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

Abstract

Wh-phrases in Mandarin have an interrogative (like English *what*) and an indefinite (like English *a/some*) interpretation (Huang 1982 a.o.). The indefinite interpretation is particularly challenging for children: its distribution is different from other indefinites in Mandarin (Lin 1998 a.o.) and indefinites formed by *wh*-phrases in other languages (Haspelmath 1997 a.o.), and adults rarely use this interpretation in child-directed speech (Fan 2012 a.o.). Previous studies find that children start using *wh*-phrases around 2 with the interrogative interpretation (Fan 2012 a.o.) and can access both interpretations around 4.5 (Zhou 2013 a.o.); but between 2 and 4.5, they do not reliably produce the indefinite interpretation in naturalistic speech or in elicited imitation tasks (Lin 2017). In this study, we find that 3-year-olds have adult-like interpretations of *wh*-phrases in two maximally 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*); 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.

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 <u>shenme</u>.
      Xiaoxiao lunch   NEG eat what
      a. "What didn't Xiaoxiao eat for lunch?"   *Interrogative*
      b. "Xiaoxiao didn't eat anything for lunch."   *Indefinite*

How do Mandarin-speaking children discover this ambiguity associated with *wh*-phrases? The indefinite interpretation, in particular, poses some challenges. First, compared to the interrogative interpretation, the indefinite interpretation is extremely rare in parents' speech to children: around 97% of adult uses of *wh*-phrases are interrogative, merely 3% are non-interrogative (Fan 2012 among others). Additionally, the distribution of *wh*-indefinites is different from that of regular indefinites like [*yi*-CL NP] (Huang 1982 among others), and *wh*-indefinites from other languages

(Haspelmath 1997 among others). Therefore, the puzzle for Mandarin-speaking children is not just that *wh*-phrases can be indefinites, but also its precise distribution, which differs from other indefinites in Mandarin and from other *wh*-indefinites in other languages. With limited input, how do children figure out the unique properties of *wh*-indefinites in Mandarin?

Before we can answer this "how" question, it is important to pin down the age when children master both interpretations. While there is some evidence that children around age 4.5 know both interpretations (Zhou and Crain 2009, Lin 2017 among others), results for younger children are far from conclusive. Lin et al. (2014) observe that before 4 years old, children rarely produce *wh*-indefinites and cannot accurately imitate sentences with *wh*-indefinites (Lin 2017). These findings from production, however, cannot conclusively prove that younger children do not have adult-like knowledge of *wh*-indefinites. It is likely that children's comprehension of the *wh*-indefinite precedes its production; in many cases, what children produce do not reflect what they know (Shipley et al. 1969 among many others).

In this paper, we address the question of *when* children acquire the two interpretations of Mandarin *wh*-phrases via two novel comprehension tasks with three-year-olds. Our results show that Mandarin-speaking three-year-olds have adult-like interpretations of *wh*-phrases, both interrogative and indefinite, in two very different contexts: Experiment 1 uses *dou*-sentences, where the indefinite interpretation is the only available interpretation and the whole sentence receives a universal reading (roughly equivalent to English *any*); Experiment 2 uses negated sentences, where the interpretation of *wh*-phrases depends on prosodic prominence, and the indefinite interpretation leads to an existential reading of the sentence. These results give us an upper bound on the acquisition of the indefinite interpretation, thus constraining theories of the acquisition trajectory.

2 Background

2.1 Mandarin *wh*-indefinites

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

(2)   Xiaoxiao mei jiandao <u>shui</u>.
        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   <u>shenme</u> 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 <u>shui</u> 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   <u>shenme</u> dongxi.
     Xiaoxiao lunch   might   eat-CL what
     a. "What might Xiaoxiao have had for lunch?"
     b. "Xiaoxiao might have had something for lunch."   *Epistemic modal*

(6) Chi dian <u>shenme</u> ba!
     Eat CL   what   SFP
     a. "What the hell do you want to eat?"
     b. "Eat something, please!"   *Imperative*

(7) Xiaoxiao qu Beijing <u>shui</u> *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 and Liao 2015; Giannakidou and Lin 2016, among many others) that needs to be licensed. In simple affirmative sentences without any licensor like (8), *wh*-indefinites are not acceptable (Lin 1998, p.231):

(8) Wo xihuan <u>shei/shenme ren</u>
     I   like   who/what person
     "Who do I like?"
     NOT: "I like someone."   *Affirmative Sentence*, ex. (38b), p. 231

However, recent discussions with corpus and experimental data suggest that the indefinite interpretation is in fact acceptable in affirmative sentences (Yang 2018; Liu and Yang 2020), and that the restriction on the acceptability of *wh*-indefinites is pragmatic. 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 and Méndez-Benito 2010) than to NPIs. Here is a naturally occurring example of a *wh*-indefinite in a simple affirmative sentence:[1]

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[1]The example is taken from the novel *Hongyan* by Kuang-pin Luo and Yiyan Yang (1961); see Liu and Yang (2020) for more examples like this.

(9) Gouxiong zhengzai disheng   he   <u>shui</u> 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. 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]

(10)   a. Gou Xiong zhengzai disheng   he   <u>shui</u> jianghua, #wo kande   qingqingchuchu,
Gou Xiong is   low voice with who speaking I   can see 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   <u>yi-ge ren</u>   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 and Sybesma 1999, Yang 2001 among others). In negated sentences, *wh*-indefinites but not *yi*-CL NPs are acceptable, as shown by the contrast between (2) and (11):[3]

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

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[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 <u>shei/shenme ren</u>
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   <u>shei/shenme ren</u>
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 and Yang (2020) for more discussion on this puzzle.

[3]For some speakers, with prosodic prominence on the numeral *yi* could make the sentence more acceptable, with an interpretation similar to "he didn't meet one person (he met two)." In this case, *yi*-CL NP is no longer an indefinite, but a numeral.

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

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

(13) Xiaoxiao mei jiandao <u>shui</u>
      Xiaoxiao NEG meet   who
      a. (<u>shui</u> without prominence) "Xiaoxiao didn't run into anyone."
      b. (<u>shui</u> 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, 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.

2.2   Acquisition of *wh*-ambiguity

In the process of figuring out the interpretations of *wh*-phrases, Mandarin-speaking children receive very little help from the input. While *wh*-phrases are relatively frequent, and occur in about 10% of adult utterances, around 97% have the interrogative interpretation; only 3% are interpreted as indefinites (Fan 2012, Lin 2017, Zhou 2013). With relatively fewer opportunities to learn the indefinite interpretation than the interrogative one, *when* do children acquire *wh*-indefinites? Previous studies show that 4.5-year-olds know both interpretations, but results for younger children are not conclusive.

Zhou and colleagues (Zhou and Crain 2009, Zhou 2011, Zhou and Crain 2011, Zhou et al. 2012a, Zhou et al. 2012b, Zhou 2013) test Mandarin-speaking 4.5-year-olds' interpretation of *wh*-phrases by using a Question-Statement Task (QST, Zhou and Crain 2009). Similar to the Truth Value Judgment Task (TVJT, Crain and Thornton 1998), in the QST, the experimenter also tells the subject and a puppet some stories, and the puppet produces a test sentence after each story. But while 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 would 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 have no exposure to, such as sentences with quantificational expressions like [*meiyou* NP] "no NP"

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(14). They take the results as support for "the early mastery of adult-like linguistic knowledge of *wh*-quantification in child Mandarin" (Zhou 2013, p.15).

(14) Meiyou   xiongmao chi <u>shenme</u> 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 et al. 2014; Lin 2017; Lin et al. 2021). Fan (2012) examines the production of *wh*-phrases by four children between 0;10 and 2;6, and she finds that children start to produce *wh*-phrases around 1;6, 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 1829 *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 et al. (2014) and Lin et al. (2021) report a similar pattern: children start to use *wh*-indefinites productively when they turn four years old, and not before.

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

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) later uses an elicited imitation task to test children's knowledge of *wh*-indefinites between the age 2;11 and 4;9. She finds that while children never have problems imitating interrogative *wh*-phrases, their accuracy rate is significantly lower (but steadily increases with age) when repeating *wh*-indefinites until 4;6. Based on these results, Lin concludes that children do not have the knowledge of *wh*-indefinites before 2;11. Between 2;11 and 4;6, children start to realize their *wh*-phrases can be indefinites before reaching adult-like grammar after 4;6 (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, replacing a *wh*-indefinite with a regular indefinite is counted 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 interpret the test sentences as declaratives with indefinites. In fact, non-imitation errors like these have been used as evidence for correct knowledge (Chien and Lust 1985; Lust et al. 1987; Lombardi and Potter 1992 among others).

Additionally, Fan (2012) and Lin et al. (2014) both report tokens of *wh*-indefinites produced by younger children, such as (15), but they both caution against drawing any inferences from this data due to its low frequency. However, children's production is not always a good indicator for their

knowledge (e.g. Shipley et al. 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*-indefinites give rise to in different environments. For example, sentences with *wh*-indefinites and *dou* are interpreted as universal statements, as in (7b) repeated below as (16), and *wh*-indefinites under negation are interpreted existentially, as in (2b) repeated here 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 <u>shui</u> *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 <u>shui</u>.
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 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 to appear, Xiang 2019):[4]

(18) Xiaoxiao <u>shenme</u> *dou* chi-le.
Xiaoxiao what DOU eat-ASP
NOT: What did Xiaoxiao eat?
"Xiaoxiao ate everything." *Dou-quantification*

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[4]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 (4), the sentence is a *wh*-question. In this paper, we focus on pre-*dou* *wh*-phrases.

(i) Xiaoxiao *dou* chi-le <u>shenme</u>
Xiaoxiao what DOU eat-ASP
a. What all did Xiaoxiao eat?
b. #"Xiaoxiao ate everything."

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 will be 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 and 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 or make statements. The participants were simply 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 without needing any explicit metalinguistic instruction.

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;0;0 participated (mean = 3;9, 18 female) in the study. 32 adult Mandarin speakers were also recruited (aged 19 to 54 years, mean 26 years). Adults and children were tested the same way.[5]

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. A session started with the experimenter telling the child 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 child 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 interacting with Xiaoxiao, the experimenter asked the child to say hi to Xiaoxiao, who would then deliver a pre-recorded message ("Nice to meet you!").
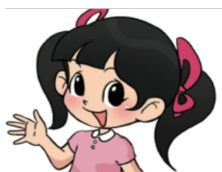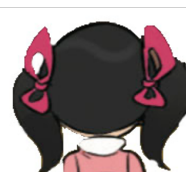

Figure 1: Introducing Xiaoxiao

Figure 2: Xiaoxiao turns around

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

After this initial interaction, the experimenter told the participant that they were going to watch stories about some contests. But Xiaoxiao cannot see anything, so the participant must help Xiaoxiao find out the winner. This manipulation sets up the overall goal of the task, namely to figure out who's the winner in each competition. Each of Xiaoxiao's utterances before the final guess then served a sub-goal of figuring out what each contestant did.

The stories all involved some competitions among animal characters (in the three practice trials, animals competed in fishing, coloring pictures, and picking vegetables; in the testing phase, animals competed in packing contests). Each story started with a short background, followed by an introduction of the contestants as well as the rules of the competition. The contest then started. When the time was up, the experimenter uttered "Let's see their performance!" to transition into revealing the outcome of the competition. The experimenter first announced which contestant was being evaluated (e.g. "First up is Little Elephant!"). A picture of the contestant and their obtained items would show up on the screen, and then the experimenter would pretend to prompt the on-screen character Xiaoxiao by uttering "Xiaoxiao?". She then delivered a sentence. The experimenter would wait for the participant to respond. If a participant paused for too long, the experimenter would prompt them 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. During practice, if the child still would not give any responses, the experimenter would provide an additional prompt: 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 prompt during the test phase.

All stories had three contestants, which means Xiaoxiao delivered three sentences in each story. After all contestants were evaluated, they appeared on the screen together. Xiaoxiao then made a guess about the winner. Her guesses were counterbalanced between correct and incorrect guesses.[6]

During practice, Xiaoxiao delivered a mix of constituent questions (*How many items are in Little Monkey's basket?*), polar questions (*Did Little Bunny pick two cucumbers?*) and statements (*Little Elephant painted two flowers*). 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 sub-question 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.

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[6]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, children were told eight stories, following the same template. A group of animals need to pack some fruits and toys into boxes, to send off to their friends. To make the packing faster, they decided to compete in groups of three, with the best packer in each group winning a gold medal. Before the competition, Teacher Kangaroo explained that to win a gold medal, the contestants need to pack all three items in the box (Figure 3).
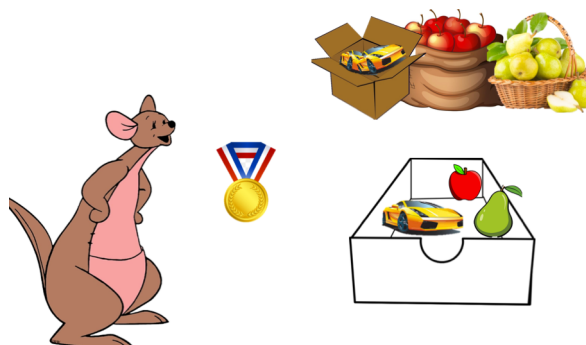

Figure 3: Teacher Kangaroo explains the winning condition: pack all three items in a box

Then the experimenter introduced the contestants, with three animals and three empty boxes showing up on screen (Figure 4). After some intense packing, the contestants were asked to stop (Figure 5).
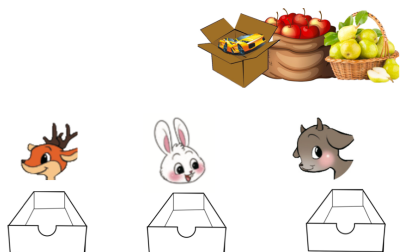

Figure 4: Introducing the competitors

Figure 5: Ready for inspection

In the next scene, the contestants' boxes were opened one by one. At each reveal, the animal with her box showed up on screen (Figure 6), 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 7). Xiaoxiao then made a guess about the winner.
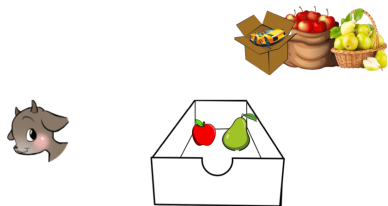
Figure 6: Critical trial (2-item condition)   Figure 7: Announcing the winner

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 4 (2*2) conditions, with 4 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 <u>shenme</u> *dou* fang zai xiangzi-li le
      Lamb   what   DOU put in box-LOC ASP
      "Little Lamb packed everything in the box."

(20)   Xiaoyang ba <u>shenme</u> fang zai xiangzili le
      Lamb   BA what   put in box   ASP
      "What did Little Lamb pack in the box?"

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 pre-verbal 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 and 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 8. 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 9, 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 Section 3.2.
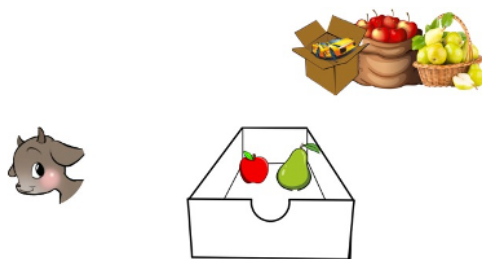
Figure 8: Critical trial in 2-out-of-3 condition; adults should reject the sentence in the [+dou] condition ("Little Lamb packed everything in the box"), and name items in the [-dou] condition ("What did Little Lamb bought?")
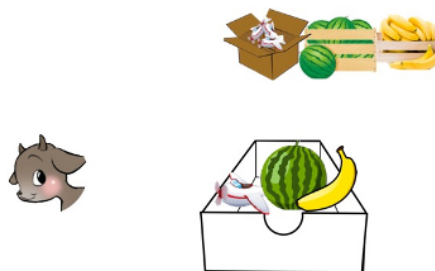
Figure 9: Critical trial in 3-out-of-3 condition; adults should accept the sentence in the [+dou] condition ("Little Lamb packed everything in the box"), and name items in the [-dou] condition ("What did Little Lamb bought?")

In addition to the 4 critical trials, we had 8 filler trials to balance the number of questions and statements: two *ji* "how-many" questions (21), 2 polar questions with particle *ma* (22), 2 true statements (23) and 2 false statements (24):

(21) Xiaotu de   xiangzili you ji-yang   dongxi?
      Bunny POSS box   have how many-CL thing
      "How many things are there in Bunny's box?"

(22) Daxiongmao de   xiangzili you pingguo ma?
      Panda   POSS box   have apple   Q-polar
      "Are there any apples in Panda's box?"

(23) Xiaoqingwa meiyou fang xiaoqiche.
      Frog   NEG   put car
      "Frog didn't pack the car."

(24) Xiaolu de   xiangzili you san-yang dongxi.
      Deer   POSS box   have three-CL thing
      "Deer packed three things in the box."

As will be detailed below, 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 was considered not understanding the task. In this experiment, no participant was removed in this way.

3.2 Data analysis

Participants' performance was video recorded, and then their utterances were transcribed based on the recording. Responses then were coded with the template below. A second coder independently coded 10% of the data using the same template, and the two coders agreed on 100% of the coding.

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 (25a), the particle *dui* (25b), the particle *shi* (25c), the verb *you* (25d), the interjection *en* (25e), or simply nodding and shaking heads.

(25) *Yes/no*-response
    a. Fang-le/ mei (you) (fang)
       Put-ASP/ NEG (have) (put)
       "(she) did/ didn't."   Bare verb response
    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 heads   Gesture

Responses like (26) with an elaboration after *bu dui* were counted as *yes/no*-responses, due to the presence of a polarity particle.

(26) 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 (27) or fragment answers (28), both of which lack markers for *yes/no*.

(27) 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."

(28) 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 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 (29) and (30).

(29) 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.

(30) 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 (31) and statements (32):[7]

(31) 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.

(32) 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 is one that biases against the hypothesis that children have the knowledge of *wh*-indefinites.

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[7]In (32), B's response is even more natural if *an apple and a pear* is focused.

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, 4 children did not produce any *yes/no*-responses during the practice trials and were considered to have failed practice (age 3;0;17, 3;5;30, 3;9;24, 3;11;10, two female). Participants who consistently offer *yes/no*-responses to filler sentences during the test phase were considered not understanding 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 were included in the analysis.

Below, Figure 10 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 both used *yes/no*-responses like (33) when *dou* was present, and responses like (34) when *dou* was absent, suggesting that both children and adults interpreted sentences with *dou* as statements.
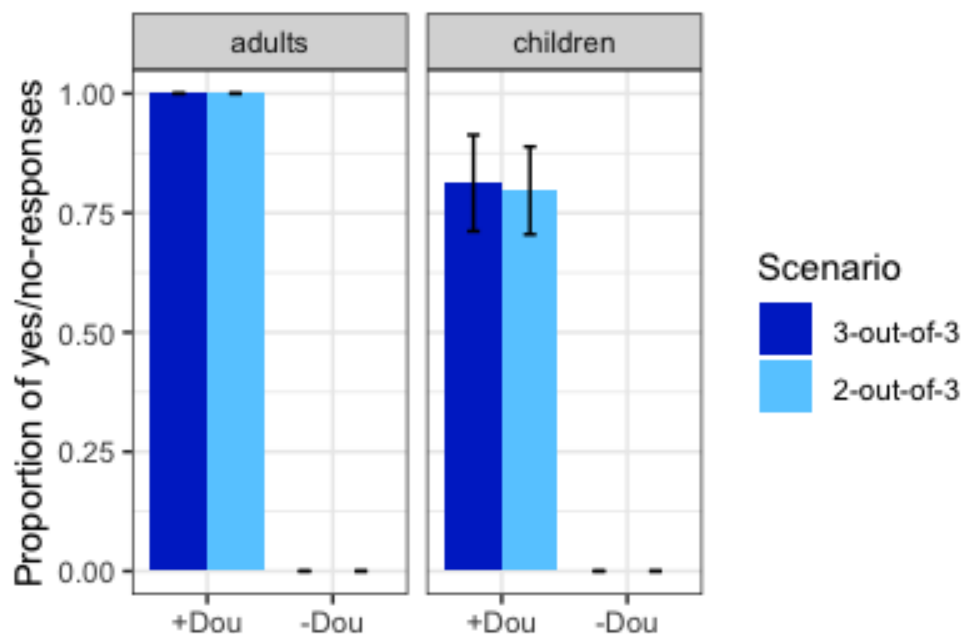
Figure 10: Proportion of *yes/no*-responses by adults and children to sentences with/without *dou*

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

(34) 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 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 and test sentences as random factors revealed that the presence of *dou* ($B = 341.95, p < 0.001$) but not type of scenarios ($B = 0.62, p = 0.6$) elicited significantly more *yes/no*-responses: similar to adults, children responded "yes" or "no" to *dou*-sentences regardless of the type of scenarios. We can infer from these results that children knew *shenme* has an indefinite interpretation and that only this interpretation is available in *dou*-sentences. Looking at each children's responses, we found that out of the 16 children in the [+dou] condition, only 3 (age 3;6;3, 3;11;9, 3;10;26) consistently named items rather than provided *yes/no*-responses.

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

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[+dou] condition. Figure 11 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 3-out-of-3 condition. 3-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.
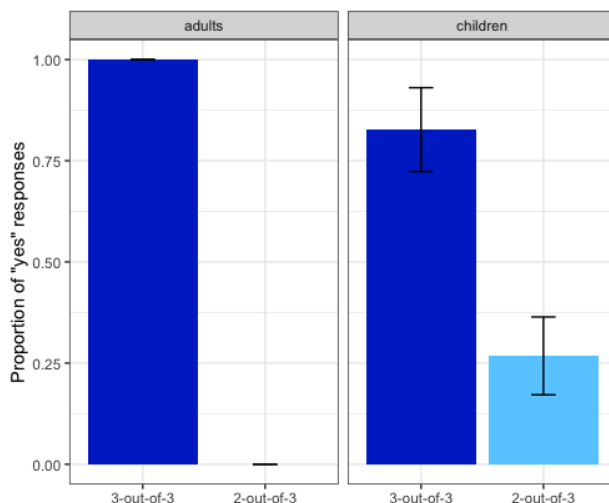

Figure 11: Proportion of "yes"-responses by adults and children to sentences with *dou* in the 3-out-of-3 and 2-out-of-3 scenarios

A mixed effects logistic regression model with number of items in a scenario (2 out of 3 vs. 3 out of 3) and age group (children vs. adults) as fixed factors and participants and test sentences as random factors revealed that the type of scenario had a significant effect on participants ($B = 11.39, p < 0.001$), and there was no difference between adults and children ($B = 1.23, p = 0.4$): children, like adults, only accepted *dou*-sentences in scenarios where everything was packed, suggesting that both children and adults 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;9;19), and two children accepted the sentences in both scenarios (age 3;9;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.

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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, interpreted *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.

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 (35). 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 prominence on *shenme*.

(35)   Xiaoyang mei zhuang <u>shenme</u> 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 et al. 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 et al. 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. While none of these studies test 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;0;26 and 3;11;28 participated in this experiment (mean = 3;8, 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"), giving us two two types of strings (36) and (37); and whether or not the critical word bears prosodic prominence [+/- Prominence]. In total, we had 4 (2*2) between-subject conditions, with 4 trials in each condition. The practice and filler items were the same as Experiment 1.

(36) Xiaoyang mei fang <u>shenme</u> 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."

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

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 and 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.

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", *xiao'e* "little goose". Before each utterance, a filler "em" (equivalent to English "um") that lasts 410ms 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 below:
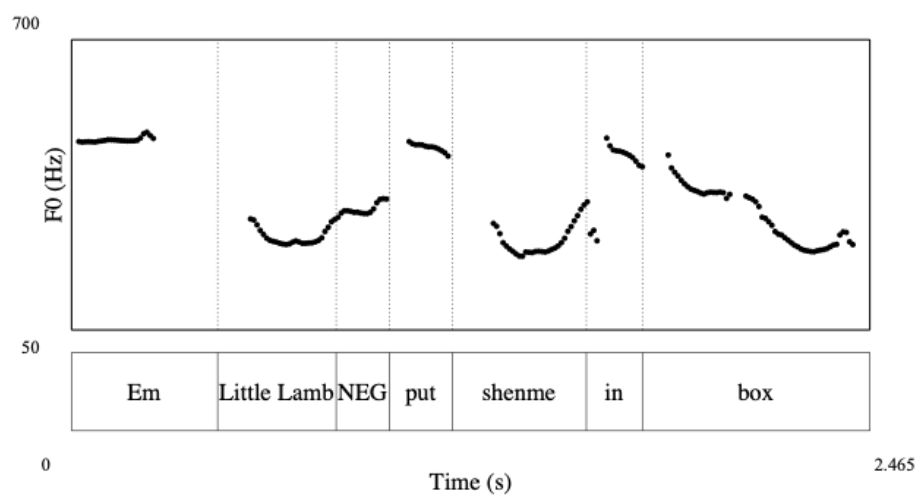
Figure 12: Pitch contour of (36) with prominence on *shenme*: "What didn't Little Lamb pack?"
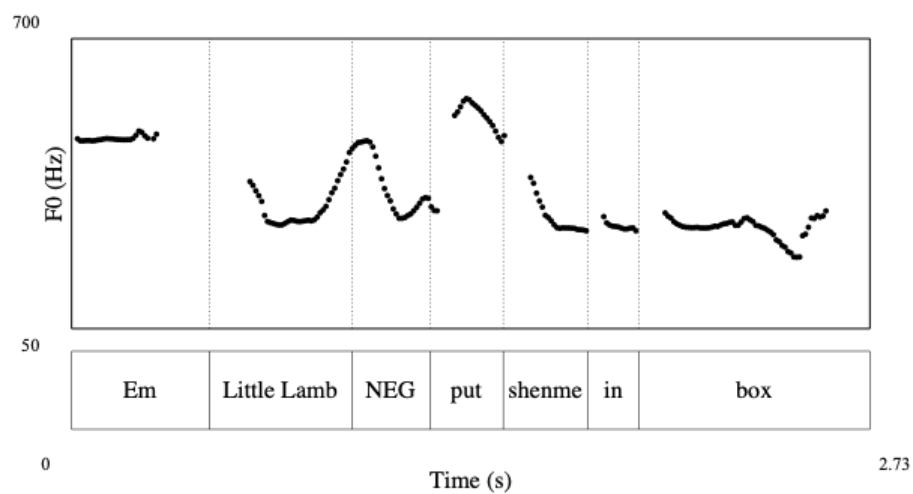

Figure 13: Pitch contour of (36) with prominence on negation instead of *shenme*: "Little Lamb didn't pack anything."
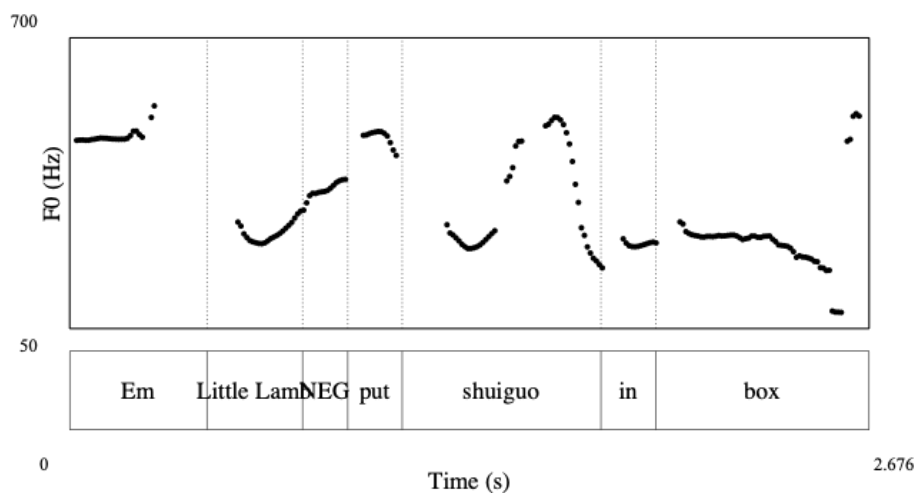
Figure 14: Pitch contour of (37) with prominence on *shuiguo*: "Little Lamb didn't pack any FRUIT."
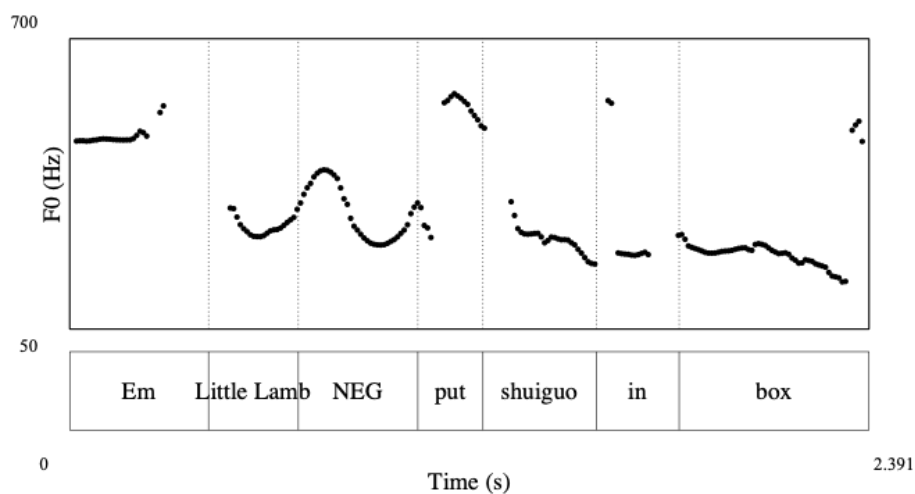

Figure 15: Pitch contour of (37) with prominence on negation instead of *shuiguo*: "Little Lamb didn't pack any fruit."

In [+Prominence] conditions, both *shuiguo* and *shenme* have extended pitch range and 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.

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 parenthesis

	[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 Material and Procedure

This experiment adopted a similar design as the first experiment. However, since we were using focus and negation, there were some differences between the two experiments. First, in each packing competition, the three competitors were also asked to pack three items (Figure 16). However, when explaining the rule of the competition, 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" is felicitous.

Figure 16: Teacher Kangaroo explains the winning condition: pack all three things in a box

Second, when indefinite *shenme* is negated like in (35), for some adults, the sentence 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 vs. 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 insignificant enough to pass as "not much." By putting a requirement that all three items must be packed, 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, the "didn't pack much" interpretation is still false. Thus, the critical trial had to be

a box with 2 items, as in Figure 17. Table 2 summarizes the possible answers to the test sentences in all four conditions.

Figure 17: Critical trial

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

	[+ Prominence]	[- Prominence]
Lamb packed *shenme*	"A car!"	"No, (an apple and a pear)"
Lamb packed *shuiguo*	"No."	"No."

4.2   Data analysis

Same as 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 (38) reject the indefinite interpretation "Little Lamb didn't pack anything/much/any fruits" while (39) accept the interpretation. The crucial difference from Experiment 1 is that the bare verb response is a rejection when it does not have negation (38c).

(38)   "No" responses:

    a. Bu   dui/   cuo
        NEG correct/ wrong
        "Incorrect/ wrong."   *Dui* response

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  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

(39) "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. Shaking head   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 to point to the item that is NOT packed by Little Lamb. So participants could either give a fragment answer (40), or a full answer as in (41). Crucially, neither form comes with the indicators for *yes/no* listed in the last section.

(40) Xiaoqiche.
   Car
   "A car."

(41) (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 (42a), the response does not count as an unpacked-item response.

(42) 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."

This measure also biases against the hypothesis that children have adult-like interpretations of *wh*-phrases. For the *yes/no*-response measure, as we have discussed in Experiment 1, children might prefer naming items in a box to achieve the sub-goal of the trial: figuring out what Little Lamb packed in the box, so when they do use the *yes/no*-responses, we can be sure that they have accessed the indefinite interpretation of *shenme*. The same can be said about unpacked-item responses: the packed-item response "Little Lamb packed an apple and a pear," indirectly answers *What didn't Little Lamb pack*. Thus, when children do use unpacked-item responses, we are confident that they must have assigned the interrogative interpretation to *shenme*.

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. If children understand that the indefinite interpretation leads to "not much/anything" interpretation, they should reject the sentence. 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, eleven were excluded from the analysis: five children (age 3;5;29, 3;6;27, 3;7;19, and 3;9;21) 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;4;24) was eliminated as he consistently shook his head in all trials, five children were eliminated due to video camera malfunction (age 3;4;26, 3;6;15, 3;6;27, 3;7;19, 3;8;25). From the 56 children (27 female) included, 7 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 18 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*.
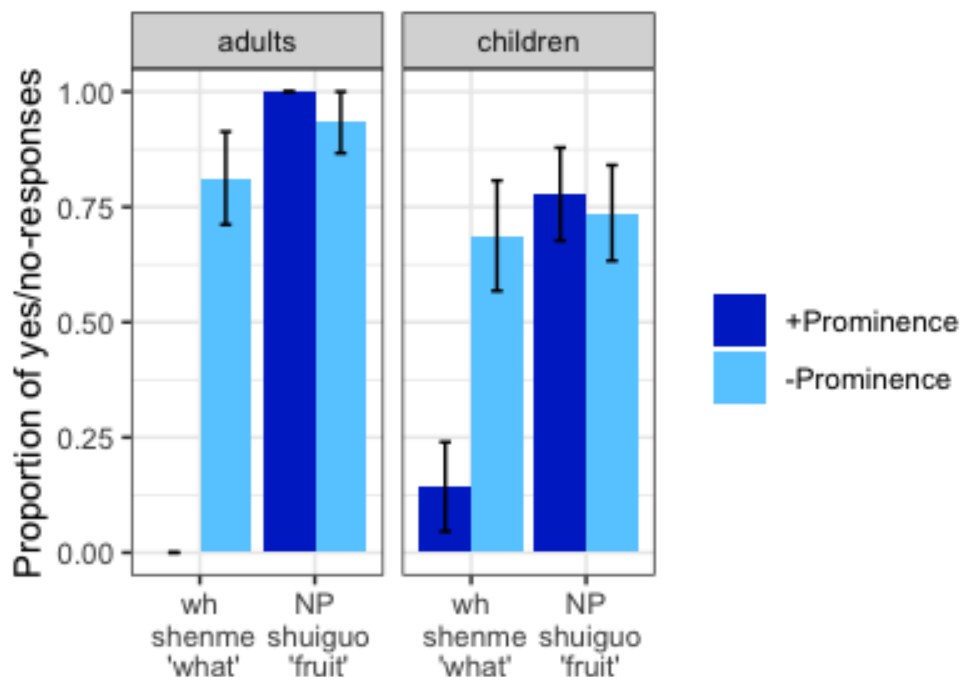

Figure 18: Proportion of *yes/no*-responses by adults and children to *wh*/NP sentences with/without prominence

A mixed effects logistic regression model with *yes/no*-responses as the dependent variable, the critical word (Wh/NP) and the presence/absence of prominence as fixed factors, and participants as the random factor revealed an interaction between prominence with the critical word ($B = -19.16, p < 0.0001$), but no main effect of prominence ($B = 0.75, p = 0.76$) or critical word ($B = -0.84, p = 0.66$). Additionally, there was no difference between children and adults ($B = -0.93, p = 0.56$), suggesting that both adults and children treated *shenme* with prosodic prominence as a question word, and *shenme* without prominence as an indefinite.

To make sure that children assign an existential interpretation to *shenme*, we need to see if they can *reject* the negated sentence. Figure 19 shows the proportion of "yes" or "no" responses in all four conditions (i.e. responses like (38) or (39) in Section 4.2.1). As seen in the figure, when children used *yes/no*-responses, they provided more "yes" than "no," suggesting that they interpreted *shenme* existentially and interpreted the whole sentence as "Little Lamb didn't pack much/anything in the box."
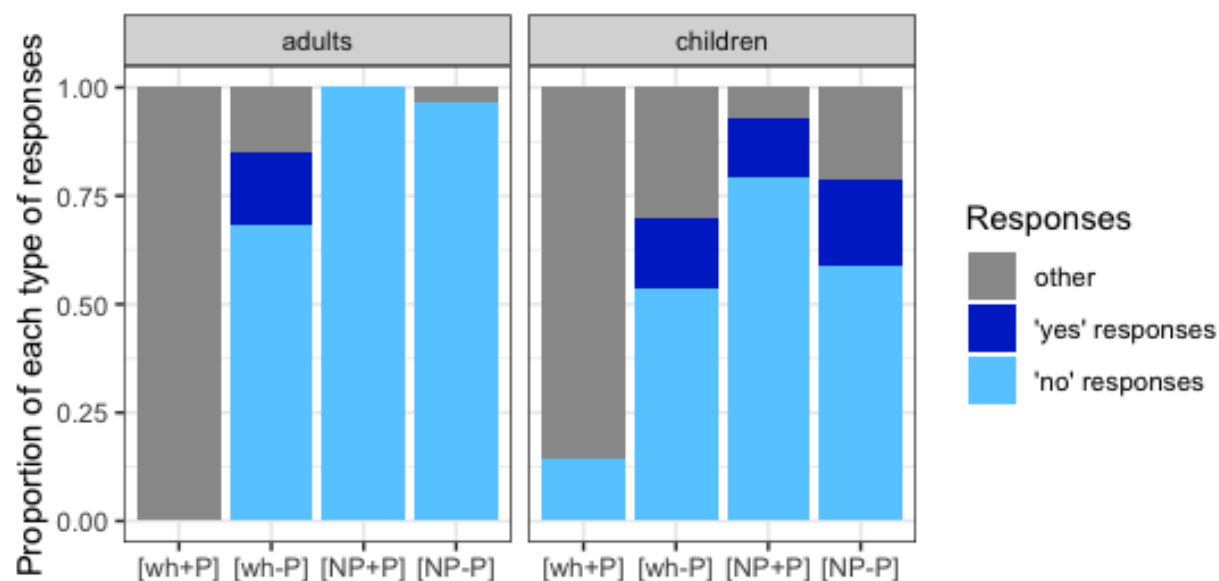
Figure 19: Proportion of 'yes' responses and 'no' responses by adults and children in all four conditions; [+/- P] stands for [+/-Prominence]

Turning to the other measure, namely the proportion of unpacked-item responses (Figure 20), 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.
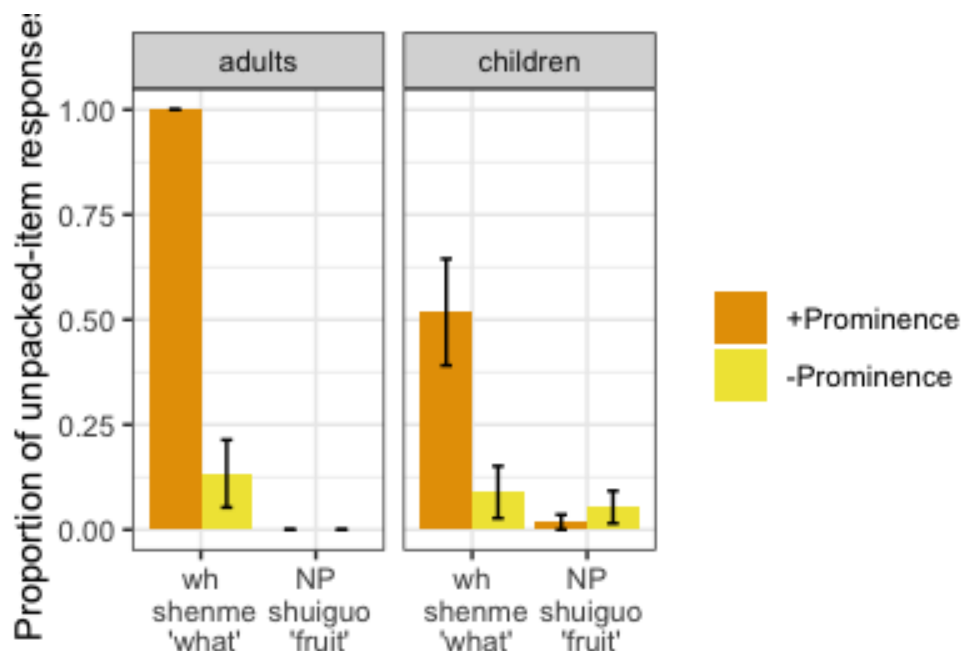
Figure 20: Proportion of unpacked-item responses by adults and children to *wh*/NP sentences with/without prominence

A mixed effects logistic regression model using unpacked-item responses as the dependent variable, the critical word (Wh/NP) and the presence/absence of prominence as fixed factors, and participant as the random factor revealed an interaction effect between prominence with the critical word ($B = 18.37, p = 0.0003$), but no main effect of prominence ($B = -0.73, p = 0.85$) or the critical word ($B = 1.19, p = 0.67$), and no main effect of age ($B = -2.11, p = 0.31$): children and adults both tend to use unpacked-item responses in the [Wh+Prominence] condition than the other three conditions.

Figure 21 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 use unpacked-item responses and packed-item responses in the former, but *yes/no*-responses in the latter.
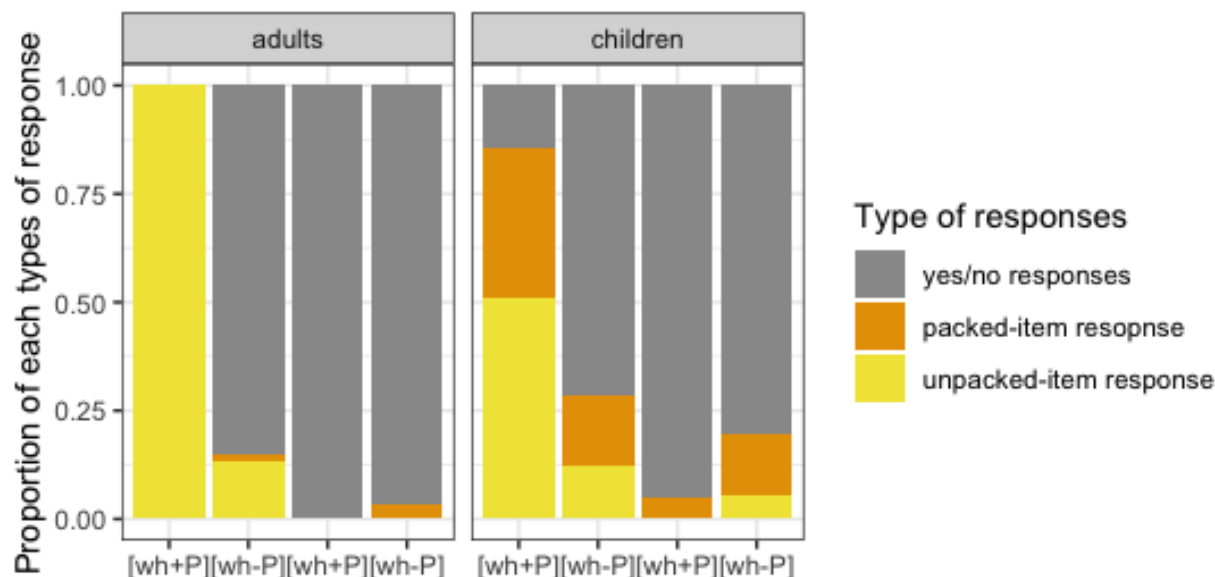
Figure 21: The proportion of 'car' and 'apple and pear' responses by adults and children in all four conditions; [+/- P] stands for [+/- Prominence].

As we have mentioned in Section 4.2, the unpacked-item response is a rather conservative measure, since children could answer the sub-question *what did Little Lamb pack?* by naming the packed items. Thus, packed-item responses like (43) are felicitous. Therefore, the low proportion of unpacked-item responses in the [Wh+Prominence] condition does not mean that children do not understand the two interpretations of *shenme*.

(43) 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.

4.4   Discussion

In this experiment, we found that 3-year-olds gave *yes/no*-responses when *shenme* is not associated with prominence, and gave unpacked-item responses when *shenme* associates with prominence. They gave the same pattern of responses to sentences with bare indefinite NP *shuiguo*. 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); 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).

Our results have implications for developing a theory of *how* children acquire *wh*-indefinites. Previously, two types theories have been proposed to answer this question. Lin and colleagues (Lin et al. 2014; Lin 2017; Lin et al. 2021), based on their results from production studies, suggest that children's knowledge of *wh*-indefinites go through multiple stages: only the interrogative interpretation is available to children at younger ages, and the indefinite interpretation comes in later. During the transition stage, children accumulate evidence from 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 multi-stage learning theory, our results imply that if there is a stage during which children are unaware of the indefinite interpretation, the stage would have to be completed before they turn three. In addition, the theory must account for the sophistication of children's knowledge, namely that children's knowledge seems to go beyond the distributions that they have been exposed to. Besides being aware that the non-interrogative interpretation is allowed in *dou* and negated sentences, 3-year-olds also know that sentences with *wh*-indefinites and *dou* are universal statements, and *wh*-indefinites under negation are interpreted existentially.

An alternative theory is developed by Zhou and colleagues based on results from comprehension that 4-year-olds have adult-like interpretation of *wh*-indefinites (Zhou and Crain 2009; Zhou 2011; Zhou and Crain 2011; Zhou et al. 2012b,a; Zhou 2013). They take the single-stage view that the indefinite and interrogative interpretations of *wh*-phrases are interconnected, and acquiring one is tantamount to acquiring the other. According to Zhou (2013), children know that *wh*-phrases are variables from early on, and with the innate mechanism of variable-binding, they get the knowledge of *wh*-indefinites for free. But if the child has not acquired *dou* (and similarly for other features that give rise to the indefinite interpretation in a sentence), then evidence that they have the right representation for *wh*-indefinites is hard to see. 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 theory: 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, the version of the single-staged theory proposed by Zhou and colleageus might be too simplistic. 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 and Sybesma 1999 among others), but *wh*-phrases have both interrogative and non-interrogative interpretations but other indefinites do not. As results from our Experiment 2 show, 3-year-olds are aware of this difference. The single-stage theory would then need to explain why 3-year-olds do not overgeneralize their knowledge of *wh*-phrases to other types of indefinites.

Moreover, Mandarin is not the only language with *wh*-indefinites, and there are cross-linguistic variations in the distribution of *wh*-indefinites (Bhat 2000, Haspelmath 1997, Postma 1994, Hengeveld et al. 2019, Tran and Bruening 2013, Yanovich 2005, 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 (44), but not when it is an adjunct (45):

(44) Er hat <u>wo</u>   gewohnt.
      He has where lived
      "He has lived somewhere."   Postma 1994, p.192, ex. (14a)

(45) *Er hat das Buch <u>wo</u>   gekauft.
      He has the book where buy
      (intended) "He bought the book somewhere."   Postma 1994, p.192, ex. (14c)

Russian *wh*-indefinites display yet another pattern, behaving like NPIs that are subject to semantic restrictions (Yanovich 2005; Hengeveld et al. 2019). Thus, simple affirmative sentences like (46) do not allow *wh*-indefinites even in contexts that support an ignorance inference, unlike Mandarin:

(46) *Petj-a   s <u>kem</u>   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."

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 et al. 2019). For example, *wem* "who" in German cannot be interpreted as "everyone" when it is in the scope of a quantificational adverb *immer* "always:"

(47)   Wenn Julian in New York ist, trifft er sich   *immer* mit <u>wem</u>.
       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."

As results from Experiment 1 show, Mandarin-speaking children can correctly interpret the *wh*-indefinite under *dou*. Therefore, our results require the single-stage theory to explain what prevents them from acquiring a grammar in which the *wh*-indefinite is more like that of German or Russian. If the single-stage theory is in the right direction, we 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. In their reports on children's production of *wh*-phrases, Fan (2012) and Lin et al. (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 the learning theory might look like. Moreover, understanding the acquisition of *wh*-indefinites in other languages would be important to understand Mandarin *wh*-indefinites too: can children acquiring German or Russian refrain from acquiring Mandarin-style *wh*-indefinites? Exploring these questions would help us answer the *how* question.

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 very 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 adult-like interpretations of *wh*-words in both environments 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 an upper bound on the age of acquisition.

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