *mei* by age four (Fan 2007; Lee and Fan 2009; Zhang et al. 2006; Zhou 2002).

However, only a few studies have looked at children's knowledge of double negation. Three studies, as far as we know, have directly investigated children's understanding of double negative sentences, and the conclusion seems to be that preschool children do not have the concept of double negation, but rather they interpret double negation as single negation (Jou 1988; Jouie 1995; Zhu 1986). Jou (1988) investigated Taiwan Mandarin-speaking children's comprehension of double negation, using an act-out task. In the task, children were asked to carry out actions with dolls according to the test sentences containing double negation. Eleven age groups of children, ranging in age from 4 to 14 years, participated in this experiment. On a typical trial children heard a sentence as in (13), and were then asked to carry out the action using the dolls provided in the experimental workspace. It was found that children younger than 7 years of age consistently acted out the double negative sentences in a similar way as they did with the corresponding single negative sentences, rather than the corresponding positive sentences. For example, instead of acting out a positive meaning as in (14), children younger than 7 consistently acted out the double negative sentence in (13) as having a negative meaning in (15). Children aged between 7 and 13 acted out the double negative sentences either as having a positive meaning or having a negative meaning. Only the 14-year-olds consistently acted out the double negative sentences as having a meaning equivalent to the corresponding positive sentences.

(13) Hong wawa meiyou bu ba lü wawa tuidao.
red doll not not cause green doll strike-down
'It is not the case that the red doll doesn't strike down the green doll.'

(14) Hong wawa ba lü wawa tuidao-le.
red doll cause green doll strike-down-ASP
'The red doll strikes down the green doll.'

(15) Hong wawa meiyou ba lü wawa tuidao.
red doll not cause green doll strike-down
'The red doll doesn't strike down the green doll.'

On the basis of these findings, Jou concluded that children go through a stage where they analyze double negation as single negation before they acquire the law of double negation. Preschool children don't have the concept of double negation. Jou attributed the late acquisition of double negation to the difficulty associated with processing negative information. The finding that preschool children have difficulty with double negation has also been reported in Zhu (1986) and has been replicated for Cantonese-speaking children by Jouie (1995). Like in Jou's study, Zhu (1986) used an act-out task in which children were asked to act out the double negative sentences produced by the experimenter, using the toy props, and she found that Mandarin-speaking children younger than 7 had difficulty processing double negative structures. Using a similar task, Jouie (1995) found that only 10-year-old

Cantonese-speaking children consistently interpreted a double negative structure as having a positive meaning.

However, we want to argue that preschool children's difficulty with double negation, observed in these previous studies, might not be due to their lack of concept of double negation, but rather due to the nature of the experimental task. These previous studies used act-out tasks. There are limitations of using an act-out task. In the task, the experimenter presents a sentence to the child participant and instructs the child to act out the sentence using toys and props that are present in the experimental workspace. We will argue that the results of this task can seriously undermine children's knowledge of double negation.[3] A major drawback of using an act-out task is that it presents the test sentences outside of a context. We suspect that younger children's failure in processing a double negative structure in previous studies might be due to this design feature. For example, in Jou's (1988) study, children were asked to act out a double negative sentence like (13) with no contexts provided. As we discussed, an appropriate context is crucial for children's interpretation of negative sentences. So it is not surprising that the younger children in Jou's study failed to process double negative structures when the sentences were presented outside of a context. In addition, it should also be noticed that the double negative structures used in Jou's study were quite complex. Consider sentence (13) *Hong wawa meiyou bu ba lü wawa tuidao* 'It is not the case that the red doll doesn't strike down the green doll.' The two negation markers in (13) are in separate clauses. Processing such a complex sentence without any supporting contexts would have already been difficult for the younger children. To act it out would have been even harder. To recap, we argue that the observed difficulty experienced by preschool children in processing a double negative structure might be due to the nature of the experimental task used in previous studies. We expect that this processing difficulty associated with double negation would be minimized if an appropriate context were provided. So to investigate the possibility that the experimental infelicities, and not the lack of the concept of double negation, were responsible for younger children's difficulties in processing a double negative structure, we used experimental tasks which presented the double negative structure in a plausible context, and instead of using a double negative structure as in (13), we used a simpler double negative structure as in (11): *Mei-you-ren mei lai* 'Nobody did not come' where the two negative markers are in the same clause. More specifically, two experiments were conducted to test children's knowledge of double negation. Experiment 1 used a truth value judgment task (Crain and Thornton 1998) to investigate the age at which children have mastered the law of double negation, whereby two negatives cancel each other out, thus yielding a positive meaning. Experiment 2 used an elicited production task to determine the age at which children correctly produce double negative structures.

[3] It should be understood that we are not condemning all studies using an act-out task. The task is not inherently defective and there are places where it could be put to good use.

5 Experiment 1

5.1 Participants

Thirty monolingual Mandarin-speaking children participated in this experiment. They were divided into two age groups[4]: 15 children were between 4;2 to 5;5 (9 boys and 6 girls) and 15 children were between 5;6 to 5;10 (9 boys and 6 girls). All the child participants were recruited from the kindergarten at Beijing Language and Culture University. They had no reported history of speech, hearing or language disorders.

5.2 Procedure

We tested children using a truth value judgment task. This research technique is designed to investigate which meanings children can and cannot assign to sentences (Crain and Thornton 1998). The task involved two experimenters. One acted out stories using toy characters and props, and the other played the role of a puppet who watched the stories alongside the child participant. At the end of the story, the puppet attempted to explain to the child participant what it thought had happened in the story using a test sentence. The child's task was to judge whether or not the puppet had said the right thing about the story. If the child informed the puppet that he was wrong, then he was asked to explain: "what really happened?" The child participants were introduced to the task individually and then tested individually. They were given four practice trials before the actual test, two in which the puppet's statements were true descriptions of the corresponding stories, and two in which the puppet's statements were false descriptions of the corresponding stories, so that children knew that the puppet could say something wrong. These practice trials were also used to familiarize children with the task. Only those children who correctly accepted the true statements and rejected the false statements were included in the actual test.

5.3 Materials and design

Six test trials were constructed. On three of the trials, the double negative structure was a true description of the corresponding story (hereafter 'true' scenario), and on the other three the double negative structure was a false description of the corresponding story (hereafter 'false' scenario). Two examples are used to illustrate.

In a typical 'true' scenario, the experimenter acted out the story depicted in Fig. 1. In the story, the little hippo invited his friends, Garfield, the little bunny and Winnie the Pooh, to his birthday party. The day before the little hippo's birthday Garfield and the little bunny already had their gifts ready, but Winnie the Pooh was having a toothache. So he hadn't had a chance to prepare the gift. The next day

[4] The division of the child participants into the two age groups was done post-hoc, based on the performance of each individual participant. The findings of the first experiment show that there was a clear distinction between the response patterns of the children younger than 5;6 and those aged 5;6 and above.

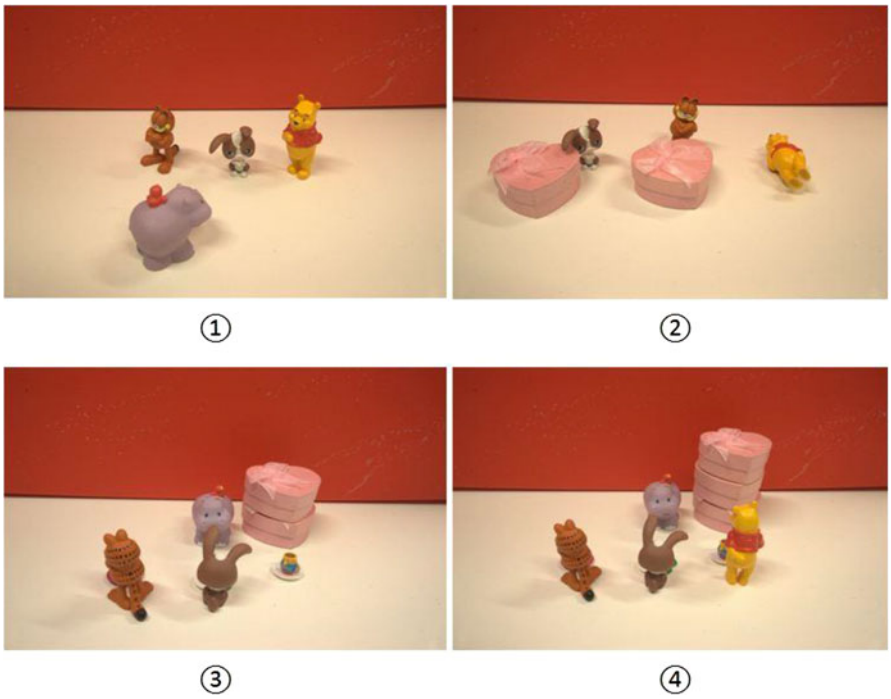

Fig. 1 Birthday party

Garfield and the little bunny went to the party with their gifts, and they told the little hippo that Winnie the Pooh might not come because he was having a toothache. But when the party was about to begin, Winnie the Pooh showed up with a birthday gift. He had made it to the party after all. After the story, the puppet described what happened in the story, using the test sentence in (16). The child was then asked to judge whether or not the puppet had said the right thing about the story.

(16) Mei-you-ren mei qu canjia shengri juhui.
not-have-person not go join birthday party
'Nobody did not go to the birthday party.'
(Meaning: Everybody went to the birthday party.)

Note that in order to use a double negative structure felicitously, the expectation/presupposition associated with the structure must be established in the context. For example, the expectation/presupposition associated with a double negative structure like (16) is that not everybody was expected to go to the party, or somebody might not go to the party. So to satisfy this felicity condition associated with the structure, an expectation about the main characters' actions was explicitly established at the beginning of the story. This was achieved by making clear the possibility that Winnie the Pooh might not go to the party because he was having a toothache and he hadn't got the gift ready. However, when the story concluded it turned out that

everybody made it to the party including Winnie the Pooh, and thereby the expectation established at the beginning wasn't fulfilled.

In a typical 'false' scenario, the experimenter acted out the story depicted in Fig. 2.

In the story, three friends, the little turtle, the little elephant and the little donkey, went to look for their moms. The mommy elephant and the mommy turtle were in the forest, but the mommy donkey wasn't there. The little elephant went to the forest and found his mom. So did the little turtle. The little donkey asked the zebra if she was his mom, but unfortunately the zebra told the little donkey that she was not.

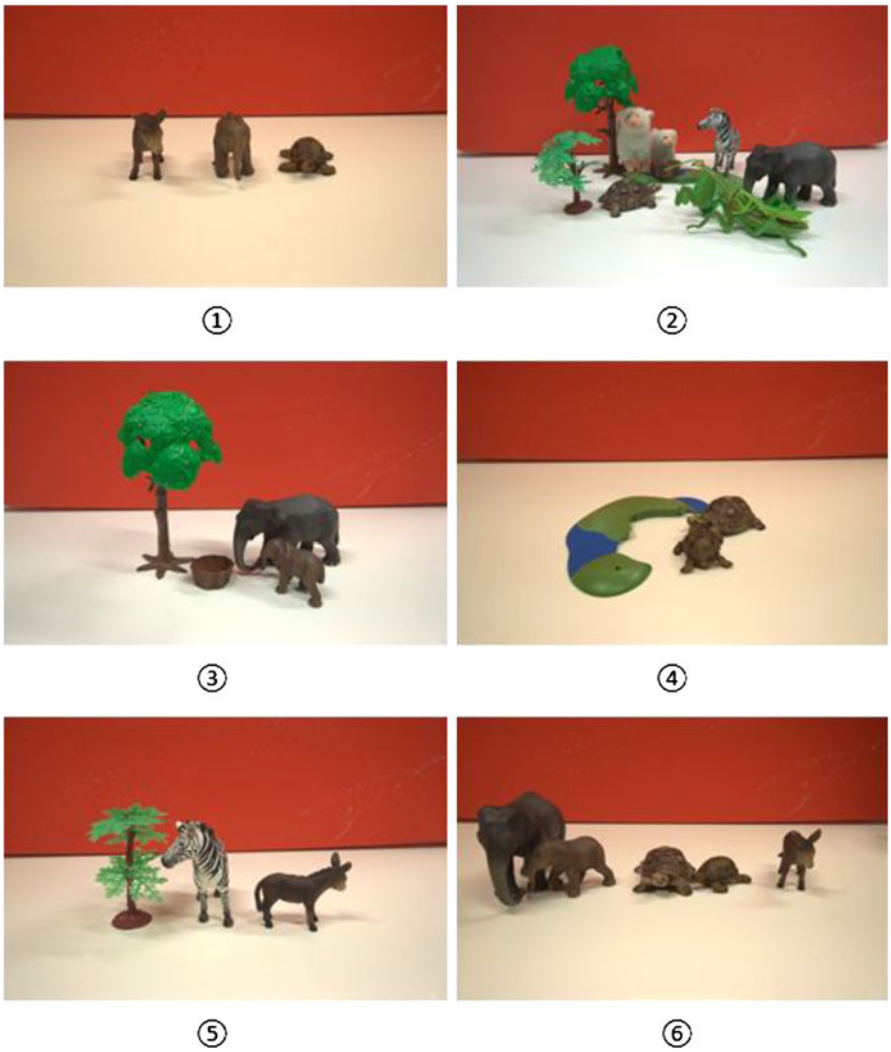

Fig. 2 Looking for moms

So the little donkey didn't find his mom. Following the story, the puppet produced the test sentence in (17). The child was then asked to judge whether or not the puppet had said the right thing about the story.

(17) Mei-you-ren mei zhaodao mama.
not-have-person not find mother
'Nobody did not find his mother.'
(Meaning: Everybody found his mother.)

Again, in order to establish the expectation/presupposition associated with the double negative structure in (17) (i.e., somebody might not be able to find his mother), at the beginning of the story it was made clear to the child that the mommy elephant and the mommy turtle were in the forest, but the mommy donkey wasn't. So, the little donkey might not be able to find his mother. In the end, the little elephant and the little turtle found their mom, but the little donkey didn't, and thus the expectation established at the beginning was fulfilled.

In addition, four control trials were included to verify that children could understand positive and single negative sentences. The stories used on the control trials were similar to those on the test trials. On two of the control trials, the puppet produced a positive structure like (18). On the other two control trials, the puppet produced a single negative structure like (19). Two of the control sentences were true descriptions of the corresponding stories and two were false descriptions of the corresponding stories. The test and control trials were presented in a pseudo-random order. All the test sentences are provided in Appendix 1.

(18) Mei-ge-ren dou dabai-le laowupo.
every-CL-person all defeat-ASP witch
'Everybody defeated the witch.'

(19) Mei-you-ren zhaodao lingdang.
not-have-person find bell
'Nobody found the bell.'

5.4 Predictions

If children have knowledge of double negation, then they would be expected to accept the double negative structures in the 'true' scenarios, and reject them in the 'false' scenarios. For example, in the example 'true' scenario children would be expected to accept sentence (16), because the sentence means *everybody went to the birthday party*, which was a true description of the corresponding story. In the example 'false' scenario, children should reject sentence (17), and should justify this response by pointing out that the little donkey didn't find his mother, because the sentence means *everybody found his mother*. If, on the other hand, children do not have the concept of double negation and thus interpret double negation as single negation as observed in previous research, then they would be expected to reject the double negative structures in both 'true' and 'false' scenarios. In the example 'true'

scenario, children would reject sentence (16) by pointing out that *everybody went to the birthday party*, since they would interpret sentence (16) as equivalent to a single negative structure like *nobody went to the birthday party*. Similarly, in the example 'false' scenario, children would be expected to reject sentence (17) by making reference to the fact that the little elephant and the little turtle found their mothers, because they would interpret sentence (17) to mean *nobody found his mother*.

5.5 Results and discussion

All the children responded correctly to the control trials 100% of the time. So, their data were all included in the final analysis. The dependent measure was the proportion of correct responses in the two types of scenarios. Figure 3 shows the proportion of correct responses in the two types of scenarios by the two age groups. The division of the child participants into the two age groups was done post-hoc, based on the performance of each individual participant. The proportion of correct responses for each participant is provided in Appendix 2. The findings showed that children aged 5;6 and above consistently gave correct responses, whereas children younger than 5;6 consistently gave incorrect responses. On the basis of these findings, we decided to divide the child participants into two age groups: 4;2–5;5 and 5;6–5;10. A detailed analysis of the data is given as follows.

As indicated in Fig. 3, the older group gave more correct responses than the younger group in both conditions. In the 'true' scenarios, children aged between

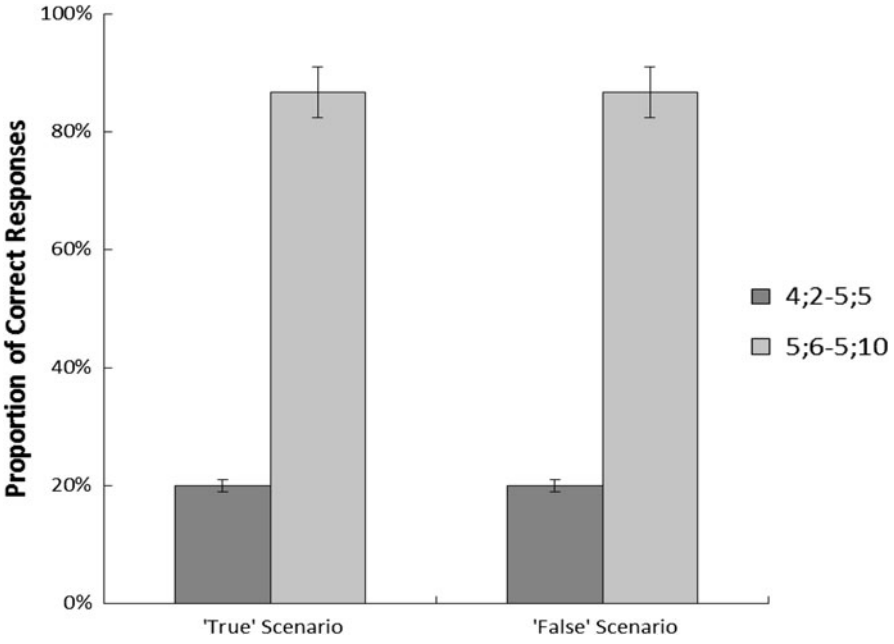

Fig. 3 Mean proportion of correct responses in the two types of scenarios by the two age groups

5;6–5;10 accepted the double negative structures 86.67% of the time, whereas children aged between 4;2–5;5 did so only 20% of the time. The other 80% of the time they consistently rejected the true test sentences by pointing out that all the characters under consideration did something. For example, in the scenario where Garfield, the little bunny and Winnie the Pooh all went to the birthday party, they rejected the double negative structure in (16), repeated here as (20). When asked to justify their rejections, they all pointed out that the characters all went to the birthday party. A representative justification from a child aged 4;7 is given in (21).

(20) Mei-you-ren mei qu canjia shengri juhui.
not-have-person not go join birthday party
'Nobody did not go to the birthday party.'
(Meaning: Everybody went to the birthday party.)

(21) After the puppet (i.e., Kermit the Frog) presented the test sentence in (20).
Experimenter: *Xiaoqingwa shuo dui le ma?*
'Was Kermit right or wrong?"
Child: *Budui.*
'Wrong.'
Experimenter: *Ni neng gaosu ta weishenme budui ma?*
'Could you tell him why he was wrong?'
Child: *Yinwei tamen dou qu le.* (Pointing to the three characters)
'Cause they all did.'

In the 'false' scenarios, children aged between 5;6–5;10 correctly rejected the test sentences 86.67% of the time, whereas children aged between 4;2–5;5 did so only 20% of the time. The other 80% of the time they rejected the test sentences for wrong reasons. For example, in the scenario where the little elephant and the little turtle found their moms, but the little donkey didn't, the older group consistently rejected the double negative structure in (17), repeated here as (22), either by pointing out that the little donkey didn't find his mother or by saying that only two guys found their mothers. A representative justification from a child aged 5;8 is given in (23). The younger group also rejected the sentence but for a different reason. When asked for reasons for rejection, the younger group consistently referred to the fact that someone found their mothers either by saying the sentence *youren zhaodao le* 'someone found their mothers', or by pointing to the fact that the little elephant and the little turtle found their mothers. A representative justification from a child aged 4;5 is given in (24).

(22) Mei-you-ren mei zhaodao mama.
not-have-person not find mother
'Nobody did not find his mother.'
(Meaning: Everybody found his mother.)

(23) After Kermit the Frog presented the test sentence in (22).
Experimenter: *Xiaoqingwa shuo dui le ma?*
'Was Kermit right or wrong?"
Child: *Budui.*
'Wrong.'
Experimenter: *Ni neng gaosu ta weishenme budui ma?*
'Could you tell him why he was wrong?'
Child: *Yinwei ta meiyou zhaodao.* (Pointing to the little donkey)
'Cause he didn't find (his mom).'

(24) After Kermit the Frog presented the test sentence in (22).
Experimenter: *Xiaoqingwa shuo dui le ma?*
'Was Kermit right or wrong?"
Child: *Budui.*
'Wrong.'
Experimenter: *Ni neng gaosu ta weishenme budui ma?*
'Could you tell him why he was wrong?'
Child: *Yinwei tamen liang zhaodao le*
'Cause these two guys found their moms.'
(Pointing to the little elephant and the little turtle)

The performance of each individual participant was consistent across the trials. In the 'true' scenarios, the participant either accepted all the three test sentences or rejected them all. In the 'false' scenarios, the participant gave similar reasons for their rejections of the three test sentences.

To assess the difference between the two groups statistically, generalized linear mixed models (GLMMs) were applied using the R software package (i.e., lme4), version 2.15.0 (R Development Core Team 2012). This analysis corresponds to a logistic regression, taking into account the variability that occurred across participants and across items (Baayen et al. 2008). We fit the data from the two conditions separately (i.e., a model for children's responses in the 'true' scenarios and a model for their responses in the 'false' scenarios). The models treated age (i.e., two age groups) as fixed effects, with random intercepts and slopes for items (Formula in R: response $\sim$ group + (1|item) + (1 + group|item)).

The models revealed that age was a reliable predictor for children's responses in both conditions. In both 'true' and 'false' scenarios, there was a higher proportion of correct responses in the older group than in the younger group ($\beta = 3.26$, $SE = 0.41$, $z = 8.01$, $p < .001$). The difference between the two age groups, as shown in Fig. 3, was supported by the statistical modelling.

The results of this experiment show that children aged between 5;6–5;10 interpreted a double negative structure as equivalent to a positive meaning, but children aged between 4;2–5;5 interpreted the same structure as equivalent to a single negative structure. The findings indicate that children have knowledge of double negation by age 5;6. This is evidence that preschool children have the concept of double negation whereby two negatives cancel each other out, and thus are logically equivalent to a positive meaning. But they pass through a stage where

double negation is analyzed as single negation. A further question to ask was then whether preschool children can apply negative markers iteratively to correctly produce a double negative structure, once they have knowledge of double negation. So a second experiment was designed to investigate whether children aged 5;6 and above can correctly produce a double negative structure in an appropriate context.

6 Experiment 2

6.1 Participants

Twenty six monolingual Mandarin-speaking children participated in this experiment. They were divided into two age groups: 13 children were between 5;6 to 5;11 (8 boys and 5 girls) and 13 children were between 6;0 to 6;5 (5 boys and 8 girls). All the child participants were recruited from the kindergarten at Beijing Language and Culture University. They had no reported history of speech, hearing or language disorders. None of them had participated in Experiment 1. In order to see whether Mandarin-speaking adults use double negative structures in the same contexts, 15 Mandarin-speaking adults (age range 23 to 26, 7 women and 8 men) were tested as controls. The adult participants were students at Beijing Language and Culture University.

6.2 Procedure

Both children and adults were tested using an elicited production task. Like the truth value judgment task, it involved two experimenters. One experimenter acted out stories with toy props to create contexts for a felicitous use of double negation. The other experimenter played the role of a puppet who watched the stories alongside the participant. The experimental session proceeded as follows. The first experimenter introduced the puppet to the participant and told the participant that the puppet was very forgetful and often forgets what happened in the story. So when the story concluded, the puppet would ask the participant a question, and the participant's task was to help the puppet answer the question, so that the puppet could better understand the story. The puppet's question after each story is a guise for an elicitation technique that allows the experimenter to probe the participant's knowledge of the double negative structure. The participants were introduced to the task individually and then tested individually. They were given two practice trials before the actual test. On the two trials, the puppet asked a simple question about the corresponding story. These practice trials were used to familiarize the participants with the task. Only those participants who provided correct answers to the questions were included in the actual test.

6.3 Materials and design

The experimental session consisted of ten trials: six test trials and four control trials. On the test trials, the stories were similar to the 'true' scenarios in Experiment 1 where all the three characters under consideration successfully did something. On

the control trials, the stories were similar to the 'false' scenarios in Experiment 1 in which two of the characters successfully did something, but one failed. The questions used on the test and control trials share the same structure. Again, we used the two example stories in Experiment 1 to illustrate.

On a typical test trial, the experimenter acted out the story where the little hippo invited his friends, Garfield, the little bunny and Winnie the Pooh, to his birthday party. In the end, the little bunny, Winnie the Pooh and Garfield all went to the party. After the story, the puppet asked a question as in (25b) preceded by a lead-in sentence like (25a). The participant was then prompted to answer the question. The questions posed by the puppet on the test trials are critical for the elicitation of double negative structures.

(25) a. Wo kandao xiao hema yaoqing ta-de haopengyou qu
I see little hippo invite his good friend go
canjia shengri juhui.
join birthday party
'In this story, the little hippo invited his good friends to his birthday party.'

b. Ni neng gaosu wo you-shei mei qu ma[5]?
you can tell me have-who not go Q
'I wonder if there is anyone who did not go.'

On a typical control trial, the experimenter acted out the story in which three friends, the little turtle, the little elephant and the little donkey, went to look for their moms. In the end, the little elephant and the little turtle found their moms, but the little donkey didn't. Following the story, the puppet produced the question in (26b) preceded by a lead-in sentence like (26a). Again, the participant was prompted to answer the question. The control trials were used to see whether children could understand the question structure used in the experiment. The questions used in the experiment are provided in Appendix 3.

(26) a. Wo kandao xiaoxiang, xiaowugui he xiaolü
I see little elephant little turtle and little donkey
qu zhao mama.
go look for mother
'In this story, the little elephant, the little turtle and the little donkey went to look for their mother.'

b. Ni neng gaosu wo you-shei mei
you can tell me have-who not
zhaodao mama ma?
find mother Q
'I wonder if there is anyone who did not find his mother.'

[5] *Ma* is a question particle in Mandarin Chinese. So sentence (25b) literally means 'could you tell me if there is anyone who did not go?'

6.4 Predictions

If children can correctly produce a double negative structure by applying two negative markers iteratively, then they would be expected to produce a structure like (27) in response to questions like (25b).

(27) Mei(you)-ren mei qu.
not(have)-person not go
'Nobody did not go.'

6.5 Data treatment

All experimental sessions were audio-recorded, and then transcribed by the experimenter. To assess the transcription reliability, the responses from six children and five adults (out of the 41 participants) were selected to be scored by a second coder. Overall, interrater reliability was high (.97). Cases in which there was disagreement were discussed with a third coder and a consensus was reached.

6.6 Results and discussion

All the participants responded correctly to the control trials 100% of the time. So, their data were all included in the final analysis. We first calculated the number of productions of double negative structures in response to the puppet's questions by each participant (see Appendix 4 for the data of each child participant). Then for each participant we computed the proportion of the productions of double negative structures out of the six total test trials. Figure 4 summarizes the proportion of double negative structures produced by the three age groups.

As Fig. 4 illustrates, the 6-year-olds exhibited adult-like performance, but not the 5-year-olds. In response to the test questions, the adults produced double negative structures 80% of the time, and the 6-year-olds did so 76.92% of the time. For example, when the puppet asked the question in (25b) after the story in which all the three friends went to the birthday party, children aged between 6;0 and 6;5 provided an answer either using the double negative structure in (28a) or the one in (28b).

(28) a. Mei-you yi-ge-ren mei qu.
not-have one-CL-person not go
'Not even a single person did not go.'
b. Mei-you-ren mei qu.
not-have-person not go
'Nobody did not go.'

The 5-year-olds, however, did not provide any double negative structures. Instead, they either used the corresponding positive structures (19% of the time), or simply used a simple negative structure (81% of the time). For example, when presented

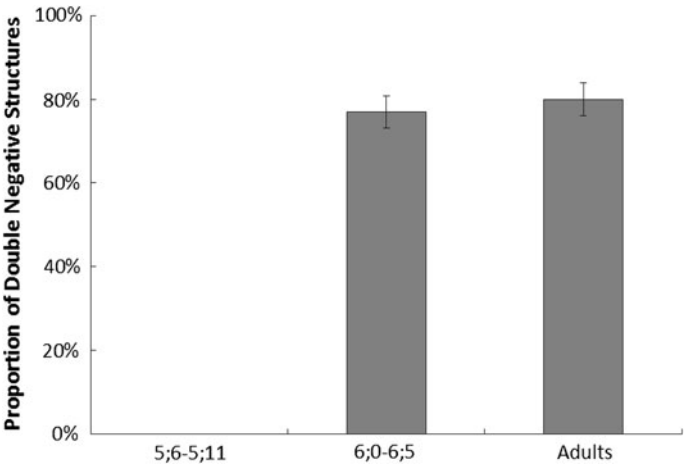

Fig. 4 Mean proportion of double negative structures produced by the three age groups

with the same question in (25b), they either produced the positive structure in (29a), or the single negative structure in (29b).

(29) a. Dou qu-le.
all go-ASP
'(They) all did.'
b. Mei-you.
not-have
'Not have (one).'

Although the 5-year-olds did not use a double negative structure, the two structures in (29a) and (29b) are also legitimate answers to a Mandarin question like (25b), repeated here as (30). Actually some of the adults (20% of the time) and the six-year-olds (23.08% of the time) also provided structures like (29a) and (29b). The five-year-olds simply tended to avoid using a double negative structure.

(30) Ni neng gaosu wo you-shei mei qu ma?
you can tell me have-who not go Q
'I wonder if there is anyone who did not go.'

Again, GLMMs were applied to assess this difference between the three age groups, using the lme4 package. The models treated age (i.e., three age groups) as fixed effects, with random intercepts and slopes for items (Formula in R: response $\sim$ group + (1|item) + (1 + group|item)). The models revealed that age was a reliable predictor of the proportion of double negative structures in the participants' productions. There was a lower proportion of double negative structures in the 5-year-olds than in the 6-year-olds ($\beta = 1.20$, $SE = 0.27$, $z = 4.48$, $p < .001$) and the adults ($\beta = 1.39$, $SE = 0.26$, $z = 5.26$, $p < .001$). Post-hoc comparisons showed that there was no difference between the 6-year-olds

and the adults in the proportion of double negative structures ($\beta = 0.18$, $SE = 0.38$, $z = 0.48$, $p > .05$).

The results of this experiment show that the 6-year-olds correctly produced a double negative structure when provided with an appropriate context, and they produced the structure to the same extent as the adults did. These findings suggest that by age 6 children can apply negative markers iteratively to correctly produce a double negative structure. The 5-year-olds, however, tended to avoid using a double negative structure to answer the questions, even though they could correctly understand the questions. We will return to this point in the general discussion.

7 General discussion

The present study investigated the age at which children have mastered the law of double negation, whereby two negatives cancel each other out, and thus are logically equivalent to a positive. Previous research on children's interpretation of double negative sentences reached the conclusion that preschool children did not have the concept of double negation (e.g., Jou 1988). However, we argued that children's failure in processing double negative structures in previous studies was likely due to an artifact of the experimental task. In previous research, children were tested using an act-out task in which they were asked to act out the double negative sentences using the toys that were available in the experimental workspace. This task is problematic, however, since it lacks the kind of supporting contexts that is needed to satisfy the felicity conditions associated with a double negative structure. As we discussed, this design feature may have seriously impeded children's ability to successfully demonstrate their knowledge of double negation. As has been shown previously in the literature on child language, a felicitous context is critical for evoking children's adult-like knowledge of negative sentences. When a felicitous context is supplied, negation has not posed serious difficulties for preschool children.

We applied the same research strategy to children's interpretation of double negative structures. Specifically, we argued that the observed difficulties experienced by young children in the processing of double negative structures might be greatly diminished if the double negative structure was presented in a felicitous context. To test this hypothesis, a truth value judgment task was conducted in which children were asked to judge whether or not a double negative structure was a true description of a given story acted out by the experimenter. A crucial design feature of this task is that the test sentences were presented in a context that satisfied the felicity conditions associated with the use of double negative structures. The findings revealed that, by age 5;6, children successfully interpreted a double negative structure in the same way as adult language users. However, the reviewers pointed out that stronger evidence for preschool children's knowledge of double negation should come from studies using the double negative structures as those used in Jou (1988). The logic is that if preschool children are also able to assign a positive meaning to the double negative structures as those used in Jou (1988), then this would constitute direct evidence that children's difficulty with double negation

observed in previous research is due to a lack of an appropriate context in the experimental tasks. We wish to note that we actually did an experiment in which a double negative structure like (31) was used. Similar to the structure used in Jou (1988) (see (13), repeated here as (32)), the two negation markers in (31) are in separate clauses.

(31) Xiaoxiong Weini mei-you bu qu shengri juhui.
Winnie the Pooh not not go birthday party
'It is not the case that Winnie the Pooh didn't go to the birthday party.'

(32) Hong wawa mei-you bu ba lü wawa tuidao.
red doll not not cause green doll strike-down
'It is not the case that the red doll doesn't strike down the green doll.'

Using a truth value judgment task as in the present study, we tested 16 Mandarin-speaking children aged between 5;6 and 5;9. A double negative structure like (31) was presented in either a context where it was a true description of the corresponding story, or in a context in which it was a false description of the corresponding story. We found that the children correctly interpreted a double negative structure like (31) 88% of the time, assigning a positive meaning to the structure.

Taken together, our findings are strong evidence that preschool children successfully convert double negation into a positive meaning if they are given appropriate contextual support. The findings also indicate that children have mastered the law of double negation by age 5;6. By age 5;6 Mandarin-speaking children have adult-like ability of logical reasoning involving double negation. However, children younger than 5;6 interpreted a double negative structure as equivalent to a single negative structure. This finding invites the conclusion that children pass through a stage where double negation is analyzed as a single negation. At this point, an interesting question to ask is what development underlies this abrupt change between children younger than 5;6 and those aged between 5;6 and above, i.e., children younger than 5;6 consistently interpreted double negation as having a meaning equivalent to a single negation, whereas children aged 5;6 and above consistently interpreted double negation as having a positive meaning. There are two conceivable explanations for this dramatic change. First, one could hypothesize that children younger than 5;6 do not have the concept of double negation, and thus interpret double negation as a single negation, while children aged 5;6 and above have knowledge of double negation. Abrupt changes in children's language development are not unusual. For example, similar abrupt changes have been reported in children's acquisition of null subjects (Hyams and Wexler 1993) and their acquisition of inflection related to negation (Thornton and Tesan 2007). We wish to note here that the development of children's linguistic knowledge is not necessarily a gradual process; sometimes it can be precipitous. However, an alternative explanation could be that younger children have the concept of double negation, yet they have difficulty implementing the law of double negation, presumably due to their limited computational resources (e.g., limitations

in working memory capacity). For example, younger children may have the knowledge that two negatives cancel each other out, but in order to implement this law, they first have to hold in their working memory the meaning of the first negative, and then apply the second negative to the first negative to yield a positive meaning. This process might pose difficulty for younger children because of their limitations in working memory capacity. Further research is required to explore the two possibilities.[6]

The first experiment was a comprehension task. Based on the findings of the first experiment, we know that children aged 5;6 and above already have the concept of double negation. The second experiment used a production task to see whether preschool children can correctly produce a double negative structure by applying the two negative markers iteratively, once they have knowledge of double negation. The research question posed by the second experiment was whether or not children of the same age can correctly produce a double negative structure when provided with contextual support. We also tested adult Mandarin-speakers as controls, to make sure that the contextual support we constructed was adequate to elicit double negative structures from adults. In the task, the experimenter acted out stories designed to create contexts for the felicitous use of double negation. After each story, the participant was asked to provide an answer to the question posed by the puppet. The puppet's question was designed to elicit a double negative structure. The results show that six-year-old children correctly produced a double negative structure in response to the test questions. In fact, six-year-old children produced double negative structures to the same extent as adults did. The five-year-olds exhibited a different pattern than the six-year-olds and the adults, however. Instead of producing a double negative structure, these children used alternative structures to answer the questions. Nevertheless, the alternative structures they used were legitimate answers to the same questions. This suggests that the five-year-olds avoid using a double negative structure if alternative structures are available. This tendency is presumably due to the least-effort processing strategy adopted by the younger children. The basic idea is that (i) if both a sentence with negation markers and one without negation markers can be used to express the same meaning, the sentence without negation markers is preferred; and (ii) if both a short sentence and a long sentence can be used to express the same meaning, the short sentence which requires less processing resources is preferred. The examples in (28) and (29), repeated here as (33) and (34), illustrate this point. The double negative structures in (33) are longer than the alternative structures in (34). In addition, although (33a), (33b) and (34a) express the same meaning, (34a) doesn't involve any negation markers. So the five-year-olds simply adopted a simple, least-effort strategy of producing the alternative structures in (34) that convey the same intended meaning.

[6] One reviewer pointed out that it seems to be more plausible to attribute the abrupt change between the two age groups to a change in linguistic knowledge than a change in working memory, or computational resources in general. We are inclined to agree with the reviewer, but decided to leave open the possibility in the current paper.

(33) a. Mei-you yi-ge-ren mei qu.
not-have one-CL-person not go
'Not even a single person did not go.'
b. Mei-you-ren mei qu.
not-have-person not go
'Nobody did not go.'

(34) a. Dou qu-le.
all go-ASP
'(They) all did.'
b. Mei-you.
not-have
'Not have (one).'

It is likely that the five-year-olds have knowledge of correctly producing a double negative structure, but avoided using the structure due to their least-effort processing strategy. So, it remains to be shown that five-year-old children can correctly produce double negative structures. However, on the basis of the data it is safe to say that, by age six, children correctly produce double negative structures by applying negative markers iteratively. Taken together, the results of these two experiments demonstrate that children have knowledge of double negation by age 5;6, but they pass through a stage where double negation is analyzed as a single negation. By age 6 children are even able to produce double negative structures in an adult-like manner. These findings invite the conclusion that preschool children have adult-like knowledge of double negation. This conclusion stands in contrast with previous research, which concluded that children did not understand double negation until the age of seven or later.

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Appendix 1

Test sentences used in Experiment 1 (the first six sentences are double negative structures, sentences (7) and (8) are affirmative structures, and sentences (9) and (10) are single negative structures)

(1) Mei-you-ren mei qu canjia shengri juhui.
not-have-person not go join birthday party
'Nobody did not go to the birthday party.'

(2) Mei-you-ren mei tui dakache.
not-have-person not push big truck
'Nobody did not push the big truck.'

(3) Mei-you-ren mei chi qingjiao.
not-have-person not eat green pepper
'Nobody did not eat green peppers.'

(4) Mei-you-ren mei zhaodao mama.
not-have-person not find mother
'Nobody did not find his mother.'

(5) Mei-you-ren mei pa-shang dashu.
not-have-person not climb-up big tree
'Nobody did not climb up the big tree.'

(6) Mei-you-ren mei nadao mofahe.
not-have-person not get magic box
'Nobody did not get magic boxes.'

(7) Mei-ge-ren dou dabai-le laowupo.
every-CL-person all defeat-ASP witch
'Everybody defeated the witch.'

(8) Mei-ge-ren dou chuanguo-le qiao.
every-CL-person all cross-ASP bridge
'Everybody crossed the bridge.'

(9) Mei-you-ren zhaodao lingdang.
not-have-person find bell
'Nobody found the bell.'

(10) Mei-you-ren tiao-guo liba.
not-have-person jump-over fence
'Nobody jumped over the fence.'

Appendix 2

The data of each participant in Experiment 1

Participant	Proportion of correct responses	
	'True'-Scenario (%)	'False'-Scenario (%)
Boy (5;6)	100	100
Boy (5;8)	100	100
Boy (5;6)	100	100
Boy (5;8)	100	100
Boy (5;8)	100	100
Boy (5;9)	0	0

Participant	Proportion of correct responses	
	'True'-Scenario (%)	'False'-Scenario (%)
Girl (5;10)	100	100
Girl (5;8)	100	100
Girl (5;7)	100	100
Girl (5;6)	100	100
Girl (5;8)	100	100
Girl (5;9)	10.0	100
Boy (5;10)	100	100
Boy (5;9)	100	100
Boy (5;9)	0	0
Girl (5;5)	100	100
Boy (5;5)	0	0
Boy (5;5)	0	0
Boy (5;3)	0	0
Boy (5;3)	0	0
Boy (5;3)	0	0
Girl (5;1)	100	100
Boy (4;6)	100	100
Girl (4;2)	0	0
Boy (4;2)	0	0
Boy (4;7)	0	0
Girl (4;5)	0	0
Girl (4;7)	0	0
Girl (5;3)	0	0
Boy (4;9)	0	0

Appendix 3

The questions used in Experiment 2 (the first six questions were used to elicit double negative structures, and the last four were control questions)

(1) Ni neng gaosu wo you-shei mei qu ma?
you can tell me have-who not go Q
'I wonder if there is anyone who did not go.'

(2) Ni neng gaosu wo you-shei mei tui dakache ma?
you can tell me have-who not push big truck Q
'I wonder if there is anyone who did not push the big truck.'

(3) Ni neng gaosu wo you-shei mei chi qingjiao ma?
you can tell me have-who not eat green pepper Q
'I wonder if there is anyone who did not eat green peppers.'

(4) Ni neng gaosu wo you-shei mei pa-shang dashu ma?
you can tell me have-who not climb-up big tree Q
'I wonder if there is anyone who did not climb up the big tree.'

(5) Ni neng gaosu wo you-shei mei nadao mofahe ma?
you can tell me have-who not get magic box Q
'I wonder if there is anyone who did not get magic boxes.'

(6) Ni neng gaosu wo you-shei mei dabai laowupo ma?
you can tell me have-who not defeat witch Q
'I wonder if there is anyone who did not defeat the witch.'

(7) Ni neng gaosu wo you-shei mei zhaodao mama ma?
you can tell me have-who not find mother Q
'I wonder if there is anyone who did not find his mother.'

(8) Ni neng gaosu wo you-shei mei tiao-guo liba ma?
you can tell me have-who not jump-over fence Q
'I wonder if there is anyone who did not jump over the fence.'

(9) Ni neng gaosu wo you-shei mei chuanguo qiao ma?
you can tell me have-who not cross bridge Q
'I wonder if there is anyone who did not cross the bridge.'

(10) Ni neng gaosu wo you-shei mei zhaodao lingdang ma?
you can tell me have-who not find bell Q
'I wonder if there is anyone who did not find bells.'

Appendix 4

The number of productions of double negative structures in response to the puppet's questions by each child participant, Experiment 2

Participant	Number of productions of double negative structures
Girl (6,3)	6
Girl (6,0)	6
Boy (6,5)	6
Boy (6,3)	0
Boy (6,5)	6
Girl (6,1)	6
Girl (6,0)	6
Girl (6,2)	6
Girl (6,3)	6
Girl (6,3)	0
Boy (6,3)	0

Participant	Number of productions of double negative structures
Girl (6,3)	6
Boy (6,3)	6
Boy (5,10)	0
Girl (5,11)	0
Boy (5,10)	0
Boy (5,8)	0
Girl (5,9)	0
Girl (5;10)	0
Boy (5,7)	0
Boy (5,9)	0
Boy (5,10)	0
Girl (5,6)	0
Girl (5,9)	0
Boy (5,10)	0
Boy (5,6)	0

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