What Inferences Do Mandarin-Speaking Children Make in Negative Sentences?

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1. Introduction
1.1. Two approaches to negation

There are two approaches to negation. We refer to them as the unified approach and the ambiguist approach (cf. Horn 1985, 2001). On the unified approach, negation markers share the same basic meaning, which corresponds to the negation operator in propositional logic. The ambiguist approach contends that there are two different negation markers, with different semantic/pragmatic functions (see Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006; Bar-Asher Siegal 2015). Adopting terminology by Bar-Asher Siegal (2015), we refer to these negation markers as internal and external negation. Syntactically, internal negation typically appears sentence-internally, as in (1), whereas external negation typically precedes the sentence that it negates, as in (2).

(1) It is true that Jack did <u>not</u> eat sushi.
(2) It is <u>not</u> true that Jack ate sushi.

Internal negation is an anti-licensor for Positive Polarity Items (PPIs). For example, the English PPI *some* takes scope over negation in sentence (3), so this sentence can be paraphrased as: *There is some sushi that Jack didn't eat*. In (4) by contrast, external negation is not an anti-licensor for PPIs. The polarity

sensitivity of *some* is cancelled in (4), so negation takes scope over the expression *some*. Therefore, sentence (4) is truth conditionally equivalent to *Jack didn't eat any sushi* (see Baker 1970; Crain 2012; Ladusaw 1980; Schwarz 2004; Bar-Asher Siegal 2015; Szabolcsi 2004).

(3) It is true that Jack did not eat some sushi.   some > NEG
(4) It is not true that Jack ate some sushi.   NEG > some

1.2. Free Choice Inferences

The present study investigated the inferences and the entailments that Mandarin-speaking children and adults assign to sentences with internal versus external negation. One of the inferences under consideration is illustrated in (5), where disjunction appears in the scope of the deontic modal verb *was allowed to*. Adult English-speakers license a Free Choice (conjunctive) Inference to (5), as indicated by the symbol '⤳'. So, adults judge sentence (5) to be true if Jack was allowed to eat pasta <u>and</u> was allowed to eat sushi. Replacing disjunction by the polarity sensitive expression *any* in (6) results in a Free Choice Inference with universal force, so adults judge (6) to be true if Jack was given permission to eat each of the dishes on offer.

(5) Jack was allowed to eat pasta or sushi.
    ⤳ *Jack was allowed to eat pasta and Jack was allowed to eat sushi.*
(6) Jack was allowed to eat any dish.
    ⤳ *Jack was allowed to eat pasta, Jack was allowed to eat sushi, Jack was allowed to eat chicken, and ...*

Because sentence (5) contains disjunction, it is surprising that the inference can be represented as a conjunction. Clearly, the modal verb *was allowed to* is responsible for this inference. Without the modal verb, the sentence (*Jack ate pasta or sushi*) generates an 'exclusivity' inference, so adults judge the sentence to be true if Jack only ate pasta or only ate sushi. In modal logic, too, a disjunctive statement with the possibility operator, $\lozenge p \vee \lozenge s$, does not entail a conjunction, $\lozenge p \wedge \lozenge s$ (see e.g. Alonso-Ovalle 2006; Chemla 2009; Chierchia 2013; Dayal 1998; Fox 2007; Franke 2011; Kamp 1973, 1978; Kratzer & Shimoyama 2002; Sauerland 2004; Schultz 2005, van Rooij 2010).

There are two theoretical solutions to the so-called free choice paradox exhibited by sentence (5). On one, Free Choice Inferences involve derivations that are similar to scalar implicatures (see e.g. Alonso-Ovalle 2006; Chemla 2009; Chierchia 2013, Fox 2007; Franke 2011; Kratzer & Shimoyama 2002; Schultz 2005; Van Rooij 2010). Another solution maintains that the interpretations of sentences like (5) are entailments, not inferences (see e.g., Aloni 2004, 2007; Geurts 2005; Zimmermann 2000). As Chierchia (2013, 2017) points out, however, the inference licensed by sentence (5) is defeasible, as illustrated by the continuation in (7). If the conjunctive inference in the first

clause of (7) were an entailment, then adding the continuation … *but I don't remember which* would yield the interpretation assigned to (8). Whereas (8) is a contradiction, (7) is not.

(7) Jack is allowed to eat pasta or sushi, but I don't remember which.
(8) Jack is allowed to eat pasta and Jack is allowed to eat sushi, but I don't remember which.

There is another diagnostic of inferences, as opposed to entailments. Inferences are typically cancelled under (internal) negation (Chierchia 2013, 2017). For example, sentence (9) entails that Jack was not allowed to eat pasta and was not allowed to eat sushi. We will refer to this as a conjunctive entailment, which is the same 'neither' interpretation that is witnessed in sentence (10), where the deontic modal verb is absent.

(9) Jack was not allowed to eat pasta or sushi.
(10) Jack did not eat pasta or sushi.

If sentence (9) licensed a Free Choice Inference, the result would be a weaker interpretation, such that (9) would be true if Jack was only allowed to eat pasta, or if Jack was only allowed to eat sushi. It follows, then, that the set of circumstances in which (9) is true (i.e., the 'neither' interpretation) constitutes a subset of the circumstances that would validate the negation of a Free Choice Inference (i.e., the 'not both' interpretation). Symbolically, a negated Free Choice Inference can be represented as $\sim(\lozenge Pj \wedge \lozenge Sj)$, whereas a negated disjunction can be represented as $\sim\lozenge Pj \wedge \sim\lozenge Sj$, where 'P' is pasta, 'S' is sushi, and 'j' is Jack.

This difference in truth conditions was used to assess the interpretations that child and adult speakers of Mandarin assign to sentences with internal versus external negation. The ambiguist approach predicts that Free Choice Inferences will be cancelled for both children and adults in sentences with internal negation, but that such inferences will be preserved in sentences with external negation. Experiment 1 examined participants' interpretation of sentences that contained internal negation, the deontic modal verb *keyi* 'is allowed to', and the polarity sensitive expression *renhe* 'any'. The polarity sensitive expression *renhe* is similar to disjunction in that it generates a Free Choice Inference in affirmative sentences with a deontic modal verb, as illustrated in (11).

(11) Jieke keyi chi lanzi   li   de renhe yi-zhong shuiguo.
     Jack   may eat basket inside DE any   one-CL   fruit
     'Jack is allowed to eat any kind of fruit in the basket.'

Because *renhe* 'any' is a Negative Polarity Item (NPI), it must be interpreted within the scope of a licensor, such as negation. Therefore, both children and adults are expected to assign a 'none' interpretation to sentence (12).

(12) Jieke bu   keyi chi lanzi   li   de renhe yi-zhong shuiguo.
    Jack Neg may eat basket inside DE any   one-CL   fruit.
    'Jack is not allowed to eat any kind of fruit in the basket.'

Experiments 2 and 3 investigated participants' interpretation of sentences with external negation, which we introduced using the focus adverb *zhiyou* 'only'. The focus adverb contributes two meaning components (see e.g., Anderson 1972; Beaver, Roberts, Simons, and Tonhauser 2017; Jacobs 1983; Rooth 1985, 1992; von Stechow 1990). One meaning component is positive, and one is negative. The positive meaning component, called the <u>presupposition</u>, is about the focus element in the sentence. The presupposition can be represented using the original sentence, minus the focus adverb. The negative meaning component, called the <u>assertion</u>, pertains to a set being contrasted with the focus element. The assertion is the denial that any member of the contrast set has the property that is attributed to the focus element. To illustrate, consider example (13).

(13) Zhiyou jieke chi-le   yidalimian huozhe shousi.
    Only   Jack eat-ASP pasta   or   sushi
    'Only Jack ate pasta or sushi.'

In (13), the focus element is *Jieke* 'Jack'. The presupposition is *Jieke chi-le yidalimian huozhe shousi* 'Jack ate pasta or sushi'. The assertion can be paraphrased as: *It is not true that anyone else ate pasta or sushi*. Experiment 2 used sentences such as (13). Both the unified and the ambiguist approach to negation anticipate that child and adult Mandarin-speakers will assign a 'neither' interpretation to such sentences.
    Experiment 3 added the deontic modal verb *keyi* 'is allowed to' into the equation, as illustrated by (14).

(14) Zhiyou Jieke keyi chi yidalimian huozhe shousi.
    Only   Jack may eat pasta   or   sushi
    'Only Jack is allowed to eat pasta or sushi.'

In (14), the presupposition is *Jieke keyi chi yidalimian huozhe shousi* 'Jack is allowed to eat pasta or sushi'. Due to the modal verb, the presupposition is expected to license a Free Choice Inference: *Jack is allowed to eat pasta <u>and</u> Jack is allowed to eat sushi*. On the ambiguist approach, the assertion is the negation of the Free Choice Inference, as indicated in (15). If so, both children and adults should judge (14) to be true even if someone in the contrast set was allowed to eat pasta, but not sushi, or if someone in the contrast set was allowed to eat sushi, but not pasta.

(15) It is not true that anyone else is allowed to eat both sushi and pasta.

The remainder of this paper is organized as follows. Section 2 reviews the previous literature on child language. Section 3 describes our experiments. Section 4 discusses the implications of the findings.

2. Free Choice Inferences in child Mandarin

In previous studies, preschool Mandarin-speaking children were found to compute Free Choice Inferences (Huang & Crain 2014; Tieu, Zhou, Romoli & Crain 2016; Zhou, Romoli & Crain 2013). A representative study is by Zhou, Romoli, & Crain (2013). Using a Truth Value Judgment Task, these researchers investigated children's interpretation of affirmative sentences that contained the disjunction word *huozhe* 'or' and the deontic modal verb *keyi 'may'*. On an example trial, Kung Fu Panda and Batman participated in a car-pushing competition. Mr. Owl was the judge of the competition, so he set the rules for the competition, proclaiming what cars each competitor was allowed to push. Mr. Owl told Kung Fu Panda that he was only permitted to push the green car, and he told Batman that he was only permitted to push the orange car. When the competition was about to start, a puppet who was watching the story alongside the child, Kermit the Frog, was asked to restate Mr. Owl's proclamations. Kermit produced sentence (16).

(16) Gongfu xiongmao keyi tui   lüse xiaoche huozhe juse xiaoche.
       Kung Fu Panda   may push green car   or   orange car
       'Kung Fu Panda may push the green car or the orange car.'

Children rejected Kermit's statements such as (16) 95% of the time. On the example trial, children justified their rejections on the grounds that Kung Fu Panda was only allowed to push the green car. This clearly indicates that children compute Free Choice Inferences in sentences like (16). Using the same methodology, Huang and Crain (2014) also found that Mandarin-speaking children computed Free Choice Inferences in affirmative sentences that contained the polarity sensitive expression *renhe* 'any' in combination with the modal verb *neng* 'is able to'.

The previous research on Free Choice Inferences is limited to affirmative sentences. The present study is the first to investigate whether or not Mandarin-speaking children license Free Choice Inferences in negative sentences. Experiment 1 assessed children's interpretation of sentences with internal negation, and Experiments 2 and 3 investigated children's interpretation of sentences with external negation.

3. Experiments
3.1. Experiment 1

Twenty-two Mandarin-speaking children participated in the experiment. They ranged in age from 4;9 to 5;8, with a mean age of 5;4. The child participants were recruited from a kindergarten affiliated with Hubei University

of Technology (HBUT), Wuhan, China. We also tested twenty Mandarin-speaking adults, who were undergraduate students at HBUT. Participants were tested using a Truth Value Judgment Task. We conducted a pre-test to ensure that children understand the meaning of the polarity sensitive expression *renhe* 'any'. On an example trial, the child participants were presented with a minimal pair of test sentences; one sentence contained *renhe* and one omitted *renhe*. In the experimental context, the presence or absence of *renhe* resulted in different truth-values for adult speakers of Mandarin. Therefore, children's different truth-value judgments in response to the two sentences could be used as evidence that they understood the semantic contribution of *renhe* (Huang & Crain 2014). Here is a typical trial.

This is a story about climbing trees. A small monkey and a big monkey were training to climb trees. Mr. Owl was the trainer. Mr. Owl said: "There are three trees: a big tree, a medium tree, and a small tree. Small Monkey, you have just recovered from an illness, so you'd better not exercise too much. You can climb the small tree, but you cannot climb the medium tree, and you cannot climb the big tree, either. Otherwise, you will get too tired. Big Monkey, you look very strong, so you can climb the medium tree and the big tree. However, you are not allowed to climb the small tree since it is too easy for you."

Being forgetful, the small monkey and the big monkey forgot Mr. Owl's rules. So, they asked the puppet to remind them of the rules when they were about to start training. At that point, the puppet produced sentences (17) and (18).

(17) Xiao houzi   keyi pa   yi-ke   shu.
      Small monkey may climb one-CL tree
      'The small monkey is allowed to climb one of the trees.'
(18) Da houzi   keyi pa   renhe yi-ke   shu.
      Big monkey may climb any   one-CL tree
      'The big monkey is allowed to climb any one of the trees.'

In the pre-test, twenty out of the twenty-two child participants accepted sentences like (17), and rejected ones like (18). On the example trial, children justified their rejections on the grounds that the big monkey was not allowed to climb the small tree. The findings indicate that these 20 child participants understand the semantic contribution of *renhe*. Therefore, these 20 children proceeded to the main test session, in which they received four trials. All of the adult participants were tested on the same four trials using a videotaped version of the stories, and they were asked to indicate on an answer sheet whether Kermit's statements were right or wrong.

The main test session consisted of 16 sentences in total, with eight target sentences and eight control sentences. The target sentences had the same form, with the negation maker *bu* 'not' in the same clause as the deontic modal verb phrase *keyi* 'is allowed to' as well as the polarity sensitive expression *renhe* 'any'. The stories were created to elicit a conjunctive entailment for four of the

target sentences (hereafter, CE targets), but to negate a Free Choice (universal) Inference for the other four targets (hereafter, NU targets). There were eight control sentences containing the deontic modal verb *keyi*. These were either clearly true or clearly false; four were positive, and four were negative. The 16 sentences were evenly distributed across four test stories so that, after each story, participants judged one CE target, one NU target, one positive control sentence, and one negative control sentence. To illustrate, here is a typical story.

> *This is a story about Fit Goat, Beauty Goat, Lazy Goat and Mayor Goat. The four goats picked a basket of fruits from an orchard. There were apples, strawberries and pears. Mayor Goat was responsible for distributing the fruits to the three other goats. After careful consideration, Mayor Goat said, "Beauty Goat, you are too slim, and you need to supplement your diet with different kinds of nutrients. So, you are allowed to eat all three kinds of fruits. Fit Goat, you are very fit and it's possible that you will gain weight. So, you should not eat too much. You are allowed to eat one kind or two kinds of fruits, but you are not allowed to eat all three kinds of fruits. Lazy Goat, you didn't help us pick the fruits. No pain, no gain. So, you are not allowed to eat a single fruit."*

After Mayor Goat established the rules, he put a sign with the numbers "3", "1 or 2", and "0" respectively in front of Beauty Goat, Fit Goat, and Lazy Goat. The numbers actually served as a reminder of the rules. Even though Mayor Goat had stated the rules clearly, the three goats were forgetful. So, they asked the puppet to remind them of the rules before they started to eat the fruits. At that point, the child participants judged the four sentences produced by the puppet: the positive control sentence (19), the NU target sentence (20), the CE target sentence (21), and the negative control sentence (22).

(19) Meiyangyang keyi chi lanzi li   de renhe yi-zhong shuiguo.
    Beauty Goat   may eat basket inside DE any   one-CL   fruit
    'Beauty Goat is allowed to eat any kind of fruit in the basket.'
(20) Feiyangyang bu keyi chi lanzi li   de renhe yi-zhong shuiguo.
    Fit Goat   Neg may eat basket inside DE any   one-CL   fruit
    'Fit Goat is not allowed to eat any kind of fruit in the basket.'
(21) Lanyangyang bu keyi chi lanzi li   de renhe yi-zhong shuiguo.
    Lazy Goat   Neg may eat basket inside DE any   one-CL   fruit
    'Lazy Goat is not allowed to eat any kind of fruit in the basket.'
(22) San-zhi   yang dou bu keyi chi lanzi li   de shuiguo.
    Three -CL goat all Neg may eat basket inside DE fruit
    'None of the three goats are allowed to eat the fruits in the basket.'

As Figure 1 indicates, the child participants rejected the NU target sentences 93% of the time, and the adult participants rejected them 100% of the time. Both groups consistently rejected (20), for example, on the grounds that Fit Goat was allowed to eat two kinds of fruit. A Mann-Whitney test of No-responses to the NU target sentences revealed no significant difference between groups ($z = 2.08$,

p = 0.106). In contrast to the NU target sentences, the child participants accepted the CE target sentences 100% of the time, and the adults accepted them 98% of the time. A Mann-Whitney test of Yes-responses to the CE target sentences also revealed no significant difference between groups (z = 1.433, p = 0.487).
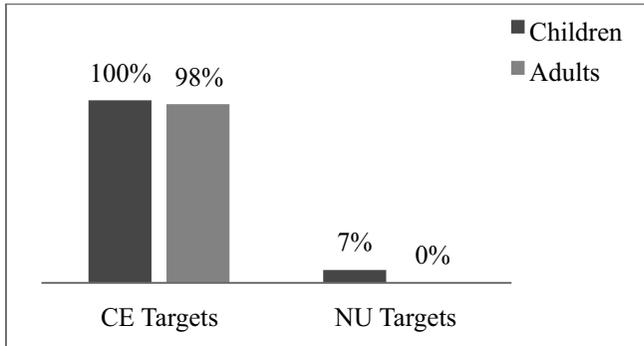

Figure 1: Acceptance Rates by Children and Adults

In summary, both the child and adult participants assigned a conjunctive entailment (the 'none' interpretation) to the target sentences in Experiment 1, suggesting that they cancel Free Choice Inferences associated with *renhe* 'any' in sentences with internal negation.

3.2. Experiment 2

Experiment 2 tested twenty-six Mandarin-speaking children who ranged in age from 4;2 to 5;2, with a mean age of 4;7. The child participants were recruited from a kindergarten affiliated with Beijing Language and Culture University, Beijing, China. We also tested 20 Mandarin-speaking adults, who were undergraduate students at Hubei University of Technology, Wuhan, China. There were a total of eight sentences: four targets and four fillers. The eight sentences were evenly distributed across four test stories so that, after each story, participants judged one target and one filler. We illustrate with a typical story.

This is a story about a big pirate and a small pirate. The big pirate and the small pirate had a coral-planting game. Mr. Owl was the judge. He set the rules first. Mr. Owl said to the big pirate "Big Pirate, you are very strong. So you are allowed to plant coral near the red mermaid and you are allowed to plant coral near the green mermaid." Mr. Owl then said to the small pirate "Small Pirate, you are much weaker than Big Pirate. So you are allowed to plant coral near the green mermaid, but you are not allowed to plant coral near the red mermaid." Both the big pirate and the small pirate were very forgetful. They forgot the rules when they were about to start the game. So, they asked the puppet to remind them of the rules.

In the end, the big pirate planted coral near the red mermaid and the green mermaid, and the small pirate planted coral near the green mermaid. When the story concluded, the puppet said: "I wasn't paying attention just now, so I don't remember what exactly happened in end of the story. But I guess…"[1] At that point, the puppet produced the target sentence (23) and the filler sentence (24).

(23) Zhiyou dahaidao zai hongse huozhe lüse meirenyu bianshang zhong-le
    shanhu.
    Only   big pirate at red   or   green mermaid side   plant-ASP
    coral
   'Only the big pirate planted coral near the red mermaid or the green
   mermaid.'
(24) Dahaidao bi xiaohaidao qiangzhuang.
    Big pirate to small pirate strong
   'The big pirate is stronger than the small pirate.'

As shown in Figure 2, the child participants rejected the target sentences 86% of the time, and the adult participants rejected them 88% of the time. Both groups rejected (23), for example, on the grounds that the small pirate also planted coral near the green mermaid. A Mann-Whitney test of the No-responses to the target sentences revealed no significant difference between groups ($z = 0.919$, $p = .358$).
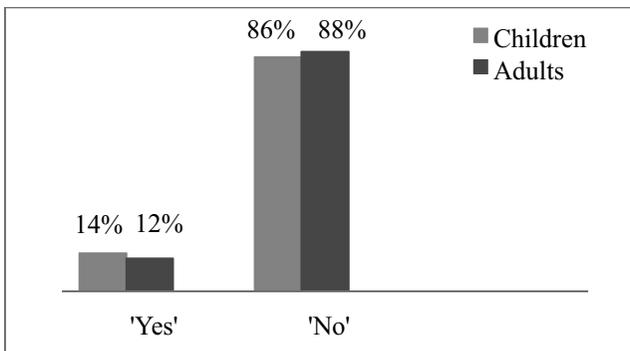

Figure 2: Responses by Children and Adults

The findings suggest that both children and adults assigned a conjunctive entailment (the 'neither' interpretation) to sentences with the disjunction word *huozhe* 'or' and the focus adverb *zhiyou* 'only'.

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[1] Note that the puppet's ignorance of the results of the coral-planting made the use of disjunction felicitous.

3.3. Experiment 3

Experiment 3 tested 25 Mandarin-speaking children, who ranged in age from 4;1 to 5;2, with a mean age of 4;6. The child participants were recruited from a kindergarten affiliated with Beijing Language and Culture University, Beijing, China. We also tested 20 Mandarin-speaking adults, who were undergraduate students at Hubei University of Technology, Wuhan, China.

Participants witnessed the same four stories as in Experiment 2, but they were presented with different target sentences, with the addition of the deontic modal verb *keyi*. The target sentences were presented immediately after the judge established the rules. For example, on the typical trial, Mr. Owl established the rules, but the two pirates forgot them and asked the puppet to remind them of the rules. At that point, the puppet produced the target sentence (25) and the filler sentence (26).

(25) Zhiyou dahaidao keyi zai hongse huozhe lüse   meirenyu bianshang zhong shanhu.
Only   big pirate may at red   or   green mermaid side   plant coral
'Only the big pirate is allowed to plant coral near the red or the green mermaid.'

(26) Zhiyou xiaohaidao keyi zai lüse   meirenyu bianshang zhong shanhu.
Only   small pirate may at green mermaid side   plant   coral
'Only the small pirate is allowed to plant coral near the green mermaid.'

As shown in Figure 3, the child participants accepted the target sentences 92% of the time, and the adult participants accepted them 78% of the time. A Mann-Whitney test of the Yes-responses to the target sentences revealed no significant difference between groups ($z = .739$, p = .46).
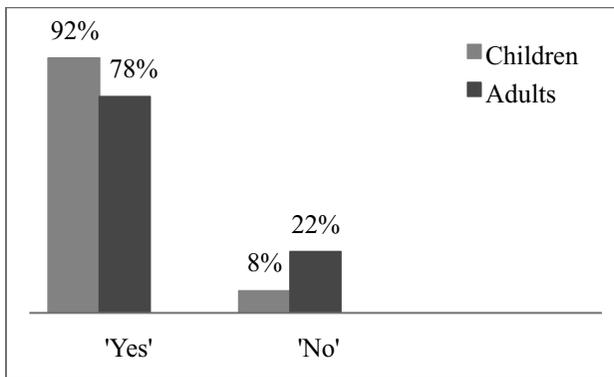

Figure 3: Responses by Children and Adults

The findings suggest that both children and adults computed the negation of a Free Choice Inference (the 'not both' interpretation) in response to sentences that contained external negation, which was introduced by the focus adverb *zhiyou* 'only'. This finding supports the ambiguist approach to negation.

4. Conclusion

The present study investigated 5-year-old Mandarin-speaking children's computation of Free Choice Inferences in sentences with internal versus external negation. The ambiguist account of negation markers predicts that Free Choice Inferences are cancelled in sentences with internal negation, but that such inferences are preserved in sentences with external negation. To assess this prediction, we conducted three experiments using a Truth Value Judgment Task.

Experiment 1 presented children and adults with sentences that contained internal negation and the polarity sensitive expression *renhe* 'any'. As expected on both approaches to negation, the child and adult participants assigned a conjunctive entailment (the 'none' interpretation) to the test sentences, which contained internal negation. Experiments 2 and 3 investigated a linguistic structure that introduces external negation, namely sentences with the focus adverb *zhiyou* 'only'. In Experiment 2, both children and adults assigned a conjunctive entailment (the 'neither' interpretation) to sentences that contained disjunction and the focus adverb *zhiyou* 'only'. Experiment 3 presented children and adults with sentences that contained an additional expression, namely the deontic modal verb *keyi* 'is allowed to'. Due to the interaction of the focus adverb and the deontic modal verb, we expected participants to negate the Free Choice Inference. This is exactly what we found.

The findings reveal that 5-year-old Mandarin-speaking children know that the position of negation determines whether or not Free Choice Inferences are licensed in sentences with negation. More specifically, they know that Free Choice Inferences associated with *renhe* 'any' are cancelled in sentences with internal negation. They also know that Free Choice Inferences associated with *huozhe* 'or' are preserved in sentences with external negation, introduced by the focus adverb *zhiyou* 'only'. The findings provide experimental evidence supporting the ambiguist account of negation markers (Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006; Bar-Asher Siegal 2015).

The question remains: How do children acquire the different patterns of entailments and inferences that we observed in the present study? A usage-based account to language acquisition argues that child language is based on linguistic input from adults. In other words, the usage-based approach is characterized as an 'input-matching' model of development (Lieven and Tomasello 2008, p. 171). According to a nativist account, by contrast, children are expected to know the different inferences and entailments that we observed in this study even in the absence of relevant input from adults.

To evaluate the different approaches, we surveyed seven Mandarin corpora on the Child Language Data Exchange System (CHILDES) database (the

Beijing corpus, the Chang corpus, the Context corpus, the Tong corpus, the Xu Min Chen Corpus, the Zhou 1 and Zhou 2 corpora) and the BJCELA corpus. As a result, we found 3545 tokens of parental utterances with *bu* 'not' and 675 tokens of parental utterances with *keyi* 'is allowed to'. However, no utterances with *renhe* 'any' were found in these corpora, so there were no utterances with the combination of *bu + keyi + renhe*. There were 675 tokens of parental utterances with *keyi*, 21 tokens of parental utterances with *huozhe* 'or' and 54 tokens of parental utterances with *zhiyou* 'only'. However, no utterances contained the combination of *zhiyou + huozhe* or *zhiyou + keyi + huozhe* in these corpuses. Due to paucity of relevant input, it is highly implausible that children learned the different patterns of entailments and inferences we observed in this study based on the linguistic input from adults. Rather, the findings invite us to conclude that children rely on the syntactic process of MERGE to combine meanings acquired in sentences with logical words in isolation. Presumably, MERGE enables children to derive the meanings of sentences with the combinations of logical words that were presented to the child participants in the present study.

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