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Do children know *wh*anything? 3-year-olds know the ambiguity of *wh*-phrases in Mandarin

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ABSTRACT

Wh-phrases in Mandarin have an interrogative (like English *what*) and an indefinite (like English *a/some*) interpretation. Previous comprehension studies find that children can access both interpretations around 4.5 years old; studies with younger children focus on production and find that children between 2 and 4.5 do not reliably produce the indefinite interpretation in naturalistic speech or in elicited imitation tasks. In this article, we use comprehension tasks to examine 3-year-olds' interpretation of *wh*-phrases. We find that they have adult-like interpretations of *wh*-phrases in two different contexts: in *dou* -sentences (Experiment 1), where the indefinite interpretation is the only available interpretation and the whole sentence receives a universal reading (roughly equivalent to English *any*), and in negated sentences (Experiment 2), where the interpretation of *wh*-phrases depends on prosodic prominence and the indefinite interpretation leads to an existential reading of the sentence.

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1. Introduction

In English, *wh*-phrases like *what* and *who* are primarily used to form constituent questions. In languages like Mandarin, *wh*-phrases have an additional non-interrogative interpretation (henceforth *wh*-indefinites, Huang 1982, Cheng 1991, Li 1992, Lin 1998, among many others). As shown in (1), when the *wh* -phrase *shenme* is interpreted as a question word, the sentence is a constituent question (1a); when *shenme* is interpreted as a simple indefinite, the sentence is an existential statement (1b).

(1) Xiaoxiao zhongwu mei chi shenme.
Xiaoxiao lunch NEG eat what
a 'What didn't Xiaoxiao eat for lunch?' *Interrogative*

b'Xiaoxiao didn't eat anything for lunch.' *Indefinite*

The indefinite interpretation of the *wh*-phrases poses some challenges for children learning Mandarin. For one, the distribution of this interpretation is infrequent compared to the interrogative interpretation (around 97% of adult uses of *wh*-phrases are interrogative; merely 3% are non-interrogative, Fan 2012 among others), so the existence of this interpretation may be harder for learners to notice. Second, it differs from other indefinites in the language (Huang 1982 among others), which means that once the indefinite interpretation is noticed by learners, it can't simply be assimilated to other types of indefinites. Third, it differs from *wh*-indefinites in other languages (Haspelmath 1997 among others), which means that children not only have to figure out that there are *wh*-indefinites in Mandarin but also the exact properties associated with Mandarin but not Russian or German *wh*-indefinites. How do children overcome these challenges?

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Two hypotheses have been proposed in the literature; we will refer to them as the "single-stage hypothesis" and the "two-stage hypothesis." The single-stage hypothesis argues that both interpretations are available to children from the earliest point at which either interpretation can be identified (Zhou 2015 a.o.). Proponents of this hypothesis argue that it is supported by comprehension studies with children around 4.5 years old, which show that children at this age have access to both interpretations. The two-stage hypothesis argues that the two interpretations are learned in two stages: The interrogative interpretation is learned first because there is more evidence for it in the input, and then children gradually figure out the indefinite interpretation as they accumulate more evidence for this interpretation (Zhou & Crain 2009 a.o.). Proponents of this hypothesis argue that it is supported by production studies with children between 2 and 4.5 years old (Lin 2017), which shows that children at this age do not seem to produce the indefinite interpretation naturally and seem to have difficulties with this interpretation in elicited production tasks.

So far then, the earliest evidence for when children have access to the indefinite interpretation is around age 4.5 years old, but do children really lack this interpretation earlier? As we we will discuss in detail in Section 2.2, there are limitations to what we can infer from children's apparent production lag. Thus, to test whether younger children have access to this interpretation, we use two comprehension studies to examine 3-year-olds' interpretation of *wh*-phrases. With two Question-Statement Tasks (QST), we found that Mandarin-speaking 3-year-olds can access the indefinite interpretation in two different contexts: in *dou*-sentences, where the indefinite interpretation is the only one available and the whole sentence receives a universal reading (roughly equivalent to English *any*, Experiment 1), in negated sentences, where the interpretation of *wh*-phrases depends on prosodic prominence and the indefinite interpretation leads to an existential reading of the sentence (Experiment 2). Our results are consistent with the predictions of both hypotheses, but it lowers the age by which children need to learn the the indefinite interpretation under the two-stage hypothesis to before age 3. We discuss implications of our studies for both hypotheses and more generally for how children might acquire *wh*-indefinites in Mandarin and other languages in Section 5.

2. Background

2.1. Mandarin *wh*-indefinites

The distribution of the indefinite interpretation of Mandarin *wh*-phrases has been heavily investigated. For over three decades, the received view has been that this interpretation is only permissible in a handful of environments (Huang 1982; Cheng 1991; Li 1992; Lin 1998; Xie 2007; Chierchia & Liao 2015; Giannakidou & Lin 2016): under negation (2b), in polar questions (3b), in the antecedent of conditionals (4b), in epistemic contexts (5b), in non-epistemic modal contexts like imperatives (6b), and with the universal quantificational particle in Mandarin, *dou* (7b).

(2) Xiaoxiao mei jiandao shui .
Xiaoxiao NEG meet who
a. 'Who did Xiaoxiao not run into?'

b. 'Xiaoxiao didn't run into anyone.' *Negated sentences*

(3) Xiaoxiao zhongwu chi-le shenme ma?
Xiaoxiao lunch eat-ASP what Q
a. NOT: 'What did Xiaoxiao eat for lunch?'

b. 'Did Xiaoxiao eat anything for lunch?' *Polar question*

(4) Ruguo shui chi-le bocai, Xiaoxiao jiu de yi-kuai jinpai.
If who eat-ASP spinach Xiaoxiao then get one-CL gold medal
a. ? 'If someone ate the spinach, Xiaoxiao gets a gold medal; who is that someone?'

b. 'If anyone ate the spinach, Xiaoxiao gets a gold medal.' *Conditional*

(5) Xiaoxiao zhongwu keneng chi-le shenme dongxi.
Xiaoxiao lunch might eat- CL what stuff
a. 'What might Xiaoxiao have had for lunch?'

b. 'Xiaoxiao might have had something for lunch.' *Epistemic modal*

(6) Chi dian shenme ba!
Eat CL what SFP
a. 'What the hell do you want to eat?'

b. 'Eat something, please!' *Imperative*

(7) Xiaoxiao qu Beijing shui *dou* jian-le.
Xiaoxiao go Beijing who DOU meet- ASP
a. NOT: 'When Xiaoxiao went to Beijing, who all did she meet?'

b. 'When Xiaoxiao went to Beijing, she met with everyone.' DOU - *quantification*

The traditional view claims that the Mandarin *wh*-indefinite is a Negative Polarity Item (NPI, Huang 1982; Li 1992; Cheng 1997; Lin 1998; Xie 2007; Chierchia & Liao 2015; Giannakidou & Lin 2016, among many others) that needs to be licensed. In simple affirmative sentences without any licensor like (8), *wh*-indefinites do not seem to be acceptable:

(8) Wo xihuan shei/shenme ren
I like who/what person
'Who do I like?'

NOT: 'I like someone.' *Affirmative Sentence*, (Lin 1998:231), ex. (38b)

However, recent investigations with corpus and experimental data suggest that the indefinite interpretation is possible in affirmative sentences, subject to further pragmatic restrictions (Yang 2018; Liu & Yang 2021). The indefinite interpretation in affirmative contexts needs to be supported by an ignorance inference, suggesting that they are more similar to epistemic indefinites like Spanish *algún* (Alonso-Ovalle & Méndez-Benito 2010) than to NPIs. Here is a naturally occurring example of a *wh*-indefinite in a simple affirmative sentence:[1]

(9) Gouxiong zhengzai disheng he shui jianghua.
Gouxiong is low voice with who speaking
'Gouxiong is talking to someone in a low voice (but I don't know who).'

The key difference between (8) and (9) is that the latter sentence is associated with an ignorance inference "I don't know who." When this ignorance inference is not supported, the indefinite reading of *wh* is infelicitous (10a), but the regular indefinite is acceptable, as seen in (10b).[2]

[1]The example is taken from the novel *Hongyan* by Kuang-pin Luo & Yiyan Yang (1961); see Liu & Yang (2021) for more examples.

[2]If we change the subject of (8) to Zhangsan, the ignorance inference could be satisfied, and yet the indefinite interpretation is not as acceptable:

(i) Zhangsan xihuan shei/shenme ren
Zhangsan like who/what person
a. 'Who does Zhangsan like?'
b. ??'Zhangsan likes someone.'

However, when we add a modification to the object *wh*-phrase, the indefinite interpretation is acceptable again:

(ii) Zhangsan xihuan yuyanxuexi de shei/shenme ren
Zhangsan like Linguistics Department POSS who/what person
a. 'Which person from Linguistics Department does Zhangsan like?'
b. 'Zhangsan likes someone from Linguistics Department.'

It is unclear why manipulating the length of object NP would affect the acceptability of *wh*-indefinites in affirmative sentences; see Liu & Yang (2021) for more discussion on this puzzle.

(10) a. Gou Xiong zhengzai disheng he shui jianghua, #wo kande
Gou Xiong is low voice with who speaking I can see
qingqingchuchu,
clearly
na-ge ren jiushi Xingxing.
that-CL person is Xingxing.
(intended) 'Gouxiong is talking to someone in a low voice. I can see it clearly, that's Xingxing.'

b. Gouxiong zhengzai disheng he yi-ge ren jianghua, wo kande
Gouxiong is low voice with one-CL person speaking I can see
qingqingchuchu, na-ge ren jiushi Xingxing.
clearly that- CL person is Xingxing
'Gouxiong is talking to someone in a low voice. I can see it clearly, that's Xingxing.'

The ignorance inference in simple affirmative sentences is not the only way *wh*-indefinites differ from other types of indefinites like *yi*- CL NP and bare NPs (Cheng & Sybesma 1999, Yang 2001 among others). In negated sentences, *wh*-indefinite s but not *yi*- CL NPs are acceptable, as shown by the contrast between (2) and (11):[3]

(11) #Xiaoxiao mei jiandao yi-ge laoshi
Xiaoxiao NEG meet one- CL teacher
(intended) 'Xiaoxiao didn't run into any teacher.'

Bare NPs are acceptable in negated sentences, but when associated with prosodic prominence, bare NPs adopt a focus interpretation (12), but *wh*-phrases adopt the interrogative interpretation ((13); Cheng 1997; Hu 2002; Dong 2009; Liu, Li & Jia 2016; Yang 2018; Gryllia et al. 2020).

(12) Xiaoxiao mei jiandao laoshi
Xiaoxiao NEG meet teacher
a. (laoshi without prominence) 'Xiaoxiao didn't run into any teachers.'
b. (laoshi with prominence) 'Xiaoxiao didn't run into any teacher (she ran into some students).'

(13) Xiaoxiao mei jiandao shui
Xiaoxiao NEG meet who
a. (shui without prominence) 'Xiaoxiao didn't run into anyone.'
b. (shui with prominence) 'Who did Xiaoxiao not run into?'

In summary, when *wh*-phrases are interpreted as indefinites, they are different from regular indefinites: They generate an ignorance inference in simple affirmative sentences and can be used under negation; when associated with prosodic prominence, *wh*-phrases switch to the interrogative interpretation,[4] a property that regular indefinites do not share. These asymmetries between *wh* -indefinites and regular indefinites will become relevant in the general discussion (Section 5) as a constraint on the shape of a theory of how Mandarin *wh*-phrases are acquired.

[3]For some speakers, prosodic prominence on the numeral *yi* could make the sentence more acceptable, assigning focus on the quantity of people that Xiaoxiao met. The sentence has an interpretation similar to "he didn't meet ONE person (he met two)." However, intuition varies across the native speakers we consulted.

[4]As correctly pointed out by a reviewer, this is true except in *dou* sentences like (7), where *wh* only has the indefinite interpretation but is associated with prominence. In Experiment 1, we took advantage of this property of *dou* -sentences to make sure that the sentences with *dou* where *wh* is interpreted as an indefinite and sentences without *dou* where *wh* is interpretation as an interrogative have similar prosodic contours.

2.2. Acquisition of *wh*-ambiguity

In the process of figuring out the interpretations of *wh*-phrases, a highly skewed distribution might make it harder for learners to notice the infrequent interpretation, in this case, the indefinite one. Although *wh*-phrases are relatively frequent (occur in about 10% of adult utterances), around 97% have the interrogative interpretation, and only 3% are interpreted as indefinites (Fan 2012; Lin 2017; Zhou 2015). This imbalance raises the possibility that the indefinite interpretation is harder to detect and hence acquired significantly later than the interrogative. Previous comprehension studies show that 4.5-year-olds might have access to both interpretations, but studies with younger children (from 2 to 4.5 years old) show that they have problems with the indefinite interpretation. However, studies with younger children focus on production and so might underestimate children's knowledge.

Zhou and colleagues (Zhou & Crain 2009; Zhou 2011; Zhou & Crain 2011; Zhou, Crain & Zhan 2012; Zhou et al. 2012; Zhou 2015) test Mandarin-speaking 4.5-year-olds' interpretation of *wh*-phrases by using a Question-Statement Task (QST, Zhou & Crain 2009). Similar to the Truth Value Judgment Task (TVJT, Crain & Thornton 1998), in the QST, the experimenter tells the subject and a puppet some stories, and the puppet produces a test sentence after each story. But although the subjects are always asked to judge whether the puppet is right or wrong in a TVJT, in the QST, the subjects are instructed to give a judgment if they hear the puppet making a guess, and give an answer if they hear the puppet asking a question. If children can access the indefinite interpretation, they will tell the puppet whether he is right or wrong. Their results show that children around age 4.5 and older have the indefinite interpretation in a variety of contexts. In particular, they find that children show adult-like interpretation of *wh*-phrases in contexts that they might have limited exposure to, such as sentences with quantificational expressions like [*meiyou* NP] "no NP" (14).[5] They take the results as support for "the early mastery of adult-like linguistic knowledge of *wh* -quantification in child Mandarin" (Zhou 2015:15).

(14) Meiyou xiongmao chi shenme shuiguo.
NEG -have panda eat what fruit
'No panda ate any fruit.'

Another group of studies focuses on children's *production* of *wh*-indefinites (Fan 2012; Lin, Weerman & Zeijlstra 2014; Lin 2017; Lin, Weerman, and Zeijlstra 2021). Fan (2012) examines the production of *wh*-phrases by four children between 0;10 and 2;06, and she finds that children start to produce *wh*-phrases around 1;06, but only with the interrogative interpretation. Although toward the end of the age range examined in her study, two children do produce *wh*-indefinites (10 instances in total, 0.5% of all 1,829 *wh*-phrases produced by children in this study) like (15), Fan states that children's production of *wh*-indefinites is far too rare to make the conclusion that they have adult-like knowledge of this interpretation. Lin, Weerman & Zeijlstra (2014) and Lin, Weerman, and Zeijlstra (2021) report a similar pattern: Children start to use *wh*-indefinites productively when they turn 4 years old, and not before.

(15) Dou pao la, zhe juzi! Wo shenme *dou* lao-bu-zhao le!
DOU run-away SFP this mandarin I what DOU left- NEG - ASP SFP
'The mandarins are rolling away! I am left with nothing!'
ZHZ 02;04,11 (Fan 2012:93) ex.(17b)

[5]In fact, Zhou & Crain (2009) examined all instances of *meiyou* from Mandarin corpora in CHILDES and found no instance of quantificaitonal *meiyou* co-occurring with *wh* -phrases. A reviewer correctly points out that this does not mean that children have no exposure to this type of structure. Although it is possible that children have some exposure to this structure, their argument here is that this structure is rare enough that children might not be able to learn the interpretation of *wh* in this specific configuration from the input.

However, the low frequency of indefinite *wh*-phrases might be a property of naturalistic production data. As we have seen earlier, the chance of observing an indefinite *wh* out of all uses of *wh*-phrases in adult input is also extremely low (around 3%). Thus, it is hard to draw any inferences about children's grammatical knowledge from the low frequency of *wh*-indefinites in their speech.

Due to the limitation of naturalistic production data, Lin (2017) uses an elicited imitation task to test children's knowledge of *wh*-indefinites between the age 2;11 and 4;09. In the task, children are asked to repeat the experimenter's sentences. She finds that while children always accurately repeat sentences containing interrogative *wh*-phrases, their accuracy rate is significantly lower (but steadily increases with age) when repeating *wh*-indefinites until 4;06. Based on these results, Lin concludes that children do not have the knowledge of *wh*-indefinites before 2;11. Between 2;11 and 4;06, children start to realize their *wh*-phrases can be indefinites before reaching adult-like grammar after 4;06 (Lin 2017).

While production studies can probe the knowledge of *wh*-indefinites in younger children, these studies might have underestimated children's knowledge. In Lin's elicited imitation study, children sometimes replace a *wh*-indefinite with a regular indefinite, and the researcher interprets this replacement as children lacking the knowledge of *wh*-indefinites in a specific environment. However, these cases might in fact show that children have correctly encoded the meaning: They correctly interpret the test sentences as declaratives with indefinites. In fact, non-imitation errors like these have been used as evidence for correct knowledge (Chien & Lust 1985; Lust, Chien & Flynn 1987 among others): in this case, failure of imitation indicates that children's knowledge (namely the *wh*-phrase is equivalent to an indefinite in the sentence) matches the grammar of the stimulus (Lust, Chien & Flynn 1987:291).

Additionally, Fan (2012) and Lin,Weerman & Zeijlstra (2014) both report tokens of *wh*-indefinites produced by younger children, such as (15), but they both caution against drawing any inferences from these data due to the low frequency. However, children's production is not always a good indicator for their knowledge (e.g., Shipley, Smith & Gleitman 1969), so it is possible that younger children can comprehend but do not produce *wh*-indefinites.

Another problem for these production studies is that observing a child producing a *wh*-indefinite in one environment doesn't guarantee that they know the *interpretations* that these *wh*-indefinite s give rise to in different environments. For example, sentences with *wh*-indefinites and *dou* are interpreted as universal statements, as in (7b) repeated as (16), and *wh*-indefinites under negation are interpreted existentially, as in (2b) repeated as (17). Hence we want to test children's understanding of *wh*-indefinites in different environments to probe the extent of their knowledge.

(16) Xiaoxiao qu Beijing shui *dou* jian-le.
Xiaoxiao go Beijing who DOU meet- ASP
'When Xiaoxiao went to Beijing, she met with everyone.' DOU *-quantification*

(17) Xiaoxiao mei jiandao shui .
Xiaoxiao NEG meet who
'Xiaoxiao didn't run into anyone.' *Negated sentences*

In this study, we address two questions: How early do children show awareness of the indefinite interpretation, and do they have adult-like knowledge of this interpretation in different environments. We focus on 3-year-olds and examine their interpretation of *wh*-phrases in *dou* -sentences (Experiment 1) and negated sentences (Experiment 2). Our results suggest that 3-year-olds have an adult-like interpretation of *wh*-indefinites in both environments.

3. Experiment 1: *dou*

In this experiment, we tested 3-year-olds' interpretation of *shenme* preceding the quantificational adverb *dou*, as in (18). In this environment, the interrogative interpretation is blocked, and the non-interrogative *wh* with *dou* yields a universal interpretation for adults (Lee 1986; Cheng 1995; Li 1995; Huang 1996; Wu 1999; Dong 2009; Xiang 2008; Liu 2019; Xiang 2020):

(18) Xiaoxiao shenme *dou* chi-le.
Xiaoxiao what DOU eat- ASP
NOT: What did Xiaoxiao eat?
"Xiaoxiao ate everything."[6] *Dou* -quantification

If 3-year-olds know the non-interrogative interpretation for *wh*-phrases, the semantics of *dou*, and the interaction between the *wh*-phrase and *dou*, they should interpret (18) as a universal statement. On the other hand, if children do not interpret the sentence as a universal statement, then further research is required to determine which of these factors is responsible for the failure.

In this experiment, we adopted a modified version of the Question-Statement Task (QST, Zhou & Crain 2009). To make the task appropriate for younger children, we asked the on-screen character Xiaoxiao to turn around, which put the character in a position where it is natural for her to either ask questions about a scene she cannot see or make guessing statements about it. The participants were instructed to help Xiaoxiao figure out the story, but the pragmatics of the task were such that the participants would organically respond to different kinds of utterances in different ways, revealing their interpretation of what Xiaoxiao said. In this way, we did not have to explicitly instruct the participant to give an answer if they hear a question; they did so naturally.[6]

3.1. Methods

3.1.1. Participants

Child participants for this experiment were recruited from four preschools in Beijing. Thirty-six typically developing, monolingual Mandarin-speaking children aged 3;0,17 to 4;00,00 participated (mean = 3;09, 18 female) in the study. Thirty two adult Mandarin speakers were also recruited (aged 19 to 54 years, mean 26 years). Adults and children were tested the same way.[7]

3.1.2. Procedure

Sessions took place in a relatively quiet space with the participant seated in front of a laptop next to the experimenter.[8] A session started with the experimenter telling the children that they were going to play a game with a girl on the computer screen, who introduced herself as Xiaoxiao (Figure 1). The experimenter explained to the children that they were going to listen to some stories with Xiaoxiao. To make the game more challenging, Xiaoxiao was asked to turn around, so she could not see what was on the screen (Figure 2). The participant was told that they were on Xiaoxiao's team, and they needed to help Xiaoxiao by giving her feedback. To further encourage the child to interact with Xiaoxiao, the experimenter asked the child to say hi to Xiaoxiao, who would then deliver a prerecorded message ("Nice to meet you!").

The experimenter then told the participants that they were going to watch stories about some competitions and asked them to help Xiaoxiao figure out the winner because she could not see anything. This manipulation set up the overall goal of the task: To figure out the winner in each

[6]As noted by many, the position of *wh*-phrases relative to *dou* matters to their interpretation too. In pre-*dou* positions, *wh*-phrases are interpreted non-interrogatively, as demonstrated in (18), but when the *wh* positions to the right of *dou* as in (i), the sentence is a *wh*-question. In this article, we focus on pre-*dou* *wh*-phrases. (i) Xiaoxiao *dou* chi-le shenme
Xiaoxiao DOU eat- ASP what
a. What all did Xiaoxiao eat?
b. (Not possible) 'Xiaoxiao ate everything.'

[7]Five adult participants chose to use headphones. Using headphones did not influence the adult behavior; all adults behaved the same way in this experiment.

[8]The experiment was run on PsychoPy3.0.0 (Peirce et al. 2019).

Figure 1. Introducing Xiaoxiao.

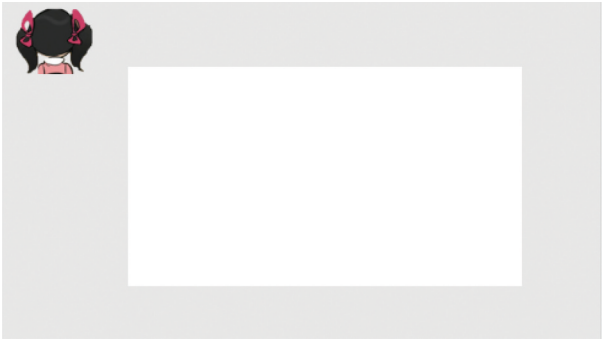

Figure 2. Screen after Xiaoxiao's introduction.

competition. Each of Xiaoxiao's utterances before the final guess then served as a subgoal of figuring out what each contestant did. After Xiaoxiao's utterance, the experimenter would prompt the participant to respond to Xiaoxiao by uttering *Nishuo ne?* 'What do you say?' (lit. 'You say?'). This prompt is equally appropriate to solicit answers to questions and judgments to statements.[9] In each story, Xiaoxiao delivered three sentences, and made a guess at the end. Half of the guesses were correct and half were incorrect.[10]

During practice, Xiaoxiao delivered a mix of constituent questions, polar questions, and statements, and the experimenter would provide feedback to children's responses. In the statement trials, if a child did not explicitly say "yes" or "no" (i.e., a *yes/no*-response; see Section 3.2) but described the contestant's obtained item (i.e., answering the subquestion of the trial), the experimenter would additionally ask *Xiaoxiao shuode dui ma?* 'Is Xiaoxiao right?' to prompt a *yes/no*-response . After the child provided a *yes/no*-response, the experimenter would add "Ok, let's tell Xiaoxiao that. Xiaoxiao, you were right/wrong!" After the three practice stories, the experimenter stopped using this additional prompt. If by the end of the practice phase, a child failed to produce any *yes/no*-responses to Xiaoxiao's statements, they failed the practice and would not move on to the test phase.

[9]During practice, if the child still would not give any responses, the experimenter would provide additional prompts: either "Let's help her. Is Xiaoxiao right?" if Xiaoxiao's utterance was a statement, or repeat the question if Xiaoxiao's utterance was a question. The experimenter stopped giving the additional prompts during the test phase.

[10]Child participants were asked to give Xiaoxiao a stamp if they agreed with Xiaoxiao's guess about the winner to keep them engaged in the game. When we were piloting this experiment, some adults were very reluctant to participate in stamping. Considering that introducing stamps stretched the length of the experiment, and that adults do not need this extra step to stay attentive, we did not include the stamp for adult participants.

3.1.3. *Material*

During the test phase, participants were told eight stories: Each contained one critical trial and two filler trials. The stories followed the same template: A group of animals decide to have a competition. Teacher Kangaroo explained that to win a gold medal, the contestants had to pack all three items in the box (Figure 3). Then the experimenter introduced the contestants (Figure 4). After some intense packing, the contestants were asked to stop (Figure 5).

In the next scene, the contestants' boxes were opened one by one. At each reveal, the animal with her box showed up on screen (Figures 6–8), the experimenter announced the animal being evaluated, and Xiaoxiao delivered a sentence that could be either a question or a statement depending on the trial. After all the animals were judged, all contestants appeared together on the screen (Figure 9). Xiaoxiao then made a guess about the winner.

3.1.4. *Design*

We manipulated two factors in this experiment: the presence or absence of *dou* as a between-subject factor and the type of scenario (2-out-of-3 vs. 3-out-of-3 scenario) as a within-subject factor. In total we had four (2*2) conditions, with four trials in each condition.

The first factor manipulated was the presence or absence of *dou* . In the [+dou] condition (19), the only interpretation available for *shenme* is the non-interrogative one, and the sentence should be a universal statement. In the [–dou] condition (20), *shenme* functions as a question word, and the sentence is a constituent question.

(19) Xiaoyang shenme *dou* fang zai xiangzi-li le
Lamb what DOU put in box - LOC ASP
'Little Lamb packed everything in the box.'

Figure 3. Teacher Kangaroo explains the winning condition: Pack all three items in a box (with Xiaoxiao listening in the background).

Figure 4. Introducing the contestants.

Figure 5. Ready for inspection.

Figure 6. Contestant No. #1 (filler trial).

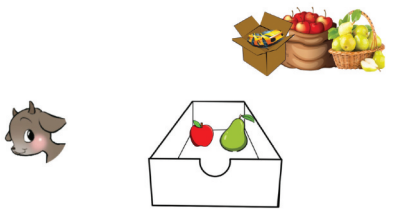

Figure 7. Contestant No. #2 (critical trial, 2-item condition).

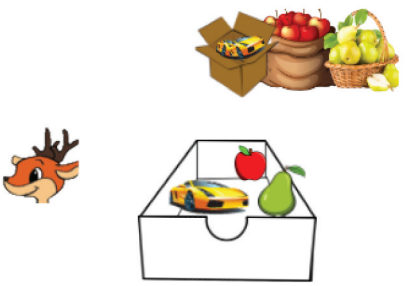

Figure 8. Contestant No. #3 (filler trial).

(20) Xiaoyang ba shenme fang zai xiangzili le
Lamb BA what put in box ASP
'What did Little Lamb pack in the box?'

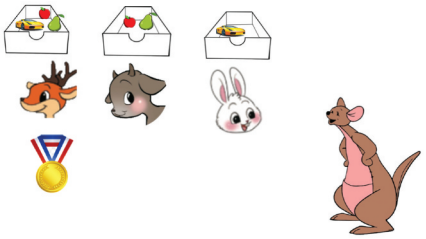

Figure 9. Announcing the winner.

By using *ba*, which requires the fronting of the object NP, in the [–dou] condition, the two types of sentences are matched in word order: *Shenme* is fronted to a preverbal position in both sentences, by *ba* in [–dou] sentences and by *dou* in [+dou] sentences. Additionally, the prosodic features on *shenme* are also matched: The preverbal position that *shenme* is displaced to in both sentences is normally associated with contrastive focus (Shyu 1995; Wu 1999; Ernst & Wang 1995 among many others). As a result, *shenme* is produced with prosodic prominence in both [+dou] and [–dou] sentences.

The number of items in the critical scenario was manipulated as a within-subject factor. In half of the trials, the animal in the critical trial packed two out of three items in her box (2-out-of-3 scenario) as in Figure 10. Participants in the [+dou] condition should reject the sentence; participants in the [–dou] condition should name the items (an apple and a pear). In the other half of the trials, the animal packed three out of three items (3-out-of-3 scenario) as in Figure 11, so participants in the [+dou] condition should accept the test sentence and participants in the [–dou] condition should name all the items in the box. We will discuss all the possible responses in the next section. In addition to the eight critical trials, we had 16 filler trials (four *how many* -questions, 4 polar questions,#four true and four false statements) to balance the number of questions and statements.

As will be detailed in the following, the most important aspect of this Question-Statement Task is the type of responses a participant offers: whether they said "yes/no" or named an item. In particular, a participant who consistently offers *yes/no*-responses to filler items (especially to *how many* questions) was considered not understanding the task. In this experiment, no participant was removed in this way.

3.2. *Data analysis*

Participants' utterances were transcribed from video recordings of the experiment sessions. Responses then were coded with the following template. A second coder independently coded 10% of the data using the same template, and the two coders agreed on 100% of the coding.

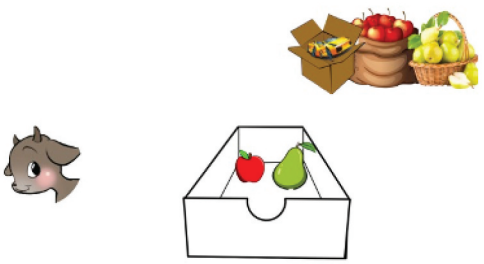

Figure 10. Critical trial in 2-out-of-3 condition; adults should reject the sentence in the [+dou] condition ("Little Lamb packed everything in the box"), and name items in the [–dou] condition ("What did Little Lamb pack?").

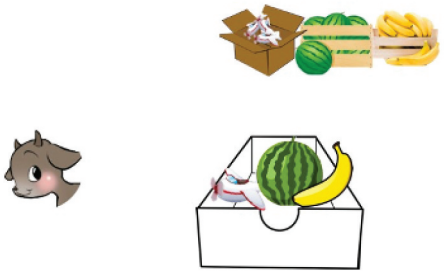

Figure 11. Critical trial in 3-out-of-3 condition; adults should accept the sentence in the [+dou] condition ("Little Lamb packed everything in the box"), and name items in the [–dou] condition ("What did Little Lamb pack?").

3.2.1 *Yes/no responses*

The dependent variable of our experiment was the percentage of *yes/no*-responses. A response was counted as a *yes/no*-response if it contained indicators for "yes" or "no." Possible variations for *yes/no* -response in Mandarin included the bare verb response (21a), the particle *dui* (21b), the particle *shi* (21c), the verb *you* (21d), the interjection *en* (21e), or simply nodding and shaking the head.

(21) *Yes/no* -response

a. Fang-le/ mei (you) (fang)
   Put- ASP /NEG (have) (put)
   '(she) did/ didn't.' — Bare verb responseb.

b. Dui/ bu dui/ cuo
   Correct/ NEG correct/ wrong
   'correct/ incorrect/ wrong.' — *Dui* response

c. Shi/ bu shi.
   Is/ NEG is
   'is/isn't' — *Shi* response

d. You/ mei you.
   have/ NEG have
   'There is/isn't' — *You* response

e. En $_{\text{falling intonation}}$/ En$_{\text{rise}}$-en $_{\text{fall}}$
   Yes/ no
   'Yes/no.' — Interjection

f. (gesture) Nodding / Shaking head — Gesture

Responses like (22) with an elaboration after *bu dui* were counted as *yes/no* -responses, due to the presence of a polarity particle.

(22) Bu dui, Xiaoyang mei fang pingguo.
NEG correct Lamb NEG put apple
'No, Little Lamb didn't pack the apple.'

Responses without these indicators were categorized as "other," including full answers in (23) or fragment answers (24), both of which lack markers for *yes/no* .

(23) Full answers

a. (Xiaoyang) fang-le (yi-ge) pingguo he (yi-ge) li (zai xiangzi-li).
   (Lamb) put- ASP (one- CL) apple and (one- cl) pear (in box- LOC).
   'Little Lamb put an apple and a pear in the box.'

b. (Xiaoyang) mei fang/you xiaoqiche.
   (Lamb) NEG put/have car
   'Little Lamb didn't put in the car.'

(24) Fragment answers
a. Pingguo he li.
Apple and pear
'An apple and a pear.'
b. Xiaoqiche.
Car
'A car.'

The reason we used the percentage of *yes/no*-responses and not full or fragment answers as the dependent variable was that only *yes/no*-responses can differentiate whether the participant responds to something they interpreted as a question or something they interpreted as a statement. A *yes/no*-response cannot be used as a reply to constituent questions, as shown by the contrast between (25) and (26).

(25) A: Xiaoyang fang-le xiaoqiche zai xiangzili.
Lamb pack- ASP car in box
'Little Lamb packed the car in the box.'
B: No, Little Lamb didn't pack the car.

(26) A: Xiaoyang fang-le na -yang dongxi zai xiangzili ne?
Lamb pack- ASP which- CL thing in box Q -wh
'What did Little Lamb pack in the box?'
#B: No, Little Lamb didn't pack the car.

But full or fragment answers can be used to respond to both constituent questions (27) and statements (28):

(27) A: Xiaoyang fang-le na -yang dongxi zai xiangzili ne?
Lamb pack- ASP which- CL thing in box Q -wh
'What did Little Lamb pack in the box?'
B: Little Lamb packed an apple and a pear in the box.

(28) A: Xiaoyang fang-le xiaoqiche zai xiangzi-li.
Lamb put- ASP car in box- LOC .
'Little Lamb packed a car in the box.'
B: Little Lamb packed an apple and a pear in the box.

Thus, the percentage of full/fragment answers cannot help us distinguish whether the participant responds to a constituent question (the [–dou] condition) or a statement (the [+dou] condition). On the flip side, using the percentage of *yes/no*-responses might underestimate children's knowledge, since interpreting the sentence as a statement does not necessarily mean that one has to use *yes/no*-responses. However, if a child does use *yes/no*-responses, we are certain that they interpret the sentence as a statement and the *wh*-phrase as an indefinite. Therefore, the *yes/no*-response measure biases against the hypothesis that children have the knowledge of *wh*-indefinites.

If children can access the indefinite interpretation of *shenme* in *dou*-sentences, we are additionally interested in whether they can assign the correct interpretation to the whole *dou*-sentence. As noted at the beginning of this section, when *shenme* interacts with *dou*, the whole sentence receives a universal interpretation. Therefore, in the 2-out-of-3 scenario where Little Lamb packed two out of the three required items, participants should reject the *dou*-sentence because not everything is packed. But in the 3-out-of-3 scenario, participants should accept the *dou*-sentence because now everything is packed. We therefore also coded whether the *yes/no*-response is a "yes" response or a "no" response.

3.2.2. *Predictions*

If 3-year-olds know that *wh*-phrases have a non-interrogative interpretation, then they should treat the *dou*-sentences as statements and sentences without *dou* as questions. Consequently, under this hypothesis we expect predominantly *yes/no*-responses in the [+dou] condition and fewer *yes/no*-responses in the [–dou] condition.

On the other hand, if they do not know that *wh*-phrases have a non-interrogative representation, then they should treat all utterances with *wh*-phrases as constituent questions. Under this hypothesis we expect very few *yes/no*-responses overall and no difference between conditions.

3.3. *Results*

From the 36 child participants recruited, four children did not produce any *yes/no*-responses during the practice trials and were considered to have failed practice, two from [+dou] (age 3;00,17, 3;05,30) and two from [–dou] condition (age 3;09,24, 3;11,10). Participants who consistently offered *yes/no*-responses to filler sentences during the test phase would be removed as they might not have understood the task; in this experiment, no participant was removed this way. From the 32 children (16 female) included in the analysis, three trials where children gave irrelevant responses (e.g., *I don't like this*) were eliminated from analysis. In total, 505 trials from 32 children and 32 adults (16 in [+dou] condition, 16 in [–dou] condition) were included in the analysis.

Figure 12 summarizes the proportion of *yes/no*-responses by children and adults in each condition. From this figure, we can see that both 3-year-olds and adults used *yes/no*-responses like (30) when *dou* was present, and non-*yes/no*-responses like (29) when *dou* was absent, suggesting that both children and adults interpreted sentences with *dou* as statements.

(29) Xiaoxiao ni shuo cuo le
Xiaoxiao ni say wrong ASP
'Xiaoxiao you are wrong.' Child participant #107

(30) You pingguo he li.
Have apple and pear
'There's an apple and a pear.' Child participant #130

The results from adult data showed no variance: Adults were at ceiling in [+dou] condition, uniformly giving *yes/no*-responses to all [+dou]-sentences; they were at floor in [-dou] condition, giving no *yes/no* -responses to [–dou] sentences, and there is no difference between 2-out-of-3 and 3-out-of-3 scenarios. Results from children show the same pattern: A mixed effects logistic regression model on children's data with the type of response (*yes/no*-response vs. other) as the dependent variable, the presence of *dou* and the number of items in a scenario (2 out of 3 vs. 3 out of 3) as fixed factors and participants as random factors revealed a significant effect of the presence of *dou* ($\beta = 182.84, p < .001$), type of scenarios ($\beta = 108.39, p < .05$), and the interaction of the two $\beta = -107.77, p < .05$: [11] Similar to adults, children responded "yes" or "no" to *dou* -sentences regardless of the type of scenarios. These results demonstrate 3-year-olds' adult-like performance with the indefinite interpretation of *shenme* . Although child performance is not quite at ceiling, it clearly patterns with the adult data. Recall also that the *yes/no*-response is a rather conservative measure: When children do offer this type of response, we can be sure that they have the indefinite interpretation, but when they do not, it could be that they still have the interpretation but simply prefer to offer more information than necessary. We designed the experiment this way because we wanted to stack the cards against the hypothesis that children have the indefinite interpretation, and therefore when they do show two types of responses to *wh*, we can be more confident in rejecting the hypothesis that they only have the interrogative interpretation. Furthermore, if we look at each child's

[11] We ran a model with both participants and test items as random factors, but the effect of items was extremely close to zero, so we excluded items as a random factor in the final model.

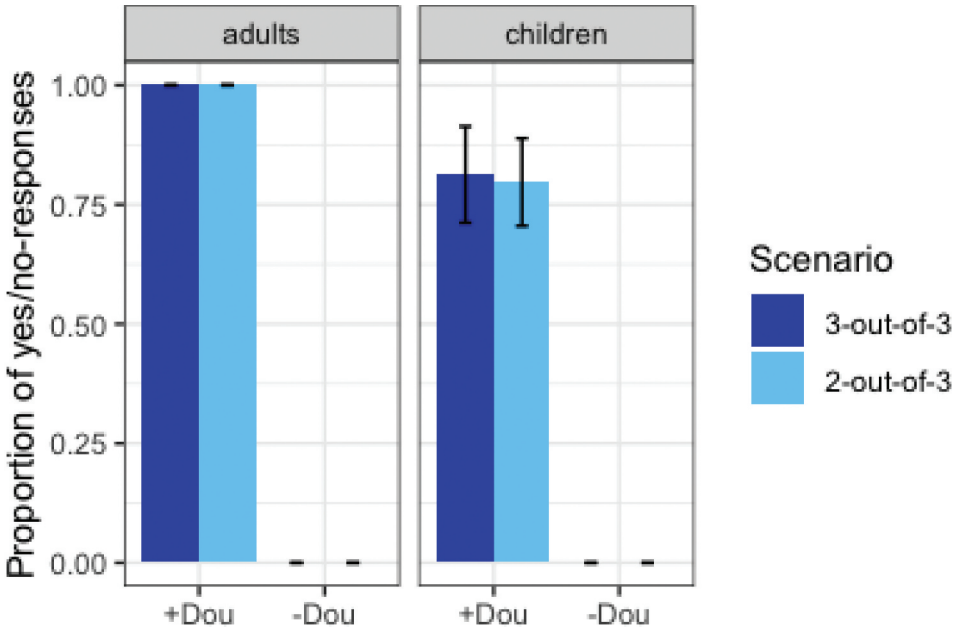

Figure 12. Proportion of *yes/no*-responses offered by adults and children to sentences with/without *dou*.

responses, we found that out of the 16 children in the [+dou] condition, only three (age 3;06,03, 3;10,26, 3;11,09) consistently named items rather than provided *yes/no*-responses. Thus we conclude that children have a sophisticated command of the indefinite interpretation of *shenme*.

Next, to make sure that children not only knew whether the sentence was an assertion or a question but also the correct interpretation of the assertions, we focused on just the *yes/no*-responses in the [+dou] condition. Figure 13 shows the proportion of "yes" responses in the two types of scenarios. Again, adults showed no variance and consistently said "yes" to the *dou*-sentences when all three items are packed in the box, and "no" in the 2-out-of-3 condition. Three-year-olds showed a similar pattern: They overwhelmingly accepted the *dou*-sentence when all items were packed and rejected the *dou*-sentence when two out of three items were packed.

A mixed effects logistic regression model on children's data with number of items in a scenario (2 out of 3 vs. 3 out of 3) as fixed factors and participants as random factors[12] revealed that the type of scenario had a significant effect on participants ($\beta = 5.0124, p < .001$): Children were more likely to accept *dou*-sentences in scenarios where everything was packed, suggesting that they associated a universal interpretation with the sentences in [+dou] condition.

Looking at the responses of each child, we found that 13 children (out of the total 16 in [+dou] condition) provided *yes/no*-responses. Out of these 13 children, 10 offered adult-like responses: They accepted *dou*-sentences when all items were packed and rejected the sentences when two out of three items were packed. Only one child (out of 13) consistently rejected *dou*-sentences in both scenarios (age 3;09,19), and two children accepted the sentences in both scenarios (age 3;09,19, 3;10,23).

In summary, 3-year-olds behaved like adults when interpreting *shenme* in *dou*-sentences: They could correctly assign the indefinite interpretation to *shenme* in this context and also interpreted the whole sentence as a universal statement.

[12]Same as *yes/no*-responses, we did run a model with both participants and items as random factors, but there was close to zero variance for items, and thus the final model did not include items as a random factor.

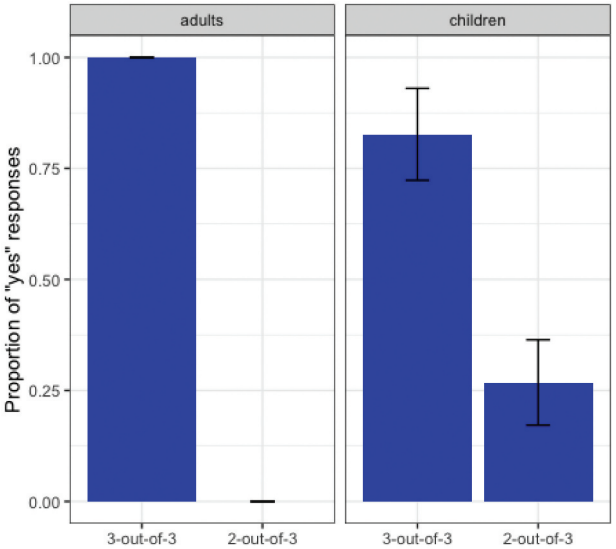

Figure 13. Proportion of "yes"-responses offered by adults and children to sentences with *dou* in the 3-out-of-3 and 2-out-of-3 scenarios.

3.4. *Discussion*

In this experiment, we tested whether 3-year-olds have the indefinite interpretation of *shenme* in *dou*-sentences. The results showed that 3-year-olds, like adults, prefer to interpret *shenme* non-interrogatively in *dou*-sentences. Additionally, 3-year-olds assigned a universal interpretation to the whole sentences, similar to adults. We can thus conclude that 3-year-olds know the non-interrogative interpretation of *shenme* in *dou*-sentences, and they also know that the whole sentence has a universal interpretation. However, an alternative explanation for our results could be that instead of understanding *wh*-indefinites and their connection with *dou*, children simply treat the two as a unit. Therefore, we need to see how children treat *wh*-indefinites in other environments.[13]

In the next experiment, we examine children's knowledge of *shenme* in negated sentences, where the two interpretations of *wh*-phrases are disambiguated by prosodic prominence instead of the presence of a particle, and the non-interrogative interpretation leads to an existential interpretation instead of a universal one. If 3-year-olds have adult-like interpretation of *wh* in two very different environments, we can be more confident that they indeed have both the interrogative and non-interrogative interpretations.

4. Experiment 2: *Under negation*

In this experiment, we used negated sentences to test children's knowledge of *shenme*, as in (31). When combined with negation, *wh*-indefinites are interpreted existentially, unlike in *dou*-sentences. Additionally, the two interpretations of the *shenme*-sentence are string-identical, but the sentential force of these two sentences changes as a function of the presence/absence of prosodic prominence on *shenme.*

[13]We thank an anonymous reviewer for pointing this out to us.

(31) Xiaoyang mei zhuang shenme zai xiangzi-li
Lamb NEG put what in box- LOC
a. 'What didn't Little Lamb put in the box?' *shenme*+ prominence
b. 'Little Lamb didn't put anything/much in the box.' *shenme*– prominence

Studies show that prosodic features associated with the two interpretations of *wh*-phrases are different (Cheng 1997; Hu 2002; Dong 2009; Liu, Li & Jia 2016; Yang 2018), both when the two interpretations are string-identical (in positive episodic sentences, Yang 2018) or when only one interpretation is available (in polar questions vs. in constituent questions, Hu 2002). The prosodic features associated with interrogative *wh*-phrases are similar to the prosodic features of focus (Dong 2009; Liu, Li & Jia 2016). Compared to *wh*-indefinites, *wh*-interrogatives are usually associated with longer duration, higher pitch range, and extended lexical tone, both in production and comprehension. Although none of these studies tests the prosodic features of *wh*-phrases in negated sentences, introspective reports suggest that the same prosodic differences between *wh*-indefinites and *wh*-interrogatives hold in negated sentences as well (Chao 1968; Cheng 1997).

This experiment also adopted the QST paradigm. If children know *wh*-indefinites, and they understand the prosodic features associated with the two interpretations, they should be able to use prosodic prominence to access the correct interpretation. If they cannot use prosodic prominence to disambiguate the two sentences, further experiments are needed to disentangle the different factors affecting their performance.

4.1. *Methods*

4.1.1. *Participants*

Child participants for Experiment 2 were recruited from six preschools in the Beijing area. Sixty-seven typically developing, monolingual Mandarin-speaking children age between 3;00,26 and 3;11,28 participated in this experiment (mean = 3;08, 35 female). Fifty-six adult Mandarin speakers were also recruited for the task (age 19 to 55 years, mean 36 years old).

4.1.2. *Design*

We manipulated two between-subject factors in this experiment: the critical word (Wh *shenme* vs. the bare indefinite NP *shuiguo* 'fruits'), gives us two types of strings (32) and (33) and whether or not the critical word bears prosodic prominence [+/– Prominence]. In total, we had 4 (2*2) between-subject conditions, with four trials in each condition. The practice and filler items were the same as Experiment 1.

(32) Xiaoyang mei fang shenme zai xiangzi-li.
Lamb NEG pack what in box- LOC
a. [+Prominence] 'What didn't Little Lamb pack in the box?'
b. [–Prominence] 'Little Lamb didn't pack anything in the box.'

(33) Xiaoyang mei fang shuiguo zai xiangzi-li.
Lamb NEG pack fruits in box- LOC
[+/– Prominence] 'Little Lamb didn't pack any fruits in the box.'

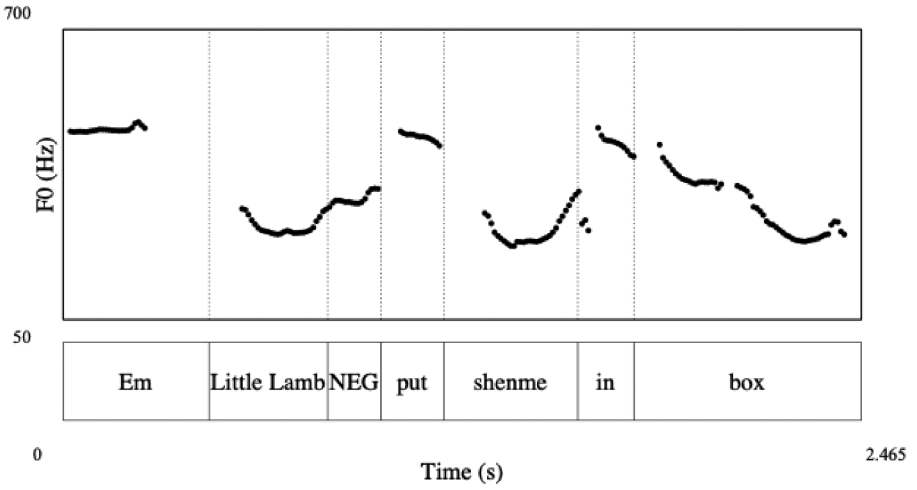

Figure 14. Pitch contour of (32) with prominence on *shenme*: 'What didn't Little Lamb pack?.'

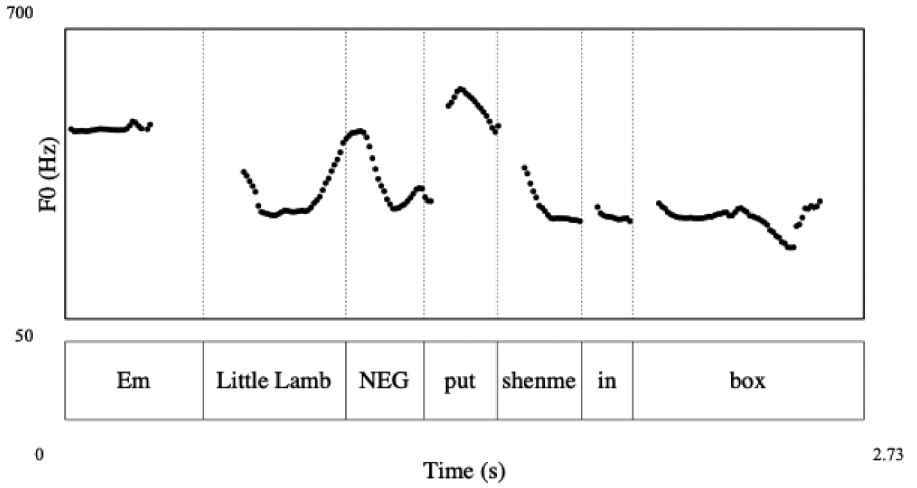

Figure 15. Pitch contour of (32) with prominence on negation instead of *shenme*: 'Little Lamb didn't pack anything.'

The first factor is the critical word. We compared speakers' interpretation of a *wh*-word and a bare NP, which are considered indefinites in Mandarin (Cheng & Sybesma 1999). When associated with prosodic prominence, bare NP indefinites are merely focused; the speech act of the whole sentence does not change. In contrast, when *shenme* is associated with prosodic prominence, it takes the interrogative interpretation.[14]

[14]For some adults, the sentence (32) elicits a vague "not much" interpretation instead of the clear-cut "nothing" interpretation: Little Lamb didn't pack much in the box. This is especially the case if the contexts allow for a contrast between significant items versus insignificant items (Huang 2013). For example, if Little Lamb only packs one piece of candy when she should have packed food to survive, the candy is negligible. In this context, the sentence *Little Lamb didn't pack shenme* would be judged as true, because although "Little Lamb didn't pack anything" is false, the candy that she packs is sufficiently insignificant to pass as "not much." In our task, since there was a requirement to pack all three items, each of these items was made significant, and thus we can avoid this ambiguity. Moreover, even if some participants still assign the "not much" inference, we have established that the agent has packed the majority of items required, so the "didn't pack much" interpretation is still false.

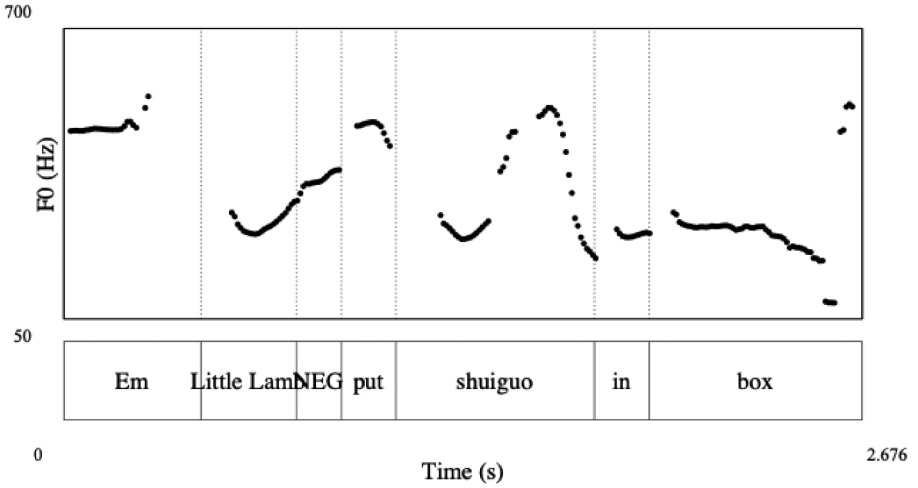

Figure 16. Pitch contour of (33) with prominence on *shuiguo*: 'Little Lamb didn't pack any FRUIT.'

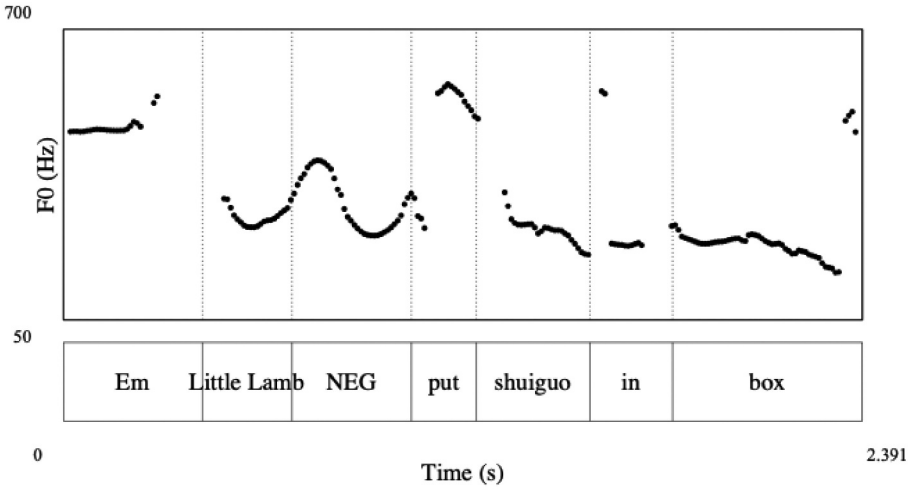

Figure 17. Pitch contour of (33) with prominence on negation instead of *shuiguo*: 'Little Lamb didn't pack any fruit.'

The second factor is the prosodic prominence on the critical word. To make sure that the pitch contour is consistent across the critical trials, we chose animal names that are disyllabic with a third tone and a second tone: *xiaoyang* 'little lamb', *xiaoxiong* 'little bear', *xiaohou* 'little monkey,' and *xiao'e* 'little goose'. Before each utterance, a filler "em" (equivalent to English "um") that lasts 554#ms was added to all test sentences to make the guesses sound more natural. The audio files were recorded by a female native speaker of Beijing Mandarin. Examples of the pitch contours of the utterance in each condition illustrated with *xiaoyang* 'little lamb' are shown in Figure 14-17.

In [+Prominence] conditions, both *shuiguo* and *shenme* have an extended pitch range and a longer duration. In the [–Prominence] conditions, both words have compressed pitch range and shorter duration. In the two [–Prominence] conditions, the prosodic prominence of the sentence falls on the negation marker *mei*, whereas in [+Prominence] conditions, *mei* has shorter duration and compressed pitch range. The details of the acoustic features are given in Table 1.

Figure 18. Teacher Kangaroo explains the winning condition: pack all three things in a box.

Figure 19. Critical trial.

Table 1. Mean duration (ms) and mean pitch range (Hz) of the target word (WH *shenme* vs. NP *shuiguo*) and negation *mei* in all four conditions; [+/– P] stands for [+/– Prominence]; standard deviation in parentheses.

	[Wh +P]	[Wh –P]	[NP+P]	[NP–P]
Duration (ms) of target word	408.3 (25.1)	279.3 (21.9)	678.0 (29.5)	331.5 (20.5)
Pitch range (Hz) of target word	192.8 (48.0)	122.0 (8.2)	273.5 (41.5)	113.8 (21.8)
Duration (ms) of *mei*	157.0 (11.9)	244.3 (42.0)	151.3 (10.2)	290.5 (46.6)
Pitch range (Hz) of *mei*	44.0 (21.9)	207.3 (22.8)	43.0 (29.0)	178.8 (37.5)

4.1.3. *Materials and procedure*

This experiment adopted a similar design to the first experiment. However, since we were using focus and negation, when explaining the rules of the competition (Figure 18), the experimenter stressed the category labels *shuiguo* 'fruit(s)' and *wanju* 'toy(s)' before moving on to list the three items within the two categories (an apple, a pear, and a toy car). Stressing the category labels was done to raise a set of alternatives: {fruit, toy}, so that the use of prosodic prominence on the indefinite NP *shuiguo* 'fruits' was felicitous. The critical trial was a box with two items, as in Figure 19. Table 2 summarizes the possible answers to the test sentences in all four conditions.

4.2. *Data analysis*

As in Experiment 1, sessions were video recorded and the participants' responses were transcribed and coded based on the recording. A second coder independently coded 10% of the data, and the two coders agreed 100% of the time. In this experiment, two types of responses would help us infer participants' interpretation of the test sentences.

4.2.1. *Yes/no responses*

As in Experiment 1, the percentage of *yes/no*-responses was one of the measures. Utterances were coded as a "*yes/no*-response" or "other," using the same criteria as Experiment 1. Since the test sentences contain negations, responses like (34) reject the indefinite interpretation "Little Lamb didn't pack anything/much/any fruits" and (35) accept the interpretation. The crucial difference from Experiment 1 is that the bare verb response is a rejection when it does not have negation (34c).

(34) "No" responses:
a. Bu dui/ cuo
NEG correct/ wrong
'Incorrect/ wrong.' *Dui* response
b. bu shi.
NEG is
'It isn't (true)' *Shi* response
c. Fang-le.
put- ASP
'She did.' Bare verb response
d. En_{rise}-en $_{fall}$
no
'Uh-uh.' Interjection
e. Shaking heads Gesture

(35) "Yes" responses:
a. Dui
Correct
'correct.' *Dui* response
b. Shi.
Is
'It is (true)' *Shi* response
c. Mei fang.
NEG put
'She didn't.' Bare verb response
d. En $_{falling\ intonation}$
Yes
'Yes.' Interjection
e. Nodding Gesture

4.2.2. *Unpacked-item responses*

Another measure adopted in this experiment is the percentage of responses that named the unpacked item. In this experiment, the constituent question interpretation is *What didn't Little Lamb pack?*, which means that the most appropriate way to answer the question is say to the item that is NOT packed by Little Lamb. So participants could either give a fragment answer (36) or a full answer as in (37). Crucially, neither form comes with the indicators for *yes/no* listed in the last section.

(36) Xiaoqiche.
Car
'A car.'

(37) (Xiaoyang) mei-fang xiaoqiche.
Lamb NEG -put car
'(Little Lamb) didn't pack the car.'

If a response contains one of the *yes/no*-markers, and "a car" is merely mentioned as part of the elaboration (38a), the response does not count as an unpacked-item response.

(38) A: What didn't Little Lamb pack in the box?
#B: Bu-dui, jiu mei-fang xiaoqiche
NEG -correct only NEG -put car
'No, she just didn't pack the car.'

Table 2. Expected responses to *shenme* and *shuiguo* with or without prominence.

	[+ Prominence]	[– Prominence]
Lamb didn't pack *shenme*	"A car!"	"No, (an apple and a pear)"
Lamb didn't pack *shuiguo*	"No."	"No."

Like in Experiment 1, this measure also biases against the hypothesis that children have the indefinite interpretation. We focus on the *yes/no*-response and the unpacked-item response because they clearly indicate adult-like indefinite and interrogative interpretation respectively; non-*yes/no*-response and packed-item responses are compatible with both interpretations.

4.2.3. *Predictions*

If 3-year-olds can access the indefinite interpretation in negated sentences, we should see an interaction between the critical word (*wh* or NP) and prominence: When *shenme* is associated with prominence, they should interpret the sentence as a constituent question and offer unpacked-item responses, but not *yes/no*-responses. When *shenme* is not associated with prominence, children should interpret the sentence as a statement and produce *yes/no*-responses instead of unpacked-item responses. When the critical word is *shuiguo*, children should always produce *yes/no*-responses regardless of prominence.

If 3-year-olds do not have the indefinite interpretation, they should produce unpacked-item responses to *shenme*-sentences regardless of prominence and *yes/no*-responses to the indefinite NP-sentences regardless of prominence.

4.3. *Results*

From the 67 children recruited, 11 were excluded from the analysis, three in the [bare NP +Prominence] conditions (age 3;06,21, 3;07,12, and 3;07,12), three in the [bare NP-Prominence] conditions (age 3;04,24, 3;04,26, and 3;08,25), three in [*wh* –Prominence] (age 3;11,07, 3;06,27, and 3;09,21), and two in [*wh* +Prominence] (age 3;05,29 and 3;06,15): Five children failed the practice trials, as they did not produce any spontaneous *yes/no* -responses to Xiaoxiao by the end of the practice phase, one child (age 3;04,24) was eliminated as he consistently shook his head in all trials, and five children were eliminated due to video camera malfunction (age 3;04,26, 3;06,15, 3;06,27, 3;07,19, 3;08,25). From the 56 children included (14 subjects in each condition), seven trials containing irrelevant responses (e.g., *Little Bear is unhappy*) were excluded. In total, 441 trials from 56 children and 56 adults were included in the final analysis.

Figure 20 summarizes the proportion of *yes/no*-responses by children and adults in each condition. We can see that 3-year-olds, like adults, produced more *yes/no*-responses when *shenme* was not associated with prominence than when it was. Additionally, they treated *shenme* without prominence in the same way as the bare indefinite NP *shuiguo* . As in the previous experiment, children's proportion of *yes/no*-responses is lower than adults, because the *yes/no*-response is a rather conservative measure: When children do offer this type of response, we can be sure that they have the indefinite interpretation, but when they do not, it could be that they still have the interpretation but simply prefer to offer more information than necessary.

A mixed effects logistic regression model with *yes/no*-responses as the dependent variable, the critical word (*wh* /NP), the presence/absence of prominence, the interaction between the critical word and prominence, and age group (adults/children) as fixed factors and participants as random factors[15] revealed an interaction between prominence with the critical word ($\beta = -19.17, p < .001$), but no main effect of prominence ($\beta = 0.75, p = .76$) or critical word ($\beta = -0.84, p = .66$). Additionally, there was no difference between children and adults ($\beta = -0.93, p = .56$), suggesting that both adults and children treated *shenme* with prosodic prominence as a question word and *shenme* without prominence as an indefinite. [16]

[15]In the model with both participants and items as random factors, the factor items had close to zero variance and were excluded from the final model.

[16]An anonymous reviewer suggests that Figure 20 gives the appearance that there should be a statistically significant age effect. When we consider all trials as independent data, we do indeed find one ($\beta = -0.70, p < .05$), but it disappears when we control for participant identity across trials by using it as a random factor. This indicates that the supposed "age effect" is a difference between individuals, not between adults and children. So the statistics are as expected if there is indeed no effect between age groups. We do want to acknowledge that there is a question about whether a larger sample size would have been appropriate. We, however, cannot do a posthoc power analysis here, as a power analysis with obtained effect size does not tell us anything that the *p* value does not already tell us (namely, that there is no significant effect in the sample, see Hoenig & Heisey (2001) for discussion on the inadequacy of power analysis with obtained effect size). Unfortunately, we could not obtain *a priori* power from a previous study of similar design (Zhou 2015), but our number of participants per condition is comparable to Zhou (2015).

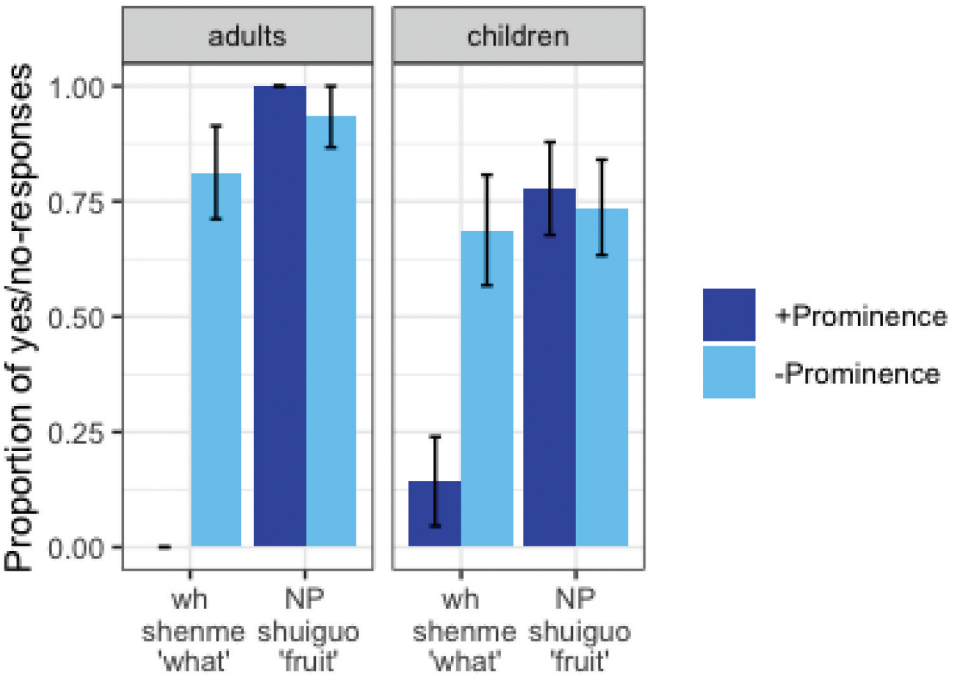

Figure 20. Proportion of *yes/no*-responses offered by adults and children to *wh* /NP sentences with/without prominence.

Breaking down children's *yes/no*-responses to "yes," "no," and packed/unpacked-item responses, we can see in Figure 21 that children predominantly used "yes" and "no" responses in the condition where *wh* is not associated with prominence, but packed/unpacked-item responses in the [*wh* +Prominence] condition. As we have discussed in Section 4.2.1, when children offer non- *yes/no*-responses (i.e., the packed/unpacked-item responses) in the [*wh* –Prominence] condition, it is still possible that they interpret *shenme* existentially. A majority of children offered the packed-item response in this condition (e.g., "She packed an apple and a pear"), which is consistent with (though doesn't necessarily imply) an indefinite interpretation, since it effectively contradicts Xiao Xiao's claim that Little Lamb didn't pack anything. Thus the majority of child responses, like the majority of adult responses, imply an indefinite interpretation ("no" and "yes" responses), and a further minority (the packed-item responses) are at least consistent with such an interpretation. Thus we conclude that children in our experiment arrived at an adult-like interpretation.[17] Additionally, when children did use *yes/no*-responses in the [*wh* –Prominence] condition, they provided more "no" than "yes," suggesting that children are more likely to interpret *shenme* existentially. [18]

Looking at the individual data, four children out of 14 offered non-*yes/no*-responses in more than half of the trials in the [*wh* –Prominence] condition (age: 3;11,06, 3;11,16, 3;08,27, 3;06,22); one child (age: 3;11,19) switched from the unpacked-item response to *yes/no*-response half-way through the

[17]A reviewer points out that the percentage of "no" responses is roughly equivalent to the percentage of "yes" and "packed/unpacked-item" responses combined in this way and argues this means that we can't conclude that children had an adult-like indefinite interpretation. However, we don't think "yes" and "packed/unpacked-item" responses can be combined. As discussed in Section 4.2, saying "yes," like saying "no," clearly indicates that the speaker is responding to a statement, while the packed/unpacked-item responses could be responding to either a statement or a *wh* -question. Thus, it doesn't make sense to collapse the "yes" responses with packed/unpacked-item responses and contrast them with the "no" responses in that way.

[18]One possible explanation for the "yes" responses that adults and children gave is that they had the "not much" interpretation mentioned in footnote 13, despite our attempt to discourage this inference (that is, they are agreeing with Xiao Xiao that Little Lamb didn't pack much because the most important item was not packed). In future work, we plan on eliminating this complication, for instance by having a condition where Little Lamb has all of the items in her box.

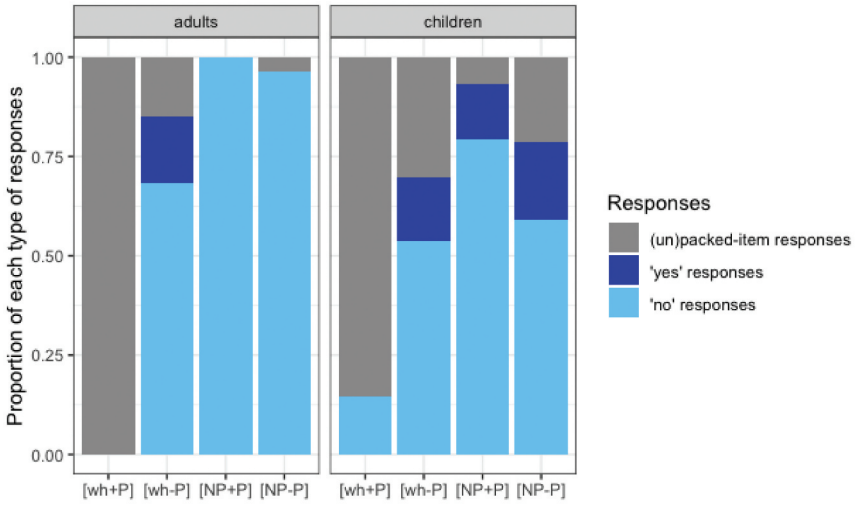

Figure 21. Proportion of "yes" responses and "no" responses offered by adults and children in all four conditions; [+/– P] stands for [+/–Prominence].

experiment. Within the nine children who did consistently offer *yes/no*-responses, seven of them rejected the sentence more than half of the time, which is consistent with an existential interpretation of the *wh*-indefinite.

Turning to the other measure, the proportion of unpacked-item responses (Figure 22), we also found an interaction effect between the critical word and prosody: Children produced more unpacked-item responses in the [*wh* +Prominence] condition than in the other three conditions.

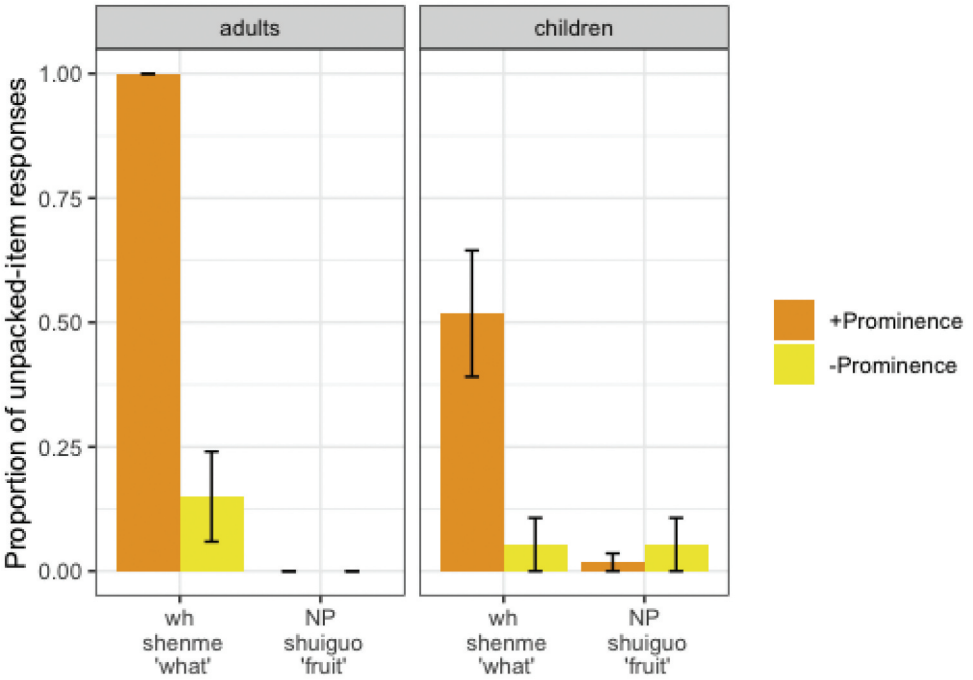

Figure 22. Proportion of unpacked-item responses offered by adults and children to *wh* /NP sentences with/without prominence.

A mixed effects logistic regression model using unpacked-item responses as the dependent variable, the critical word (*wh* /NP), the presence/absence of prominence, the interaction of critical word and prominence, and age group as fixed factors and participant and test items as the random factor revealed an interaction effect between prominence with the critical word ($\beta = 20.72, p < .01$), but no main effect of prominence ($\beta = -0.21, p > .1$) or the critical word ($\beta = 1.65, p > .1$), and no main effect of age ($\beta = -2.78, p > .1$): Children and adults both tend to use unpacked-item responses in the [*wh* +Prominence] condition than the other three conditions.

Figure 23 summarizes the proportion of each type of responses. As we can see, there is a sharp contrast between the [*wh* +Prominence] and the [*wh* –Prominence] conditions: Children predominantly used unpacked-item responses and packed-item responses in the former but *yes/no*-responses in the latter. Looking at each child individually, in the [*wh* +Prominence] condition, two out of 14 children (age 3;09,13 and 3;09,10) consistently rejected the sentence instead of listing the items in the box. Just like with the *yes/no*-response, the unpacked-item response is a rather conservative measure, since children could answer the subquestion *what did Little Lamb pack?* by naming the packed item (e.g., (39)). Nevertheless, we observed a clear difference in their response to [*wh* +Prominence] sentences and [*wh* –Prominence] sentences, suggesting that they have both interpretations. In the [*wh* –Prominence] condition, two out of 14 children (age 3;08,27, 3;11,16) gave unpacked-item responses over half of the trials, suggesting that the majority of children do not associate the interrogative interpretation with *shenme* without prominence.

(39) Zhi fang-le shuiguo
Only put-ASP fruits.
'(She) only put in fruits.' (Child participant #172)

In summary, results from both the *yes/no*-response and unpacked-item response measure show that there is an interaction effect between the critical word (Wh vs. NP) and prosody on both measures unpacked-item responses and *yes/no*-responses. These results suggest that children, like adults, treated *shenme* with prosodic prominence as an interrogative and without prosodic prominence as an indefinite.

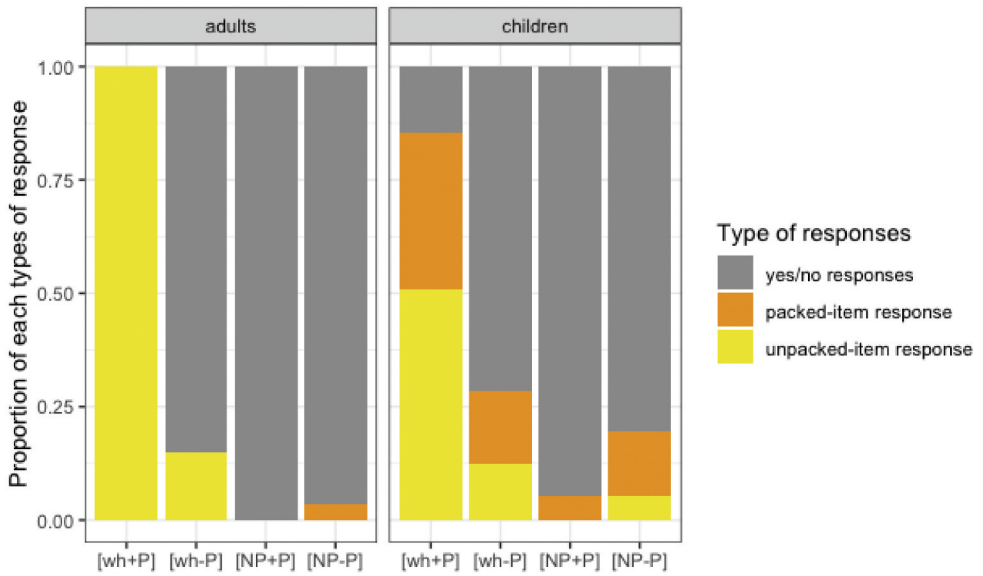

Figure 23. The proportion of "car" and "apple and pear" responses offered by adults and children in all four conditions; [+/– P] stands for [+/– Prominence].

4.4. Discussion

In this experiment, we found that 3-year-olds gave *yes/no*-responses when *shenme* was not associated with prominence, and gave unpacked-item responses when *shenme* was associated with prominence. In contrast, they gave *yes/no*-responses to sentences with bare indefinite NP *shuiguo* regardless of prominence. These results suggest that children interpret *shenme* as an indefinite when it is not associated with prominence. We can thus conclude that 3-year-olds can access the indefinite interpretation of *wh*-phrases in negated sentences. Therefore, 3-year-olds showed adult-like interpretation of *wh*-phrases in two very different environments, suggesting that they indeed have both interrogative and indefinite interpretations.

5. General discussion

Our results from these two experiments show that Mandarin-speaking 3-year-olds have a sophisticated knowledge of Mandarin *wh*-indefinites: They know that Mandarin *wh*-phrases can be interpreted non-interrogatively in *dou* and negated sentences; they have an adult-like interpretation of *wh*-indefinites in these two environments (universal and existential respectively); and they can use the appropriate cues to disambiguate the two interpretations of *wh*-phrases (the presence or absence of *dou* in Experiment 1 and the presence or absence of prominence in Experiment 2). These results provide evidence for a lower age of the indefinite interpretation than previous studies.

Our results have implications for developing a theory of *how* children acquire *wh*-indefinites. Previously, two hypotheses have been proposed to answer this question. Lin and colleagues (Lin, Weerman & Zeijlstra 2014; Lin 2017; Lin, Weerman, and Zeijlstra 2021), based on their results from production studies, suggest that children's knowledge of *wh*-indefinites go through two stages: Children first learn the interrogative interpretation and gradually switch to a grammar that can accommodate the indefinite interpretation later. During the transition stage, children accumulate evidence from the input that when *wh*-phrases occur in these environments, sometimes the sentence is a declarative rather than a constituent question. After gathering enough evidence, they switch to a grammar where *wh*-phrases have both interrogative and indefinite interpretations.

For this two-stage hypothesis, our results show that children acquire the indefinite interpretation earlier than Lin and colleagues originally suggested and that the production lag that is used to support the two-stage hypothesis is not due to children's lack of knowledge of the indefinite interpretation. Instead, the lag in natural production could simply reflect the huge skew toward the interrogative interpretation in their input, and the errors that children make in elicited imitation task might in fact reflect their knowledge of *wh*-indefinites. If there is a stage during which children are unaware of the indefinite interpretation, our results imply that this stage would have to be completed by the time they turn 3. In addition, the hypothesis must account for the sophistication of children's knowledge—that children are not only aware of the distribution of the two interpretations but are also aware of the prosodic features associated with different interpretations in different environments as well as the interpretation of the whole sentence (universal when occurring before *dou* and existential under negation).

An alternative hypothesis is developed by Zhou and colleagues based on results from comprehension that 4.5-year-olds have adult-like interpretation of *wh*-indefinites (Zhou & Crain 2009; Zhou 2011; Zhou & Crain 2011; Zhou et al. 2012; Zhou, Crain & Zhan 2012; Zhou 2015). They take the single-stage view that children's initial hypothesis of *wh*-phrases is that they have both interpretations, and acquiring one is tantamount to acquiring the other. According to Zhou (2015), children know that *wh*-phrases are variables from early on. They additionally assume that the mechanism of variable-binding is innate, so once children establish what counts as a binder and its property (e.g., *dou* and negation in Mandarin) in their language, they get the knowledge of *wh*-indefinites for free. However, Zhou and colleagues suggest that children's knowledge of *wh*-indefinites might be masked by them not

having yet acquired the properties of the relevant binders. Consequently, their account predicts that the limiting factor on the age at which we see evidence of children acquiring the indefinite interpretation depends on the age that children acquire negation, *dou*, modals, and other semantic contexts that support the indefinite interpretation. Our results can be captured by this hypothesis: There is evidence suggesting that at least some 3-year-olds have knowledge of *dou* (Lee 1986; Fan 2017) and negation (Fan 2007), and our results suggest that they also have the indefinite interpretation of *wh*-phrases in these environments.

However, we might need a more sophisticated version of the hypothesis if we want to account for the cross-linguistic differences in *wh*-indefinites and between regular indefinites and *wh*-indefinites in Mandarin. As we have shown, *wh*-indefinites in Mandarin differ in subtle ways from other indefinites in Mandarin and *wh*-indefinites in other languages. First, other types of indefinites in Mandarin have also been treated as variables (Chierchia 1998; Cheng & Sybesma 1999 among others), but only *wh*-phrases have both interrogative and non-interrogative interpretations. As results from our Experiment 2 show, 3-year-olds are aware of this difference. The single-stage hypothesis would then need to explain why Mandarin-speaking 3-year-olds do not overgeneralize their knowledge of *wh*-phrases to other types of indefinites and vice versa.

Moreover, Mandarin is not the only language with *wh*-indefinites, and there is cross-linguistic variation in the distribution of *wh*-indefinites (Bhat 2000; Haspelmath 1997; Postma 1994; Hengeveld, Iatridou & Roelofsen 2019; Tran & Bruening 2013; Yanovich 2020; Yun 2013; Ishihara 2002). German *wh*-indefinites, for example, are subject to syntactic restrictions (Postma 1994). For instance, Postma (1994) observes that *wo* 'where' has the indefinite interpretation when it is in an argument position (40), but not when it is an adjunct (41):

(40) Er hat wo gewohnt.
He has where lived
'He has lived somewhere.' Postma 1994:192, ex. (14a)

(41) *Er hat das Buch wo gekauft.
He has the book where buy
(intended) 'He bought the book somewhere.' Postma 1994:192, ex. (14c)

Russian *wh*-indefinites display yet another pattern, behaving like NPIs that are subject to semantic restrictions (Yanovich 2005; Hengeveld, Iatridou & Roelofsen 2019). Thus, simple affirmative sentences like (42) do not allow *wh*-indefinites even in contexts that support an ignorance inference, unlike Mandarin:

(42) *Petj-a s kem vstreča-l-sja v Nju-Jork-e.
Peter- SG.NOM with who. INS meet- PST.SG.M-MED in New-York- SG.PREP
(intended) "Peter met with someone in New York."
(Maria Polinsky & Polina Pleshak, p.c.)

Most relevant for our experiments, the universal reading that Mandarin *wh*-indefinites take on in the scope of quantificational adverb *dou* is missing in other *wh*-indefinite languages (Hengeveld, Iatridou & Roelofsen 2019). For example, *wem* 'who' in German cannot be interpreted as "everyone" when it is in the scope of a quantificational adverb *immer* 'always:'

(43) Wenn Julian in New York ist, trifft er sich *immer* mit wem.
When Julian in New York is meets he himself always with who. DAT
'When Julian is in New York, he always meets with someone.'
NOT: 'When Julian is in New York, he always meets with everyone.'
(Aaron Doliana & Julian Schlöder, p.c.)

As results from Experiment 1 show, Mandarin-speaking children can correctly interpret the *wh*-indefinite under *dou* . Therefore, our results require the single-stage hypothesis, and indeed, any learning hypothesis for how children acquire *wh*-indefinites, to explain what prevents children from acquiring a grammar in which the *wh*-indefinite is more like that of German or Russian. If the single-stage hypothesis is on the right track, we still need to know what underlying mechanism explains this cross-linguistic variation, so Mandarin-acquiring children do not entertain a non-Mandarin grammar for *wh*-indefinites.

As our next step, we plan to probe the knowledge of even younger children. Our current results suggest that if there is a stage where children are unaware of the indefinite interpretation, it would have to be earlier than 3 years old. Data from younger children would help us verify this revised prediction of the two-stage hypothesis. In their reports on children's production of *wh*-phrases, Fan (2012) and Lin, Weerman & Zeijlstra (2014) both note that children younger than 3 do produce a few *wh*-indefinites. Do younger children have adult-like knowledge of *wh*-indefinites? How much do they know about *wh*-indefinites? We also need to go beyond *dou* and negated sentences, to see the full range of distributional and semantic properties of *wh*-indefinites that children know. For example, as mentioned in Section 2, the indefinite interpretation in affirmative sentences must be supported by an ignorance inference. It would be interesting to see if children accept *wh*-indefinites in affirmative contexts and whether they can infer speakers' ignorance in these contexts. Answering these questions will give us a better idea of what children know at what age.

Now that we have an upper bound for the "when" question, we can ask what sort of cues are available in the input, to see what might signal to learners that the indefinite interpretation is available. Previous studies reporting *wh*-phrases in children's input primarily focus on the distribution of the two interpretations (Fan 2012 a.o). However, there might be other cues in the input that are informative, such as prosody and the sociopragmatic context of the sentences containing *wh*-phrases.[19] For example, if children could recognize that parents' sentences with *wh*-phrases are sometimes used to inform rather than solicit responses, and are associated with a declarative prosody, it might help them realize that the *wh*-phrase is indefinite. Annotation of these two features are currently underway. We also plan to model the acquisition process computationally once we have enough data properly annotated. Moreover, understanding the acquisition of *wh*-indefinites in other languages would be important to understanding Mandarin *wh*-indefinites too: Can children acquiring German or Russian refrain from acquiring Mandarin-style *wh*-indefinites? Answering these questions could help us establish what information is available in the input, and what properties follow from general properties of the language faculty, which will take us one step closer to answering "how" children acquire *wh*-indefinites.

6. Conclusion

In this study, we examined whether Mandarin-speaking 3-year-olds have the indefinite interpretation of the Mandarin *wh*-phrase *shenme* 'what' in two maximally different environments: *dou*-sentences, where the two interpretations of *wh* are disambiguated by syntactic/semantic cues (the presence and absence of *dou*) and the non-interrogative representation yields a universal reading, negated sentences, where the two interpretations are disambiguated by prosodic cues (the presence and absence of prominence) and *wh*-indefinites are interpreted existentially. With two experiments using the Question-Statement Task (QST), we showed that children have access to both interpretations of *wh*-words before their fourth birthday, earlier than reported in previous studies. Considering the differences of these two environments, our results suggest that 3-year-olds' knowledge of *wh* is quite sophisticated, setting a new upper bound on the age of acquisition.

[19]We thank an anonymous reviewer for this suggestion.

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