# Mandarin-speaking children's knowledge of entailments and inferences

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A thesis submitted in fulfilment of the requirements for the degree of

**DOCTOR OF PHILOSOPHY**

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# Declaration

The research presented in this thesis is my original work and it has not been submitted for a higher degree in any other institution. In addition, I certify that all information sources and literatures used are indicated in the thesis. The research presented in this thesis received ethics approval from Macquarie University (5201500028).

Some of the contents in this dissertation has already been submitted or published for journals or conference proceedings. Chapter 2 is based on the paper as in (1). Chapter 3 is based on the paper as in (2), and Chapter 4 is based on the paper as in (3).

(1) Huang, Hai-Quan & Stephen Crain. When OR is assigned a conjunctive inference in child Mandarin (Under review).

(2) Huang, Hai-Quan, Rosalind Thornton & Stephen Crain. How Mandarin-speaking children interpret sentences with negation (Under review).

(3) Huang, Hai-Quan, Peng Zhou & Stephen. *Wh*-questions, universal statements and free choice inferences in child Mandarin (In press). *Journal of Psycholinguistic Research*.

I drafted each chapter of the thesis and my supervisors assisted with editing.

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June 24, 2017

## Thesis Abstract

Human languages contain the ingredients for logical reasoning. Consequently, part of the language acquisition process involves acquiring the meanings of basic logical expressions, and how these expressions interact with one another to yield different kinds of entailments and inferences. A central issue in linguistic research is whether or not children draw upon innate knowledge of logic in assigning meanings to logical expressions. This thesis investigates Mandarin-speaking children's knowledge of the entailments and inferences associated with a number of logical expressions, including the disjunction word *huozhe* 'or', the deontic modal verb *keyi* 'is allowed to', the negation markers *bu*/*mei* 'not', the focus adverb *zhiyou* 'only', the universal quantifier *dou* 'all', the polarity sensitive item *renhe* 'any' and *wh*-words like *shei* 'who'. These experimental investigations focus on three questions:

(i) How children interpret simple sentences, i.e., ones with basic logical expressions;

(ii) How children interpret complex sentences, i.e., ones that contain a combination of logical expressions;

(iii) The extent to which the interpretations of children and adults are the same, or differ.

These three questions are addressed in a series of experimental studies of children acquiring Mandarin. Chapter 1 introduces the main questions to be addressed in the thesis. Chapter 2 investigates when OR is assigned a conjunctive inference in child Mandarin. Chapter 3 investigates how Mandarin-speaking children interpret sentences with negation. Chapter 4 explores the meanings children assign to *wh*-words like *shei* in declarative and interrogative sentences with the quantificational adverb *dou*.

Chapter 5 summarizes the main findings and discusses their implications for linguistic theory and for language learnability. The experimental findings suggest that although young children interpret certain complex sentences in the same way as adults do, children and adults assign different meanings in some cases. The findings that children differ from adults invite us to conclude that children do not learn logical expressions via adult input, but draw upon innate knowledge of logic.

# Acknowledgments

First of all, I would like to express my great gratitude to my thesis committee including Stephen Crain, Rosalind Thornton, Peng Zhou, and Lyn Tieu. Without their detailed comments, instructions, and suggestions, I would not have developed this work.

I am deeply grateful to Stephen Crain, my primary supervisor and the chair of my dissertation committee. Before I started my PhD study, I knew little about formal semantics and child language acquisition. Stephen spent enormous time leading me into the worlds of semantics and teaching me how to conduct research in the area of child language acquisition. Through frequent meetings, he taught me semantic knowledge step by step. He also taught me how to conduct research, including how to design experiments, run experiments, analyse data, present experimental findings, and write journal articles. He is extremely clear and organized in teaching, and he can always help me understand difficult concepts using simple examples. He is always patient so that I never worry about asking him basic and silly questions. He is so open-minded that I can always be honest in telling him my thoughts. Whenever I am frustrated, he always encourages me. Whenever I am in trouble, he is always there, ready to help. I am extremely lucky to have him as my supervisor. He is my lifetime role model. It is impossible to use words to describe my gratitude to him. His influence is evident on every page of this thesis.

I also want to thank Rosalind Thornton. It was she who taught me Syntax. I benefited a lot from her intelligent teaching. In addition, Rozz taught me how to design experiments, including even tiny things like making test stories. She is very approachable, patient and kind. I could always turn to her for help whenever I had

difficulties. She looks after the whole language acquisition group, which makes us feel at home and have a sense of belonging. She organized many seminars and workshops, from which we gained numerous opportunities to communicate with other researchers in the larger linguistic community. Without her help, I would not have learned so much about Syntax and experimental techniques. For that, I am incredibly grateful.

My heartfelt thanks also go to Peng Zhou. He spent numerous hours teaching me how to design and conduct experiments. In addition, he provided excellent feedback and thought-provoking questions for my research, from which I benefited a lot. In daily life, he is my friend rather than my supervisor. I enjoyed every drink and meal with him. I missed him a lot when he transferred to Tsinghua University in the third year of my PhD study. I am appreciative for his academic support and friendly company.

I am also indebted to Lyn Tieu. I met Lyn in the third year of my PhD study. I was impressed by her skills in giving conference presentations. With her help, I successfully delivered a talk at the 7th Generative Approaches to Language Acquisition North America Conference. I also benefited a lot from discussing my complicated data with her. She is always smart in helping me sort out my line of thought. Most importantly, she spent many hours reading through my writings and providing excellent feedback. In short, she is always ready to help whenever I meet trouble. I am grateful to her for all her help and support in the critical year leading up to this thesis.

Besides the members of my thesis committee, I am also grateful to the language acquisition group at ARC Centre of Excellence in Cognition and its Disorder (CCD). This group includes incredibly intelligent and gifted linguists such as Loes Koring, Mike Iverson, Weiyi Ma, Iain Giblin, Elena D' Onofrio, Nichola Shelton, Cory Bill,

am grateful to these financial supports, which have made the research in this dissertation possible.

In the past three years, I met many friendly people, who made my academic journal more colourful and interesting. They are Shasha An, Yü Li, Yi Pu, Jasmina Vrankovic, Gordon Doyle, Yonggang Ren, Kunkun Zhang, Jiangbo Hu, Wei He, Vishnu K.K. Nair, Thembi Dube, Nick, Iris and David Meng. I enjoyed having sports, excursions, and meals with them. With their company, my academic life was not that boring. In addition, some of them always help me when I am in trouble and encourage me when I am down. For that, I am extremely grateful.

Finally, I am deeply indebted to my family. Special thanks to my parents. The way they educated me brought in the confidence and perseverance for me to complete my PhD study. Moreover, they helped me look after my triplet children during the busiest periods of my PhD study. Whenever I need help, I can count on them always and forever. I owe them a lifetime of gratitude for their unconditional love and unselfish sacrifice. I am also grateful to my younger sister, Yixia Huang, for her financial support and love during the process of my PhD study. I thank my lovely triplets, Wenxiang Huang, Wenting Huang, and Wenxin Huang, for being sweet and tolerant during the time when I was unable to accompany them. My wife, Lina Qian, started her PhD study nearly at the same time of mine. As you can imagine, it is extremely hard for a couple to do a PhD while looking after multiple children in an overseas country. My wife always encourages me whenever I feel discouraged, and she undertook many family chores when I was exhausted from academic work. I am grateful to her for her company and love during the most difficult time of my life. This thesis is for her and for all the rest members of my family.

# Chapter 1: Introduction

# Introduction

**Background**

One of the central issues in cognitive science is to understand how children acquire language. In the past five decades, developmental psycholinguists have responded to a theoretical approach to language that views language acquisition as a fundamental goal of linguistic theory. In so doing, researchers in the study of child language have made a number of significant achievements, and many of them are consistent with the general theoretical approach known as generative linguistics (Chomsky 1965, 1975). However, the field has not reached a consensus on a solution to the *logical problem of language acquisition*. That is, the question of how young children attain adult-like grammatical knowledge remains open.

In response to this question of language learnability, researchers in the generative tradition have argued that language acquisition receives a major contribution from an innate faculty of language (Chomsky 1965, 1986, 1995; Pinker 1995) and that children draw upon a priori linguistic knowledge to rapidly achieve linguistic competence that is equivalent to that of adult speakers of their local language (Chomsky 1965, Crain & Pietroski 2001; Crain, Gualmini & Pietroski 2005; Crain & Thornton 2006; Crain, Thornton & Khlentzos 2009). This view of language acquisition, with its emphasis on human biology, is now typically referred to as the biolinguistic approach to language acquisition. However, the biolinguistic approach is not the only perspective that researchers on child language have taken. In particular, it has been found that children can learn certain linguistic properties based on regularities in the input (e.g., Saffran, Aslin, and Newport, 1996). The alternative learning approach to language acquisition is still a major contender to the biolinguistic approach. So, the 'nature versus nurture' debate is far from settled.

In the acquisition literature, many previous studies have focused on the domain of syntax. Less attention has been paid to the domain of semantics. Therefore, we are still missing an important piece of the puzzle. Clearly, the language acquisition process involves acquiring the meanings of expressions, and the meanings that are derived when these expressions interact with one another. The research findings reported in this thesis attempt to provide a more complete picture of children's development of semantic knowledge, including knowledge of the entailments and inferences that are generated by sentences that contain logical expressions.

**Significance**

The study of children's knowledge of entailments and inferences has great practical as well as theoretical significance. First, the experimental investigations in this study help us understand the degree to which human languages are logical. It was assumed for centuries that human languages were logical. However, in the past fifty years, developmental psychologists have uncovered numerous instances of people's failures to follow logical principles. On the other hand, another body of research has shown that even young children have mastered the basic meanings of logical expressions, and these meanings seem to conform to the corresponding meanings in classical logic, at least in several cases (Crain & Pietroski 2001, 2002; Crain & Khlentzos 2008, 2012; Crain 2012; Crain, Koring & Thornton 2016). The present series of experiments are designed to shed further light on the extent to which human languages are logical. These experimental investigations of the interpretations assigned by children and adults to sentences with logical expressions help us understand whether or not the meanings they assign to logical expressions are parallel to the truth conditions associated with the corresponding expressions in classical logic.

The present research is significant for a second reason. The present studies are designed to add to our understanding of how children and adults interpret sentences that contain combinations of logical expressions. Adults can apparently understand various entailments and inferences without effort. These logical reasoning abilities represent the end state of the language faculty, however. The investigation of children's knowledge of entailments and inferences helps us understand how logical reasoning operates at the early stages of language development, and how logical reasoning about entailments and inferences develops over time.

Finally, the research reported in this thesis promises to help adjudicate between the two main competing theories of language acquisition, the usage-based approach and the biolinguistic approach. The usage-based approach contends that children acquire linguistic knowledge using input from caretakers, and that the input is culled and analysed using domain-general learning mechanisms, such as analogy and distributional analysis (see e.g., Lieven & Tomasello, 2008; Saxton, 2010). The linguistic knowledge that children acquire is seen to consist of constructions, also known as templates, schemas, and constructs (see Goldberg 2003, 2006). Constructions are "shallow" records of the input that children have experienced, rather than the kinds of abstract hierarchical structures that are posited by advocates of the biolinguistic approach.

The basic tenet of the usage-based approach to language acquisition is that children tend to master more frequent constructions earlier than less frequent ones in the course of language development (Lieven & Tomasello 2008). In addition, children are expected to produce less articulated versions of constructions than adults, missing certain linguistic ingredients that adult language contains. With the acquisition of more and more constructions, child language is expected to match the adult language. In other words, the usage-based approach is an 'input-matching' model of language development. This

perspective can be seen in the following remarks by advocates of the usage-based approach, Lieven and Tomasello (2008, p. 171).

*"The difference between young children's inventories and those of adults is one of degree: many more, initially all, of children's constructions are either lexically-specific or contain relatively low-scope slots. As well as being less schematic than many adult constructions they are also simpler with fewer parts."*

At the final stage of language acquisition, children form abstract semantic relations among constructions. This perspective is outlined as follows by Lieven and Tomsasello (2008, p. 171):

*"Finally, the child has to abstract the relations between constructions. Evidence that this has occurred is that the child is able to transform an utterance in one construction into another construction, for instance a declarative into a wh-question or an active into a passive. This could be done by forming a semantic representation of what the speaker wishes to say, thereby allowing the production of the other construction. Whether and when the learner actually maps the form-function mappings of one construction to those of the other is an empirically open question at the moment. It depends on the metalinguistic expertise and/ or educational level of different speakers."*

As for the acquisition of logical expressions, the usage-based approach predicts that children learn the meanings of logical expressions by attending to statistical regularities in the environment input. In addition, children are also expected to use domain-general learning mechanisms (e.g., analogy and distributional analysis) to abstract meanings from constructions with logical words.

By contrast, the biolinguistic approach contends that children are equipped with human biological endowment for language, which is called Universal Grammar (Chomsky 1965). Universal Grammar is a theory of the initial state of language acquisition device (LAD), and it contains core principles that all human languages share, as well as parameters that encode information about ways in which languages vary from each other. In other words, Universal Grammar is a system of principles and parameters. In addition, child language can differ from adult language that is spoken in the local community before certain parameters are set to the values adopted by the local adult-speakers. However, such differences between children and adults are highly circumscribed in that child language can only differ from adult language in a way that adult languages differ from each other. This is called the Continuity Assumption (Crain 1991; Pinker 1984; Crain & Pietroski 2001).

The biolinguistic approach contends that children acquire logical expressions using domain specific linguistic knowledge. Much of the knowledge that children bring to the task of language acquisition is innately endowed, as part of Universal Grammar. This knowledge includes the basic meanings of logical expression. For the most part, the meanings of logical expressions in Universal Grammar are consistent with the truth conditions associated with the corresponding expressions in classical logic (Crain 2008, 2012; Crain & Khlentzos, 2008). On this approach, the semantic properties of many logical expressions are part of Universal Grammar. Children are seen to draw upon Universal Grammar throughout the course of language development, and to draw most heavily upon it at the initial stages of language acquisition (see Crain, Gualmini & Pietroski 2005; Crain & Pietroski 2002). On the biolinguistic approach, therefore, young children across languages are expected to know the truth conditions associated with

logical expressions as soon as they identify the words of their local language that map onto these expressions (e.g., Crain 2008, 2012; Crain & Khlentzos 2008).

If children differ from adults in interpreting certain sentences with a combination of logical words, the difference is expected to be in a way in which adult languages differ from each other. This is stated in the Continuity Assumption of the biolinguistic approach. By contrast, according to the usage-based approach, the difference must be a result of lacking relevant adult input.

By studying children's knowledge of logical entailments and pragmatic inferences, the present series of experiments are designed to assess what are called *Poverty of the Stimulus Argument* (Chomsky 1965, 1975). More specifically, these experiments are designed to reveal children's knowledge which they are unlikely to have acquired based on linguistic input from adults. Therefore, the present thesis, hopefully, will help adjudicate further between the competing theories of language acquisition.

**Key concepts**

This thesis is about children's ability to generate logical entailments and their ability to license pragmatic inferences. This section introduces the key concepts that are investigated in the experimental studies reported in the thesis. Here we will introduce the critical distinctions that will be investigated in future chapters.

**1. Conjunctive Entailments**

By definition, an entailment is a relation that holds between propositions. Consider the propositions P and Q. If P entails Q, then the truth of Q necessarily follows from the truth of P, and the falsity of Q necessarily follows from the falsity of P (e.g., Lyons 1977).

Example (1) illustrates the entailment relation. If the proposition (1a) is true, then so is the proposition (1b). So, (1a) entails (1b), as indicated by the symbol '$\Rightarrow$'.

(1) a. John bought a Toyota.

b. $\Rightarrow$ John bought a car.

Sometimes, a sentence with a combination of logical expressions generates two entailments. These two propositions can form a conjunction, so this kind of entailment has been called a conjunctive entailment. To illustrate, consider example (2). In (2), disjunction appears in the scope of local negation, so it generates a conjunctive entailment. That is, (2) entails two propositions, namely the propositions expressed by the sentences *John didn't eat sushi* and *John didn't eat pasta*. These two propositions can be conjoined, so (2) entails (2a).

(2) John didn't eat sushi or pasta.

a. $\Rightarrow$ John didn't eat sushi <u>and</u> he didn't eat pasta.

Sentence (2) also illustrates how researchers assess children's knowledge of entailments in sentences that contain combinations of logical expressions. These assessments have been made in the previous literature mainly using an experimental technique known as the Truth Value Judgment Task (see Crain & Thornton 1998). In this task, children are presented with sentences such as (2) in contexts that either satisfy or contradict the entailments that they generate. Suppose that children consistently judge sentence (2) to be true in circumstances in which both sentences *John didn't eat sushi* and *John didn't eat pasta* are correct descriptions of the events that took place in the context, and that they

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judge (2) to be false if either of these sentences is not an accurate describe the events. If so, we are invited to infer that children know the conjoined entailment that (2) generates.

## 2. Conjunctive (Free Choice) inferences

In addition to entailments, the present study is concerned with several different semantic/pragmatic inferences. One of these inferences is witnessed in sentence (3), where disjunction appears in the scope of the deontic modal verb phrase *is allowed to*.

(3) John is allowed to eat sushi or pasta.

    a. ↝*John is allowed to eat sushi <u>and</u> he is allowed to eats pasta.*

Due to the presence of the modal verbal element *is allowed to*, adult English-speakers assign (3) a conjunctive inference, as indicated (3a) (where inferences are represented using the symbol '↝'). So, adult speakers of English have been found to judge (3) to be true if John is allowed to eat pasta and is allowed to eat sushi. We will refer to this as a conjunctive Free Choice Inference (FCI) (Kamp 1973, 1978).

It is surprising that people make the conjunctive FCI (3a) from statement (3). In standard logic, a formula with disjunction does not entail the corresponding formula with conjunction. In fact, disjunctive statements without a modal verbal element (e.g., *John ate sushi or pasta*) are often taken to imply the negation of the corresponding statements with conjunction (e.g., *John didn't eat both sushi and pasta*). In modal logic, too, a disjunctive formula with the possibility operator, $\lozenge$ $(p \lor s)$, does not entail the corresponding conjunctive formula $(\lozenge p \land \lozenge s)$ (for discussion see Alonso-Ovalle 2006; Chemla 2009; Chierchia 2013; Fox 2007; Franke 2011; Kamp 1973, 1978; Klinedinst 2007; Kratzer & Shimoyama 2002; Schultz 2005; Van Rooij 2010).

There are several diagnostic tests that distinguish between inferences and entailments. One of these tests is defeasibility. More specifically, the negation of an entailment leads to a contradiction, whereas the negation of an inference does not. Rather, the inference is simply cancelled (Chierchia 2013, 2017). To illustrate, consider examples (4) and (5).

(4) John was allowed to eat sushi or pasta, but I don't remember which.
(5) John didn't eat sushi or pasta, # but I don't remember which.

Sentence (4) licenses the conjunctive inference that John was allowed to eat sushi <u>and</u> was allowed to eat pasta. The conjunctive inference is defeasible, as illustrated by the acceptability of the continuation … *but I don't remember which*. By contrast, sentence (5) generates the conjunctive entailment that John didn't eat sushi <u>and</u> didn't eat pasta. Adding the same continuation … *but I don't remember which*, leads to a contradiction.

There is another test that pertains to (some, but not all) inferences, as compared to entailments. Inferences are often cancelled under negation (Chierchia 2013, 2017). To illustrate, compare example (6) to the previous example of a conjunctive FCI, without negation: *John was allowed to eat sushi or pasta*. When negation is added, as in (6), the conjunctive FCI disappears, so the continuation …*but I don't know which*, leads to a contradiction. Under negation, then, the conjunctive inference is cancelled, and the result is a conjunctive entailment.

(6) John wasn't allowed to eat sushi or pasta, # but I don't remember which.

Despite the presence of a modal verb, sentence (6) generates the conjunctive entailment that John wasn't allowed to eat sushi <u>and</u> wasn't allowed to eat pasta.

### 3. Scope assignments

A sentence is potentially ambiguous if there are two possible scope assignments at the level of semantic interpretation. Consider the sentence *Every boy did not catch a fish*. This sentence is ambiguous. It can be interpreted as: *None of the boys caught a fish*, with the universal quantifier taking scope over negation (EVERY > NOT). By contrast, it can also mean that not all of the boys caught a fish, with negation taking scope over the universal quantifier (NOT > EVERY). This difference in semantic interpretation is referred to as scope phenomena. In recent research, the linguistic inquiry of how children understand scope phenomena has attracted considerable attention because it helps to gain insight into children's knowledge of linguistic principles that are operative at the initial stage of language development. Moreover, it helps to establish whether children differ from adults in scope assignments of certain sentences at the level of semantic interpretation. This thesis also investigates how Mandarin-speaking children and adults interpret sentences with disjunction and local negation, which are putatively ambiguous in scope assignments between disjunction and local negation.

Before turning to Mandarin examples, let's reconsider the English example in (2), repeated here as (7).

(7) John didn't eat sushi or pasta.

    a. $\Rightarrow$ John didn't eat sushi and he didn't eat pasta.

For both English-speaking children and adults, (7) generates a conjunctive entailment (7a), with negation taking scope over disjunction (NOT > OR). Suppose there is an inverse scope interpretation, with disjunction taking scope over negation (OR >NOT), then sentence (7) should be interpreted using the English cleft sentence (8).

(8) It was sushi or pasta that John didn't eat.

In sentence (8), the basic meaning of disjunction is used. The interpretations are not inferences, but the literal meaning of disjunction, which includes the possibility that John didn't eat sushi and he didn't eat pasta, but also the possibility that John didn't eat just one of these dishes. Therefore, sentence (8) can be followed by a continuation that negates one of the truth conditions, such as … *but I don't remember which*.

In many languages, including Mandarin Chinese and Japanese, disjunction is interpreted as taking scope over local negation, regardless of its position in the surface syntax (see e.g., Crain 2012; Goro & Akiba 2004; Notley, Zhou, Jensen & Crain 2012). So, the Mandarin sentence in (9) is equivalent to the English cleft sentence in (8), as indicated below. It allows the continuation *…but I don't remember which.*

(9) Yuehan mei chi shousi huozhe yidalimian.

    John    Neg eat sushi  or     pasta

    'It was sushi or pasta that John didn't eat.'

In contrast to adult-speakers of Mandarin, children initially assign an inverse scope interpretation to sentences like (8), with negation taking scope over disjunction (NOT> OR) (see e.g., Crain 2012; Goro & Akiba 2004; Notley et al. 2012). In other words, Mandarin-speaking children initially interpret sentences like (9) in the same way that both English-speaking children and adults interpret the corresponding sentences in English.

## 4. Internal and external negation

There are two approaches to negation. We refer to them as the unified approach and the ambiguist approach (cf. Horn 1985, 2001). On the unified approach, negation markers

share the same basic meaning, which corresponds to the negation operator in propositional logic. The ambiguist approach contends that there are two different negation markers, with different semantic/pragmatic functions (see Bar-Asher Siegal 2015; Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006). Adopting terminology by Bar-Asher Siegal (2015), we refer to these negation markers as internal and external negation. Syntactically, internal negation typically appears sentence-internally, as in (10), whereas external negation typically precedes the sentence that it negates, as in (11).

(10) John didn't eat some sushi.

(11) It is not true that John eat some sushi.

Example (10) is interpreted as in (12), with the polarity sensitive expression *some* taking scope over negation. This shows that when *some* resides in the scope of internal negation, it is analysed as a Positive Polarity Item. By definition, a PPI takes scope over internal negation (Crain 2012; Szabolcsi 2002, 2004).

(12) There is some sushi that John didn't eat.

Now consider example (11), where the polarity sensitive expression *some* appears in the scope of external negation. The PPI status of English 'some' is rendered inert, so it has the same interpretation as English *any* (Crain 2012; Szabolcsi 2002, 2004). This is illustrated in (13).

(13) It is not true that John ate any sushi.

Recall that the Mandarin example (9) has the meaning of English cleft sentence, with disjunction taking scope over internal negation. This indicates that disjunction is a PPI in Mandarin (see e.g., Crain 2012; Goro & Akiba 2004; Notley et al. 2012). Although it appears in the scope of internal negation, it must be interpreted outside the scope of negation at the level of semantics.

However, we should expect that Mandarin disjunction to be interpreted within the scope of external negation, because its PPI status should be rendered inert in sentences with external negation. The prediction is that the Mandarin sentence in (14) will be equivalent in meaning to the English sentence in (15).

(14) Bingfei ruci:     yuehan chi-le    shousi huozhe yidalimian.

     Neg     like this: John     eat-ASP sushi  or        pasta

     'It is not true that John ate sushi or pasta.'

(15) It is not true that John ate sushi or pasta.


Now consider what will happen when a modal verbal element is added into the equation. As we saw in the English example (6), disjunction generates a conjunctive entailment when it resides in the scope of internal negation, despite the presence of a modal verb. If disjunction appears in the scope of external negation and a modal verb, however, there is no conjunctive entailment. Rather, the conjunctive FCI remains. So, the English sentence (16) is true if John is just allowed to eat sushi or just allowed to eat pasta. The same is true in Mandarin, as example (17) indicates.


(16) It is not true that John is allowed to eat sushi or pasta.

(17) Bingfei ruci:     yuehan keyi chi shousi or yidalimian.

     Neg     like this: John    may eat sushi   or pasta

'It is not true that John is allowed to eat sushi or pasta.'

Another way to introduce external negation is to use the Mandarin focus adverb *zhiyou* 'only'. The focus adverb contributes two meaning components (see e.g., Anderson 1972; Beaver, Roberts, Simons & Tonhauser 2017; Jacobs 1983; Rooth 1985, 1992; von Stechow 1990). One meaning component is positive, and one is negative. The positive meaning component, called the <u>presupposition</u>, is about the focus element in the sentence. The presupposition can be represented using the original sentence, minus the focus adverb. The negative meaning component, called the <u>assertion</u>, pertains to a set being contrasted with the focus element. The assertion is the denial that any member of the contrast set has the property that is attributed to the focus element. Therefore, external negation is introduced in the assertion. To illustrate, consider example (18).

(18) Zhiyou yuehan keyi chi shousi huozhe yidalimian.

    Only    John    may eat sushi  or       pasta

    'Only John is allowed to eat sushi or pasta.'

In (18), the presupposition is *Jieke keyi chi shousi huozhe yidalimian* 'Jack is allowed to eat sushi or pasta'. Due to the modal verb, the presupposition is expected to license a conjunctive FCI: *Jack is allowed to eat pasta <u>and</u> Jack is allowed to eat sushi*. The assertion is the negation of the FCI, as indicated in (19). So, sentence (18) should be judged to be true even if someone in the contrast set was allowed to eat pasta, but not sushi, or if someone in the contrast set was allowed to eat sushi, but not pasta. The same is true in English, as illustrated in example (20).

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

(20) Only John is allowed to eat sushi or pasta.

This concludes our discussion of the distinctions between entailments and inferences that will be explored in the experimental studies of child Mandarin. The next section outlines the structure of the thesis.

**Structure of the thesis**

This thesis investigates Mandarin-speaking children's knowledge of the entailments and inferences associated with a number of logical expressions. These logical expressions include the disjunction word *huozhe* 'or', the deontic modal verb *keyi* 'is allowed to', the negation markers *bu*/*mei* 'not', the focus adverb *zhiyou* 'only', the adverbial quantifier *dou* 'all', the polarity sensitive expression *renhe* 'any', and *wh*-words like *shei* 'who'. These experimental investigations focus on three questions:

(i)  How children interpret simple sentences, i.e., ones with basic logical expressions;

(ii)  How children interpret complex sentences, i.e., ones that contain a combination of logical expressions;

(iii) The extent to which the interpretations of children and adults are the same, or differ.

The three questions are addressed in a series of experimental studies of children acquiring Mandarin. Here is a brief sketch of the experimental studies.

Chapter 2 is an investigation of children's knowledge of the entailments and inferences arising from disjunction. One of the main areas of research in semantics has focused on the meaning of disjunction in human languages. The meaning of disjunction in human languages is clouded by a semantic/pragmatic inference, called a scalar

implicature. Before we introduce the inference, let us first establish the basic meaning of disjunction in one human language, English. In classical logic, disjunction has the truth conditions of inclusive-*or*. These truth conditions are also associated with the English disjunction word, *or*, in certain circumstances. Consider example (21), produced by a speaker who is looking forward to supper.

(21) I'll bet you $5 we will have pasta or sushi for supper.

Suppose that it turns out that the speaker is served both pasta and sushi at supper. Intuitively, sentence (21) is a true description of what will have transpired. Although the speaker did not commit him/herself to there being both pasta and sushi for dinner, neither did the speaker rule out this possibility. Such circumstances are therefore referred to as contexts of uncertainty. In contexts of uncertainty, a disjunctive statement is felicitous in the full range of truth conditions that are associated with disjunction in classical logic, viz., inclusive-*or*. Sentence (21) is true in any one of the following three circumstances.

a. The speaker just has pasta for supper.
b. The speaker just has sushi for supper
c. The speaker has both pasta and sushi for supper.

Sentences containing logical words sometimes convey inferences that are not explained by classical logic. To illustrate, consider example (22).

(22) John ate sushi or pasta for supper.

⤳ *John did not eat both sushi and pasta for supper.*

Sentence (22) is not likely to be produced in a context of uncertainty. This is indicated by the use of the past tense morpheme, *ate*, which indicates that the speaker is describing an event that has already taken place.  In response to sentence (22), a hearer will most likely infer that the speaker knows what John ate, and will infer that John either just ate pasta, or just ate sushi. The inference that John did not eat both pasta and sushi is based on a pragmatic principle, the Principle of Cooperation (Grice 1975). The Principle of Cooperation entreats speakers to convey what they believe to be true using the most direct means at their disposal. If the speaker believed that John had eaten both pasta and sushi, then s/he would have conveyed this using a sentence with conjunction, *John ate pasta and sushi,* rather than using a sentence with disjunction. The fact that the speaker chose to use disjunction invites the hearer to infer that the speaker was not in a position to use the sentence with conjunction, presumably because the speaker does not believe that John ate both dishes. In an attempt to make the hearer's mental model of the world align with that of the speaker, the hearer adjusts his/her current mental model with the information that John ate pasta or sushi, but not both. This inference of 'exclusivity' is not made in contexts of uncertainty, as we saw in example (21). This shows the importance of the non-linguistic context in allowing or ruling out semantic/pragmatic inferences.

Another kind of inference is conjunctive FCI, as illustrated in (23). This inference is at odds with the 'exclusivity' inference just discussed. In response to sentence (23), the hearer will infer that John was allowed to eat sushi and was allowed to eat pasta.

(23) John was allowed to eat sushi or pasta.

      ⤳ *John was allowed to eat sushi and John was allowed to eat pasta.*

As indicated in (23), adult English-speakers take certain disjunctive statements to generate conjunctive FCIs. Such inferences are not generated in the absence of certain licensing expressions, however.

We have seen that, in addition to logical entailments, human languages are used by speakers to generate different kinds of semantic/pragmatic inferences. The present thesis focuses both on entailments and on inferences, including FCIs, as illustrated by sentence (23).

According to a recent proposal, children license conjunctive FCIs for ordinary statements with disjunction, even in the absence of a licensing expression (Singh, Wexler, Astle, Kamawar & Fox 2016). This proposal hinges on the observation that, unlike adults, young children often fail to make an exclusivity ('not both') inference in interpreting sentences with disjunction (see e.g., Chierchia, Crain, Guasti & Thornton 1998; Chierchia, Guasti, Gualmini, Meroni, Crain & Foppolo 2004; Gualmini, Crain, Meroni, Chierchia & Guasti 2001; Paris 1973; Zhou, Romoli & Crain 2013, and among others). The lack of exclusivity inferences by young children has been attributed to their inability to access the 'stronger' alternative sentence with *and* (see e.g., Barner, Brooks & Bale 2011; Bale & Barner 2013; Chierchia et al. 1998; Gualmini et al. 2001; Papafragou & Skordos 2016; Tieu, Romoli, Zhou & Crain 2016). In the absence of the stronger, conjunctive alternative, several of the researchers just cited have proposed that children adopt the basic, inclusive-*or* meaning of disjunction. This proposal is consistent with the finding of much previous research that children accept sentences with disjunction, when both of the disjuncts are true in the experimental workspace, and as well as when only one of the disjuncts is true.

Children's inability to access the stronger, conjunctive alternative has recently been interpreted differently beginning with the paper by Singh et al. (2016) (also see Tieu et al. 2017). According to these researchers, in the absence of the alternative with *and*, children

should be expected to license conjunctive inferences in response to sentences with disjunction, using the same mechanisms that adults use when they compute conjunctive FCIs.

To illustrate this proposal, consider the sentence *Jack ate sushi or pasta*. On the proposal under consideration, children often fail to access the informationally stronger sentence with *and*, i.e., *Jack ate sushi and pasta*. In the absence of this alternative, children access two alternatives instead. These alternatives are statements that contain just one of the disjuncts in the original disjunctive statement: *Jack ate sushi* and *Jack ate pasta*. Children then apply the recursive exhaustification algorithm to these two alternatives. At the first step in the algorithm, the alternatives to the original disjunctive statement are 'enhanced' with inferences that they would have licensed had they been asserted, instead of the original disjunctive statement. This step yields two propositions: *Jack ate sushi but not pasta* and *Jack ate pasta but not sushi*. At the second step in the algorithm, enhanced alternatives that are stronger than the original disjunctive statement are negated. The result of this step in the algorithm is the following two propositions: *It's not the case that Jack ate sushi but not pasta* and *It's not the case that Jack ate pasta but not sushi*. These statements are logically equivalent to the following conditional statements: *If Jack ate sushi, then he ate pasta* and *If Jack ate pasta, then he ate sushi*. The output of the exhaustification algorithm, then, is the set of propositions: *Jack ate sushi or pasta*, *If Jack ate sushi then he ate pasta*, and *If Jack ate pasta, then he ate sushi*. The conjunctive inference follows from these three propositions: *Jack ate sushi <u>and</u> Jack ate pasta.* The critical empirical observation is that this inference should lead children to reject sentences with disjunction in circumstances in which only one disjunct is true, even when they do not contain a licensing expression.

We do not intend to challenge the proposal that some children license conjunctive inferences for ordinary sentences with disjunction in certain test conditions. The studies that have evoked a pattern of responses that might be attributed to a conjunctive inference have had several notable features, as we will discuss. By contrast, previous studies that used a different experimental technique have not documented children's conjunctive inferences in ordinary sentences with disjunction (Boster & Crain 1993; Chierchia et al. 2004; Crain, Gardner, Gualmini & Rabbin 2002; Goro, Minai, & Crain 2005; Su & Crain 2013; Zhou et al. 2013; Tieu et al. 2016). Chapter 2 attempts to systematically investigate children's interpretation of disjunction in sentences with and without a licensing expression, viz., a deontic modal verb. Experiment 1 replicated the previous finding that children compute a conjunctive FCI in sentences with disjunction in the scope of a deontic modal verb, as in (24) (Zhou et al. 2013; Tieu et al. 2016). Experiment 2 presented the same children with sentences containing plain disjunction, as in (25). In this context, the child participants rarely computed conjunctive inferences.

(24) Yuehan keyi chi yidalimian huozhe shousi.

    John    may eat pasta    or    sushi

    'John is allowed to eat pasta or sushi.'

(25) Yuehan hui xuanze hongse huozhe lüsede qiqiu.

    John    will choose red    or    green    balloon

    'John will choose a red balloon or a green balloon.'

Chapter 3 investigates Mandarin-speaking children's interpretation of sentences with negation. Previous research has found that Mandarin-speaking children compute conjunctive FCIs in sentences with the disjunction word *huozhe* 'or' as well as in sentences with the polarity sensitive expression *renhe* 'any' (Huang & Crain 2014; Tieu

et al. 2016; Zhou et al. 2013). Previous research used affirmative sentences, whereas Chapter 3 investigates children's understanding of the inferences and entailments that follow from sentences with internal negation versus sentences with external negation. More specifically, the research question is concerned with Mandarin-speaking children's assignment of FCIs. For adults, FCIs are generated in negative sentences with the disjunction word *huozhe* 'or' and in negative sentences with the existential expression *renhe* 'any', but only if these sentences involve external negation. FCIs are cancelled in negative sentences with internal negation. Chapter 3 investigates children's interpretation of both kinds of sentences, to determine whether or not children distinguish between the two kinds of negative markers.

Chapter 3 first examines the interpretations assigned by English-speaking adults to sentences with internal versus external negation. A typical minimal pair of test sentences is illustrated in (26) and (27).

(26) It is true that Jack is not allowed to eat sushi or pasta.

(27) It is not true that Jack is allowed to eat sushi or pasta.

Sentence (26) contains internal negation, so it generates a conjunctive entailment (the 'neither' interpretation). Sentence (26) is true if Jack is not allowed to eat either pasta or sushi. By contrast, sentence (27) contains external negation. The ambiguist approach to negation predicts that (27) should be interpreted as the negation of a FCI. That is, sentence (27) should be judged to be true if Jack is only allowed to eat sushi, or if Jack is only allowed to eat pasta. Sentence (26), with internal negation, is false in these circumstances. To recap, the ambiguist approach predicts that English-speaking adults should generate a conjunctive entailment (the 'neither' interpretation) in sentences like (26), but license the negation of a FCI (the 'not both' interpretation) in sentences like (27).

As predicted, the English-speaking adult participants consistently generated a conjunctive entailment (the 'neither' interpretation) in response to sentences like (26), whereas they consistently licensed the negation of a FCI (the 'not both' interpretation) in response to sentences like (27). The findings suggest that, for English-speaking adults, FCIs are cancelled in sentences with internal negation, whereas these inferences are preserved in sentences that contain external negation.

Following that, Chapter 3 investigates Mandarin-speaking children's computation of conjunctive/universal FCI in sentences with internal or external negation. Typical examples of sentences with internal negation are illustrated in (28) and (29).

(28) Zhangsan mei  bei yunxu  chi yidalimian huozhe shousi.

Zhangsan Neg PM allow   eat pasta          or      sushi

   a. **Expected child interpretation**: 'Zhangsan was not allowed to eat pasta or sushi.'

   b. **Expected adult interpretation**: 'It was pasta or sushi that Zhangsan was not allowed to eat.'

(29) Zhangsan bu  keyi chi lanzi  limian de renhe yi-zhong shuiguo.

 Zhangsan Neg may eat basket inside DE any   one-CL   fruit

'Zhangsan isn't allowed to eat any kind of fruit in the basket.'

Because disjunction is analysed as a PPI by Mandarin-speaking adults (see e.g., Crain 2012; Goro & Akiba 2004; Notley et al. 2012), we expect adults to interpret disjunction as taking scope over both the internal negation marker and the deontic modal verb in (28), resulting in the 'not both' interpretation, as indicated in (28b). Because disjunction initially is not analysed as a PPI by children (see e.g., Crain 2012; Goro & Akiba 2004; Notley et al. 2012), we expect them to assign the 'neither' interpretation indicated in (28a). As anticipated, the Mandarin-speaking child participants consistently generated a

conjunctive entailment (the 'neither' interpretation) in response to sentences like (28), suggesting that they cancelled the conjunctive FCIs. This mirrors the fact that Mandarin-speaking children do not initially analyse disjunction as a PPI. By contrast, the adult participants generated a 'not both' interpretation in response to the same sentences. This indicates that Mandarin-speaking adults analyse disjunction as a PPI and thus interpret disjunction as taking scope over both negation and the deontic modal verb.

We do not expect Mandarin-speaking children and adults to generate different interpretations in sentences like (29), however, because such sentences contain the polarity sensitive expression *renhe* 'any', instead of the disjunction word *huozhe* 'or'. Unlike disjunction, the polarity sensitive expression *renhe* is a negative polarity item and it must be interpreted within the scope of its licensor, i.e., negation. Therefore, we anticipate that both children and adult should cancel FCIs associated with *renhe* in sentences like (29), resulting a conjunctive entailment (the 'none' interpretation). As anticipated, both the child and adult participants consistently generated a conjunctive entailment (the 'none' interpretation) in response to sentences like (29). The findings suggest that both children and adults cancel FCIs associated with *renhe* in sentences with internal negation.

Sentences with external negation are illustrated in (30) and (31). In these sentences, external negation is introduced by the focus adverb *zhiyou* 'only'.

(30) Zhiyou Zhangsan chi-le    shousi huozhe yidalimian.

    Only    Zhangsan eat-ASP sushi   or      pasta

    'Only Zhangsan ate sushi or pasta.

(31) Zhiyou Zhangsan keyi chi shousi huozhe yidalimian.

    Only    Zhangsan may  eat sushi    or      pasta

'Only Zhangsan is allowed to eat sushi or pasta.'

The focus adverb *zhiyou* 'only' introduces external negation, which cancels the polarity sensitivity of linguistic expressions. If the polarity sensitivity of the Mandarin disjunction word *huozhe* 'or' is cancelled in (30), both children and adults are expected to generate the same conjunctive entailment (the 'neither' interpretation), which can be paraphrased as: *Nobody else ate sushi and nobody else ate pasta.* As predicted, both the child and adult participants consistently generated a conjunctive entailment in response to sentences like (30).

Now consider example (31), which contains the deontic modal verb *keyi* 'is allowed to'. In (31), the presupposition is *Jieke keyi chi yidalimian huozhe shousi* 'Jack is allowed to eat pasta or sushi'. Due to the addition of the modal verb, the presupposition is expected to license a conjunctive FCI: *Jack is allowed to eat pasta <u>and</u> Jack is allowed to eat sushi*. The assertion is the negative meaning component. If the focus adverb introduces (covert) external negation, the sentence should be judged to be true even if someone in the contrast set is allowed to eat pasta, but not sushi, or sushi, but not pasta. This is illustrated in (32).

(32) It is not true that anyone other than Zhangsan is allowed to eat both sushi and pasta

Therefore, the experimental hypothesis is that both children and adults will preserve the FCI in sentences like (31). The interpretation that results is the weaker 'not both' interpretation, rather than the stronger 'neither' interpretation. As anticipated, both the child and adult participants consistently generated a 'not both' interpretation in response to sentences like (31). The findings indicate that both children and adults preserve FCIs in sentences with external negation, introduced by focus adverb *zhiyou* 'only'.

Chapter 4 is an investigation of Mandarin sentences with *wh*-words (e.g., *shei* 'who', *shenme* 'what'). In Mandarin, sentences with *wh*-words can either be interpreted as declarative statements or as *wh*-questions. In certain sentences, this difference in interpretation is triggered by the presence or absence of the adverbial quantifier *dou* 'all'. In the absence of *dou* 'all', Mandarin sentences with *wh*-words are interpreted as *wh*-questions, as in (33). However, when a *wh*-word is followed by the adverbial quantifier *dou* 'all', the sentence is a statement, with universal force, as illustrated in (34) (see e.g., Cheng 1991, 1994; Huang 1982; Li 1992; Lin 1996, 1998).

(33) Shei chi-le   pingguo?

   Who eat-ASP apple?

   'Who ate the apples?'

(34) Shei dou chi-le   pingguo.

   Who all  eat-ASP apple

   'Everyone ate the apples.'

Another difference in interpretation is triggered by the presence or absence of a deontic modal verb, such as *beiyunxu* 'was allowed to'.[1] When a deontic modal verb is present, as in (35), the sentence is interpreted as licensing a FCI, (see e.g., Chierchia 2006, 2010, 2013; Liao 2011; Zhou 2017). So, (35) implies that anyone in the conversational context was allowed to eat apples. This free choice interpretation is also generally regarded as a kind of universal, conjunctive interpretation, to distinguish it from an existential, disjunctive 'at least one' interpretation. As (36) illustrates, *dou* 'all' is normally required

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[1] Note that *beiyunxu* is a passive modal verb, with *bei* as the passive voice marker and *yunxu* as the modal operator.

to license a free choice interpretation. Without *dou* 'all', the sentence becomes a *wh*-question.

(35) Shei dou bei yunxu-le chi pingguo.

Who all PM allow-ASP eat apple

'Anyone was allowed to eat the apples.'

(36) Shei bei yunxu-le chi pingguo?

Who PM allow-ASP eat apple

'Who was allowed to eat the apples?'

Finally, when a *wh*-word follows *dou,* the sentence, again, is a *wh*-question, as illustrated in (37) (see e.g., Li 1995; Pan 2006; Zhang, Li & Pan 2012).

(37) Dou (you) shei bei yunxu-le chi pingguo?

All (have) who PM allow-ASP eat apple

'Who were all the people that were allowed to eat the apples?'

Chapter 4 assesses the interpretations that Mandarin-speaking children assign to sentences like (33)-(37). The research question is whether or not young children acquiring Mandarin use the different elements in sentences (33)-(37) to determine whether a speaker is asking an information-seeking question, or is asserting a declarative statement. One experiment in Chapter 4 investigates whether Mandarin-speaking children understand that sentences with a *wh*-word followed by *dou* generate a declarative statement with universal force. That experiment contrasts children's interpretation of sentences with a *wh*-word alone, as in (33), with sentences in which a *wh*-word is followed by *dou*, as in (34).

Another experiment in Chapter 4 examines Mandarin-speaking children's knowledge that sentences with a *wh*-word followed by *dou* and a modal verb license a universal FCI. The experiment compares children's understanding of minimal pairs of sentences, namely sentences with a *wh*-word followed by *dou* and a modal verb, as in (35), and ones with a *wh*-word followed by a modal verb alone, as in (36).

A third experiment addresses another research question - children's knowledge of exhaustivity. The experiment investigates Mandarin-speaking children's knowledge that sentences with *dou* 'all' followed by a *wh*-word, as in (37), are interpreted as exhaustive *wh*-questions. Specifically, the experiment compares children's interpretation of sentences with a *wh*-word followed by *dou*, as in (34), with their interpretation of sentences with *dou* followed by a *wh*-word, as in (37).

The main findings were as follows. Both the child and adult participants consistently accepted sentences with *shei + dou*, suggesting that they generated a universal interpretation. By contrast, both the child and adult participants consistently rejected sentences with *shei + dou + beiyunxu*, indicating that they computed a FCI. As the two experiments were conducted in the same non-linguistic contexts, the findings are compelling evidence that children are able to tease apart universal statements and FCIs. In the third experiment, both the child and adult participants consistently rejected sentences with *shei + dou*, suggesting that they interpreted such sentences as declarative statements with universal force. By contrast, both groups provided an exhaustive answer to sentences with *dou + shei*, indicating that they interpreted these sentences as exhaustive *wh*-questions. The findings suggest that Mandarin-speaking children distinguish between universal statements and exhaustive *wh*-questions.

Chapter 5 summarizes the main findings and discusses the implications of the findings for linguistic theory and for language learnability. To account for children's rapid

acquisition in the absence of reliable input from adults, the evidence gathered in the present series of experimental studies is taken as presumptive support for the biolinguistic approach to language acquisition. According to this approach, children draw upon a priori linguistic knowledge of the logical expressions including the disjunction word *huozhe* 'or', the polarity sensitive expression *renhe* 'any', and *wh*-words like *shei* 'who' such that they are able to compute the entailments and inferences of these sentences, in the same way as adults do, at least in the majority of cases. When differences do arise, these are explained using the linguistic apparatus from the biolinguistic approach to language acquisition. The thesis concludes with a brief discussion of future directions.

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# Chapter 2: When OR is assigned a conjunctive inference in child Mandarin

**Abstract**

Recent research has reported that young children assign a conjunctive interpretation to statements with disjunction. It has been proposed that children's conjunctive interpretation is derived using the same mechanisms that adults use to compute Free Choice Inferences (FCIs) from sentences in which disjunction is combined with a modal verb. However, the rates of children's conjunctive inferences in sentences without any licensing expression vary considerably across studies, and are entirely absent in several studies. The observed variation may be due to differences in experimental tasks and materials. The present study attempts to establish a baseline for children's interpretation of disjunction by presenting sentences with disjunction in circumstances that suppress pragmatic inferences for adults, namely when sentences are used to make predictions about future events, rather than as descriptions of events that have already taken place. A Truth Value Judgment Task including the prediction mode of presentation was conducted with five-year-old Mandarin-speaking children, and a control group of adults. Although both the child and adult participants computed FCIs when disjunction was combined with a deontic modal verb, they rarely computed conjunctive inferences in the absence of the modal verb. We discuss the factors that may have contributed to the varying rates of conjunctive inferences in previous studies of children's interpretation of sentences with disjunction.


**Key words:**  free choice inferences, disjunction, child language acquisition, conjunctive inferences

## 1. Introduction

In classical logic, the logical connective for disjunction has the truth conditions associated with inclusive-*or*. A statement of the form **[A or B]** is true in three circumstances: when only A is true, when only B is true, and when both A and B are true. In human languages, however, the inclusive-*or* interpretation of disjunction typically yields an exclusivity 'not both' inference, such that a statement of the form [**A or B]** is true if only A is true, or only B.

On the standard pragmatic account, the exclusivity inference that is assigned to sentences with disjunction is derived by a pragmatic algorithm. This algorithm is based on the observation that sentences that contain words expressing disjunction and conjunction in human languages differ in information strength, such that, for example, English sentences with *or* are less informative than the corresponding sentences with *and* (e.g., Gazdar 1979; Horn 1972; Levinson 1983, 2000). When a speaker uses a sentence that contains a less informative expression, hearers take the speaker to imply the negation of the corresponding sentence with the more informative expression. This explains why a speaker who produces sentence (1) is taken to imply (1a), as indicated by the inference symbol '⤳'.

(1) Jack ate sushi or pasta.

    a. ⤳ *Jack did not eat both sushi and pasta.*

One way to account for the derivation of such inferences is to invoke an algorithm that introduces a covert exhaustivity operator, which we refer to as ONLY. The application of the operator ONLY eliminates alternatives that are stronger than the

original assertion. So, a sentence with disjunction such as *Jack ate sushi or pasta* is 'exhaustified' by negating the stronger alternative, *Jack ate sushi and pasta*. Following the application of ONLY, the original assertion is judged to be true only in circumstances in which Jack did not eat both sushi and pasta.

The exhaustivity algorithm can be viewed as a formal implementation of certain conversation norms that language users follow. One conversational norm is for speakers to be as informative as possible. This is stated in the Principle of Cooperation, and one of its maxims, Quantity (Grice 1975). Assuming that speakers adhere to the Principle of Cooperation, the speaker's selection of a sentence with disjunction, rather than one with conjunction, invites the hearer to infer that the speaker was not in a position to use the stronger statement. Therefore, the statement with conjunction is inferred by the hearer to be inaccurate as a description of the speaker's mental model of the current state of affairs (e.g., Sauerland, Andersen & Yatsushiro 2005; Spector 2007; van Rooij & Schulz 2004). The pragmatic account allows that the literal meaning of disjunction is inclusive-*or*, but the literal meaning can be strengthened into a derived meaning, the exclusive-*or* 'not both' interpretation.

A puzzle arises, however. Certain statements with disjunction, such as (2), do not license an exclusivity inference. This statement is judged to be true in circumstances in which both of the disjuncts are true, not just one of the disjuncts. We will refer to this as a conjunctive Free Choice Inference (FCI, hereafter). The inference is indicated in (2a).

(2) Jack is allowed to eat sushi or pasta.

  a. ⤳ *Jack is allowed to eat sushi and he is allowed to eat pasta.*

It is surprising that people make the conjunctive FCI (2a) from statement (2). In standard logic, a formula with disjunction does not entail the corresponding formula with

conjunction. In fact, disjunctive statements like (1) are often taken to imply the negation of the corresponding statements with conjunction. In modal logic, a disjunctive formula with the possibility operator, $\lozenge(p \vee s)$, does not entail the corresponding conjunctive formula ($\lozenge p \wedge \lozenge s$). Conjunctive FCIs are not computed in sentences that lack a licensing expression such as the deontic modal verb *is allowed to*, however (see e.g., Alonso-Ovalle 2006; Chemla 2009; Chierchia 2013; Fox 2007; Franke 2011; Kamp 1973, 1978; Klinedinst 2007; Kratzer & Shimoyama 2002; Schultz 2005; Van Rooij 2010).

In the theoretical literature, several accounts have been advanced to explain how conjunctive FCIs are generated from sentences like (2). On one account, FCIs are derived in two steps (Kratzer & Shimoyama 2002; Alonso Ovalle 2006; Fox 2007; Klinedinst 2007; Chemla 2009; van Rooij 2010; Franke 2011; Chierchia 2013). The first step compares sentence (2) to alternatives that the speaker could have produced. Among the alternatives for (2) are the statements *Jack is allowed to eat sushi* and *Jack is allowed to eat pasta*. If either of these sentences had been produced, it would have licensed an inference. The statement *Jack is allowed to eat sushi* would have licensed the inference that Jack isn't allowed to eat pasta, and the statement *Jack is allowed to eat pasta* would have licensed the inference that Jack isn't allowed to eat sushi. When the alternatives are combined with the associated inferences, the results are called enhanced alternatives.

At the second step in computing conjunctive FCIs, hearers compare the original disjunctive assertion to its enhanced alternatives. Hearers then negate any enhanced alternatives that are stronger than the original assertion. Both of the enhanced alternatives, *Jack is allowed to eat sushi but not pasta* and *Jack is allowed to eat pasta but not sushi*, are stronger than the original statement *Jack is allowed to eat sushi or pasta*, so they are negated. At this point in the derivation, there are three propositions under consideration. One is the original disjunctive statement (2). The other two propositions are negations of

the enhanced alternatives, namely *It's not the case that Jack is allowed to eat sushi but not pasta* and *It's not the case that Jack is allowed to eat pasta but not sushi.* These two propositions can be recast as conditional statements: *If Jack is allowed to eat sushi, then he is allowed to eat pasta* and *If Jack is allowed to eat pasta, then he is allowed to eat sushi.* Taken together, the three propositions assert that Jack is allowed to eat sushi or pasta, and if Jack is allowed to eat either food, then he is allowed to eat the other. Thus, the output of the algorithm is the conjunctive FCI that Jack is allowed to eat sushi <u>and</u> Jack is allowed to eat pasta.

Recently some researchers have interpreted the findings of their studies as evidence that young children assign a conjunctive FCI to sentences such as (1), without a licensing expression, as well as to sentences with one, as in (2) (Singh, Wexler, Astle, Kamawar & Fox 2016; Tieu, Yatsushiro, Cremers, Romoli, Sauerland & Chemla 2017). This proposal hinges on the observation that, unlike adults, young children often fail to make an exclusivity ('not both') inference in interpreting sentences with disjunction (see e.g., Chierchia, Crain, Guasti & Thornton 1998; Chierchia, Guasti, Gualmini, Meroni, Crain & Foppolo 2004; Gualmini, Crain, Meroni, Chierchia & Guasti 2001; Guasti, Chierchia, Crain, Foppolo, Gualmini & Meroni 2005; Noveck 2001; Paris 1973; Zhou, Romoli & Crain 2013, and among others). The lack of exclusivity inferences by young children has been attributed to their inability to access the 'stronger' alternative sentence with *and* (see e.g., Barner, Brooks & Bale 2011; Bale & Barner 2013; Chierchia et al. 1998; Gualmini et al. 2001; Guasti et al. 2005; Noveck 2001; Papafragou & Skordos 2016; Tieu, Romoli, Zhou & Crain 2016, and among others). Several of the researchers just cited have proposed that, in the absence of the stronger, conjunctive alternative, children adopt the basic, inclusive-*or* meaning of disjunction. This proposal is consistent with the finding reported in much previous research-that children accept sentences with disjunction when

both of the disjuncts are true in the experimental workspace, and as well as when only one of the disjuncts is true.

Children's inability to access the stronger, conjunctive alternative of disjunctive statements has recently been interpreted differently, beginning with the paper by Singh et al. (2016) (also Tieu et al. 2017). According to these researchers, in the absence of the alternative with conjunction, children should be expected to license conjunctive inferences in response to sentences with disjunction, using the same mechanisms that adults use when they compute conjunctive FCIs for sentences with disjunction and a modal verb.

To illustrate this proposal, consider sentence (1). On the proposal under consideration, children often fail to access the informationally stronger sentence with *and*, i.e., *Jack ate sushi and pasta*. In the absence of this alternative, children access two alternatives instead. These alternatives are corresponding statements that contain just one of the disjuncts in the original statement: *Jack ate sushi* and *Jack ate pasta*. Children then apply the recursive exhaustification algorithm to these two alternatives. At the first step in the algorithm, the alternatives to the original disjunctive statement are 'enhanced' with inferences that they would have licensed had they been asserted, instead of the original disjunctive statement. This step yields two propositions: *Jack ate sushi but not pasta* and *Jack ate pasta but not sushi*. At the second step in the algorithm, enhanced alternatives that are stronger than the original disjunctive statement are negated. The result of this step in the algorithm is the following two propositions: *It's not the case that Jack ate sushi but not pasta* and *It's not the case that Jack ate pasta but not sushi*. These statements are logically equivalent to the following conditional statements: *If Jack ate sushi, then he ate pasta* and *If Jack ate pasta, then he ate sushi*. The output of the exhaustification algorithm, then, is the set of propositions: *Jack ate sushi or pasta*, *If Jack ate sushi then he ate pasta*,

and *If Jack ate pasta, then he ate sushi*. The conjunctive inference follows from these three propositions: *Jack ate sushi <u>and</u> Jack ate pasta.* The critical empirical observation is that this inference should lead children to reject ordinary sentences with disjunction in circumstances in which only one disjunct is true, even when they do not contain a licensing expression.

We do not intend to challenge the proposal that some children license conjunctive inferences for ordinary sentences with disjunction in certain test conditions. The studies that have evoked a pattern of responses that might be attributed to a conjunctive inference have had several notable features, as we will discuss. By contrast, previous studies that used a different experimental technique have not documented children's conjunctive inferences in ordinary sentences with disjunction (Boster & Crain 1993; Chierchia et al. 2004; Crain, Gardner, Gualmini & Rabbin 2002; Goro, Minai & Crain 2005; Su & Crain 2013; Tieu et al. 2016; Zhou et al. 2013). The present study attempted to systematically investigate children's interpretation of disjunction in sentences with and without a licensing expression, viz., a deontic modal verb. Using a Truth Value Judgment Task (TVJ task, hereafter) (Crain & Thornton 1998), we conducted two experiments. Experiment 1 replicated the previous finding that children license a conjunctive FCI for sentences in which disjunction resides in the scope of a deontic modal verb (Tieu et al. 2016; Zhou et al. 2013). Experiment 2 presented the same children with sentences containing plain disjunction, using the prediction mode of the TVJ task. In this context, the child participants rarely computed conjunctive inferences. Therefore the findings support the conclusion of much previous work – that children resort to the basic inclusive-*or* meaning of statements with disjunction, and do not license conjunctive FCIs.

This concludes our introductory remarks. The remainder of the paper is organized as follows. Section 2 reviews the acquisition of disjunction. Section 3 describes our experiments. Section 4 discusses the implications of our findings and concludes the paper.

## 2.  Acquisition of disjunction

Three findings on children's interpretation of disjunction are relevant to the present study. First, as we noted, some recent studies have reported that some children reject statements with disjunction in circumstances in which only one disjunct is true, but accept them in circumstances in which both disjuncts are true (Singh et al. 2016; Tieu et al. 2017). This pattern of responses has been taken as evidence that some children license conjunctive inferences in the absence of a licensing expression. However, several prior studies have reported that children accept statements with disjunction when only one disjunct is true (Boster & Crain 1993; Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005; Morris 2008; Su & Crain 2013). Another relevant finding of several recent studies is that children compute conjunctive FCIs when disjunction is combined with a modal verb (Zhou et al. 2013; Tieu et al. 2016). The next sections review the relevant literature.

### 2.1 Children's conjunctive interpretation of disjunction

Evidence in support of the proposal that children sometimes license a conjunctive inference for ordinary disjunctive statements has been offered in two recent studies, one by Singh et al. 2016 and the other by Tieu et al. 2017. First, Singh et al. (2016) investigated English-speaking children's interpretation of disjunction in sentences with a referential subject NP, such as *The boy is holding an apple or a banana*, as well as in sentences with a universally quantified subject NP, such as *Every boy is holding an apple or a banana*. The sentences were presented as descriptions of pictures. In one condition,

only one of the disjuncts was true. In a second condition, both of the disjuncts were true. In response to sentences with a definite description (*the boy*), the child participants who passed the control trials[2] accepted the test sentences 35% in contexts in which just one disjunct was true, whereas the adult participants accepted them 75% of the time. When both disjuncts were true, the child participants accepted the test sentences 76% of the time, and adults accepted them 67% of the time.

The sentences with the universal quantifier, *every,* were also presented in two conditions. In one, two characters were holding one object (e.g., an apple), and one was holding another object (e.g., a banana). They called this the 'every-one' condition. In the other condition, each of the characters was holding both of the objects. They called this the 'every-both' condition. In the 'every-one' condition, children accepted the test sentences 46% of the time, and adults accepted them 85% of the time. In the 'every-both' condition, children accepted the test sentences 75% of the time, and adults accepted them 74% of the time.

A similar pattern of responses has been observed by Tieu et al. (2017), who investigated children's interpretation of disjunction in sentences with a referential subject NP, such as *The hen pushed the bus or the airplane*. Each trial in the study consisted of three stages. At Stage 1, the child was presented with a picture, and an introduction to the picture. On the trial about the hen, the child was told that the hen loved to push her toys around. One day, the hen's father had given her two new toys, a bus and an airplane, and she was thinking about pushing the new toys. Then came Stage 2. Before the hen pushed

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[2] Two unexpected findings from the Singh et al. study are worth noting. First, the authors excluded 25 of the 56 child participants in the analysis because these children failed to respond at above chance level on the control trials with conjunction. The excluded child participants tended to accept sentences with conjunction in circumstances in which only one conjunct was true. The second unexpected finding was that the adult control group failed to compute exclusivity inferences in responding to sentences with disjunction. For some unknown reason, the adult participants accepted sentences with disjunction in the same proportions when both disjuncts were true, as compared to when only one disjunct was true. In other words, adults failed to compute an exclusivity inference, for some unknown reason.

the toys, a puppet appeared on the screen of a laptop computer. The puppet was asked to make a guess about what would happen next. At that point, the puppet produced the target sentence: *The hen pushed the bus or the airplane*. The child participants were invited to repeat the puppet's sentence, to ensure that they could correctly recall it. At Stage 3, the hen pushed one, or both, of the new toys. Then, the child participants were asked to judge whether the puppet's statement about what would happen was right. As a group, the child participants rejected the test sentences about 50% of the time in circumstances in which only one disjunct was true, but the child participants accepted the test sentences roughly 80% of the time in the condition in which both disjuncts were true. More precisely, 19 of the 46 child participants consistently rejected the test sentences when only one of the disjuncts was true, but accepted them when both of the disjuncts were true.[3]

The findings we have reviewed so far have been taken as evidence that some children compute conjunctive inferences in response to ordinary sentences, without a licensing expression such as a modal verb. However, evidence of children's conjunctive inferences in ordinary sentences with disjunction has not been reported in previous studies using different experimental techniques. The next section reviews a series of studies on children's interpretation of sentences with disjunction.

## 2.2 Children's interpretation of disjunction

The findings of both production and comprehension studies have shown that children assign an inclusive-*or* meaning to disjunction. In particular, children have been found to produce or accept statements with disjunction in circumstances in which only one disjunct is true (Boster & Crain 1993; Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005; Morris 2008; Su & Crain 2013). For example, a review of 240 transcriptions of audio-

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[3] The responses of 10 child participants were excluded from the analysis because they responded at chance levels in at least one of the test conditions.

taped exchanges between 2- to 5-year-old children and their parents was undertaken by Morris (2008), using the CHILDES database. Morris reports 465 uses of 'or' out of a total of 100,626 conversational turns. The main findings were that both English–speaking children and adults rarely used disjunction in circumstances that were uniquely consistent with an inclusive-*or* interpretation. For children, utterances in which disjunction could uniquely be analysed as inclusive-*or* were produced less than 10% of the time, and adults used 'or' in circumstances that were uniquely consistent with an inclusive-*or* interpretation only slightly more often than 10% of the time. The vast majority of time, both children and adults produced sentences with disjunction in circumstances in which only one disjunct was true. Although this finding is consistent with the conclusion from the comprehension studies that we will review next-that children initially analyse disjunction as inclusive-*or* - the findings of the Morris study is difficult to reconcile with the findings reported by Singh et al. and by Tieu et al.

Turning to comprehension studies, several previous studies have failed to report any evidence of children requiring both disjuncts to be true in response to disjunctive statements, as in the Singh et al. study. First, several previous studies have reported that children do not require both disjuncts to be true in response to sentences with a referential NP subject (e.g. the mouse) and disjunction in the predicate phrase (Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005). Using the prediction mode of the TVJ task, Chierchia et al. (2004) investigated Italian-speaking children's interpretation of ordinary sentences with disjunction. On a typical trial, the experimenter explained that Batman was going to select one or more of three food options: a cake, an apple, and a banana. Batman and the food items were then hidden behind the curtain of a stage. The puppet made a prediction, such as (3), about what would be revealed once the curtain was opened. The test sentence

contained disjunction. The child's task was to judge whether the puppet was right or wrong.

(3) I think Batman will take a cake or an apple.

The child participants judged the puppet to be right 78% of the time when the referent of just one of the disjuncts was on the stage. Adults provided similar responses. The findings are evidence that children and adults accept ordinary sentences with disjunction in circumstance in which only one disjunct is true.

Similar findings have also been observed by Crain et al. (2002). These researchers investigated English-speaking children's interpretation of sentences in which negation preceded but didn't c-command disjunction. On one trial, the child participants were told a story about two girls who had each lost a tooth. The girls knew that the tooth fairy would come during the night to reward them, in exchange for their lost teeth. One girl decided to stay up late to see what the tooth fairy looked like. Later the tooth fairy arrived, with two jewels and two dimes. At that point, the puppet was asked to predict what would happen next. Then, the child participants heard the puppet's statement in (4).

(4) The girl who didn't go to bed will get a dime or a jewel.

Following that, the story resumed. The tooth fairy gave a dime and a jewel to the girl that was sleeping, but the tooth fairy was disappointed when she saw that the other girl was still awake. So, she decided to give a jewel, but not a dime to the girl. The experimental hypothesis was that the child participants would accept the test sentences since negation did not c-commend disjunction. The findings confirmed the hypothesis. The child

participants accepted the test sentences like (4) 87% of the time when only one disjunct was made true.

Finally, a study by Goro et al. (2005) investigated another linguistic structure with disjunction, and found again that children accepted disjunctive statements when just one disjunct was true. The study also used the prediction mode of the TVJ task. English-speaking children were presented with sentences that contained the focus adverb *only* in sentence-initial position and disjunction in the predicate phrase, as in (5). On a typical trial, Pooh, Bunny Rabbit, and Cookie Monster went to a vegetable patch with carrots and green peppers. The puppet predicted what each of the characters would take. Different circumstances were used to assess children's interpretation of the presupposition versus the assertion of sentences with the focus adverb *only*. For our purposes, the relevant findings are how children analysed the presupposition in the circumstance just described.

(5) Only Bunny Rabbit will eat a carrot or a green pepper.

   **Presupposition**: Bunny Rabbit will eat a carrot or a green pepper.

   **Assertion**: For all x ≠ Bunny Rabbit, x will not eat a carrot or a green pepper.

Following the puppet's prediction, as illustrated in (5), Pooh and Cookie Monster decided not to eat either a carrot or a green pepper. However, Bunny Rabbit decided to eat a carrot. Therefore, just one disjunct was true. The child participants accepted the puppet's statements like (5) in such contexts 93% of the time. Goro et al. (2005) replicated the study in Japanese, and Japanese-speaking children produced the same pattern of responses.

The findings of the comprehension studies we have reviewed in this section failed to identify any children who consistently required both disjuncts of a disjunctive statement to be true. The same outcome was found in studies using sentences in which disjunction

appeared in the predicate phrase of the universal quantifier, *every*. We will review three of these studies. First, Boster and Crain (1993) investigated English-speaking children's interpretation of disjunction in the predicate phrase of sentences with the universal quantifier *every*. On a typical trial, three ghostbusters visited a pet store to choose a pet to help them fight ghosts. They could choose pigs, cats, or lions. Before the ghostbusters made their selections, a puppet (Kermit the Frog, played by one of the experimenters) was invited to predict what the three ghostbusters would choose. Kermit produced sentence (6).

(6) Every ghostbuster will choose a cat or a pig.

The story then continued until its final outcome was reached. The child was asked to judge whether Kermit's prediction had turned out to be an accurate description of the final outcome of the story. The final outcomes in the study included circumstances in which the ghostbusters selected different kinds of animals, and circumstances in which they all selected the same kind of animal, e.g., a cat. The findings were as follows. Adults consistently accepted the test sentences, such as (6), as a description of an outcome in which two of the ghostbusters selected a cat, one selected a pig, and none of them selected a lion.

Ten of the 15 child participants also accepted the test sentences in what can be called the distributivity condition, where at least one ghostbuster chose a cat, and at least one chose a pig. Four of the 15 child participants required every ghostbuster to choose the same kind of animal. Boster and Crain (1993) referred to the interpretation that resulted in

this response by children as the 'egalitarian' interpretation.[4] Notably, none of the child participant rejected the test sentences on the grounds that none of the ghostbuster chose both animals.

Two other studies, by Su and Crain (2013), assessed Mandarin-speaking children's understanding of sentences with a universal quantifier and disjunction. A typical Mandarin test sentence from one study is (7), where disjunction appears in the predicate phrase, as in the Singh et al. study.

(7) Mei-ge    dai-zhe    gou de gongzhu dou    tou-le    baoshi huozhe jienzhi.

  Every-CL carry-ASP dog DE princess   DOU steal-ASP jewel   or      ring

  'Every princess who brought a dog stole a jewel or a ring.'

In the story, a wicked witch had absconded with treasure from around the world, and five princesses were determined to take back some treasure that belonged to their country. They brought animals with them on the journey for protection. One princess brought a magic bird, and four of them brought dogs. The princess with a magic bird was included to make it felicitous to use the restrictive relative clause, *... princess who brought a dog*. This, in turn, permitted the Su and Crain study to assess children's interpretation of disjunction in the relative clause, a Downward Entailing linguistic context (see the paper

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[4] Children's egalitarian interpretation was also reported in a study by Kiguchi and Thornton (2015), who investigated English-speaking children's interpretation of pseudocleft sentences such as (i).

(i) A shell or a plant is what every diver brought back.

Five children consistently accepted sentences like (i) in a follow-up study, despite having rejected them earlier, in the main experiment, in the distributive condition. Like Boster and Crain, Kiguchi and Thornton (2015) do not report that any of the children rejected the target sentences because only one disjunct was true.

for details). The princess with a magic bird was successful in bringing a blue flower back from the journey. Two of the four princesses with dogs brought back jewels, and the other two brought back rings. This was a distributivity context, in which some of the princesses with dogs brought back jewels and the others brought back rings. The 20 child participants in the study accepted the test sentences 95% of the time (76/80).

Because the quantificational adverb *dou* 'all' is sometimes analysed as a distributivity operator, a second experiment presented sentences with *mei* alone, rather than in combination with the adverbial quantifier *dou*. This was achieved by positioning the universal quantifier and disjunction within a double object structure, as illustrated in (8).

(8) Miqi     gei-le     mei-ge    dedao-le diezi de xiaohai bingjilin   huozhe dangao.

Mickey give-ASP every-CL get-ASP plate DE child   ice-cream or       cake

'Mickey gave every child who got a plate ice-cream or cake.'

In one condition, sentence (8) was presented as a description of a distributive context. In the story, four children had plates, and another child had something else. Mickey Mouse gave ice-cream to two children with plates, and cake to the other two children with plates. A different group of 34 children (average age = 4;11) participated in the second experiment. The children accepted sentences like (8) 97% of the time (90/93). There were no conjunctive inferences in either of the experiments reported in Su and Crain (2013).

To recap, the studies we have reviewed in this section invite the conclusion that children do not compute conjunctive inferences in ordinary sentences with disjunction. Rather, children accept ordinary sentences with disjunction in circumstances in which only one disjunct is true. This pattern of responses has been observed both in the description mode as well as in the prediction mode of the TVJ task. For example, using the prediction mode, Cherchia et al. (2004) found that children accepted ordinary

sentences with disjunction 78% of the time when only one disjunct was made true. Using the description mode, Su and Crain (2013) found that children accepted sentences with disjunction in the predicate phrase of the universal quantifier 97% of the time when only one disjunct was true. In addition, using the prediction mode, Tieu et al. (2017) found that children accepted ordinary sentences with disjunction roughly 50% of the time in circumstance in which one disjunct was true. This proportion of conjunctive inferences was similar to that reported by Singh et al. using a picture verification task in the description mode. Singh et al. reported that children accepted sentences with disjunction in the predicate of the universal quantifier 46% of the time when one disjunct was true. Taken together, the findings suggest that, for children, there is no difference between the description mode and the prediction mode in terms of the interpretation of sentences with disjunction. Children accept or reject sentences with disjunction in circumstances in which only one disjunct is true regardless of whether they are presented in the prediction or in the description mode.

Another relevant finding for the present study is that children compute conjunctive FCIs when disjunction is combined with a modal verb (Zhou et al. 2013; Tieu et al. 2016). We next turn to the finding on children's computation of FCIs.


**2.3 Children's computation of Free Choice Inferences**

A representative study of children's computation of conjunctive FCIs is by Zhou et al. (2013). Using a TVJ task, these researchers investigated Mandarin-speaking children's interpretation of sentences that contained the disjunction word *huozhe* 'or' and the deontic modal verb *keyi 'may'*. On an example trial, Kung Fu Panda and Batman participated in a car-pushing competition. Mr. Owl was the judge of the competition, so he set the rules for the competition, proclaiming what cars each competitor was allowed to push. Mr. Owl

told Kung Fu Panda that he was only permitted to push the green car, and he told Batman that he was only permitted to push the orange car. When the competition was about to start, Kermit was asked to restate Mr. Owl's proclamations. Kermit produced sentence (9).

(9) Gongfu xiongmao keyi tui    lüse xiaoche huozhe juse xiaoche.

    Kung Fu Panda    may push green car        or        orange car

    'Kung Fu Panda may push the green car or the orange car.'

    a. ⤳ *Kung Fu Panda may push the green car and he may push the orange car.*

Children rejected Kermit's statements such as (9) 95% of the time. On the example trial, children justified their rejections on the grounds that Kung Fu Panda was only allowed to push one of the cars. This clearly indicates that children computed conjunctive FCIs, as indicated in (9a), in sentences like (9).

Taking stock, there are conflicting findings in the literature on children's interpretation of disjunction. On the one hand, it has been reported that children license a conjunctive inference for ordinary sentences with disjunction, rejecting them in circumstances in which only one disjunct is true. On the other hand, it has been found that children accept sentences with disjunction in circumstances in which only one disjunct is true, except when these sentences are combined with a modal verb.

The observed variation may be due to the different experimental tasks and materials across studies. In particular, studies that have reported that children license a conjunctive inference adopted a picture verification task, rather than a TVJ task. The next section discusses the factors that may contribute to the different patterns of responses across studies.

**2.4 Possible reasons for the conflicting findings**

In this section, we outline differences in the tasks that found children licensing conjunctive inferences versus ones that did not report this finding.

It should be noted first that the Singh et al. study failed to satisfy the felicity conditions on the use of disjunction, for adults. In the Singh et al. study, disjunctive statements were asserted to describe events that had already taken place. It is pragmatically odd, at least for adults, to use a disjunctive statement with a referential subject NP as a description of events that have already taken place. If the events that took place made both disjuncts true, then it would be pragmatically more appropriate to use a sentence with conjunction. If the events that took place made only one disjunct true, then it would have been pragmatically more appropriate to mention just the true disjunct; mentioning both disjuncts is an instance of the logical rule known as Weakening (Disjunction Introduction). In circumstances in which only one disjunct is true, disjunctive statements are weaker than the alternative statements that mention only that disjunct. Although Weakening is logically valid, adults find it pragmatically odd (but cf. Zimmerman 2000, who argues that Weakening is not logically valid).

Adults do accept disjunctive statements in other circumstances, even when both disjuncts are true. For example, adults accept disjunctive statements that are used to make a prediction or a wager about what will take place in the future. To illustrate consider sentence (10).


 (10) I'll bet we are having pasta or sushi for supper.


Suppose that it turns out that both pasta and sushi are served for supper. Intuitively, sentence (10) would be judged to be a true description of what will have transpired. Although the speaker did not commit herself to there being both pasta and sushi for dinner, neither was this possibility ruled out. In context of uncertainty, then, a disjunctive

statement is felicitous in the full range of truth conditions that are associated with inclusive disjunction, as in classical logic. In studies of child language, this observation is incorporated into what is called the 'prediction mode'.

Recall that the study by Singh et al. (2016) included test sentences with disjunction in the scope of the universal quantifier *every*, such as *Every boy is holding an apple or a banana*. These sentences were presented in two contexts. In one condition, two characters were holding one object (e.g., an apple), and one was holding another object (e.g., a banana). In the other condition, each of the characters was holding both of the objects (e.g., an apple and a banana). In contrast to the test sentences with a referential NP, it is felicitous to use disjunction in this condition, because such sentences license what is called a distributive inference. To illustrate, consider the sentence *Every boy is holding an apple or a banana.* This sentence implies that at least one boy is holding an apple and that at least one other boy is holding a banana. This so-called distributive inference is derived by the application of the exhaustification algorithm, negating the stronger alternative statements that could have been asserted, i.e., *Every boy is holding an apple* and *Every boy is holding a banana*. Due to the distributive inference, the use of disjunction in sentences with the universal quantifier is felicitous when they are presented in the 'every-one' condition.

Because English-speaking adults license a distributive inference, it is not felicitous for us to use sentences with a universal quantifier in a different context, however. An infelicitous context would be a circumstance in which all of the characters perform an action that makes just one disjunct true. This would be another instance of Weakening, which adults find pragmatically odd. Let us call this the egalitarian condition. Interestingly, some children have been found to accept sentences with the universal quantifier in the egalitarian condition, but to reject them in circumstances that satisfy the

distributive inference (Boster & Crain 1993; Kiguchi & Thornton 2015). So, it is possible that children would have only accepted the sentence *Every boy is holding an apple or a banana* if every boy had been holding just an apple, or just a banana. The Singh et al. study did not assess this possibility. Therefore, we can conjecture that some of children's rejections that are interpreted by Singh et al. as evidence of a conjunctive inference might have a different source; some children may have rejected the test sentences because not all of the boys were holding the same thing.

We would suggest another reason for the different findings in previous research. Note that Singh et al. (2016) and Tieu et al. (2017) adopted picture verification tasks, whereas studies that did not evoke conjunctive inferences, such as Boster and Crain (1993) and Su and Crain (2013), adopted a TVJ task. In the TVJ task, two experimenters act out stories in real time, using toy characters and props. This enables the experimenter to verbally debate the pros and cons of the actions performed by the characters as the events unfolded in front of the child participant. It also allows the experiment to satisfy any presuppositions that are associated with the test sentences that are produced by the puppet, either as a prediction about how events will unfold, or as a description of how events have taken place in the stories (Thornton 2017). These dynamic events in the story contexts cannot be easily accomplished using pictures, even using a series of pictures that are presented sequentially. By their nature, picture verification tasks are static representations of events that have already taken place.

Another possible difference can probably be discounted. This is the effect of presenting sentences as predictions of what would happen next on each trial. Although this is a common feature of the TVJ tasks that were used in previous research, this was also a feature of the study by Tieu et al. (2017), who also presented the test sentences as predictions about how events would unfold.

We will discuss one last possible reason for the variable findings in previous research. In contrast to studies using the TVJ task, the studies by Singh et al. and by Tieu et al. didn't include the third set of objects/individuals for the protagonists to choose from. This difference in the experimental contexts might also lead to the conflicting findings. More specifically, the tasks in which children adopted the basic inclusive-*or* meaning of disjunction introduced at least three objects/individuals for the protagonists to choose from, whereas the tasks in which the child participants computed conjunctive inferences only contained two sets of objects/individuals.

The presence of the additional set of objects/individuals engages one of the main functions of disjunction, which is to raise uncertainty about certain agents of an action, but to eliminate uncertainty about other agents (Chierchia 2013, 2017; Fox 2007; Spector 2007). For example, suppose there are three individuals in the domain of discourse: Bill, Tom, and Henry. If someone makes a statement about the three individuals, as in (11), then the statement with disjunction eliminates the unmentioned individual, namely Henry, from further consideration.

(11) Bill or Tom laughed.

By contrast to the TVJ task, the picture verification tasks that found children licensing conjunctive inferences only included the sets of objects/individuals that were mentioned in the test sentences. This meant that these studies did not have an extra set of objects/individuals for the protagonist to choose from. As a result, the function of disjunction under consideration was not engaged in the contexts that invoked conjunctive inferences from children.

**2.5 The present study**

Previous studies differ in whether they report that children license a conjunctive inference in disjunctive sentences without a licensing expression (Boster & Crain 1993; Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005; Su & Crain 2013; Singh et al. 2016; Tieu et al. 2017). One the other hand, previous research is consistent on reporting that children compute a conjunctive FCI when disjunction is combined with a modal verb (Tieu et al. 2016; Zhou et al. 2013). The present study was designed to systematically investigate a same group of children's interpretation of disjunction in sentences with and without a deontic modal verb. In view of the methodological concerns of the previous studies, the present study adopted a TVJ task rather than a picture verification task.

Two experiments were conducted. Experiment 1 tested Mandarin-speaking children's interpretation of sentences with the disjunction word *huozhe* 'or' in the scope of the deontic modal verb *keyi* 'is allowed to', as in (12). Experiment 2 assessed the same children's interpretation of sentences with the disjunction word *huozhe*, but without the deontic modal verb *keyi*, as in (13).

(12)  Zhangsan keyi he    pijiu huozhe hongjiu.

      Zhangsan may  drink beer  or      wine

      'Zhangsan is allowed to drink beer or wine.'

(13)  Zhangsan hui  mai pijiu huozhe hongjiu.

      Zhangsan will buy beer or      wine

      'Zhangsan will buy beer or wine.'

Experiment 2 used the prediction mode of the TVJ task. This enabled us to satisfy the felicity conditions on the use of disjunction in sentences without a licensing expression. If the outcome of the story was known, certain outcomes could license exclusivity inferences for sentences with disjunction, and other outcomes could be instances of

Weakening (Disjunction Introdcution), which adults find pragmatically odd. Since Mandarin Chinese is a typologically different language from English, the present study was also designed to demonstrate whether children across languages assign an inclusive-*or* meaning to ordinary sentences with disjunction.

## 3. Experiments

### 3.1 Experiment 1

#### 3.1.1 Methods

**Participants**

We tested twenty-two Mandarin-speaking children, who ranged in age from 4;10 to 5;8, with an average age of 5;6. The child participants were recruited from a kindergarten affiliated with Hubei University of Technology (HBUT), Wuhan, China. We also tested 20 adult speakers of Mandarin, who were undergraduate students at HBUT.

**Procedures**

Participants were presented with a TVJ task, conducted in the description mode. Two experimenters were involved in the task. One experimenter acted out stories using toy characters and props. The other experimenter played the role of a puppet, Kermit the Frog, who watched the stories together with the child. At the end of each story, Kermit described what had happened in the story. The child's task was to judge whether Kermit's statement was right or wrong. If the child indicated Kermit was wrong, then he was asked to explain what had really happened in the story.

The child participants were introduced to the task as a group, and then they were tested individually in a quiet room. Before the main test session, each child was familiarised with the task through a practice trial. On the practice trial, there were two test

sentences, one was designed to elicit a positive answer and one was designed to elicit a negative answer. For example, the test sentence *There is a red pen on the desk* was presented with the child participants in a scenario where there was a red pen on the desk. This test sentence was to elicit a positive answer from the child participants. Following that, another test sentence *There is a green pen on the desk* was presented with the child participants in a scenario where there was a red pen on the desk. This test sentence was to elicit a negative answer from the child participants. All children responded correctly on the practice trial, indicating that they understood the task clearly. They were then presented with the main test session, which consisted of four test stories. The adult participants were tested in groups of five at a time. They began the main test session directly, without any practice trials. The adult participants were presented with the same test stories as the child participants, but with a videotaped version. On each trial, adults were asked to indicate on an answer sheet whether Kermit's statement was right or wrong. If they judged that Kermit was wrong, they were asked to explain what had really happened in the story.

**Materials**

There were four trials in the main test session. On each trial, participants were presented with one target sentence and one control sentence, both of which contained the disjunction word *huozhe* 'or' embedded under the deontic modal verb *keyi* 'is allowed to'. The control sentences were clearly true, whereas the target sentences were designed to elicit a No-response if participants computed a conjunctive FCI, so an equal number of 'Yes' and 'No' responses were expected. To illustrate, here is a typical trial.

*This is a story about two athletes and their coach. The small dog and the big dog are athletes. Mr. Horse is their coach. To keep them fit, Mr. Horse strictly monitors their diet. One day, when the small dog and the big dog were about to have lunch, Mr. Horse explained the rules to them. He said: "For today's lunch, there is fried rice. There is pork soup (see Fig. 1-①). Big dog, it seems that you are gaining weight. So, you are allowed to eat fried rice, but not pork soup. Small dog, you are looking very slim. So, you are allowed to eat fried rice. You are allowed to eat pork soup. It's up to you (see Fig. 1-②)." The big dog and the small dog were very forgetful. They forgot the rules when they started to have lunch, so they asked the puppet to remind them of the rules.*



Fig. 1-①　　　　　　　Fig. 1-②

At that point, Kermit produced the control sentence (14) and the target sentence (15).

(14) Xiaogou　keyi chi chaofan　huozhe zhuroutang.

　　　Small dog may eat fried rice　or　　　pork soup

　　　'The small dog is allowed to eat fried rice or pork soup.'

(15) Dagou　keyi chi chaofan huozhe zhuroutang.

　　　Big dog may eat fried rice or　　　pork soup

　　　'The big dog is allowed to eat fried rice or pork soup.'

### 3.1.2 Experimental Hypothesis

As we can see from the above story, the relevant rule for the small dog stated by Mr. Horse was (16), which can be rendered as in (17). By contrast, the relevant rule for the big dog was (18), which can be represented as in (19).

(16) The small dog is allowed to eat the fried rice and he is allowed to eat the pork soup.

(17) $\lozenge A \wedge \lozenge B$

(18) The big dog is allowed to eat the fried rice, but not the pork soup.

(19) $\lozenge A \wedge \sim \lozenge B$

The puppet's statements, on the other hand, were (14) and (15). The meaning of the control sentence (14) can be rendered as in (20), which is compatible with (17); in fact it is entailed by (17). In addition, from (20) participants might compute the conjunctive FCI in (19), which is also consistent with (17). Therefore, participants were expected to accept the control sentence (14), regardless of whether they accessed the literal meaning or computed the FCI. Now consider the target sentence (15). On its literal meaning, (15) can also be rendered as in (20), which is consistent with (19). However, from (20) participants might compute the FCI in (21), which is crucially incompatible with (19). Therefore, participants were expected to reject the target sentence (13), if they computed the FCI. Alternatively, participants were expected to accept (15), if they accessed the literal meaning. Taken together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials.

(20) $\lozenge (A \vee B)$

(21) $\lozenge A \wedge \lozenge B$

### 3.1.3 Results

A summary of children's and adults' responses to the two types of sentences is provided in Table 1.

| Response Type | Children | Adults |
|---|---|---|
| 'Yes' Response to the Control Sentences | 98% (86/88 trials) | 94% (75/80 trials) |
| 'No' Response to the Target Sentences | 95% (84/88 trials) | 98% (78/80 trials) |

**Table 1** Children's and Adults' Percentages of Each Response Type to the Test Sentences

As Table 1 shows, children correctly accepted the control sentences 98% of the time (on 86/88 trials), and adults accepted them 94% of the time (on 75/80 trials). A Mann-Whitney test on the Yes-responses to the control sentences revealed no significant difference between groups ($z =1.365$, $p = .172$). In contrast to the control sentences, children correctly rejected the target sentences 95% of the time (on 84/88 trials), and adults rejected them 98% of the time (on 78/80 trials). For example, on the typical trial, both children and adults rejected (15) on the grounds that the big dog was permitted to eat just one of the dishes. A Mann-Whitney test on the No-responses to the target sentences revealed no significant difference between groups ($z = .620$, $p = .535$).

In summary, the findings suggest that both children and adults compute conjunctive FCIs from disjunctive statements with a deontic modal verb. In addition, the results corroborate previous findings on children's ability to compute FCIs in disjunctive sentences containing a deontic modal verb (Zhou et al. 2013; Tieu et al. 2016).

### 3.2 Experiment 2

In this experiment, we investigated whether the same children compute conjunctive inferences in disjunctive sentences without a deontic modal verb.

### 3.2.1 Methods

**Participants**

After an interval of 3 days, we tested the same group of children and adults. The interval between the two experiments was made to avoid carry-over effects.

**Procedures**

Participants were tested using the prediction mode of the TVJ task. Two experimenters were involved in the task. One experimenter manipulated a puppet, Kermit the frog. The other experimenter first introduced some characters and toys, to the child and Kermit. He then hid the characters and the toys behind a curtain of a small theatre stage. Following that, he invited Kermit to predict what would happen on the stage. Immediately after Kermit's prediction, the contents of the stage were revealed. The child's task was to judge whether Kermit's prediction was right or wrong. If the child judged that Kermit was wrong, then s/he was asked to explain what had really happened. Apart from the above, both children and adults were tested using the same procedures as in Experiment 1.

**Materials**

There were a total of four test sentences and four filler sentences. The eight sentences were evenly arranged into four different stories such that after each story, the participants judged one test sentence and one filler sentence. The four test sentences all contained the disjunction word *huozhe* 'or', and they were presented in two conditions. In one condition, only one of the disjuncts mentioned in the test sentence was made true. Hereafter, we will refer to this as the 'one' condition. In the second condition, both of the disjuncts mentioned in the test sentence were made true. Hereafter, we will refer to this as the 'both' condition. In each condition, the test sentence was interspersed with a clearly false filler

sentence. Considered together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials. To illustrate, here is a typical trial for the 'one' condition.

*Experimenter: "This is a story about a penguin and a panda. Kermit, the penguin and the panda are going to a birthday party. They are looking for some decorative balloons to liven up the party. Here are the balloons that they can have: pink balloons, yellow balloons and green balloons (see Fig. 2-①). I am going to put the penguin, the panda, and the balloons behind the curtain. I would like you to guess what colour balloon the penguin and the panda respectively, will choose. Kermit, first of all, can you guess what colour balloon the penguin will choose?"*

*Kermit said: "Let me see… I really don't know what colour the penguin likes, but I guess…"*

At that point, Kermit produced test sentence (22).

(22) Qi e      hui xuanze fenhongse huozhe huangsede qiqiu.

   Penguin will choose pink     or     yellow     balloon

   'The penguin will choose a pink balloon or a yellow balloon.'

Immediately after Kermit's statement, the experimenter opened the curtain so that Kermit and the child participant could see what the penguin had chosen. It was a pink balloon (see Fig. 2-②). The child was then asked to judge whether Kermit's prediction had been right or wrong. After that, the experiment continued. Kermit was invited to make another prediction.

*The experimenter: "Now, Kermit, can you guess what colour balloon the panda will choose?"*

*Kermit replied: "OK, I don't know what colour the panda likes, either. But I guess…"*

At that point, Kermit produced the filler sentence (23).

(23) Xiongmao hui  xuanze lüsede qiqiu.

    Panda      will choose green   balloon

    'The panda will choose a green balloon.'

When the curtain was opened, Kermit and the child could see that the panda had chosen a pink balloon (see Fig. 2-③). The child was also asked to judge whether Kermit's prediction had been right or wrong.
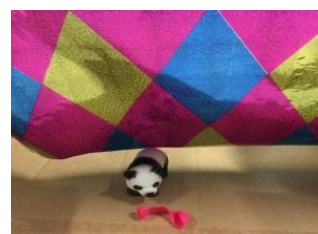


      Fig. 2-①            Fig. 2-②            Fig. 2-③

In the 'both' condition, the protagonist chose both of the objects mentioned in the test sentences, as illustrated in (24). In addition, the protagonist didn't choose the object mentioned in the filler sentences, as illustrated in (25).

(24) Huangniu    hui  mai lunyi       huozhe qiche.

    Yellow cow will buy wheelchair or       car

    'The yellow cow will buy a wheelchair or a car.'

(25) Huaniu       hui  mai  lunyi

   Spotted cow will buy wheelchair

   'The spotted cow will choose a wheelchair.'

**3.2.2 Experimental Hypothesis**

In the 'one' condition, participants who accessed the inclusive-*or* interpretation of disjunction were expected to accept the test sentences, but they were expected to reject these sentences if they computed a conjunctive inference. The filler sentences were clearly false, so participants were expected to reject them. In the 'both' condition, participants were expected to accept the test sentences if they accessed the inclusive-*or* interpretation of disjunction. Participants were also expected to accept them if they computed a conjunctive inference. The filler sentences were clearly false, so participants were expected to reject them.

**3.2.3 Results**

Both the child and adult participants responded correctly to the filler sentences 100% of the time. Therefore, all their data were included in the analysis. A summary of children's and adults' responses to the test sentences is provided in Table 2.

| Response Type | Children | Adults |
|---|---|---|
| 'Yes' Response in 'one' condition | 86% (38/44 trials) | 98% (39/40 trials) |
| 'Yes' Response in 'both' condition | 98% (43/44 trials) | 75% (30/40 trials) |

**Table 2** Children's and Adults' Percentages of Each Response Type to the Test Sentences

As indicated in Table 2, children accepted the test sentences in the 'one' condition 86% (on 38/44 trials) of the time, and adults accepted them 98% (on 39/40 trials) of the time. A Mann-Whitney test on the Yes-responses to the test sentences revealed no significant difference between groups ($z = 1.344$, $p = .179$). The findings suggest that both children and adults did not compute conjunctive inferences from ordinary sentences with disjunction in the prediction mode. However, a Mann-Whitney test revealed a significant difference between groups in the 'both' condition ($z = 2.253$, $p = .024$). The child participants accepted the test sentences 98% of the time in this condition (on 43/44 trials), whereas the adult participants accepted them significantly less often, 75% of the time (on 30/40 trials). The 25% reduction in acceptances by the adult participants in the 'both' condition can be taken as evidence that the adult participants generated an exclusivity inference from the disjunctive sentences, even in the prediction mode. The child participants were not expected to generate such inferences, and the results are consistent with this expectation.

In addition, three of 22 children rejected the test sentences 50% of the time when only one disjunct was made true. One of 22 children rejected the test sentences 25% of the time when both disjuncts were made true. This pattern of responses invite us to conclude that children don't consistently reject more when one disjunct is true than when both disjuncts are true.

To recap, most of the children and adults we tested accepted ordinary sentences with disjunction in circumstances in which only one disjunct was true as well as in circumstances in which both disjuncts were true. These results corroborate previous findings in cross-linguistic studies on children's interpretation of disjunction (see e.g., Chierchia et al. 2004; Gualmini, Crain & Meroni 2000; Jasbi & Frank 2017; Su 2015, and

among others). That is, children across languages draw the inclusive-*or* meaning from ordinary sentences with disjunction.

## 4.  General discussion and conclusion

Recently it has been reported that children interpret disjunction conjunctively, rejecting statements with disjunction in circumstances in which only one disjunct is true, but accepting them in circumstances in which both disjuncts are true (Singh et al. 2016; Tieu et al. 2017). The findings have been taken as evidence that some children license conjunctive inferences for statements with disjunction, even in the absence of a licensing expression that adults require, e.g., the deontic modal verb *is allowed to.*

We do not challenge the proposal that some children license conjunctive inferences for ordinary sentences with disjunction in certain test conditions. However, evidence of children's conjunctive inferences in ordinary sentences with disjunction has not been reported in previous studies using different experimental techniques. Rather, previous studies using a TVJ task have shown that children accept statements with disjunction in circumstances in which only one disjunct is true, except when disjunction is combined with a modal verb (Boster & Crain 1993; Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005; Su & Crain 2013; Tieu et al. 2016; Zhou et al. 2013, and among others). As documented in the literature, children's conjunctive inferences have been elicited in picture verification tasks, but not in the TVJ tasks.

In view of the methodological concerns, the present study adopted a TVJ task rather than a picture verification task. The difference of previous findings lies in whether children compute a conjunctive inference in disjunctive statements without a licensing expression. Therefore, the present study conducted two experiments investigating a same group of Mandarin-speaking children's interpretation of disjunction in sentences with and

without the deontic modal verb *keyi* 'is allowed to'. Experiment 1 replicated the previous finding that Mandarin-speaking children can indeed license a conjunctive FCI for sentences with disjunction in the scope with the deontic modal verb *keyi*. Experiment 2 presented the same children with sentences containing plain disjunction in the prediction mode of the TVJ task. It was found, however, children did not require both disjuncts to be true in Experiment 2. Rather, they accepted the test sentences in circumstances in which only one disjunct was true as well as in circumstances in which both disjuncts were true.

In summary, children computed a conjunctive inference in sentences with the deontic modal verb *keyi* 'is allowed to'. In the absence of the modal verb, children drew the basic, inclusive-*or* meaning of disjunction. Since Mandarin Chinese is a typologically different language, the findings contribute yet further evidence that children across languages draw an inclusive-*or* meaning from ordinary sentences with disjunction (Boster & Crain 1993; Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005; Gualmini et al. 2000; Jasbi & Frank, 2017; Su 2015, and among others). The results of the present study, in conjunction with those of the previous studies, are inconsistent with the findings by Singh et al. (2016) and Tieu et al. (2017).

We conclude by raising some possible explanations for the variant findings. First, it should be noted that some of children's rejections that are interpreted by Singh et al. as evidence of a conjunctive inference might have a different source. In response to the test sentences with a universal quantifier, some children may have assigned an egalitarian interpretation to the disjunction phrase. According to the egalitarian interpretation, *Every boy is holding an apple or a banana* is true only if every boy is holding just an apple, or just a banana. Therefore, some children may have rejected the test sentences because not all of the boys were holding the same thing, i.e., an apple. The Singh et al. study was not

designed to assess the egalitarian interpretation, so we conjecture that this could have contributed to children's high rejection rate.

There is a second factor that may have contributed to the different findings. As noted, Singh et al. (2016) and Tieu et al. (2017) adopted picture verification tasks, whereas studies that did not evoke conjunctive inferences, such as Boster and Crain (1993) and Su and Crain (2013), adopted a TVJ task. In the TVJ task, stories are enacted by two experimenters in real time. This enables the experimenter to verbally debate the pros and cons of the actions of the characters as events unfold. It also allows the experiment to satisfy any presuppositions that are associated with the test sentences that are produced by the puppet, either as a prediction about how events will unfold, or as a description of how events have taken place in the stories (Thornton 2017). These dynamic events in the story contexts cannot be easily accomplished using pictures, as in study by Singh et al. (2016), even using a series of pictures that are presented sequentially, as in the study by Tieu et al. (2017). By its nature, picture verification tasks are static representations of events that have already taken place.

There is a third factor that can probably be discounted. This is the effect of presenting sentences as predictions of what would happen on each trial. As noted earlier, the study by Tieu et al. (2017) also adopted the prediction mode, presenting the child participants with disjunctive sentences as predictions of what would happen on each trial, but these researchers have found that children appear to reject the test sentences when only one disjunct is true. Similar findings were also observed by Singh et al. (2016) who used the picture verification task in the description mode. Moreover, previous studies have demonstrated that children consistently accept sentences with disjunction in circumstances in which only one disjunct is true regardless of whether they are presented in the prediction mode or in the description mode (Boster & Crain 1993; Su & Crain

2013). Taken together, children accept or reject sentences with disjunction regardless of whether they are presented in the prediction mode or in the description mode of the TVJ task. In other words, for children, there is no difference between the prediction mode and the description mode in terms of the interpretation of sentences with disjunction.

There is one last factor that could have possibly contributed to the observed variation in findings. Compared to studies using the TVJ task, the studies by Singh et al. and by Tieu et al. didn't include the third set of objects/individuals for the protagonists to choose from. This difference in the experimental contexts might also lead to the conflicting findings. More specifically, the picture task used by Singh et al. (also by Tieu et al.) contained just two objects (e.g., an apple and a banana). By contrast, the TVJ tasks that were used in the present experiment and in most previous studies included more than two (e.g., the example trial from Experiment 2 included pink, green, and yellow balloons). This may have made the test sentences in this experiment more natural for children. Statements with disjunction engage a covert exhaustivity operator, which we will render as ONLY. One function of the covert operator ONLY is to eliminate from further consideration of those individuals in the domain of discourse that are not mentioned in the sentence (Chierchia 2013, 2017; Fox 2007; Spector 2007). Suppose there are three individuals in the domain of discourse: John, Mary, and Sue. If someone asks a question about all of the individuals in the domain, as in (26a), then an answer that contains a disjunction of a subset of these individuals, as in (26b), eliminates the unmentioned individuals from further consideration (see e.g., Chierchia 2017). The process is schematically represented in (27).

(26) a. John, Sue and Mary were at the party. Who left early?

b. John or Mary.

(27) ONLY [ALT = John, Mary, ~~Sue~~]

⤳ John or Mary left early, and it is not the case that Sue left early.

In a context in which there are only two individuals or objects, as in the Singh et al. and Tieu et al. studies, this pragmatic function of disjunctive statements is not engaged. In previous research, including the present study, there were more individuals or objects in the domain of discourse than those mentioned in the test sentence. Therefore, this pragmatic function (exhaustivity) was engaged. This difference in the experimental contexts may have contributed to the different patterns of responses by the child participants across studies.

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# Chapter 3: How Mandarin-speaking children interpret sentences with negation

This chapter is based on the following paper, which has been submitted to *Natural Language Semantics.*

Huang, Hai-Quan, Rosalind Thornton & Stephen Crain. How Mandarin-speaking children interpret sentences with negation (Under review).

**Abstract**

This study investigated 5-year-old Mandarin-speaking children's computation of Free Choice Inferences (FCIs) in negative sentences. In previous research, Mandarin-speaking children were found to compute FCIs in affirmative sentences with the disjunction word *huozhe* 'or' and in ones with the polarity sensitive expression *renhe* 'any'. This study investigated the entailments and inferences that children draw from both kinds of sentences when they contain either internal or external negation. Experiment 1 examined whether English-speaking adults assign different interpretations to sentences with internal versus external negation. Experiments 2 and 3 presented Mandarin-speaking children and adults with negative sentences that contained the disjunction word *huozhe* (Experiment 2) and the polarity sensitive expression *renhe* (Experiment 3). External negation was investigated in Experiments 4 and 5, using sentences with the focus adverb *zhiyou* 'only' in combination with disjunction (Experiment 4) and in combination with both disjunction and a modal verb (Experiment 5). Experiment 1 confirmed the distinction between internal and external negation. One difference between children and adults emerged when disjunction was combined with internal negation; because disjunction was interpreted to take scope over negation by adults, but not by children. Both children and adults, however, computed a negated FCI in sentences with external negation, introduced by the focus adverb *zhiyou*. In conclusion, 5-year-old Mandarin-speaking children understand that FCIs are cancelled in sentences with internal negation, but are preserved in sentences with external negation. In view of the paucity of relevant input to children, the findings support an innateness account of acquisition of logical expressions.


**Key words** Free choice inferences, Child Mandarin, Disjunction, Internal and external negation, Focus adverbs, Modal verbs

# How Mandarin-speaking children interpret sentences with negation

## 1. Introduction

### 1.1 Two approaches to negation

There are two general approaches to negation. We will refer to them as the unified approach and the ambiguist approach (cf. Horn 1985, 2001). On the unified approach, negation markers all share the same basic meaning, corresponding to negation in classical logic. The ambiguist approach contends that there are different negation markers, with different semantic/pragmatic functions (see Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006; Bar-Asher Siegal 2015). Adopting terminology by Bar-Asher Siegal (2015), we refer to the two kinds of negation markers as internal and external negation.

According to Bar-Asher Siegal, these negation markers have different syntactic distributions and distinct semantic contributions to sentence meaning. Syntactically, internal negation typically appears sentence-internally, in the predicate phrase, as in (1). External negation typically precedes the sentence that it negates, as in (2).

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

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

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

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

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

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

**1.2 Free choice inferences**

The present study investigated the inferences and entailments that Mandarin-speaking children and adults assign to sentences with internal versus external negation. One of the inferences under consideration is witnessed in sentence (5). In (5), disjunction appears in the scope of the deontic modal verb phrase *was allowed to*. Due to the presence of *was allowed to*, adult English-speakers assign a free choice (conjunctive) inference to sentence (5), so adults judge the sentence to be true if Jack was allowed to eat pasta and Jack was allowed to eat sushi. Replacing disjunction by the polarity sensitive expression *any* in (6) results in a free choice inference with universal force. That is, adults judge sentence (6) to be true if Jack was given permission to eat all of the dishes on offer. The symbol ' ⤳ ' represents inferences.

(5) Jack was allowed to eat pasta or sushi.

　　⤳ *Jack was allowed to eat pasta and Jack was allowed to eat sushi.*

(6) Jack was allowed to eat any dish.

　　⤳ *Jack was allowed to eat pasta, Jack was allowed to eat sushi, Jack was allowed to eat chicken, and ...*

Since sentence (5) contains disjunction, it is surprising that the inference made by adult speakers can be represented using conjunction. In standard logic, a formula with disjunction (p ∨ s) does not entail one with conjunction (p ∧ s). This is also true in human languages. Clearly, the modal verb *was allowed to* is responsible for the free choice (conjunctive) inference in (5). If we remove the modal verb, the sentence that results is *Jack ate pasta or sushi*. In judging this statement, adult English speakers typically make an inference of 'exclusivity'; they judge the sentence to be true if Jack only ate pasta or only ate sushi. The inference of exclusivity is not generally regarded as being part of the basic meaning of disjunction but, rather, as being derived by an implicature (see e.g., Chierchia, Crain, Guasti, Gualmini & Meroni 2001; Gazdar 1979; Horn 1972; Levinson 1983, 2000; Sauerland 2004).

In modal logic, too, a disjunctive statement with the possibility operator '◊' does not entail the corresponding formula with conjunction, (◊p ∧ ◊s). Again, this is another indication shows that the deontic modal verb in (5) and (6), *was allowed to*, is responsible for licensing the free choice (conjunctive/universal) inference. For discussion, see Alonso-Ovalle 2006; Chemla 2010; Chierchia 2006, 2013; Dayal 1998; Fox 2007; Franke 2011; Giannakidou 2001; Kamp 1973, 1978; Klinedinst 2007; Kratzer & Shimoyama 2002; Sauerland 2004; Schultz 2005; van Rooij 2006, 2010, and von Wright 1969.

There are two theoretical solutions to the so-called free choice paradox exhibited by sentences (5) and (6). According to one camp, free choice (conjunctive/universal) inferences involve derivations that are similar to scalar implicatures (see e.g., Alonso-Ovalle 2006; Chemla 2010; Chierchia 2006, 2013, Fox 2007; Franke 2011; Klinedinst 2007; Kratzer & Shimoyama 2002; Schultz 2005; Van Rooij 2006, 2010). Another camp contends that the conjunctive/universal interpretations of sentences like (5) and (6) are entailments, not inferences (see e.g., Aloni 2004, 2007; Geurts 2005; Zimmermann 2000).

For example, Zimmermann (2000) proposes that disjunctions can be analysed as lists of epistemic possibilities. As Chierchia (2013, 2017) points out, however, the conjunctive inference licensed by sentence (5) is defeasible, as illustrated by the continuation in (7). If the conjunctive inference in the first clause of (7) is an entailment, then adding the continuation *but I don't remember which* would yield the interpretation in (8). However, (8) is a contradiction. The fact that (7) is not contradictory is not anticipated by the semantic account.

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

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

There is another diagnostic of inferences, as opposed to entailments. Inferences are typically cancelled under (internal) negation (see e.g., Chierchia 2013, 2017). Consider example (9). Sentence (9) entails that Jack was not allowed to eat pasta, and that Jack was not allowed to eat sushi. We will refer to this as a conjunctive entailment, the 'neither' interpretation. A conjunctive entailment is also computed in (10), where the deontic modal verb *was allowed to* is absent.

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

(10) Jack did not eat pasta or sushi.

Sentence (9) shows that the deontic modal verb does not contribute a free choice (conjunctive) inference in sentences with internal negation. If a free choice (conjunctive) inference was generated in (9), the result would be a weaker interpretation. On the weaker interpretation, sentence (9) would be true if Jack was only allowed to eat sushi, or if Jack

was only allowed to eat pasta. These truth conditions are not accessible for sentence (9), according to our intuitions. Sentence (9) would also be true in the one circumstance that corresponds to a conjunctive entailment. That is, Jack was not allowed to eat either dish. It follows from these observations that the set of circumstances that make (9) true constitutes a subset of the circumstances that would validate the negation of the free choice inference. Symbolically, a negated free choice (conjunctive) inference results in a 'not both' interpretation, $\sim (\Diamond Pj \wedge \Diamond Sj)$, whereas an entailment generated by disjunction under negation results in a 'neither' interpretation, $\sim \Diamond Pj \wedge \sim \Diamond Sj$. This difference in truth conditions - between a negated inference and a negated entailment were used in several of the experiments that we conducted to assess the circumstances in which child and adult speakers of Mandarin assign inferences or entailments to sentences with internal versus external negation.

The main thesis of the present study is that free choice (conjunctive/universal) inferences are cancelled in sentences with internal negation, but such inferences are preserved in sentences with external negation. To illustrate, consider examples (11) and (12).

(11) It is true that Jack is not allowed to eat pasta or sushi.

(12) It is not true that Jack is allowed to eat pasta or sushi.

Sentence (11) contains internal negation, so it generates a conjunctive entailment (the 'neither' interpretation). Sentence (11) is true if Jack is not allowed to eat either pasta or sushi. In contrast, sentence (12) contains external negation. The ambiguist account of negation markers predicts that (12) should be interpreted as the negation of a free choice inference. That is, sentence (12) should be judged to be true if Jack is only allowed to eat pasta, or if Jack is only allowed to eat sushi. Sentence (11), with internal negation, is false

in these circumstances. Experiment 1 was an empirical test of this prediction of the ambiguist approach.

Experiments 2 and 3 compared the interpretations assigned by Mandarin-speaking children and adults to sentences with internal negation. Before we introduce the Mandarin sentences, consider the English sentence in (13).

(13) Jack did not eat pasta or sushi.

Sentence (13) generates the 'neither' interpretation. A straightforward translation of sentence (13) in Mandarin is (14).

(14) Jieke mei  chi  yidalimian huozhe shousi.

   Jack Neg  eat  pasta            or      sushi

Mandarin-speaking adults assign a different interpretation to (14), as compared to the interpretation assigned by English-speaking adults to (13). For adult speakers of Mandarin, sentence (14) expresses the interpretation conveyed by the following English cleft sentence: *It was either pasta or sushi that Jack didn't eat.* The English cleft sentence generates the 'not both' interpretation. Adult Mandarin-speakers assign the 'not both' interpretation to (14) because the disjunction word *huozhe* 'or' is a Positive Polarity Item (PPI) in adult Mandarin (see e.g., Crain 2012; Goro & Akiba 2004; Notley, Zhou, Jensen & Crain 2012). By definition, a PPI takes scope over internal negation at the level of semantic interpretation. Consequently, adult Mandarin-speakers do not require the stronger 'neither' interpretation that English-speaking adults assigned to (13). In contrast to adults, however, Mandarin-speaking children do not initially analyse the disjunction word *huozhe* 'or' as a PPI (see e.g., Crain 2012; Goro & Akiba 2004; Notley, Zhou,

Jensen & Crain 2012). For Mandarin-speaking children, negation has scope over disjunction in sentences like (14). This results in a 'neither' interpretation, as in English.

Experiments 2 and 3 were designed to investigate how Mandarin-speaking children and adults interpret sentences with internal negation and a deontic modal verb. In Experiment 2, these expressions were combined with the disjunction word *huozhe* 'or'. In Experiment 3, they were combined with the polarity sensitive expression *renhe* 'any'. Because the test sentences in Experiment 2 contained internal negation, we anticipated that Mandarin-speaking children and adults would generate different scope assignments. An example of the test sentences is (15), where the negation marker *mei* 'not'[5] appears along with the deontic modal verb *beiyunxu* 'was allowed to' and the disjunction word *huozhe* 'or'.

(15) Jieke mei beiyunxu chi yidalimian huozhe shousi.

Jack NEG PM allow eat pasta        or        sushi

a**. Expected child interpretation:** 'Jack was not allowed to eat pasta or sushi.'

b. **Expected adult interpretation:** 'It was either pasta or sushi that Jack was not allowed to eat.'

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[5] *Bu* and *mei* are two primary negation markers in Mandarin Chinese. Basically, *bu* is used to negate habitual or future/volitional situations, whereas *mei* negates the completion of an event (see, e.g., Li and Thompson, 1980). Consider sentences (i) and (ii), for example.

(i) Ta bu chi yangrou.
   He not eat mutton
   'He doesn't eat mutton/he will not eat mutton/he doesn't want to eat mutton.'

(ii) Ta mei chi yangrou.
   He not eat mutton
   'He didn't eat mutton.'

Because disjunction is a PPI for adults, we expected adults to interpret disjunction as taking scope over internal negation and the deontic modal verb in (15), resulting in the 'not both' interpretation, as indicated in (15b). Because disjunction is not a PPI for children, we expected them to assign the 'neither' interpretation indicated in (15a).

We did not expect children and adults to generate different interpretations in Experiment 3. The test sentences in this experiment contained the polarity sensitive expression *renhe* 'any', instead of the disjunction word *huozhe* 'or'. Like disjunction, the polarity sensitive expression *renhe* generates a free choice (universal) inference in affirmative sentences with a deontic modal verb. This is illustrated in (16), which is true if Jack has been given permission to eat all of the fruit on offer.

(16) Jieke  keyi chi lanzilide        renhe yi-zhong shuiguo.

    Jack   may eat  basket inside DE any   one-CL   fruit

    'Jack is allowed to eat any kind of fruit in the basket.'

Because *renhe* 'any' requires a licensing expression, such as negation, both children and adults were expected to assign a 'none' interpretation to sentences such as (17).

(17) Jieke bu   keyi  chi lanzili        de renhe yi-zhong shuiguo.

    Jack Neg  may  eat  basket inside DE any   one-CL   fruit.

    'Jack is not allowed to eat any kind of fruit in the basket.'

Experiments 4 and 5 investigated a linguistic structure that introduces external negation. According to the ambiguist approach, free choice (conjunctive) inferences should be preserved in sentences with external negation. The result is the negation of the inference, the 'not both' interpretation, rather than the 'neither' interpretation. To

introduce external negation, the test sentences in Experiments 4 and 5 contained the focus adverb *zhiyou* 'only'. The focus adverb *zhiyou* 'only' is typically associated with some expression in a sentence, called the focus element. In addition to its association with the focus element, the focus adverb *zhiyou* 'only' contributes two meaning components (see e.g., Anderson 1972; Beaver, Roberts, Simons & Tonhauser 2017; Jacobs 1983; Rooth 1985, 1992; von Stechow 1990). One of the two meaning components is positive, and the other is negative. The positive meaning component is called the <u>presupposition</u>. The presupposition expresses the content of the original sentence, but without the focus adverb *only*. The negative meaning component is called the <u>assertion</u>. The assertion pertains to a set of individuals (or predicates) being contrasted with the focus element. The semantic contributions of the focus adverb can be illustrated using (18). This is the kind of test sentence used in Experiment 4.

(18)  Zhiyou jieke chi-le    yidalimian huozhe shousi.

Only   Jack  eat-ASP pasta       or      sushi

'Only Jack ate pasta or sushi.'

The focus element in (18) is *Jieke* 'Jack'. The presupposition is the sentence without *zhiyou* 'only', *Jieke chi-le yidalimian huozhe shousi* 'Jack ate pasta or sushi'. The assertion entails that none of the individuals in the set of individuals being contrasted with Jack ate pasta or sushi.

The focus adverb introduces external negation. As we noted earlier, external negation cancels the polarity sensitivity of linguistic expressions (see examples 11 and 12). If the polarity sensitivity of the Mandarin disjunction word *huozhe* 'or' is cancelled in (18), then both children and adults are expected to interpret this sentence in the same way. The interpretation that results can be paraphrased as follows: *It is not true that any member of*

*the set of individuals being contrasted with Jack ate pasta or sushi*. That is, the ambiguist account anticipates that both Mandarin-speaking children and adults will generate the 'neither' interpretation in response to the test sentences in Experiment 4.

Experiment 5 added the deontic modal expression *keyi* 'is allowed to' into the equation, as illustrated in (19).

(19) Zhiyou Jieke keyi chi yidalimian huozhe shousi.

　　 Only　Jack　may eat pasta　　　　or　　　sushi

　　 'Only Jack is allowed to eat pasta or sushi.'

In (19), the presupposition is *Jieke keyi chi yidalimian huozhe shousi* 'Jack is allowed to eat pasta or sushi'. Due to the presence of the deontic modal verb *keyi* 'is allowed to', the presupposition is expected to license a free choice (conjunctive) inference: *Jack is allowed to eat pasta <u>and</u> Jack is allowed to eat sushi*. The assertion is the negative meaning component. If the focus adverb introduces (covert) external negation, the sentence should be judged to be true even if someone in the contrast set is allowed to eat pasta, but not sushi, or sushi, but not pasta. This is illustrated in (20).

(20) It is not true that anyone other than Jack is allowed to eat both sushi and pasta

Because external negation is introduced in (19), the ambiguist approach anticipates that Mandarin-speaking children and adults should judge (19) to be true in circumstances that are consistent with the weaker 'not both' interpretation in Experiment 5, rather than the stronger 'neither' interpretation that was expected in Experiment 4.

In this introduction, we have set out several empirical predictions that distinguish the ambiguist approach and the unified approach. The remainder of this paper is organized as

follows. Section 2 reviews the previous literature on child language. Section 3 describes our experimental studies. Section 4 discusses the implications of our findings. Section 5 concludes the paper.

## 2.  Free choice inferences in child Mandarin

In previous studies, preschool Mandarin-speaking children were found to compute free choice (conjunctive/universal) inferences in affirmative sentences (Huang & Crain 2014; Tieu, Zhou, Romoli & Crain 2016; Zhou, Romoli & Crain 2013). A representative study is by Zhou, Romoli, & Crain (2013). Using a Truth Value Judgment Task (Crain & Thornton 1998), these researchers investigated Mandarin-speaking children's interpretation of affirmative sentences that contained the disjunction word *huozhe* 'or' and the deontic modal verb *keyi 'may'*. On a typical trial, Kung Fu Panda and Batman participated in a car-pushing competition. Mr. Owl was the judge of the competition, so he set the rules for the competition, proclaiming what cars each competitor was allowed to push. Mr. Owl told Kung Fu Panda that he was only permitted to push the green car, and he told Batman that he was only permitted to push the orange car. When the competition was about to start, Kermit was asked to restate Mr. Owl's proclamations. Kermit produced sentence (21).

(21) Gongfu xiongmao keyi tui   lüse xiaoche huozhe juse xiaoche.

    Kung Fu Panda    may push green car        or       orange car

    'Kung Fu Panda may push the green car or the orange car.'

(22) ↝ *Kung Fu Panda may push the green car and he may push the orange car.*

Children rejected Kermit's statements such as (21) 95% of the time. On the typical trial, children justified their rejections on the grounds that Kung Fu Panda was only allowed to

push one of the cars. This clearly indicates that children computed free choice (conjunctive) inferences, as indicated in (22), in sentences like (21).

Using the same methodology, Huang and Crain (2014) also found that Mandarin-speaking children computed free choice (universal) inferences in affirmative sentences that contained the polarity sensitive expression *renhe* 'any' and the modal verb *neng* 'is able to'. On a typical trial, Kung Fu Panda and Grasshopper engaged in a car-pushing competition and a fence-jumping competition. In each competition, the two characters had the opportunity to try three different objects. In the car-pushing competition, Grasshopper successfully pushed one small car, but he failed with the other two big ones. At that point, the puppet produced test sentence (23). The child's task was to judge whether or not the puppet had said the right thing. Sentence (23) did not contain *renhe* 'any', and it was a true description of the story, so children were expected to accept it.

(23) Zhameng    neng tuidong yi-ge    chezi.

   Grasshopper can   push    one-CL car

   'Grasshopper was able to push one of the cars'.

Following the child's assessment of the puppet's statement (23), the story continued. Kung Fu Panda successfully pushed two cars, but he failed with the biggest one. Then, the puppet produced test sentence (24).

(24)  Gongfuxiongmao neng tuidong renhe yi-ge   chezi.

    Kung Fu Panda    can   push     any   one-CL car

    'Kung Fu Panda was able to push any one of the cars'.

In contrast to (23), (24) contained *renhe* 'any' and it appeared in the scope of the modal verb *neng*. This configuration gives rise to a free choice (universal) inference. That is, Kung Fu Panda was able to push all of the cars on offer. If children computed the free choice inference, they were expected to reject (24) since Kung Fu Panda failed to push the biggest car.

The story continued. Because Grasshopper failed in the first competition, he proposed to have a fence-jumping competition. In the second competition, Kung Fu Panda successfully jumped over a low fence, but failed to jump over the other two big ones. Then, the puppet produced test sentence in (25).

(25)  Gongfuxiongmao neng tiaoguo renhe yi-ge    zhalan.

      Kung Fu Panda    can  jump    any  one-CL fence

      'Kung Fu Panda was able to jump over any one of the fences'.

Like (24), (25) gives rise to a free choice inference. That is, Kung Fu Panda was able to jump all of the fences. If children computed the free choice inference, they were expected to reject (25) since Kung Fu Panda failed to jump over two of the fences. Finally, Grasshopper jumped over all of the three fences. Then, the puppet produced test sentence (26).

(26) Zhameng     neng tiaoguo renhe yi-ge zhalan.

      Grasshopper can  jump    any one-CL fence

      'Grasshopper was able to jump over any one of the fences.'

Sentence (26) gives rise to a free choice inference. If children computed the free choice inference, they were expected to accept (26) since Grasshopper successfully jumped over all of the fences.

The findings were exactly as anticipated. Children accepted test sentences like (23) 100% of the time, but rejected ones like (25) 82% of the time. This pattern of responses indicated that children understood the semantic contribution of *renhe* 'any', since test sentences like (23) and (25) were presented in the similar scenarios and they differed only in the presence or absence of *renhe* 'any'. In addition, children rejected test sentences like (24) 83% of the time, but accepted ones like (26) 83% of the time. The main finding was that Mandarin-speaking children compute a universal free choice inference in affirmative sentences that contain the polarity sensitive expression *renhe* 'any' and the modal verb *neng* 'is able to'.

The present study investigated Mandarin-speaking children's computation of free choice inferences in sentences with internal versus external negation. Compared to previous research that used affirmative sentences, the present study assessed children's interpretation of negative sentences with the disjunction word *huozhe* 'or' and ones with the polarity sensitivity expression *renhe* 'any'.

## 3. Experiments

This section presents experimental studies on Mandarin-speaking children's computation of free choice (conjunctive/universal) inferences in sentences with internal versus external negation. There were five experiments. Experiment 1 examined whether English-speaking adults assign different interpretations to sentences with internal versus external negation. Experiments 2 and 3 investigated how Mandarin-speaking children interpret sentences with internal negation. The negative sentences in Experiment 2 contained the

disjunction word *huozhe* 'or' and a deontic modal verb. The negative sentences in Experiment 3 contained the polarity sensitive expression *renhe* 'any' and a deontic modal verb. Experiments 4 and 5 investigated how Mandarin-speaking children interpret sentences with external negation, introduced by the focus adverb *zhiyou* 'only'. The focus adverb *zhiyou* 'only' was combined with disjunction in Experiment 4, and it was combined with disjunction and a deontic modal verb in Experiment 5.

**3.1 Experiment 1**

Experiment 1 was designed to investigate English-speaking adults' interpretation of sentences with internal negation, such as (27), and sentences with external negation, such as (28).

(27)  It is true that Jack is not allowed to eat sushi or pasta.

(28)  It is not true that Jack is allowed to eat sushi or pasta.

**Participants**

Forty-two adult native-speakers of English were recruited through Amazon Mechanical Turk, and were paid $1 for their participation in the 10-minute experiment.

**Procedures**

The experiment was implemented and hosted on the Qualtrics platform. Participants were presented with an 'adult' version of the Truth Value Judgment Task. In the task, the participant was asked to read a series of short stories. After each story, s/he read a puppet's two descriptions about the story (each description was one sentence long). The participant's task was to judge whether or not the puppet said 'the right thing' about the story. If the participant judged that the puppet was right, then s/he was asked to click the

'Yes' button. Alternatively, if the participant judged that the puppet was wrong, then s/he was asked to click the 'No' button.

**Materials**

There were a total of 16 sentences. Four sentences were internal negation targets like (27), four were external negation targets like (28), and there were eight filler sentences. Four of the fillers were clearly true, as in (29) and four were clearly false, as in (30).

(29)   It is true that Jack is allowed to eat a cracker.

(30)   It is true that Jack is only allowed to eat pasta.

The 16 sentences were arranged into four different stories such that each story contained one test sentence with internal negation, or one with external negation, as well as one true filler or one false filler. To avoid carry-over effects, we adopted a between-subject design. 21 participants saw the internal negation targets. After each story, this group judged one test sentence with internal negation and one true filler. We will refer to these 21 participants as the internal negation group. After each story, the remaining 21 participants judged one test sentence with external negation and one false filler. These participants will be called the external negation group. Here is a typical story.

> *Mr. Tiger, Mr. Horse, and Mr. Hippo are weight-lifting athletes, and their diet is strictly monitored by their coach. It is lunch time. The coach explains to each of the athletes what he is allowed to eat, and what he is not allowed to eat. The coach says: "for today's lunch, there is sushi and pasta. There is also a cracker for a snack. I know everyone loves sushi and pasta. However, I will tell you what you can eat and what you cannot eat. OK, Mr. Tiger, let me look at you. It seems that*

*you are gaining weight. You could eat nothing. However, you have tried very hard to control your weight. I don't want you to become weak, so you can eat sushi. You cannot eat pasta because it may increase your weight. (The coach puts the sushi in front of Mr. Tiger.) Mr. Horse, let me look at you next. Mr. Horse, you are looking very fit. You are doing a good job with your training. So, you can eat sushi. You can eat pasta. It's up to you. (The coach puts the sushi and the pasta in front of Mr. Horse.) Mr. Hippo, you are next. Mr. Hippo, you are exceeding your weight class. You are eating too much. So, you cannot eat sushi. You cannot eat pasta. You can have a cracker." (The coach puts the cracker in front of Mr. Hippo.)*

*Mr. Tiger          Mr. Horse          Mr. Hippo*

*s          s & p          c*

*Kermit says: "I know what happened in the story…"*

At that point, the internal negation group judged the target in (31) and the true filler in (32).

(31) It is true that Mr. Tiger is not allowed to eat sushi or pasta.

(32) It is true that Mr. Hippo is allowed to eat a cracker.

By contrast, the external negation group judged the target in (33) and the false filler in (34).

(33) It is not true that Mr. Tiger is allowed to eat sushi or pasta.

(34) It is true that Mr. Horse is only allowed to eat pasta.

The test sentences with internal negation were expected to receive negative judgments, so it was important for us to ensure that our test stories met the felicity conditions for the use of negation (cf. Crain & Thornton 1998). For this purpose, we adopted the research strategy advocated by Crain, Thornton, Boster, Conway, Lillo-Martin, and Woodams (1996) who refer to the felicity conditions associated with negation as the Condition of Plausible Dissent. According to the Condition of Plausible Dissent, a negative judgement is appropriate only when the corresponding positive judgement is under consideration in the discourse context. To satisfy this condition, all of the test stories contained a discrepancy that was created between the possible outcome and the actual outcome. In the example story, the possible outcome was that Mr. Tiger would not be allowed to eat sushi and he would not be allowed to eat pasta. The actual outcome was that Mr. Tiger was allowed to eat sushi. Adding the possible outcome enabled us to satisfy the Condition of Plausible Dissent.

**Experimental hypothesis**

The internal negation group was expected to reject the target sentence in (31) if they computed a conjunctive entailment (the 'neither' interpretation), since Mr. Tiger was permitted to eat sushi. The internal negation group was expected to accept (31) if they generated a negated conjunctive inference (the 'not both' interpretation). By contrast, the external negation group was expected to accept the target sentence in (33) if they generated a negated conjunctive inference (the 'not both' interpretation), and this group was expected to reject (33) if they computed a conjunctive entailment (the 'neither' interpretation). Finally, the internal group was expected to accept the filler in (32), but the external group was expected to reject the filler in (34). Together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials.

**Results**

Two participants were excluded for failing to score 80%[6] correct on the true/false filler sentences, leaving 20 participants in the internal negation group and 20 in the external negation group. A summary of the responses by both groups to the target sentences is provided in Table 1.

| Group | Response Type | |
|---|---|---|
| | 'Yes' Responses (%) | 'No' Responses (%) |
| Internal negation group | 4  (3/80 trials) | 96  (77/80 trials) |
| External negation group | 70 (56/80 trials) | 30  (24/80 trials) |

**Table 1** English-speaking Adults' Percentages of Each Response Type to the Targets

As Table 1 shows, the internal negation group rejected the target sentences 96% of the time, whereas the external negation group accepted the target sentences 70% of the time[7]. A Mann Whitney test on the No-responses to the target sentences revealed a significant effect between groups (Z = 4.78, p < .001). In summary, the findings were twofold. Most English-speaking adults we tested computed a conjunctive entailment (the 'neither' interpretation) in sentences in which negation was in the same clause as disjunction and a deontic modal verb. By contrast, most English-speaking adults we tested computed a

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[6] As an exclusion criterion, participants who scored less than 80% correct on the filler or control sentences would be excluded in the final data analysis. The exclusion criterion was applied in all of the five experiments in the present study.

[7] The 30% reduction in acceptances by the external negation group is taken as evidence that the adult participants cancelled free choice inferences even in sentences with external negation. For these adult participants, there is no distinction between internal negation and external negation, so they generated a 'neither' interpretation even from sentences with external negation.

negated conjunctive inference (the 'not both' interpretation) in sentences in which negation resided outside the clause that contained disjunction and a deontic modal verb. The findings reveal that English-speaking adults typically cancel free choice (conjunctive) inferences in sentences with internal negation, but preserve such inferences in sentences with external negation.

As we saw, the position of negation determines whether free choice inferences are licensed in English sentences with negation. This distinction between internal and external negation in lcensing free choice inferences is expected to exist in Mandarin Chinese as well. In what follows, we turn to Mandarin-speaking children's computation of free choice (conjunctive/universal) inferences in sentences with internal versus external negation.

## 2.2 Experiment 2

Experiment 2 was designed to investigate Mandarin-speaking children's interpretation of sentences with internal negation. A typical test sentence is illustrated in (35), where the negation marker *mei* 'not' appears in the same clause as the deontic modal verb *beiyunxu* 'was allowed to' and the disjunction word *huozhe* 'or'.

(35) Zhangsan mei beiyunxu   chi yidalimian huozhe jirou.

    Zhangsan Neg PM allow eat pasta       or       chicken

**Participants**

We tested twenty-two Mandarin-speaking children who ranged in age from 4;9 (years; months) to 5;8, with a mean age of 5;4. The children were recruited from a kindergarten affiliated with Hubei University of Technology (HBUT), Wuhan, China. We also tested twenty Mandarin-speaking adults, who were undergraduate students at HBUT.

**Procedures**

This experiment used a Truth Value Judgment Task. Two experimenters were involved in the task. One experimenter acted out stories with toy characters and props, while the other experimenter manipulated a puppet, Kermit the frog. The child watched the acted-out story alongside Kermit. At the end of the story, Kermit described what had happened in the story, using a test sentence. The child's task was to judge whether Kermit's description was right or wrong. If the child indicated what Kermit had said was wrong, then s/he was asked to explain what had really happened in the story.

The child participants were first introduced to the task as a group. Then they were tested individually in a quiet room. Before the main test session, each child was familiarised with the task through a practice trial. On the practice trial, there were two sentences. One was designed to elicit a 'Yes' response and the other was designed to elicit a 'No' response. All children responded correctly on the practice trial, indicating they understood the task very clearly.

In the main test session, the child participants received four trials. The adult participants directly began the main session without any practice trials. In the main session, they were tested on the same four trials as children, but using a videotaped version of the stories. On each trial, the adult participants were asked to indicate on an answer sheet whether Kermit had said 'the right thing'. If they judged that Kermit was wrong, they were instructed to explain why they judged Kermit to be wrong.

**Materials**

Participants heard a total of eight sentences: four were targets such as (35) and four were clearly true fillers such as (36).

(36) Wo zhidao yijian shiqing: Zhangsan beiyunxu chi shousi.

    I   know one-CL thing:   Zhangsan PM allow eat sushi

    'I know one thing: Zhangsan was allowed to eat sushi.'

The eight sentences were evenly distributed across four test stories so that after each story, participants had to judge one target and one true filler. To illustrate, here is a typical story.

*This is a story about Batman and Superman. Batman was training to become a better superhero, and he had asked Superman to help him get in shape. Superman said, "Batman, if you want to be a better superhero, you will have to lose weight. You are eating too much, and you must go on a strict diet. For today's lunch, there are three dishes: sushi, pasta and chicken. (see Fig. 1) Batman, you are only allowed to eat sushi. You cannot eat pasta, and you cannot eat chicken." (see Fig. 2) But Batman said, "Superman, I can't just eat sushi. I will be too weak to be a superhero. Please let me eat one more thing." Superman said, "OK, Batman, you are allowed to eat one more thing: there is pasta and there is chicken. You can choose one of them, but not both." (see Fig. 3) Batman was a shy boy, so he took the three dishes into a dining room, where he could hide up his table manners. Batman said to himself: "I love sushi very much, so I will eat the sushi first. Hmmm, the sushi is yummy!" After that, he ate a second dish and returned with two empty plates to show Superman. (see Fig. 4) Batman said, "Superman, I am still hungry. Can I eat the third dish?" Superman replied, "No, you will gain weight if you eat too much." Batman said reluctantly, "OK, Superman, I will follow your instructions!"*

Fig. 1 Food Options        Fig. 2 Rule One



Fig. 3 Rule Two        Fig. 4 The Last Scene

When the story concluded, the experimenter first asked Kermit to say what Batman was allowed to eat. At that point, Kermit produced the filler sentence in (37).

(37)  Wo zhidao yijian  shiqing: bianfuxia bei yunxu chi shousi.

    I   know one-CL thing:   Batman   PM allow eat sushi

    'I know one thing: Batman was allowed to eat sushi.'

Following that, the experimenter asked Kermit to say what Batman wasn't allowed to eat in the end. Then, Kermit produced the target sentence in (38).

(38) Bianfuxia mei bei yunxu chi yidalimian huozhe jirou.

    Batman   Neg PM allow eat pasta       or      chicken

    a. **Expected child interpretation**: 'Batman wasn't allowed to eat pasta or chicken.'

b. **Expected adult interpretation**: 'It was pasta or chicken that Batman was not allowed to eat.'

Since Batman had eaten the second dish in the dining room, Kermit and the participant didn't witness what exactly he ate. Because they were ignorant of which dish (pasta or chicken) Batman didn't eat, it was felicitous for Kermit to use the disjunction word *huozhe* 'or'.

As the targets also involved negative judgments, it was important for us to ensure that our test stories met the Condition of Plausible Dissent. As in Experiment 1, all of the test stories included a discrepancy that was created between the possible outcome and the actual outcome. For example, in the given story, it was made clear to the participants that it was possible that Batman wouldn't be allowed to eat pasta or chicken. The actual outcome was that Batman was allowed to eat either pasta or chicken. Adding the possible outcome enabled us to satisfy the Condition of Plausible Dissent.

**Experimental hypotheses**

The child participants were expected to compute a conjunctive entailment (the 'neither' reading) if they cancelled the free choice (conjunctive) inferences in the test sentences. For example, children were expected to interpret (38) as having the meaning in (38a). Therefore, they were expected to reject (38), because the meaning in (38a) is inconsistent with the actual outcome - Batman was allowed to eat either pasta or chicken. However, they were expected to accept (38) if they generated a 'not both' interpretation.

In contrast to children, we anticipated adults to assign a different interpretation. For adults, sentences like (38) were expected to generate a 'not both' interpretation, because disjunction is analysed as a PPI in adult Mandarin. Therefore, adults were expected to

interpret (38) as having the meaning in (38b). Therefore, they were expected to accept (38), because the meaning in (38b) is consistent with the actual outcome. Alternatively, they were expected to reject (38) if they computed a conjunctive entailment (the 'neither' reading). Finally, the filler sentence (37) was clearly true, so both children and adults were expected to accept it.

**Results**

Two child participants were excluded for failing to score 80% correct on the true fillers, leaving a total of 20 child participants. All of the adult participants responded correctly to the fillers 100% of the time, so the data from 20 children and 20 adults were included in the analysis. A summary of their responses to the targets is provided in Table 2.

| Group | Response Type | |
|---|---|---|
| | 'Yes' Responses (%) | 'No' Responses (%) |
| Children | 29 (23/80 trials) | 71 (57/80 trials) |
| Adults | 70 (56/80 trials) | 30 (24/80 trials) |

**Table 2** Children's and Adults' Percentages of Each Response Type to the targets

As Table 2 indicates, children rejected the target sentences 71% of the time. For example, children rejected (38) on the grounds that Batman was allowed to eat either pasta or chicken. By contrast, adults accepted the target sentences 70% of the time. A Mann-Whitney test on the No-responses to the target sentences indicated a significant difference between groups ($z = 3.138$, $p = .001$).

In summary, Mandarin-speaking children computed a conjunctive entailment (the 'neither' reading) in sentences in which negation was in the same clause as disjunction and a deontic modal verb. This suggests that Mandarin-speaking children cancel free choice (conjunctive) inferences associated with disjunction in sentences with internal negation. By contrast, Mandarin-speaking adults generated a 'not both' interpretation in response to the same sentences. This reflects the fact that that disjunction is analysed as a PPI in adult Mandarin, so it is interpreted as taking scope over negation and the deontic modal verb.

## 2.3 Experiment 3

Experiment 3 was devised to investigate Mandarin-speaking children's interpretation of sentences with internal negation and the polarity sensitive expression *renhe* 'any'. A typical test sentence is illustrated in (39), where the negation marker *bu* 'not' appears in the same clause as the deontic modal verb *keyi* 'is allowed to' and the polarity sensitive expression *renhe* 'any'.

(39) Zhangsan  bu   keyi  chi lanzi   li      de  renhe yi-zhong shuiguo.

    Zhangsan  Neg may  eat basket  inside  DE any   one-CL   fruit

    'Zhangsan is not allowed to any kind of fruit in the basket.'

## Participants

We tested twenty-two Mandarin-speaking children between the ages of 4;9 and 5;8, with a mean age of 5;4. The child participants were recruited from a kindergarten affiliated with Hubei University of Technology (HBUT), Wuhan, China. We also tested twenty Mandarin-speaking adults, who were undergraduate students at HBUT.

**Procedures**

Participants completed a Truth Value Judgment Task. Notice that the test sentences contained the word *zhong* 'kind', which the child participants might not understand. In order to see whether the child participants understood the meaning of *zhong* 'kind', they were invited to participate in a pre-test. In the pre-test, the experimenter placed two different kinds of fruits (e.g., an apple and a pear) on the table on one trial, but placed two fruits of the same kind on the table (e.g., two apples) on the other trial. On both trials, the experimenter asked the puppet (manipulated by another experimenter), "*Zhuoshang you jizhong shuiguo*?" ("How many kinds of fruits are there on the table?") Then the puppet replied either "*Liangzhong*" ("Two kinds") or "*Yizhong*" ("one kind"). The child's task was to judge whether or not the puppet provided the right answer. Note that the puppet's response was true on one trial but false on the other. The correct judgements by the child participants were used as an indicator that they understood the meaning of *zhong* 'kind'. All twenty-two children provided correct judgments on the two trials, indicating they understood the meaning of *zhong* 'kind' clearly.

The pre-test also included two trials to determine whether or not the child participants understood the meaning of *renhe* 'any'. On each trial, the child participants were presented with a minimal pair of test sentences, namely one with *renhe* versus one without *renhe*. The presence or absence of *renhe* resulted in different truth-values for adult speakers of Mandarin. Therefore, children's different truth-value judgments in responses to the two sentences could be used as evidence that they understood the semantic contribution of *renhe* (Huang & Crain 2014). Here is a typical trial.

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

Being very forgetful, the small monkey and the big monkey forgot Mr. Owl's rules. So, they asked the puppet to remind them of the rules when they were about to start training. At that point, the puppet produced sentences (40) and (41).

(40) Xiao houzi    keyi pa    yi-ke    shu.

Small monkey may climb one-CL tree

'The small monkey is allowed to climb one of the trees.'

(41) Da  houzi    keyi pa    renhe yi-ke   shu.

Big monkey may climb any    one-CL tree

'The big monkey is allowed to climb any one of the trees.'

In (40), the indefinite NP *yi ke shu* 'one-CL-tree' is combined with the deontic modal verb *keyi* 'is allowed to'. Without *renhe*, the sentence simply means that the small monkey is allowed to climb one of the trees, which is consistent with Mr. Owl's rules. Therefore, children were expected to accept (40). By contrast, (41) contains *renhe,* and the existential expression *renhe yi-ke shu* 'any + one-CL-tree' is embedded under the

deontic modal verb *keyi*. This configuration gives rise to a universal free choice inference. That is, (41) implies that the big monkey is permitted to climb all of the trees on offer, which is inconsistent with Mr. Owl's rules. Therefore, children were expected to reject (41) if they understood the meaning of *renhe*.

Twenty out of twenty-two children responded correctly to the two types of test sentences, indicating that they computed the meaning of *renhe*. Therefore, only these children proceeded to the main test session. The adult participants were directly tested on the main session without any pre-tests. During the main test session, both children and adults were tested using the same procedures as in Experiment 2.

**Materials**

The main test phase consisted of 16 sentences in total, eight target sentences and eight control sentences. The target sentences had the same form, with the negation maker *bu* 'not' in the same clause as the deontic modal verb phrase *keyi* 'is allowed to' and the polarity sensitive expression *renhe* 'any'. The stories were created to make four of the targets true on the conjunctive entailment reading (hereafter, CE targets), but the other four targets true on the negated universal (free choice) reading (hereafter, NU targets). The eight control trials corresponded to clearly true or clearly false sentences containing the deontic modal verb phrase *keyi*; four were positive, as in (42), and four were negative, as in (43).

(42) Zhangsansan keyi chi lanzi  li    de    renhe yi-zhong shuiguo.

   Zhangsan    may eat basket inside DE   any   one-CL   fruit

   'Zhangsan is allowed to eat any kind of fruit in the basket.'

(43) San-zhi gou   dou bu   keyi chi lanzi   li    de    shuiguo.

   Three-CL dog all  Neg   may eat basket inside  DE    fruit

'None of the three dogs are allowed to eat the fruits in the basket.'

The 16 sentences were evenly distributed across four test stories, so that after each story, participants judged one CE target, one NU target, one positive control, and one negative control. A typical story is used to illustrate.

*This is a story about Fit Goat, Beauty Goat, Lazy Goat and Mayor Goat. The four goats picked a basket of fruits from an orchard. There were apples, strawberries and pears in the basket. Mayor Goat was responsible for distributing the fruits to the three goats* (see Fig. 5). *After careful consideration, Mayor Goat said, "Beauty Goat, you are too slim, and you need to supplement your diet with different kinds of nutrients. So, you are allowed to eat all three kinds of fruits. Fit Goat, you are very fit and it's possible that you will gain weight. So, you should not eat too much. You are allowed to eat one kind or two kinds of fruits, but you are not allowed to eat all three kinds of fruits. Lazy Goat, you didn't help us pick the fruits. No pain, no gain. So, you are not allowed to eat a single fruit."*



Fig. 5                                        Fig. 6

After Mayor Goat established the rules, he put a sign with the numbers "3", "1 or 2", and "0" respectively in front of Beauty Goat, Fit Goat, and Lazy Goat. The numbers actually served as a reminder of the rules (see Fig. 6). Then the story continued. Even though Mayor Goat had set up the rules very clearly, the three goats were very forgetful, so they

asked the puppet to remind them of the rules when they started to eat the fruits. At that point, participants judged four sentences produced by the puppet, as indicated in (44)-(47).

(44) Meiyangyang keyi chi lanzi li de renhe yi-zhong shuiguo.

Beauty Goat may eat basket inside DE any one-CL fruit

'Beauty Goat is allowed to eat any kind of fruit in the basket.'

(45) Feiyangyang bu keyi chi lanzi li de renhe yi-zhong shuiguo.

Fit Goat Neg may eat basket inside DE any one-CL fruit

'Fit Goat is not allowed to eat any kind of fruit in the basket.'

(46) Lanyangyang bu keyi chi lanzi li de renhe yi-zhong shuiguo.

Lazy Goat Neg may eat basket inside DE any one-CL fruit

'Lazy Goat is not allowed to eat any kind of fruit in the basket.'

(47) San-zhi yang dou bu keyi chi lanzi li de shuiguo.

Three -CL goat all Neg may eat basket inside DE fruit

'None of the three goats are allowed to eat the fruits in the basket.'

**Experimental hypotheses**

As we can see, the above story made the positive control in (44) clearly true and the negative control in (47) clearly false. Therefore, participants were expected to accept (44), but reject (47). As for the targets, participants were expected to accept the CE target in (46) if they computed the conjunctive entailment, since Lazy Goat indeed was prohibited from eating any of the fruit. By contrast, participants were expected to reject the NU target in (45) if they computed a conjunctive entailment, since Fit Goat was permitted to eat one kind or two kinds of fruits. Alternatively, if participants computed a negated universal inference from the targets, they were expected to accept the NU target in (45),

but reject the CE target in (46). Considered together, the expected number of 'Yes' responses and 'No' responses was counterbalanced across trials.

**Results**

The child participants correctly accepted the positive controls 99% of the time (adults did so 98% of time), and they correctly rejected the negative controls 99% of the time (adults did so 100% of the time). Therefore, the responses for all of the child and adult participants were included in the analysis. Table 3 summarises the pattern of responses from the two groups to the targets.

| Response Type | Group | |
|---|---|---|
| | Children | Adults |
| 'Yes' Response for the CE Targets | 100% (80/80 trials) | 98% (78/80 trials) |
| 'No' Response for the NU Targets | 93% (74/80 trials) | 100% (80/80 trials) |

**Table 3** Children's and Adults' Percentages of Each Response Type to the targets

As indicated in Table 3, children rejected the NU targets 93% of the time, and adults rejected them 100% of the time. For example, both children and adults consistently rejected (45) on the grounds that Fit Goat is allowed to eat one kind or two kinds of fruits in the basket. A Mann-Whitney test on the No-responses to the NU targets revealed no significant differences between groups ($z = 2.08$, $p = 0.106$). By contrast, children accepted the CE targets 100% of the time, and adults accepted them 98% of the time. A Mann-Whitney test on the Yes-responses to the CE targets revealed no significant difference between groups ($z = 1.433$, $p = 0.487$).

In summary, both Mandarin-speaking children and adults generated a conjunctive entailment rather than a negated universal (free choice) reading from the target sentences. The findings suggest that both Mandarin-speaking children and adults cancel universal (free choice) inferences associated with *renhe* 'any' in sentences with internal negation.

Turning next to Experiments 4 and 5, we aimed to investigate how Mandarin-speaking children interpret sentences with external negation. We focused on external negation introduced by the focus adverb *zhiyou* 'only'. More specifically, the experiments contrasted minimal pairs of sentences, namely disjunctive sentences with *zhiyou* 'only' alone versus ones with *zhiyou* 'only' and the deontic modal verb *keyi* 'is allowed to'. A typical minimal pair of test sentences is illustrated in (48) and (49).

(48) Zhiyou Zhangsan  chi-le    yidalimian huozhe shousi.

   Only    Zhangsan  eat-ASP pasta        or        sushi

   'Only Zhangsan ate pasta or sushi.

(49) Zhiyou Zhangsan keyi chi yidalimian huozhe shousi.

   Only    Zhangsan may eat pasta        or        sushi

   'Only Zhangsan is allowed to eat pasta or sushi.'

We anticipated that both Mandarin-speaking children and adults would assign a conjunctive entailment (the 'neither' interpretation) to sentences like (48). This experimental hypothesis was evaluated in Experiment 4. By contrast, we expected that both Mandarin-speaking children and adults would generate a negated conjunctive (free choice) inference (the 'not both' interpretation) in sentences like (49). This experimental hypothesis was evaluated in Experiment 5.

**2.4 Experiment 4**

**Participants**

We tested 26 Mandarin-speaking children between the ages of 4;2 and 5;2, with a mean age of 4;7. The child participants were recruited from a kindergarten affiliated with Beijing Language and Culture University, Beijing, China. We also tested 20 Mandarin-speaking adults, who were undergraduate students at Hubei University of Technology, Wuhan, China.

**Procedures**

Participants were tested using the same methodology and procedures as in Experiment 2.

**Materials**

Participants heard a total of eight sentences: four were targets, as in (48) and four were fillers, as in (50).

(50) Zhangsan bi Lisi qiangzhuang.

    Zhangsan to Lisi strong

   'Zhangsan is stronger than Lisi.'

The eight sentences were evenly distributed across four test stories so that after each story, participants judged one target and one filler. To illustrate, here is a typical story.

*This is a story about a big pirate and a small pirate. The big pirate and the small pirate had a coral-planting game. Mr. Owl was the judge. He set the rules first. Mr. Owl said to the big pirate "Big Pirate, you are very strong. So you are allowed to plant coral near the red mermaid and you are allowed to plant coral near the green mermaid"* (see Fig. 7). *Mr. Owl then said to the small pirate "Small Pirate, you are much weaker than Big Pirate. So you are allowed to plant*

*coral near the green mermaid, but you are not allowed to plant coral near the red mermaid"* (see Fig. 8). *Both the big pirate and the small pirate were very forgetful. They forgot the rules when they were about to start the game. So, they asked the puppet to remind them of the rules.*



Fig. 7                                                    Fig. 8

In the end, the big pirate planted coral near the red mermaid and the green mermaid, and the small pirate planted coral near the green mermaid. When the story concluded, the puppet said: "I wasn't paying attention just now, so I don't remember what exactly happened in end of the story. But I guess…"[8] At that point, he produced the target in (51) and the filler in (52).

(51) Zhiyou dahaidao zai hongse huozhe lüse  meirenyu bianshang zhong-le    shanhu.

   Only   big pirate at red        or     green mermaid side        plant-ASP  coral

   'Only the big pirate planted coral near the red mermaid or the green mermaid.'

(52) Dahaidao bi  xiaohaidao qiangzhuang.

   Big pirate to small pirate strong

   'The big pirate is stronger than the small pirate.'

**Experimental hypotheses**

We anticipated that the participants would generate a conjunctive entailment (the 'neither' interpretation) in response to target sentences such as (51). As discussed, the focus adverb

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

*zhiyou* 'only' in (51) contributes two meaning components. The presupposition expresses the content without the focus adverb *zhiyou* 'only'. This meaning component can be expressed as follows: *The big pirate planted coral near the red mermaid or the green mermaid*. The assertion entails that none of the individuals in the contrast set (alternatives to the big pirate) planted coral near the red mermaid or the green mermaid. In the assertion, the focus adverb introduces external negation. As external negation cancels the polarity sensitivity of the disjunction word *huozhe* 'or', both children and adults were expected to generate a conjunctive entailment, which can be paraphrased as: *Nobody else planted coral near the red mermaid and nobody else planted coral near the green mermaid*. Therefore, both children and adults were expected to reject the target sentence in (51) on the grounds that the small pirate planted coral near the green mermaid. Alternatively, they were expected to accept (51) if they did not compute a conjunctive entailment. Finally, the filler in (52) was clearly true, so participants were expected to accept it. Taken together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials.

**Results**

Children accepted filler sentences like (52) 100% of the time. Adults accepted them 95% of the time. Therefore, the data of both groups were included in the analysis. A summary of children's and adults' responses to the targets is provided in Table 4.

| Response Type | Children | Adults |
|---|---|---|
| 'Yes' | 14% (15/104 trials) | 12% (10/80 trials) |
| 'No' | 86% (89/104 trials) | 88% (70/80 trials) |

**Table 4** Children's and Adults' Percentages of Each Response Type to the Targets

As shown in Table 4, children rejected the target sentences 86% of the time, and adults rejected them 88% of the time. When asked for justifications for their rejections, both children and adults made reference to the fact that the other character also performed one of the two actions mentioned in the target sentences. For example, both children and adults justified their rejections to (51) by pointing out the fact that the small pirate also planted coral near the green mermaid. A Mann-Whitney test on the No-responses to the target sentences revealed no significant difference between groups ($z = 0.919$, p = .358). The findings suggest that both Mandarin-speaking children and adults generate a conjunctive entailment (the 'neither' interpretation) from disjunctive sentences that contain the focus adverb *zhiyou* 'only'.

## 2.5 Experiment 5

### Participants

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

### Procedures

Participants were tested with the same methodology and procedures as Experiment 2.

### Materials

We used the same test stories as in Experiment 4. Participants heard a total of eight sentences: four were targets, as in (49) and four were fillers, as in (53).

(53) Zhiyou Zhangsan keyi chi shousi.

    Only    Zhangsan may eat sushi

    'Only Zhangsan is allowed to eat sushi.'

The eight sentences were evenly distributed across the same four test stories so that participants judged one target and one filler in each story. The target sentences in Experiment 5 contained one additional expression, as compared to Experiment 4, namely the deontic modal verb *keyi* 'is allowed to'. In addition, the target sentences in Experiment 5 were presented immediately after the judge established the rules. In the example story, even though the judge, Mr. Owl, set up the rules, the two pirates were very forgetful. When they were about to start the game, they forgot the rules, and they asked the puppet to remind them. At that point, the puppet produced the target in (54) and the filler in (55).

(54) Zhiyou dahaidao   keyi zai hongse huozhe lüse   meirenyu bianshang zhong   shanhu.

    Only   big pirate  may at  red     or      green mermaid  side      plant   coral

    'Only the big pirate is allowed to plant coral near the red or the green mermaid.'

(55) Zhiyou xiaohaidao  keyi zai lüse  meirenyu bianshang zhong shanhu.

    Only   small pirate may at  green mermaid side       plant  coral

    'Only the small pirate is allowed to plant coral near the green mermaid.'

**Experimental hypotheses**

We anticipated that the participants would generate a negated free choice (conjunctive) inference (the 'not both' interpretation) in response to the target sentences like (54). The focus adverb *zhiyou* 'only' in (54) contributes two meaning components. The presupposition can be paraphrased as follows: *The big pirate is allowed to plant coral*

*near the red mermaid or the green mermaid*. Due to the presence of the deontic modal verb, the presupposition licenses a free choice (conjunctive) inference: *The big pirate is allowed to plant coral near the red mermaid and the big pirate is allowed to plant coral near the green mermaid*. The assertion entails that it is not true that any member of the set of individuals being contrasted with the big pirate is allowed to plant coral near the red mermaid and the green mermaid. This 'not both' interpretation is consistent with the fact that the small pirate is only allowed to plant coral near the green mermaid. Therefore, participants were expected to accept the target in (54). Alternatively, participants were expected to reject (54) if they computed a conjunctive entailment (the 'neither' interpretation). Finally, the filler in (55) was clearly false, so participants were expected to reject it. Taken together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials.

**Results**

Children correctly rejected fillers like (55) 97% of the time, and adults did so 100% of the time. When asked for justifications for their rejections, both children and adults made reference to the fact that the other character also performed the action mentioned in the test sentences. For example, both children and adults justified their rejections to (55) by pointing out the fact that the big pirate was also allowed to plant coral near the green mermaid. Therefore, all their data were included in the final analysis. Table 5 provides a summary of children's and adults' responses to the target sentences.

| Response Type | Children | Adults |
| --- | --- | --- |
| 'Yes' | 92% (92/100 trials) | 78% (62/80 trials) |
| 'No' | 8% (8/100 trials) | 22% (18/80 trials) |

**Table 5** Children's and Adults' Percentages of Each Response Type to the Targets

As indicated in Table 5, children accepted the target sentences 92% of the time, and adults accepted them 78% of the time. A Mann-Whitney test on the Yes-responses to the target sentences revealed no significant difference between groups ($z = .739$, p = .46). In summary, the findings suggest that both Mandarin-speaking children and adults generate a negated free choice (conjunctive) inference (the 'not both' interpretation) from disjunctive sentences that contain the focus adverb *zhiyou* 'only' and the deontic modal verb *keyi* 'is allowed to'.

## 4. General discussion

The present study investigated 5-year-old Mandarin-speaking children's computation of free choice (conjunctive/universal) inferences in sentences with negation. The ambiguist account of negation markers predicts that free choice inferences are cancelled in sentences with internal negation, but preserved in sentences with external negation. To assess this prediction, we conducted five experiments.

Experiment 1 examined English-speaking adults' interpretation of sentences with internal negation such as (56) and ones with external negation such as (57).

(56) It is true that John is not allowed to order beer or wine.
(57) It is not true that John is allowed to order beer or wine.

It was found that English speaking adults computed a conjunctive entailment (the 'neither' interpretation) in sentences like (56), but a negated free choice (conjunctive) inference (the 'not both' interpretation) in sentences like (57). On the one hand, the findings indicate that English-speaking adults cancel free choice (conjunctive) inferences in sentences with internal negation. This provides experimental evidence supporting the

inferential account of the so-called free choice paradox, according to which free choice inferences are typically cancelled in sentences with internal negation (Chierchia 2013, 2017). The findings do not conform to the semantic account of the so-called free choice paradox (Aloni 2004, 2007; Geurts 2005; Zimmermann 2000), according to which conjunctive interpretations are entailments rather than inferences, such that the conjunctive interpretations should be preserved under (internal) negation. This would result in a 'not both' interpretation rather a 'neither' interpretation.

On the other hand, the findings suggest that English-speaking adult understand that free choice inferences are preserved in sentences with external negation. Taken together, the findings provide evidence supporting the prediction of the ambiguist account of negation markers (Bar-Asher Siegal 2015; Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006), according to which free choice (conjunctive) inferences are typically cancelled in sentences with internal negation, but are preserved in sentences with external negation.

To further assess the prediction of the ambiguist account, we conducted another four experiments investigating how Mandarin-speaking children and adults interpret sentences with internal versus external negation. Mandarin is a useful language in assessing when speakers do and do not license free choice inferences, because disjunction is analysed by adult speakers as taking scope over internal negation. In contrast to adults, Mandarin-speaking children analyse both internal and external negation as taking scope over disjunction. This leads to an intricate pattern of linguistic behaviours, where children and adults sometimes, but not always, generate the same scope assignments for sentences with negation.

Experiment 2 investigated how children and adults interpret sentences with internal negation that contained the deontic modal verb *beiyunxu* 'was allowed to' and the

disjunction word *huozhe* 'or'. The findings were twofold. The child participants computed a conjunctive entailment (the neither' reading) in response to such sentences, suggesting that they cancelled the free choice (conjunctive) inferences. This mirrors the fact that Mandarin-speaking children do not initially analyse disjunction as a Positive Polarity Item (PPI). By contrast, the adult participants generated a 'not both' interpretation in response to the same sentences. This indicates that Mandarin-speaking adults analyse disjunction as a PPI and thus interpret disjunction as taking scope over both negation and the deontic modal verb. To some extent, the findings replicated the results of previous studies on both children's and adults' interpretation of simple negative sentences with disjunction by Goro and Akiba (2004a, b) for Japanese, by Notley, Zhou, Jensen and Crain (2012) for Mandarin Chinese, and by Szabolcsi (2002) for Hungarian.

Experiment 3 assessed the interpretation assigned by both children and adults to sentences in which the disjunction word *huozhe* 'or' is replaced by the polarity sensitive expression *renhe* 'any'. Unlike *huozhe* 'or', *renhe* 'any' is an NPI, which has to be interpreted within the scope of a (downward entailing) licensor (cf. Carlson 1980; Chierchia 2006; Ladusaw 1980; Kadmon & Landman 1993). Therefore, both Mandarin-speaking children and adults computed the same conjunctive entailment (the 'none' interpretation) in Experiment 3. The findings suggest that both children and adults cancel free choice inferences associated with *renhe* in sentences with internal negation.

Experiment 4 and 5 investigated a linguistic structure that introduces external negation, namely sentences with the focus adverb *zhiyou* 'only'. In Experiment 4, both children and adults were presented with sentences that contained the focus adverb *zhiyou* 'only' and the disjunction word *huozhe* 'or'. The focus adverb *zhiyou* 'only' contributes two components to sentence meaning: one positive and one negative. The positive meaning component is the presupposition that expresses the content of the original sentence, but

without the focus adverb. The negative meaning component is called the assertion. The assertion entails that it is not true that any member of the set of individuals being contrasted with the focus element has the property attributed to the focus element. In the assertion, the focus adverb introduces (covert) external negation. External negation is expected to cancel the polarity sensitivity of linguistic expressions. The polarity sensitivity of disjunction is cancelled, so it is interpreted *in situ*. Therefore, both children and adults generated a conjunctive entailment (the 'neither' interpretation) in Experiment 4.

In Experiment 5, the deontic modal verb *keyi* 'is allowed to' is added in the test sentences. Due to the addition of the deontic modal verb, the presupposition generates a free choice (conjunctive) inference. The assertion entails that it is not true that any member of the set of individuals being contrasted with the focus element has the property contributed to the focus element. In the assertion, the focus adverb *zhiyou* 'only' introduces external negation. The free choice (conjunctive) inference is preserved under external negation, though it is negated. Therefore, both children and adults generated a negated free choice inference (the 'not both' interpretation) in Experiment 5.

Taken together, the findings reveal that 5-year-old Mandarin-speaking children know that the position of negation determines whether or not free choice inferences are licensed in sentences with negation. More specifically, they know that free choice inferences associated with *huozhe* 'or' and *renhe* 'any' are cancelled in sentences with internal negation. They also know that free choice (conjunctive) inferences associated with *huozhe* 'or' are preserved in sentences with external negation, introduced by the focus adverb *zhiyou* 'only'. However, adults add complexity to the picture. Adults assign a 'not both' interpretation to disjunction in sentences with internal negation. On the surface, the interpretation is equivalent to a negated conjunctive inference, but it is actually a matter

of scope assignment between negation and disjunction. This assumption is attested by the fact that Mandarin-speaking adults cancel the free choice inferences associated with *renhe* in sentences with internal negation. This is because *renhe* is not a PPI and it must be interpreted within the scope of internal negation.

The findings also provide experimental evidence supporting the ambiguist account of negation markers (Bar-Asher Siegal 2015; Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006). The question remains: How do children acquire the different patterns of entailments and inferences that we observed in these experiments? An innateness account to language acquisition contends that children are endowed with the linguistic knowledge of the meanings of basic logical expressions and that these meanings are consistent with the truth conditions associated with the corresponding expressions in classical logic (Crain 2008, 2012; Crain & Khlentzos, 2008, 2012). The semantic meanings of logical expressions are considered to be part of a Universal Grammar (Chomsky 1965) that children draw upon in the course of language development (Crain, Gualmini & Pietroski 2005; Crain & Pietroski 2001).

By contrast, a usage-based account to language acquisition argues that child language is expected to match that of adult language. In other words, the usage-based approach is characterized as an 'input-matching' model of development (Lieven & Tomasello 2008, p. 171). The usage-based account predicts that children acquire the different inferences and entailments that we observed in this study via adult input. To assess this prediction, let's reconsider the first kind of sentences with internal negation, where negation appeared in the same clause as the deontic modal verb *beiyunxu* 'was allowed to' and the disjunction word *huozhe* 'or'. In response to such sentences, children computed a conjunctive entailment (the 'neither' interpretation). By contrast, adults generated a 'not both' interpretation. Therefore, it seems quite unlikely that children's computation of the

conjunctive entailment as such would be drawn from adult input, given their distinctive interpretation patterns.

In the second kind of sentences with internal negation, negation appeared in the same clause as the deontic modal verb *keyi* 'is allowed to' and the expression *renhe* 'any'. In response to such sentences, both children and adults generated the same conjunctive entailment (the 'none' interpretation). Therefore, it is also worth considering the possibility that children's initial interpretation is based on adult input. This could be the case, for example, if statements with the *renhe* 'any' phrase embedded under a negated deontic modal verb *bukeyi* 'isn't allowed to' were highly frequent in adult input. If so, children might be able to use the input to converge on adult interpretation. To assess this possibility, we surveyed seven Mandarin corpora on the Child Language Data Exchange System (CHILDES) database (the Beijing corpus, the Chang corpus, the Context corpus, the Tong corpus, the Xu Min Chen Corpus, the Zhou 1 and Zhou 2 corpora) and the BJCELA corpus. As a result, we found 3545 tokens of parental utterances with *bu* 'not' and 675 tokens of parental utterances with *keyi* 'is allowed to'. However, no utterances with *renhe* 'any' were found in these corpuses, not to mention the utterances with the combination of *bu* + *keyi* + *renhe*. In view of the paucity of the relevant input, it seems unlikely that children compute the conjunctive entailment (the 'none' interpretation) associated with *renhe* 'any' on the basis of adult input.

Consider sentences with external negation. In the first kind of sentences with external negation, the focus adverb *zhiyou* 'only' was combined with the disjunction word *huozhe* 'or'. In response to such sentences, both children and adults generated the same conjunctive entailment (the 'neither' interpretation). In the second kind of sentences with internal negation, the focus adverb *zhiyou* 'only' was combined with the deontic modal verb *keyi* 'is allowed to' and the disjunction word *huozhe* 'or'. In response to such

sentences, both children and adults computed a negated free choice inference (the 'not both' reading). Similarly, one may propose that children acquire the conjunctive entailment and the negated free choice inference through adult input since they share the same interpretations with adults. If there were sufficient quantities of adult utterances containing the combination of *zhiyou + huozhe* or *zhiyou + keyi+ huozhe*, it would be likely for children to learn the interpretations by adult input. To test this possibility, we did another corpus analysis. Again, we searched the same seven Mandarin corpora on the Child Language Data Exchange System (CHILDES) database and the BJCELA corpus. There were only 675 tokens of parental utterances with *keyi*, 21 tokens of parental utterances with *huozhe* and 54 tokens of parental utterances with *zhiyou*. However, no utterances contained the combination of *zhiyou + huozhe* or *zhiyou + keyi + huozhe* in these corpuses. Therefore, the paucity of the relevant adult input makes it unlikely that children learn either the conjunctive entailment or the negated conjunctive inference merely relying on adult input. The results of the corpus study indicate that it is unlikely that children acquire the different patterns of entailments and inferences that we observed in this study merely relying on relevant input. We interpret the findings as evidence supporting the innateness account of acquisition of logical expressions.

## 5. Conclusion

The experimental findings of the present study reveal that 5-year-old Mandarin-speaking children understand that free choice (conjunctive/universal) inferences associated with *huozhe* or *renhe* are cancelled in sentences with internal negation, but free choice (conjunctive) inferences associated with *huozhe* are preserved in sentences with external negation, introduced by the focus adverb *zhiyou* 'only'. On the one hand, the findings lend support to the inferential account of the so-called free choice paradox. On the other

hand, the findings provide experimental evidence supporting the ambiguist approach to negation. A corpus study suggests that it is unlikely for children to learn the different patterns of inferences and entailments that we observed in this study merely via adult input. This provides support for the innateness account of acquisition of logical expressions.

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# Chapter 4: *Wh*-questions, universal statements and free choice inferences in child Mandarin

This chapter is based on the following paper, which has been accepted for publication by *Journal of Psycholinguistic Research.*

Huang, Hai-Quan, Peng Zhou & Stephen Crain. *Wh*-questions, universal statements and free choice inferences (In press). *Journal of Psycholinguistic Research*.

## Abstract

This study investigated 5-year-old Mandarin-speaking children's comprehension of *wh*-questions, universal statements and free choice inferences. Previous research has found that Mandarin-speaking children assign a universal interpretation to sentences with a *wh*-word (e.g., *shei* 'who') followed by the adverbial quantifier *dou* 'all' (Zhou 2013). Children also compute free choice inferences in sentences that contain a modal verb in addition to a *wh*-word and *dou* (Zhou 2017). The present study used a Question-Statement Task to assess children's interpretation of sentences containing *shei + dou*, both with and without the modal verb *beiyunxu* 'was allowed to', as well as the contrast between sentences with *shei + dou,* which are statements for adults*,* versus ones with *dou + shei,* which are *wh*-questions for adults. The 5-year-old Mandarin-speaking child participants exhibited adult-like linguistic knowledge of the semantics and pragmatics of *wh*-words, the adverbial quantifier *dou*, and the deontic modal verb *beiyunxu*.

**Key words**: *wh*-questions, free choice inferences, adverbial quantifier *dou*, child Mandarin, language acquisition

**_Wh_-questions, universal statements and free choice inferences in child Mandarin**

## 1. Introduction

In Mandarin Chinese, sentences with _wh_-words (e.g., _shei_ 'who', _shenme_ 'what') can either be interpreted as declarative statements or as _wh_-questions, depending on the presence or absence of the adverbial quantifier _dou_ 'all'. In the absence of _dou_ 'all', Mandarin sentences with _wh_-words are interpreted as _wh_-questions, as in (1). However, when a _wh_-word is followed by the adverbial quantifier _dou_ 'all', the sentence is a statement with universal force, as illustrated in (2) (see e.g., Cheng 1991, 1994; Huang 1982; Li 1992; Lin 1996, 1998).

(1) Shei chi-le    pingguo?

Who eat-ASP apple?

'Who ate the apples?'

(2) Shei dou chi-le    pingguo.

Who all  eat-ASP apple

'Everyone ate the apples.'

Another difference in interpretation is triggered by the presence or absence of a deontic modal verb, such as _beiyunxu_ 'was allowed to'. When a deontic modal verb is present, as in (3), the sentence licenses a free choice inference (e.g., Chierchia 2006, 2010, 2013; Liao 2011; Zhou 2017). So, (3) implies that anyone in the conversational context was allowed to eat apples. This free choice inference is generally regarded as a kind of universal, conjunctive interpretation, to distinguish it from an existential, disjunctive 'at

least one' interpretation. As (4) illustrates, *dou* 'all' is normally required to license a free

choice interpretation.[9] Without *dou* 'all', the sentence becomes a *wh*-question.

(3) Shei  dou bei  yunxu-le    chi pingguo.

    Who all   PM allow-ASP eat apple

    'Anyone was allowed to eat the apples.'

(4) Shei  bei   yunxu-le   chi pingguo?

    Who PM allow-ASP eat apple

    'Who was allowed to eat the apples?'

Finally, when a *wh*-word follows *dou,* the sentence, again, is a *wh*-question, as illustrated

in (5) (see e.g., Li 1995; Pan 2006; Zhang, Li & Pan 2012).

(5)  Dou (you)[10] shei bei  yunxu-le    chi pingguo?

    All   (have) who PM allow-ASP eat apple

    'Who were all the people that were allowed to eat the apples?'

The present study assesses the interpretations that Mandarin-speaking children assign

to sentences like (1)-(5). We conducted three experiments using a Question-Statement

Task. One of the aims of these experiments was to determine whether or not young

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[9] There are sentences in which a *wh*-word combined with a modal verb licenses a free choice
inference in the absence of *dou*. In these sentences, a classifier suppresses the interrogative force
of the *wh*-word (Liao 2011). For example, sentence (i) implies that Zhangsan has the freedom to
read any of the books accessible to him. Here, the classifier *ben* suppresses the interrogative force
of the *wh*-word *shenme* 'what', thereby licensing a free choice interpretation.

(i) Zhangsan bixu  kan  ben shenme shu.
   Zhangsan must read CL what     book
   'Zhangsan must read a book, any book.'

[10] Note that when a *wh*-word is followed by *dou*, as in (5), the sentence is more acceptable if it
includes the verb *you* 'have'.

Mandarin-speaking children distinguish differences in illocutionary force conveyed by these sentences. More specifically, the research question is whether or not young children acquiring Mandarin use the different elements in sentences (1)-(5) to determine if a speaker is asking an information-seeking *wh*-question, or is asserting a declarative statement. Experiment 1 investigated whether Mandarin-speaking children understand that sentences with a *wh*-word followed by *dou* generate a statement with universal force. The experiment contrasted children's interpretation of sentences with a *wh*-word alone, as in (1), as compared to sentences with a *wh*-word followed by *dou*, as in (2). Experiment 2 examined Mandarin-speaking children's knowledge that sentences with a *wh*-word followed by *dou* and a modal verb licenses a free choice inference. The experiment compared children's understanding of minimal pairs of sentences, namely sentences with a *wh*-word followed by *dou* and a modal verb, as in (3), and ones with a *wh*-word followed by a modal verb alone, as in (4). In Experiment 3, we introduced another research question, about children's knowledge of exhaustivity. The experiment investigated Mandarin-speaking children's knowledge that sentences with *dou* 'all' followed by a *wh*-word are interpreted as exhaustive *wh*-questions. This study is the first of its kind, comparing children's interpretation of sentences with a *wh*-word followed by *dou*, as in (2), with their interpretation of sentences with *dou* followed by a *wh*-word, as in (5).

The structure of the paper is as follows. Section 2 reviews the relevant theoretical literature. Section 3 reviews previous studies on child language. Section 4 describes the experimental studies, and reports the findings. Section 5 discusses the implications of the findings, and Section 6 concludes the paper.

## 2. Theoretical literature

## 2.1 *Wh*-words as existential expressions

In the theoretical literature, *wh*-words in different languages have been analysed as inherently existential quantifiers, the so-called ∃-items of Chierchia (2013) (also see Chomsky 1966; Fox 2007; Haspelmath 1997; Karttunen 1977; Liao 2011). Both syntactic and semantic arguments have been given for an existential analysis of *wh*-words. Chomsky (1966) advanced a syntactic argument that *wh*-words and their corresponding existential declarative statements are syntactically related. The conclusion of his argument is represented in the following quote:

*"... the distribution of natural and deviant interrogatives mirrors quite closely that of natural and deviant declaratives with singular indefinite unspecified Noun Phrases of the form "someone X", "something X", or their variants."*

(Chomsky 1966, p 39)

For Chomsky, the declarative and interrogative forms of *wh*-words are related by a transformation rule.

From a semantic perspective, *wh*-words have been analysed as existentially quantified items beginning with the seminal work of Karttunen (1977). More recently, Chierchia (2006, 2010, & 2013) and Fox (2007) have proposed a unified semantics for existential expressions, including *wh*-words. Consider a finite domain with two individuals, Jack and Susan. The semantics of the *wh*-question in (6) is typically assumed to be denoted by the set of its possible answers (or the set of its true answers), as in (7).

(6) Who left?

(7) {Jack left, but not Susan; Susan left, but not Jack; both Jack and Susan left.}

Notice that the set of possible answers corresponds to the truth conditions associated with the disjunctive statement *Jack or Susan left*, where the English word for disjunction, *or*, is assigned the meaning associated with inclusive-*or*, as in classical logic. Moreover, the disjunctive statement *Jack or Susan left* is logically equivalent to the existential statement *Someone left,* in the domain under consideration. Taking these phenomena together, then, *wh*-words, indefinite NPs and disjunction phrases can all be classified as existential expressions, i.e., as ∃-items.

### 2.2 *Dou* as a universal adverbial quantifier

Both the syntax and the semantics of the Mandarin quantificational adverb *dou* 'all' have received considerable attention in the theoretical literature. Despite continuing debate, it is generally agreed that *dou* 'all' is an adverbial quantifier with universal force. Interestingly, the quantificational adverb *dou* 'all' takes scope over expressions that occur to its left (e.g., Cheng 1995; Lee 1986; Pan 2006). Consider examples (8) and (9).

(8) Tamen chi-le    yi-ge   xigua.

    They   eat-ASP one-CL watermelon

    'They ate a watermelon.'

(9) Tamen dou chi-le    yi-ge   xigua.

    They    all   eat-ASP one-CL watermelon

    'They each ate a watermelon.'

In the absence of *dou* 'all', sentence (8) means that the set of individuals denoted by *tamen* 'they' collectively ate a watermelon. By contrast, with the addition of *dou*,

sentence (9) is assigned a universal interpretation. That is, sentence (9) means each individual in the set denoted by *tamen* 'they' ate his/her own watermelon. The contrastive meanings between (8) and (9) illustrate that *dou* contributes universal force.

**2.3 Universal statements and universal free choice inferences**

As noted earlier, *wh*-words have been analysed as ∃-items. It is a puzzle, then, why *wh*-words are assigned universal force in declarative statements with the quantificational adverb *dou* 'all', and why *wh*-words generate free choice inferences when they are combined with both *dou* and a modal verb. An analysis was first advanced in Kratzer and Shimoyama (2002). According to Krazer and Shimoyama (2002), a *wh*-phrase denotes a set of individuals. The set of individuals keeps expanding via pointwise functional application until a set of propositions is derived once the set is bound by a quantificational expression. Various quantificational expressions may be applied to this set, yielding different interpretations. When a universal quantifier, ∀, is the operative quantifier, the set of propositions yields a universal interpretation. For example, consider sentence (10) (previously example 2). The *wh*-word *shei* 'who' in (10) denotes a set of individuals, as illustrated in (11). This set keeps expanding, as in (12), until the universal adverbial quantifier *dou* is applied to the set; the result is a set of propositions, yielding a universal interpretation.

(10) Shei dou chi-le    pingguo.

    Who all eat-ASP apple

    'Everyone ate the apples.'

(11) $|| \text{Who} ||^{w, g} = \{a, b, c, \ldots\}$

(12) $|| \text{Who ate the apples} ||^{w, g} = \{a \text{ ate the apples, } b \text{ ate the apples, } c \text{ ate the apples, } \ldots\}$

When a deontic modal verb, such as *beiyunxu* 'was allowed to', is added as well, as in (13), the sentence gives rise to a free choice inference. Again, the *wh*-word *shei* 'who' in (13) denotes a set of individuals, as shown in (14). This set keeps expanding, as in (15), until the universal adverbial quantifier *dou* is applied to the set; the result is a free choice inference [11].

(13) Shei dou bei yunxu-le   chi pingguo.

   Who all PM allow-ASP eat apple

   'Anyone was allowed to eat the apples.'

(14) $|| \text{Who} ||^{w, g}$ = {a, b, c, …}

(15) $|| \text{Who was allowed to eat the apples} ||^{w, g}$ = {a was allowed to eat the apples, b was allowed to eat the apples, c was allowed to eat the apples, …}

## 2.4 Universal statements and exhaustive *wh*-questions

There are two competing accounts of *dou*-association. One account contends that *dou* 'all' is governed by a Leftness Condition, such that *dou* only quantifies over expressions that precede it (Cheng 1995; Lee 1986; Lin 1998). On an alternative account, *dou* can also be associated with expressions that follow it, again yielding statements with universal force (Pan 2006; Zhang, Li & Pan 2012). When *dou* is associated with a *wh*-word to its right, however, the result is an exhaustive *wh*-question (Li 1995; Pan 2006; Zhang, Li & Pan 2012). To illustrate, consider the *wh*-question (16), in a conversational context in which

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[11] An anonymous reviewer points out that the universal interpretation in example (10) does not differ from the universal free choice interpretation in example (13) since both interpretations are derived via the same mechanism. We agree with the reviewer that both interpretations are derived from the same mechanism. However, (13) contains the deontic modal verb *beiyunxu* 'was allowed to', which contributes to the free choice meaning. By contrast, (10) does not contain the modal verb, so it only generates a universal interpretation.  Therefore, these two sentences are different from each other due to the presence or absence of the deontic modal verb.

there are three individuals, John, Mary and Sue, and all of them ate sushi. In this case, the answer to the question is felicitous only if it mentions all three people in the conversational context. In the same context, however, it is not infelicitous for the answer to a simple *wh*-question, as in (17), to mention a subset of the individuals. Experiment 3 was designed to see if young Mandarin-speaking children provide exhaustive answers to questions like (16).

(16) Dou (you) shei chi-le    shousi?

    All (have) who eat-ASP sushi

    'Who were all the people that ate the sushi?'

(17)  Shei chi-le    shousi?

    Who eat-ASP sushi

    'Who ate the sushi?'


## 3.  Previous studies on child language

### 3.1 Universal statements in child Mandarin

Previous research has found that Mandarin-speaking children assign a universal interpretation to sentences with a *wh*-word followed by *dou* (Zhou & Crain 2011; Zhou 2013). For example, using a variant of the Truth Value Judgment Task called the Question-Statement Task, Zhou (2013) tested Mandarin-speaking children's interpretation of sentences with a *wh*-word followed by *dou* versus ones with a *wh*-word alone (see Zhou & Crain 2011). On a typical trial, a white horse, a black horse and a yellow horse participated in a jumping competition. The objective of the competition was to jump over a fence and a house. All three horses successfully jumped over the fence. However, the house was much higher than the fence, so it was quite challenging for the

horses. In the end, only the white horse and the black horse jumped over the house. The yellow horse did not even try to jump over the house. When the story concluded, the puppet produced either test sentence (18) or (19), to different groups of children.

(18) Shei dou tiaoguo-le     fangzi.

Who all  jump over-ASP house

'Everyone jumped over the house.'

(19) Shei  tiaoguo-le     fangzi?

Who jump over-ASP house

'Who jumped over the house?'

Those child participants who were presented with test sentences like (18) rejected them 95% of the time, and the corresponding adult group of participants rejected them 100% of the time. When asked to justify their rejections, both the child and adult participants pointed out that the yellow horse did not jump over the house. The other groups of child and adult participants provided answers to sentences like (19) 100% of the time; these answers mentioned the horses that had jumped over the house. These findings indicate that Mandarin-speaking children have adult-like knowledge that sentences with a *wh*-word followed by *dou* 'all' form declarative statements with universal force, whereas the corresponding sentences without *dou* are *wh*-questions.

## 3.2 Universal free choice inferences in child Mandarin

A related finding is that children compute universal free choice inferences in sentences with a *wh*-word followed by both *dou* and a modal verb. Using the Question-Statement Task, Zhou (2017) investigated Mandarin-speaking children's interpretation of sentences with a *wh*-word followed by both *dou* and a modal verb, as compared to sentences with a

*wh*-word followed by a modal verb alone. On a typical trial, Kung Fu Panda and Batman were participants in a car-pushing competition. Before the competition, the judge, Mr. Owl, established the rules for the competition. He permitted Kung Fu Panda to push the orange car and the green car, but not the purple car. He only permitted Batman to push the purple car, because he thought that Batman was too weak to push two cars at once. But Kung Fu Panda and Batman were very forgetful. They forgot the rules when the competition was about to start. So they asked the puppet to remind them of the rules. Being absent-minded, the puppet only remembered the rules some of the time. When the puppet thought that he remembered a rule, he would state it, as in (20). When the puppet did not remember a rule, he would ask a question about it, as in (21).

(20) Shenme che Gongfu xiongmao dou keyi tui.

What    car  Kung Fu panda     all  may push

'Kung Fu Panda may push any car.'

(21) Shenme che Bianfuxia keyi tui?

What    car  Batman    may push

'What car may Batman push?'

The test items like (20) and (21) were presented to two different groups of child participants. Those child participants who were presented with test sentences like (20) rejected them 96% of the time. When asked to justify their rejections, they pointed out, on the example trial, that Kung Fu Panda was not permitted to push the purple car. In response to test sentences like (21), the other group of child participants provided answers 100% of the time, and indicated which of the cars Batman may push.

Taken together, the findings from previous studies indicate that Mandarin-speaking children assign a universal interpretation to sentences with a *wh*-word followed by *dou*

and compute a free choice inference in response to sentences with a *wh*-word followed by both *dou* and a modal verb. However, previous studies tested children's interpretation of the two constructions in different non-linguistic contexts. The present study investigated children's interpretation of the two constructions in the same contexts. The experimental hypothesis was that if children were able to distinguish between the universal statements and free choice inferences, then they should be expected to assign different interpretations to sentences with and without a deontic modal verb. In addition, previous studies have focused on the semantic contribution of *dou* to sentences with *wh*-words in child language, where the *wh*-word preceded *dou* (Zhou & Crain 2011; Zhou 2013; Zhou 2017). The present study investigated children's interpretation of sentences in which *dou* was preceded by a *wh*-word, and sentences in which *dou* was followed by a *wh*-word. The experimental hypothesis was that children would assign a universal interpretation to sentences with a *wh*-word followed by *dou*, but would interpret sentences with *dou* followed by a *wh*-word as exhaustive *wh*-questions. This concludes the review of previous theoretical and experimental research. The next section reports the details of the experiments that were designed to address the issues outlined in this section.

## 4 Experiments

### 4.1 Experiment 1

Experiment 1 was designed to investigate whether Mandarin-speaking children understand that sentences with a *wh*-word followed by *dou* generate a universal interpretation. The experiment contrasted children's interpretation of sentences with a *wh*-word followed by *dou* and ones with a *wh*-word alone. A typical pair of test sentences is illustrated in (22) and (23).

(22) Shei  chi-le    qiaokeli?

    Who eat-ASP chocolate

    'Who ate chocolate?'

(23) Shei dou chi-le    qiaokeli.

    Who all  eat-ASP chocolate

    'Everyone ate chocolate.'

**Participants**

Thirty monolingual Mandarin-speaking children participated, who ranged in age from 4;8 to 5;11(years; months), with an average age of 5;6. The child participants were recruited from a kindergarten affiliated with the Hubei University of Technology (HUT), Wuhan, China. We also tested 20 Mandarin-speaking adults, who were undergraduates at HUT.

**Procedures**

The experiment used a Question-Statement Task. In the task, the experimenter acted out stories in front of the child participant using toy characters and props. At the same time, a puppet on a laptop computer screen appeared to watch the stories alongside the child. It was made clear to the child that the puppet did not always pay close attention to the stories. After each story, the puppet, expressed its uncertainty about what had happened in the story, and either made a guess about what had happened or asked a question about the events that had taken place.

The test sentences were pre-recorded and were presented to the child using a video clip that was aligned with the puppet's facial movements, so it appeared that the puppet was talking. The child's task was to judge whether the puppet had made a statement or had asked a question. If the child judged that the puppet had made a statement, then s/he

was asked to say whether the statement was right or wrong. If the child judged that the puppet had asked a question, then s/he was asked to answer the question.

The child participants were introduced to the task as a group. They were tested individually, however, in a quiet room. Before the main testing session, each child was familiarised with the task on two practice trials. On one trial, the puppet made a statement informing the child of what had happened in the story. On the other trial, the puppet asked the child a question. Twenty-two out of the thirty child participants correctly differentiated between a statement and a question on the practice trials, indicating they understood the task. The adult participants began the main session directly without any practice trials. They were presented with a video-taped version of the stories witnessed by the child participants. Adults were asked to write down their answers on an answer sheet.

**Materials**

There were six trials. On each trial, two types of test sentences were created. One contained the *wh*-word *shei* 'who' alone, and the other contained the *wh*-word *shei* and *dou* 'all'. To illustrate, here is a typical trial.

*This is a story about eating ice-cream. Uncle Panda has three little neighbours: Donald Duck, Minnie Mouse, and Snoopy. One day, it was Uncle Panda's birthday, so he invited the three children to have a celebration. The three accepted the invitation happily and arrived at the birthday party on time. At the party, Uncle Panda served some ice cream for dessert. Before having the dessert, Uncle Panda noticed that Minnie Mouse coughed at lot. However, Donald Duck and Snoopy looked well. Therefore, he decided to establish a rule for eating the ice cream. He said: "Donald and Snoopy, you two look very healthy, so both of you can eat ice*

*cream. Minnie, normally you could eat ice cream. But you have a bad cough. For the sake of your health, you cannot eat ice cream. Otherwise, you will cough more seriously"* (Fig. 1)*. When it came to dessert time, both Donald and Snoopy ate ice cream. At the beginning, Minnie decided to follow Uncle Panda's rule. However, she couldn't resist the temptation to eat the delicious ice cream, so she ate some too* (Fig. 2).



Fig.1  Uncle Panda's Rule



Fig.2  The Last Scene

When the story concluded, the puppet first made a lead-in statement, as in (24), which helped to make the test sentences sound more natural.

(24) Shinupi, mini    he  tanglaoya qu canjia shengru juhui, zuihou…

     Snoopy, Minnie and Donald   go attend birthday party, in the end,

     'Snoopy, Minnie and Donald attended a birthday party, in the end…'

Following the lead-in statement, the puppet either produced test sentence (25) or (26).

(25)  Shei  chi-le    bingqilin?

      Who eat-ASP ice-cream

      'Who ate ice-cream?'

(26) Shei dou chi-le bingqilin.

Who all eat-ASP ice-cream

'Everyone ate ice-cream.'

Each participant saw six trials in total; three contained questions and three contained statements. The presentation of the questions and statements was counterbalanced, so that for any given trial (e.g., the 'ice cream' trial), half of the participants heard a question, and half heard a statement. The trials were ordered so that participants heard the questions and statements in alternating sequences. To avoid intonation cues influencing the participants' judgments, all test sentences were presented with level intonation.[12]

In addition to a test sentence, the participants heard a control sentence on each trial. For example, test sentence (25) was paired with control sentence (27), a simple *wh-*question. Test sentence (26) was paired with control sentence (28), a simple sentence with *dou*. As an exclusionary criterion, the data from the child participants who were less than 80% accurate on the control sentences were excluded from the analysis.[13]

(27) Shei qingzhu-le zijide shengru?

Who celebrate-ASP self-DE birthday

'Who celebrated his/her own birthday?'

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[12] The test sentences were recorded in a sound-attenuated laboratory at the Hubei University of Technology, Wuhan, China. Then, we conducted a post-recording survey of ten adult native speakers of Mandarin who confirmed that the test sentences had level intonation.

[13] The exclusionary criterion of a score of 80% or above was applied in all three experiments in the present study. In Experiment 1, one child was excluded, leaving a total of 29 children. All of the adults always responded correctly to the control sentences, so all the adult data were included.

(28) Tamen dou zai shengri  juhuishang kesou.

They  all  at  birthday party       cough

'They all coughed at the birthday party.'

**Experimental Hypothesis**

Children who understand that sentences with *shei + dou* generate a universal interpretation were expected to judge (26) to be true. By contrast, they were expected to provide an answer to (25), and to mention *Tanglaoya, Shinupi, he Mini* 'Donald Duck, Snoopy and Minnie'. Children were also expected to provide an answer to control sentence (27), mentioning *Xiongmaoshushu* 'Uncle Panda', and to reject control sentence (28) on the grounds that Donald Duck and Snoopy did not cough at the party. If the pattern of responses by the child participants was as predicted, there would be an equal number of 'Yes' and 'No' responses across trials. If children did not differentiate between declarative statements and *wh*-questions, they were expected to interpret both sentences as *wh*-questions.

**Results**

The responses to the test sentences by children and adult are summarized in Table 1.

| Sentence Type | Response Type | | | |
|---|---|---|---|---|
| | Statement | | Question | |
| | Children (%) | Adults (%) | Children (%) | Adults (%) |
| Sentences with *shei + dou* | 76 | 90 | 24 | 10 |
| Sentences with *shei* alone | 0 | 0 | 100 | 100 |

**Table 1** Percentages of Responses by Type for Children and Adults

As Table 1 indicates, children accepted test sentences with *shei + dou* 76% of the time (66/87), and adults accepted them 90% of the time (54/60). For example, children accepted (26) by saying *Shide* 'Yes' or *Duide* 'right'. Similarly, adults accepted (26) by writing a positive remark, e.g., *Duide* 'right' or *Shide* 'Yes', on their answer sheets. A Mann-Whitney test on the Yes-responses to the test sentences indicated no significant difference between groups (z = 1.36, p = .174). By contrast, both children and adults provided answers to test sentences with *shei* alone 100% of the time. For example, most children and adults responded to (25) by mentioning *Tanglaoya, Shinupi he Mini* 'Donald Duck, Snoopy and Minnie'. However, some of them only gave a partial answer by pointing out *Tanglaoya he Shinupi* 'Donald Duck and Snoopy'.

The majority of the Mandarin-speaking child and adult participants in Experiment 1 interpreted sentences with *shei + dou* as universal declarative statements, and interpreted sentences with *shei* alone as *wh*-questions. The child participants exhibited adult-like linguistic knowledge that sentences with a *wh*-word followed by *dou* 'all' generate a universal interpretation. The results corroborated the previous finding that Mandarin-speaking children understand that *dou* is a universal adverbial quantifier that quantifies over *wh*-words that precede it (Zhou & Crain 2011; Zhou 2013).


**4.2 Experiment 2**

Experiment 2 was designed to assess Mandarin-speaking children's understanding of sentences with a *wh*-word followed by both *dou* and a modal verb. For adults, such sentences license free choice inferences. The experiment contrasted children's interpretation of sentences with a *wh*-word followed by both *dou* and a modal verb, and

ones with a *wh*-word followed by a modal verb alone. A typical pair of test sentences is (29) and (30).

(29) Shei bei  yunxu-le   chi bingqilin?

    Who PM allow-ASP eat ice-cream

    'Who was allowed to eat ice-cream?'

(30)  Shei dou bei yunxu-le   chi bingqilin.

    Who all PM allow-ASP eat ice-cream

    'Anyone was allowed to eat ice-cream.'

**Participants**

We tested 30 monolingual Mandarin-speaking children, who ranged in age from 4;8 to 5;10, with a mean age of 5;5. The child participants were recruited from a kindergarten affiliated with the Hubei University of Technology (HUT), Wuhan, China. We also tested 20 Mandarin-speaking adults, who were undergraduates at HUT.

**Procedures**

Both the child and adult participants were tested using the same procedures as Experiment 1.

**Materials**

Participants were tested using the same six stories as in Experiment 1, but these stories were combined with a different pair of test sentences on each trial, e.g., (29) and (30). The presentation order of the test sentences followed the same pattern as in Experiment 1. For example, participants first heard the same lead-in statement, numbered here as (31).

(31)  Shinupi,  mini    he tanglaoya   qu canjia shengru juhui,  zuihou…

Snoopy, Minnie and Donald      go attend birthday party, in the end,

'Snoopy, Minnie and Donald attended a birthday party, in the end…'


Following that, half of the participants heard test sentence (29) and control sentence (32), and half heard test sentence (30) and control sentence (33).


(32)  Shei qingzhu-le    zijide      shengru?

Who celebrate-ASP self-DE birthday

'Who celebrated his/her own birthday?'

(33)  Tamen dou dao-le     shengru  juhuide   difang.

They   all   arrive-ASP birthday party De place

'They all arrived at the venue of the birthday party.'


The critical test sentences involved negative judgments, so it was important to ensure that our test stories met the felicity conditions for the use of negation (cf. Crain & Thornton 1998). We adopted the research strategy advocated by Crain, Thornton, Boster, Conway, Lillo-Martin and Woodams (1996) who refer to the felicity conditions pertaining to negation as the Condition of Plausible Dissent. According to this condition, a negative judgement is appropriate only when the corresponding positive judgement is under consideration in the discourse context. To satisfy this condition, all test stories contained a discrepancy that was created between the possible outcome and the actual outcome. For example, in the given story, it was made clear to participants that the possible outcome was that Minnie could eat ice-cream. The actual outcome was that Minnie wasn't allowed to eat ice-cream. Adding the possible outcome enabled us to satisfy the Condition of Plausible Dissent.

## Experimental Hypothesis

If children understood that sentences with *shei + dou + beiyunxu* license free choice inferences, they were expected to reject (30) on the grounds that Minnie Mouse was not allowed to eat the ice-cream. By contrast, they were expected to provide an answer to (29) by mentioning *Tanglaoya he Shinupi* 'Donald Duck and Snoopy'. Alternatively, they were expected to interpret both types of test sentences as *wh*-questions if they did not compute a free choice inference. As for the control sentences, children were expected to provide an answer to (32) by pointing out *Xiongmao shushu* 'Uncle Panda', but they were expected to accept (33) because it was consistent with the fact that Donald Duck, Snoopy and Minnie all arrived at the venue of the party. Taken together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials.

## Results

All of the child and adult participants responded correctly to the control sentences 100% of the time, so their data were included in the analysis. A summary of both children's and adults' responses is provided in Table 2.

| Sentence Type | Response Type | | | |
|---|---|---|---|---|
| | Statement | | Question | |
| | Children (%) | Adults (%) | Children (%) | Adults (%) |
| Sentences with *shei + dou + beiyunxu* | 76 | 85 | 24 | 15 |
| Sentences with *shei + beiyunxu* | 0 | 0 | 100 | 100 |

**Table 2** Percentages of Responses by Type for Children and Adults

As Table 2 indicates, children rejected test sentences with *shei + dou + beiyunxu* 76% of the time (68/90)[14], and adults rejected them 85% of the time (51/60). When asked to justify their rejections, both children and adults pointed out the fact that one of the characters wasn't permitted to perform the action mentioned in the test sentences. For example, on the given trial, both children and adults consistently rejected (30) by pointing out the fact that Minnie Mouse was not allowed to eat the ice-cream.

A Mann-Whitney test on the No-responses to the test sentences showed no significant between-group difference (z = 1.204, p = .229). By contrast, both children and adults provided answers to test sentences with *shei + beiyunxu* alone 100% of the time. For example, most children and adults we tested provided an answer to (30) by mentioning *Tanglaoya he Shinupi* 'Donald Duck and Snoopy'. However, some of them only gave a partial answer by mentioning either *Tanglaoya* 'Donald Duck' or *Shinupi* 'Snoopy'. The findings suggest that the majority of Mandarin-speaking children and adults in Experiment 2 understand that sentences with *shei + dou + beiyunxu* license a universal free choice inference. The results also replicated the previous finding by Zhou (2017).

Both Experiments 1 and 2 were conducted using the same kind of non-linguistic contexts. In Experiment 1, both children and adults consistently accepted test sentences with *shei + dou*. By contrast, both children and adults consistently rejected test sentences with *shei + dou + beiyunxu* in Experiment 2. The findings indicate that children, like adults, are able to differentiate between universal declarative statements and universal free choice inferences. In the presence of the deontic modal verb, children compute a universal free choice inference. In the absence of the deontic modal verb, they generate a

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[14] 24 % reduction in the rejection rates indicates that some child participants interpret sentences with a *wh*-word followed by *dou* as *wh*-questions. For these children, sentences containing *wh*-words are interpreted interrogatively regardless of the presence of the quantificational adverb *dou* 'all'.

universal interpretation. In other words, children are sensitive to the licensing expression of free choice inferences such as the deontic modal verb *beiyunxu* 'was allowed to'.

## 4.3 Experiment 3

Experiment 3 was designed to investigate whether Mandarin-speaking children distinguish between universal statements and exhaustive *wh*-questions. The experiment compared children's interpretation of minimal pairs of sentences, namely sentences with a *wh*-word followed by *dou* versus ones with *dou* followed by a *wh*-word. A typical minimal pair of test sentences is illustrated in (34) and (35).

(34) Dou (you)[15] shei  chi-le    qiaokeli?

　　 All  (have) who eat-ASP chocolate

　　 'Who were all the people that ate chocolate?'

(35) Shei dou chi-le    qiaokeli.

　　  Who all  eat-ASP chocolate

　　  'Everyone ate chocolate.

## Participants

Thirty monolingual Mandarin-speaking children participated. The child participants ranged in age from 4;8 to 5;11, with an average age of 5;6. The child participants were recruited from a kindergarten at the Hubei University of Technology (HUT), Wuhan, China. We also tested 20 Mandarin-speaking adults, who were undergraduates at HUT.

## Procedures

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[15] An anonymous reviewer queried whether the existential verb *you* 'have' was used in the test sentences of Experiment 3. We would like to make it clear that the verb *you* 'have' was not included in the actual experiments, so the test sentences like (34) and (35) were minimal pairs.

Both the child and adult participants were tested using the same procedures as Experiment 1.

**Materials**

There were six trials in total. On each trial, a minimal pair of test sentences was created, namely sentences like (34) and (35). The presentation order of the test sentences followed the same pattern of Experiment 1. To illustrate, here is a typical trial.

*This is a story about buying toys. Xiaoming, Xiaoqiang and Xiaoli are good friends. One day, the three went to buy some toys. When arriving at the toy shop, they found there was a selection of toys, including cars and Barbie dolls. Both Xiaoming and Xiaoqiang loved cars very much, so each of them bought a car. Xiaoli could also buy a car if she would like to. However, Xiaoli was not interested in cars. Instead, she loved Barbie dolls, so she bought a Barbie doll in the end* (see Fig. 3). *After shopping, both Xiaoming and Xiaoqiang went home by bus, but Xiaoli took a train.*



Fig. 3

After the story, participants first heard a lead-in statement by the puppet, as in (36).

(36) Xiaoming, Xiaoqiang  he Xiaoli  qu mai wanju, zuihou…

Xiaoming, Xiaoqiang and Xiaoli go buy toy,     in the end…

'Xiaoming, Xiaoqiang and Xiaoli went to buy toys, in the end…'

Following that, half of the participants heard test sentence (37) and control sentence (39), and half heard test sentence (38) and control sentence (40).

(37) Dou (you) shei mai-le      xiaoqiche?

All   (have) who buy-ASP small car

'Who were all the people that bought a small car?'

(38) Shei dou mai-le     xiaoqiche.

Who all  buy-ASP  small car

'Everyone bought a small car.'

(39) Shei  zuo-le   huoche huijia?

Who sit-ASP train    go home

'Who went home by train?'

(40) Tamen dou mai-le yi-ge   wanju.

They all buy-ASP one-CL toy

'They all bought a toy.'

As the critical test sentences also involved negative judgments, it was important for us to meet the Condition of Plausible Dissent. To satisfy this condition, all test stories contained a discrepancy that was created between the possible outcome and the actual outcome, just as was the case in Experiment 1. For example, in the given story, it was made clear to participants that the possible outcome was that Xiaoli would buy a small

car. The actual outcome was Xiaoli did not buy a small car. Adding the possible outcome enabled us to satisfy the Condition of Plausible Dissent.

**Experimental Hypothesis**

 If children distinguished between universal statements and exhaustive *wh*-questions, they were expected to provide exhaustive answers to sentences with *dou* + *shei*, but to interpret sentences with *shei* + *dou* as universal statements. For example, children were expected to provide an answer to (37) by pointing out Xiaoming and Xiaoqiang. By contrast, they were expected to reject (38) on the grounds that Xiaoli did not buy a small car. As for the control sentences, children were expected to provide an answer to (39) by mentioning Xiaoli, but they were expected to accept (40) because it was consistent with the fact that the three characters each bought a toy. Taken together, the expected number of 'Yes' and 'No' responses was counterbalanced across trials.

**Results**

All of the child and adult participants responded correctly to the control sentences 100 % of the time, so their data were included in the analysis. A summary of children's and adults' responses is provided in Table 3.

| Sentence Type | Response Type | | | |
| --- | --- | --- | --- | --- |
| | Statement | | Question | |
| | Children (%) | Adults (%) | Children (%) | Adults (%) |
| Sentences with *shei* + *dou* | 84 | 87 | 16 | 13 |
| Sentences with *dou* + *shei* | 0 | 0 | 100 | 100 |

**Table 3** Percentages of Responses by Type for Children and Adults

As Table 3 indicates, children provided an exhaustive answer to test sentences with *dou + shei* 100% of the time (90/90), and adults did so 100% of the time (60/60). For example, on the given trial, twelve children explicitly responded to (37) by mentioning *Xiaoming he Xiaoqiang* 'Xiaoming and Xiaoqiang'. The remaining three children responded to (37) by pointing to Xiaoming and Xiaoqiang. By contrast, children rejected test sentences with *shei + dou* 84% of the time (76/90), and adults rejected them 87% of the time (54/60). When asked to justify their rejections, both children and adults pointed out the fact that one of the characters did not perform the action mentioned in the test sentences. For example, on the given trial, both children and adults rejected (38) by pointing out the fact that Xiaoli did not buy a small car. A Mann-Whitney test on the No-responses to the test sentences showed no significant between-group difference (z = .355, p = .722).

In summary, both children and adults interpreted sentences with *shei + dou* as universal statements, but interpreted sentences with *dou + shei* as exhaustive *wh*-questions. The findings indicate that 5-year-old Mandarin-speaking children exhibited adult-like linguistic knowledge of *wh*-words and the quantificational adverb *dou* 'all'. That is, the child participants distinguished between universal statements and exhaustive *wh*-questions. The findings also suggest that children are sensitive to the relative order of *wh* and *dou*.


## 5 General discussion

This study assessed 5-year-old Mandarin-speaking children's ability to distinguish between *wh*-questions, universal statements and free choice inferences. The assessment was undertaken in three experiments, using a Question-Statement task. Experiments 1 and 2 presented children and adults with sentences that contained the *wh*-word *shei* 'who' and

the adverb *dou* 'all', with and without the deontic modal verb *beiyunxu* 'was allowed to'. The main findings were as follows. Both children and adults accepted sentences with *shei + dou* in Experiment 1, suggesting that they generated a universal interpretation. By contrast, both children and adults rejected sentences with *shei + dou + beiyunxu* in Experiment 2, indicating that they computed a free choice inference. As the two experiments were conducted in the same non-linguistic contexts, the findings are compelling evidence that children are able to tease apart universal statements and free choice inferences. In addition, the findings also suggest that children are sensitive to the licensing expression of free choice inferences, e.g., the deontic modal verb *beiyunxu* 'was allowed to'. That is, in the presence of the modal verb, they compute a universal free choice inference. In the absence of the modal verb, they generate a universal interpretation.

Experiment 3 presented children and adults with sentences containing the *wh*-word *shei* followed by *dou* and ones with *dou* followed by the *wh*-word *shei*. The findings were twofold. Both children and adults rejected sentences with *shei + dou*, suggesting that they interpreted such sentences as declarative statements with universal force. By contrast, both groups provided an exhaustive answer to sentences with *dou + shei*, indicating that they interpreted these sentences as exhaustive *wh*-questions. The findings are compelling evidence that, by age of five, Mandarin-speaking children distinguish between universal statements and exhaustive *wh*-questions. Furthermore, the findings indicate that children at this age also understand that *dou* 'all' can be associated with a *wh*-word either to its right or to its left, and that it exerts universal force in either case. Obviously, the interpretation of *dou* 'all' is not constrained by the Leftness Condition (Cheng 1995, Lee 1986; Lin 1998), Rather, our findings support the proposal that *dou* can be associated

with a *wh*-word to its right or to its left, and that it exerts universal force in either case (Li 1995; Pan 2006; Zhang, Li & Pan 2012).

The question remains: How do young children distinguish between universal statements and free choice inferences associated with the *wh*-word *shei?* One possibility is that children acquire such complex linguistic knowledge based on the adult input. This could be the case, however, only if utterances containing the combination of *shei + dou* or *shei + dou + beiyunxu* were highly frequent in the adult input. If so, children could rely on the adult input to converge on adult-like interpretations of these constructions.

To assess this possibility, we surveyed a corpus of 472,610 tokens of adult utterances that were contained in six Mandarin corpora in the Child Language Data Exchange System (CHILDES): Beijing corpus, Beijing 2 corpus, Chang corpus, Context corpus, Zhou 1 and Zhou 2 corpora). There were 673 tokens of parental utterances with *shei*, and there were 844 tokens of parental utterances containing *dou*. However, there were no utterances containing the combination of *shei + dou.* In addition, no utterances with *beiyunxu* were found, nor were there any sentences that contained the combination *shei + dou + beiyunxu*. In view of the paucity of relevant input,[16] it seems unlikely that children distinguish between universal statements and the free choice inferences that are associated with the *wh*-word *shei* on the basis of the adult input.

Therefore, we propose an alternative acquisition scenario. This scenario is based on the assumption that children know that *wh*-words are inherently ∃-items (Chomsky 1966; Chierchia 2013; Fox 2007; Karttunen 1977; Liao 2011). Here is the proposal. Initially, the child language learner knows that a class of words in the local language are likely to correspond to the existential quantifier ∃. One of the candidate expressions are *wh*-words,

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[16] Admittedly these corpora are relatively small, so the target constructions might be present in larger corpora, but their entire absence in the smaller corpora suggests that the constructions are not likely to be highly frequent even in larger corpora.

such as *shei* 'who' in Mandarin Chinese. The child also knows that *wh*-words must be licensed in declarative statements by a licensor, just as the ∃-item *renhe* 'any' needs a (Downward Entailing) licensor. Previous research has demonstrated that, before the age of four, Mandarin-speaking children know that the adverbial quantifier *dou* can quantify over *wh*-words to its left (Zhou & Crain 2011, Zhou 2013). Therefore, when a child encounters a sentence with *shei + dou*, s/he infers that the *wh*-word *shei* is bound by *dou*, yielding a universal interpretation.

Now suppose a child encounters a sentence with *shei + dou + beiyunxu,* as in (41). The child is familiar with every word in the sentence, except *beiyunxu* 'is allowed to.'

(41) Shei dou beiyunxu-le    chi bangbangtang.

Who all PM allow-ASP eat lollipop

'Anyone was allowed to eat the lollipops.'

Our experimental findings suggest that children are sensitive to the semantic contribution of the deontic modal verb *beiyunxu* 'was allowed to'. If the child's current mental dictionary lacks knowledge of the lexical expression *beiyunxu* 'was allowed to', this would suggest that the children can infer the intended meaning of the entire sentence, based on the non-linguistic context (Wexler & Culicover 1980). This would enable the child to infer the semantic contribution of *beiyunxu*. This inference would establish its meaning to be similar to other deontic modal verbs, including *keyi* 'is allowed to'. Putting everything together, the child, therefore, is able to compute a free choice inference.

The further question arises: How do young children acquire the exhaustive *wh*-question interpretation associated with *dou* and *shei*? Again, it is worth first considering the possibility that children acquire this construction based on the adult input. To evaluate this possibility, we surveyed the same six corpora mentioned earlier. There were no

utterances in these corpora that contained the combination of *dou* + *shei*. This renders it unlikely that children learn to acquire the exhaustive interpretation using the adult input.

Therefore, we propose the following learning scenario. Upon encountering a sentence with *dou* + *shei*, as in (42), the child analyses the *wh*-word *shei* as an ∃-item. As before, the child anticipates that such items require a licensor.

(42) Dou (you) shei mai-le bangbangtang?

All (have) who buy-ASP lollipop

'Who are all the people that bought lollipops?

Our experimental findings suggest that children are sensitive to the relative order of *shei* and *dou*. Because *shei* occurs to the right of *dou*, the child infers *shei* is not bound by *dou*. This leads the child to the inference that *shei* is bound by a covert licensor that is operative whenever a sentence is an information-seeking *wh*-question. Therefore, the child infers that (42) is a request for the identity of the individuals that bought lollipops. To avoid vacuous quantification, the child infers that *dou* must quantify over some expression in the sentence. The likely candidate is the set of individuals that bought lollipops. Therefore, the most cooperative response to (42) is to provide a list of those individuals who bought lollipops. Although this is highly speculative, it offers a rough account of how children acquire the exhaustive *wh*-question interpretation of sentences with *shei* and *dou*.

## 6 Conclusion

As far as we know, this is the first study to investigate Mandarin-speaking children's understanding of the three prominent manifestations of *wh*-words in Mandarin Chinese, in forming *wh*-questions, universal declarative statements and free choice inferences. The

findings revealed that 5-year-old Mandarin-speaking children exhibited adult-like linguistic knowledge of the semantics and pragmatics of *wh*-words, the adverbial quantifier *dou* and the deontic modal verb *beiyunxu*. Children proved able to successfully differentiate *wh*-questions, universal statements and free choice inferences. The findings add to the growing body of experimental evidence that support the theoretical proposal that *wh*-words are inherently ∃-items (Chomsky 1966; Chierchia 2013; Fox 2007; Karttunen 1977; Liao 2011). Hopefully, the findings will also be seen as contributing to the theoretical debate on the correct semantic analysis of *dou* 'all' in Mandarin Chinese.

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# Chapter 5: Conclusions

This chapter summarizes the major findings and discusses more globally the implications of the results of the various experiments that were conducted as part of this thesis. At the broadest level, the thesis investigated Mandarin-speaking children's knowledge of the entailments and inferences arising mainly from three logical expressions: the disjunction word *huozhe* 'or', the polarity sensitive item *renhe* 'any', and the *wh*-word *shei* 'who'. There was a series of experiments, focused on three questions:

(iii) How children interpret simple sentences, i.e., ones with basic logical expressions;

(ii) How children interpret complex sentences, i.e., ones that contain a combination of logical expressions;

(iii) The extent to which the interpretations of children and adults are the same, or differ.

This thesis adopted the biolinguistic approach to child language. According to the biolinguistic approach, children acquire a first (and even a second or third) language rapidly and effortlessly, without formal instruction. Part of the responsibility for this acquisition scenario can be attributed to the principles and parameters of a Universal Grammar (Crain, Koring & Thornton 2016). The theory of Universal Grammar contends that human languages and their learners exhibit *deep-seated regularities* that can only be explained by abstract principles, at considerable remove from the experience children encounter in their first years of life. Several of the deep-seated regularities exhibited by children and adults are manifestations of core linguistic principles that pertain to logical expressions, including both the basic meanings of logical expressions and the interpretations that are assigned to combinations of these expressions (Crain 2012).

In addition to these regularities, the biolinguistic approach offers an explicit account of the ways in which child and adult languages can vary. This feature of language

acquisition is explained, in part, by the parameters of Universal Grammar. Parameters determine, at least in part, how adult languages can differ from each other. More importantly, for our purposes, parameters also explain certain aspects of children's non-adult linguistic behaviour. The limits on the ways that child language can differ from adult language are stated in the Continuity Assumption. The Continuity Assumption maintains that children's non-adult linguistic behaviour follows the natural seams of human languages. More specifically, child language can differ from adult language only in ways in which adult languages can differ from each other.

An alternative to the biolinguistic approach is the usage-based approach to language acquisition. According to the usage-based approach, children accrue linguistic knowledge piecemeal, in response to environmental input, using domain-general learning mechanisms such as analogy and distributional analysis (Lieven & Tomasello, 2008; Saxton, 2010). Because we assume the biolinguistic approach to language acquisition, we were led to expect that the basic meanings of logical expressions and the interpretations that can be assigned to combinations of these expressions would be witnessed in child language as soon as these meanings can be tested. This expectation holds even in cases in which children lack decisive evidence for these meanings in the primary linguistic data they encounter. When children differ from adults in the interpretation they assign to logical expressions, moreover, the differences are predicted to be characteristic of some possible human language, just not the language spoken by the local community.

Another construct of the theory of Universal Grammar is unification. In order to explain children's rapid mastery of logical expressions, both in isolation and in combination, it is likely that logical expressions form classes, or natural kinds. One such class of expressions was proposed in recent work by Chierchia (2013) and Fox (2007). These researchers put forward a unified semantic account of several kinds of logical

expressions. According to this account, disjunction phrases, existential (polarity) expressions, and *wh*-expressions are all contained in a single class, which is designated ∃-items. Following Chierchia and Fox, we assume that the disjunction word *huozhe* 'or', the polarity sensitive expression *renhe* 'any' and *wh*-words such as *shei* 'who' in Mandarin Chinese are ∃-items even though these expressions are disparate-looking on the surface.

The experiments conducted in this thesis put the unified account of ∃-items to an empirical test. The experiments attempted to determine whether ∃-items exhibit similar semantic properties in child Mandarin. More specifically, there were three studies. The first study investigated the linguistic contexts in which the word for disjunction, *or*, is assigned a conjunctive inference in child Mandarin. The second study investigated how Mandarin-speaking children interpret sentences with negation. The third study investigated how Mandarin-speaking children interpret sentences with universal force, and sentences that license free choice inferences in (adult) Mandarin. The following paragraphs summarise the main findings and discuss the relevant implications for the alternative approach to child language acquisition.

**When OR is assigned a conjunctive inference in child Mandarin (Chapter 2)**

According to a recent proposal, children generate free choice (conjunctive) inferences in interpreting statements that contain disjunction, even in the absence of the kind of licensing expressions that adults require. For adults, a disjunctive statement licenses a free choice inference only if the statement contains a licensing expression, such as an epistemic modal verb (e.g., English *can,* or *is able to*) or a deontic modal verb (*e.g.,* English *may,* or *is allowed to*). This proposal was made originally by Singh et al. (2016), and was empirically tested by Tieu et al. (2017). We do not intend to challenge the proposal that some children license conjunctive inferences for ordinary sentences with

disjunction in certain test conditions. However, evidence of children's conjunctive inferences in ordinary sentences with disjunction has not been reported in previous studies using different experimental techniques. Rather, previous studies using a Truth Value Judgment task have shown that children accept statements with disjunction in circumstances in which only one disjunct is true (Boster & Crain 1993; Chierchia et al. 2004; Crain et al. 2002; Goro et al. 2005; Su & Crain 2013, and among many others). Using a Truth Value Judgment Task, Chapter 2 systematically investigated Mandarin-speaking children's interpretation of disjunctive sentences with a deontic modal verb, as in (1), and ones without a deontic modal verb, as in (2).

(1) Yuehan keyi chi pisa huozhe dangao.

   John    may eat pizza  or      cake

   'John is allowed to eat pizza or cake.'

(2) Yuehan hui xuanze hongse huozhe lüsede qiqiu

   John    will choose red      or    green  balloon

   'John will choose a red balloon or a green balloon.'

The findins were twofold. Both the child and adult participants computed a free choice (conjunctive) inference in response to sentences that contained the deontic modal verb *keyi* 'is allowed to'. In sentences without a deontic modal verb, however, the child and adult participants assigned an inclusive-*or* interpretation, rather than computing a free choice inference. In particular, both children and adults accepted ordinary sentences with disjunction in circumstances in which only one of the disjuncts was true. The findings from the present study as well as those of previous studies do not conform to the proposal by Singh et al. (2016) and Tieu et al. (2017).

To explain the divergence in the findings, we considered several possibilities. First, it should be noted that some of children's rejections that are interpreted by Singh et al. as evidence of a conjunctive inference might have a different source. In response to the test sentences with a universal quantifier, some children may have assigned an egalitarian interpretation to the disjunction phrase. According to the egalitarian interpretation, *Every boy is holding an apple or a banana* is true only if every boy is holding just an apple, or just a banana. Therefore, some children may have rejected the test sentences because not all of the boys were holding the same thing, i.e., an apple. The Singh et al. study was not designed to assess the egalitarian interpretation, so we conjecture that this could have contributed to children's high rejection rate.

There is a second factor that may have contributed to the different findings. As noted, Singh et al. (2016) and Tieu et al. (2017) adopted picture verification tasks, whereas studies that did not evoke conjunctive inferences, such as Boster and Crain (1993) and Su and Crain (2013), adopted a TVJ task. In the TVJ task, stories are enacted by two experimenters in real time. This enables the experimenter to verbally debate the pros and cons of the actions of the characters as events unfold. It also allows the experiment to satisfy any presuppositions that are associated with the test sentences that are produced by the puppet, either as a prediction about how events will unfold, or as a description of how events have taken place in the stories (Thornton 2017). These dynamic events in the story contexts cannot be easily accomplished using pictures, as in study by Singh et al. (2016), even using a series of pictures that are presented sequentially, as in the study by Tieu et al. (2017). By its nature, picture verification tasks are static representations of events that have already taken place.

There is a third factor that can probably be discounted. This is the effect of presenting sentences as predictions of what would happen on each trial. As noted earlier, the study

by Tieu et al. (2017) also adopted the prediction mode, presenting the child participants with disjunctive sentences as predictions of what would happen on each trial, but these researchers have found that children appear to reject the test sentences when only one disjunct is true. Similar findings were also observed by Singh et al. (2016) who used the picture verification task in the description mode. Moreover, previous studies have demonstrated that children consistently accept sentences with disjunction in circumstances in which only one disjunct is true regardless of whether they are presented in the prediction mode or in the description mode (Boster & Crain 1993; Su & Crain 2013). Taken together, children accept or reject sentences with disjunction regardless of whether they are presented in the prediction mode or in the description mode of the TVJ task. In other words, for children, there is no difference between the prediction mode and the description mode in terms of the interpretation of sentences with disjunction.

There is one last factor that could have possibly contributed to the observed variation in findings. Compared to studies using the TVJ task, the studies by Singh et al. and by Tieu et al. didn't include the third set of objects/individuals for the protagonists to choose from. This difference in the experimental contexts might also lead to the conflicting findings. More specifically, the picture task used by Singh et al. (also by Tieu et al.) contained just two objects (e.g., an apple and a banana). By contrast, the TVJ tasks that were used in the present experiment and in most previous studies included more than two (e.g., the example trial from Experiment 2 included pink, green, and yellow balloons). This may have made the test sentences in this experiment more natural for children. Statements with disjunction engage a covert exhaustivity operator, which we will render as ONLY. One function of the covert operator ONLY is to eliminate from further consideration of those individuals in the domain of discourse that are not mentioned in the sentence (Chierchia 2013, 2017; Fox 2007; Spector 2007). Suppose there are three

individuals in the domain of discourse: John, Mary, and Sue. If someone asks a question about all of the individuals in the domain, as in (3a), then an answer that contains a disjunction of a subset of these individuals, as in (3b), eliminates the unmentioned individuals from further consideration (see e.g., Chierchia 2017). The process is schematically represented in (4).

(3) a. John, Sue and Mary were at the party. Who left early?

    b. John or Mary.

(4) ONLY [ALT = John, Mary, ~~Sue~~]

    ⤳ John or Mary left early, and it is not the case that Sue left early.

In a context in which there are only two individuals or objects, as in the Singh et al. and Tieu et al. studies, this pragmatic function of disjunctive statements is not engaged. In previous research, including the present study, there were more individuals or objects in the domain of discourse than those mentioned in the test sentence. Therefore, this pragmatic function (exhaustivity) was engaged. This difference in the experimental contexts may have contributed to the different patterns of responses by the child participants across studies.

**How Mandarin-speaking children interpret sentences with negation (Chapter 3)**

Previous research has demonstrated that Mandarin-speaking children compute free choice (conjunctive/universal) inferences in affirmative sentences with the disjunction word *huozhe* 'or' and in sentences with the polarity sensitive expression *renhe* 'any' (Huang & Crain 2014; Tieu et al. 2016; Zhou et al. 2013). Compared with previous research that used affirmative sentences, Chapter 3 investigated Mandarin-speaking children's computation of free choice inferences in negative sentences. The use of negative

sentences allowed us to evaluate the ambiguist approach to negation. This approach anticipates that that free choice inferences will be cancelled in sentences with internal negation. However, in sentences with external negation, free choice inferences are expected to be negated, but they are expected to be preserved. There is a clear set of circumstances that distinguish between a cancelled free choice inference and a negated one. A cancelled free choice inference results in a strong, 'neither' interpretation (a conjunctive entailment), whereas a negated free choice inference statement results in a weaker 'not both' inference. To assess this prediction of the ambiguist, we conducted five experiments using the Truth Value Judgment Task.

Experiment 1 assessed the interpretation that English-speaking adults assign to sentences with internal negation, such as (5), as compared to sentences with external negation, such as (6). The ambiguist approach to negation anticipates that English-speaking adults will cancel free choice inferences in English sentences like (5), but they are expected to preserve such inferences in sentences like (6). As we just noted, sentence (5) is expected to generate a strong, 'neither' interpretation (a conjunctive entailment), whereas sentence (6) is expected to license the negation of a free choice inference, which yields a weaker 'not both' interpretation. This is exactly what we found in a study with English-speaking adults.

(5) It is true that John is not allowed to eat pasta or sushi.
(6) It is not true that John is allowed to eat pasta or sushi.

Experiments 2 and 3 investigated Mandarin-speaking children's interpretation of sentences containing internal negation and a deontic modal verb. Experiment 2 presented Mandarin-speaking children and adults with negative sentences containing disjunction, as in (7). Because disjunction is a Positive Polarity Item (PPI) for adults, we expected adults

to interpret disjunction as taking scope over both the negation marker and the deontic modal verb in (7). With disjunction taking wide scope, for adults, the expected result is the 'not both' interpretation, as indicated in (7b). Because disjunction is not a PPI for children, however, we expected the child participants to assign the 'neither' interpretation indicated in (7a). The pattern of results was exactly as predicted.

(7) Yuehan mei bei yunxu chi yidalimian huozhe shousi.

   John    Neg PM allow eat  pasta        or        sushi

   a. **Expected child interpretation**: 'John wasn't allowed to eat pasta or sushi.'

   b. **Expected adult interpretation**: 'It was pasta or sushi that John was not allowed to eat.'

Experiment 3 presented Mandarin-speaking children and adults with negative sentences containing the polarity sensitive expression *renhe* 'any', as in (8).

(8) Yuehan bu keyi chi lanzili        de renhe yi-zhong shiwu.

   John    Neg may eat basket inside DE any  one-CL    food

   'John is not allowed to eat any kind of food in the basket.'

In contrast to sentences with disjunction, as in (7), the polarity sensitive expression *renhe* 'any' must be interpreted within the scope of its licensor; in the present case, the licensor is the negation marker. Therefore, we anticipated that both children and adults would cancel free choice inferences associated with *renhe* 'any' in sentences like (8). The interpretation that results is a conjunctive entailment (the 'none' interpretation). Again, the findings were consistent with the experimental hypothesis.

Experiment 4 and 5 examined Mandarin-speaking children's interpretation of sentences with external negation. In this experiment, external negation was introduced covertly, by the focus adverb *zhiyou* 'only'. Consider sentence (9). This sentence entails that it is not the case that anyone being contrast with John ate either pasta or sushi. So, sentence (9) generates a conjunctive entailment; the 'neither' interpretation. Now consider sentence (10). If the focus adverb *zhiyou* 'only' in (10) introduces a covert external negation, then the free choice inference should be negated. This would yield a 'not both' interpretation, rather than a 'neither' interstation, so (10) would mean that it is not the case that anyone other than John was allowed to eat both sushi and pasta. If the ambiguist approach is on the right track, then both the child and adult participants should accept (10) in circumstances in which someone except John was allowed to eat just one of the two dishes. If the free choice inference is cancelled, resulting in the 'neither' interpretation, then both the child and adult participants would reject sentence (10) in these circumstances. This pattern of responses would count as evidence against the ambiguist approach.

(9) Zhiyou yuehan chi-le    yidalimian huozhe shousi.

    Only    John    eat-ASP pasta        or        sushi

    'Only John ate pasta or sushi.'

(10) Zhiyou yuehen keyi chi yidalimian huozhe shousi.

     Only    John    may eat pasta            or        sushi

     'Only John is allowed to eat pasta or sushi.'

To summarize, Experiment 4 and 5 contrasted children's interpretation of minimal pairs of sentences. There were disjunctive sentences with the focus adverb *zhiyou* 'only' alone, as in (9), and there were sentences with the focus adverb *zhiyou* 'only' and the deontic

modal verb *keyi* 'is allowed to', as in (10). The findings of Experiments 3 and 4 supported the ambiguist approach. Both the child and adult participants responded in a way that was predicted by the ambiguist approach, but not by an approach that posits only one kind of negation.

The findings of these experiments revealed that Mandarin-speaking children know that free choice inferences associated with *huozhe* 'or' and *renhe* 'any' are cancelled in sentences with internal negation. They also know that free choice (conjunctive) inferences associated with *huozhe* 'or' are preserved in sentences with external negation, introduced by the focus adverb *zhiyou* 'only'.

There was only one condition in which the child and adult participants produced a different pattern of behaviour. This difference appeared in Experiment 2. In this experiment, the adult participants assigned a 'not both' interpretation to negative sentences with disjunction, whereas the child participants assigned a 'neither' interpretation. We attribute this to a difference in the assignment of scope to negation and disjunction. This conclusion is supported by the fact that Mandarin-speaking adults cancelled the free choice inference associated with *renhe* 'any' in the sentences in Experiment 3. Because *renhe* must be interpreted within the scope of negation, the polarity sensitivity that adults assigned to disjunction did not carry over to *renhe* 'any'. In sum, the findings provide experimental evidence supporting the ambiguist account of negation markers (Bar-Asher Siegal 2015; Bochvar 1981; Horn 1985, 2001; Karttunen & Peters 1979; Ladusaw 1980; Schwarz & Bhatt 2006).


## *Wh*-questions, universal statements and free choice inferences in child Mandarin (Chapter 4)

Chapters 2 and 3 looked at the entailments and inferences that children and adults associate with the Mandarin disjunction word *huozhe* 'or' and the polarity sensitive

expression *renhe* 'any', Chapter 4 investigated Mandarin-speaking children's knowledge of another kind of ∃-items, namely *wh*-words. Previous studies found that Mandarin-speaking children assign a universal interpretation to sentences with a *wh*-word (e.g., *shei* 'who') followed by the adverbial quantifier *dou* 'all' (Zhou & Crain 2011; Zhou 2013). A related finding is that Mandarin-speaking children compute free choice inferences in sentences in which a *wh*-word is followed by *dou* and a deontic modal verb (Zhou 2017).

However, previous studies tested children's interpretation of these two structures in different non-linguistic contexts. It remains unclear, therefore, whether children are able to tease apart the two interpretations in the same non-linguistic context. In addition, previous studies focused on the semantic contribution of *dou* to *wh*-sentences in which the *wh*-word preceded *dou* (Zhou & Crain 2011; Zhou 2013; Zhou 2017). As far as we know, no study has examined children's sensitivity to the relative order of *wh* and *dou*, by seeing how children respond to sentences in which a *wh*-word follows *dou*.

In the theoretical literature, there are two competing accounts of *dou*-association. One account contends that *dou* is subject to the Leftness Condition, such that it only quantifies over expressions that precede it (Cheng 1995; Lee 1986; Lin 1998). On an alternative account, *dou* can be associated with an element to its left or to its right and that it contributes universal force in either case (Pan 2006; Zhang, Li & Pan 2012). On this account, when *dou* is associated with a *wh*-word to its left, the combination *wh + dou* generates a universal interpretation; but when *dou* is associated with a *wh*-word to its right, the combination *dou + wh* yields an exhaustive *wh*-question (Li 1995; Pan 2006; Zhang, Li & Pan 2012).

Chapter 4 investigated Mandarin-speaking children's comprehension of *wh*-questions, universal statements and free choice inferences. The goal was to see whether children are

able to distinguish between universal statements, free choice inferences and *wh*-questions. Using a Question-Statement Task (Zhou & Crain 2011), we conducted three experiments.

Experiment 1 in Chapter 4 built on the previous study by Zhou et al. (2011, 2013), investigating children's interpretation of sentences with a *wh*-word alone, as in (11), as compared to sentences with a *wh*-word followed by *dou*, as in (12).

(11) Shei  chi-le    pingguo?

Who eat-ASP apple?

'Who ate the apples?'

(12) Shei dou chi-le    pingguo.

Who all  eat-ASP  apple

'Everyone ate the apples.'

Using the same non-linguistic contexts, Experiment 2 in Chapter 4 replicated the previous study by Zhou (2017), investigating children's interpretation of sentences with a *wh*-word, *dou* and a deontic modal verb, as in (13), and sentences with a *wh*-word and a deontic modal verb alone, as in (14).

(13)  Shei dou beiyunxu-le chi pingguo.

Who all PM allow-ASP eat apple

'Anyone was allowed to eat the apples.'

(14)  Shei beiyunxu-le    chi pingguo?

Who PM allow-ASP eat apple

'Who was allowed to eat the apples?'

The experimental hypothesis was that if children were able to distinguish between universal statements and universal free choice inferences, they would assign different interpretations to sentences with and without a deontic modal verb in the same non-linguistic context.

Experiment 3 in Chapter 4 directly compared children's interpretation of sentences with a *wh*-word followed by *dou*, as in (15), and sentences with *dou* followed by a *wh*-word, as in (16).

(15) Shei dou chi-le    pingguo.

Who all  eat-ASP  apple

'Everyone ate the apples.'

(16) Dou (you) shei chi-le    pingguo?

All (have) who eat-ASP apple

'Who were all the people that ate the apples?'

Based on the alternative account of *dou*-association, we anticipated that children would interpret sentences like (15) as universal statements, but interpret sentences like (16) as exhaustive *wh*-questions. The findings were exactly as anticipated. In Experiment 1, both children and adults accepted sentences like (12), indicating that they generated a universal interpretation. By contrast, both children and adults rejected sentences like (13) in Experiment 2, suggesting that they generated a universal free choice inference.

The findings are compelling evidence that children are able to differentiate between universal statements and universal free choice inferences. In Experiment 3, both children and adults provided an exhaustive answer to sentences like (16), suggesting that they interpreted those sentences as exhaustive *wh*-questions. By contrast, both children and adults rejected sentences like (15), indicating that they interpreted sentences like (15) as

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universal statements. The findings indicate that children are able to distinguish between universal statements and exhaustive *wh*-questions. Taken together, the findings reveal that Mandarin-speaking children exhibit adult-like linguistic knowledge of the semantics and pragmatics of *wh*-words, the adverb *dou* and the deontic modal verb *beiyunxu*. On the one hand, the findings support the theoretical proposal that *wh*-words are inherently ∃-items (Chomsky 1966; Chierchia 2013; Fox 2007; Karttunen 1977; Liao 2011). On the other hand, the findings contribute to the theoretical debate on the correct semantic analysis of *dou* in Mandarin Chinese.

**Implications**

In Mandarin Chinese, the disjunction word *huozhe* 'or', the polarity sensitive expression *renhe* 'any' and *wh*-words like *shenme* 'what' and *shei* 'who' are disparate-looking on the surface, but these expressions exhibit *deep-seated regularities*. These three expressions all license a free choice (conjunctive/universal) inference when they are combined with a modal verb such as *keyi* 'is allowed to' in affirmative sentences. To illustrate, consider examples (17) - (19).

(17) Yuehan keyi chi yidalimian huozhe shousi.

    John    may eat pasta     or     sushi

    'John is allowed to eat pasta or sushi.'

    ⤳ *John is allowed to eat pasta and John is allowed to eat sushi.*

(18) Yuehhan keyi chi renhe shiwu.

    John     may eat any    food

    'John is allowed to eat any food.'

⤳*John is allowed to eat pasta, John is allowed to eat sushi, John is allowed to eat chicken, and ...*

(19) Yuehan shenme shiwu dou keyi chi.

John    what    food    all    may eat

'John is allowed to eat any food.'

⤳ *John is allowed to eat pasta, John is allowed to eat sushi, John is allowed to eat chicken, and ...*

In conjunction with those of previous studies, the present studies demonstrate that pre-school Mandarin-speaking children are able to compute free choice inferences associated with these three ∃-items when they appear in the scope of a modal verb (Huang and Crain 2014; Zhou, Romoli, and Crain 2013; Zhou 2017).

Another finding of this study was that free choice inferences are cancelled in sentences with internal negation. To illustrate, consider examples (20) - (22).

(20) Yuehan mei bei  yunxu chi yidalimian huozhe shousi.

John    Neg PM allow  eat pasta        or        sushi

**Child interpretation:** 'John wasn't allowed to eat pasta or sushi.'

**Adult interpretation:** 'It was pasta or sushi that John was not allowed to eat.'

(21) Yuehhan bu   keyi chi renhe shiwu.

John      Neg may eat any    food

'John isn't allowed to eat any food.'

⇒ John isn't allowed to eat pasta, John isn't allowed to eat sushi, John isn't allowed to eat chicken, and …

(22)  Yuehan shenme shiwu dou bu    keyi chi.

John    what    food    all   Neg may eat

'John isn't allowed to eat any food.'

$\Rightarrow$ John isn't allowed to eat pasta, John isn't allowed to eat sushi, John isn't allowed to eat chicken, and …

The experiments we conducted have shown that pre-school Mandarin-speaking children cancel free choice inferences associated with the disjunction word *huozhe* 'or' and the polarity sensitive expression *renhe* 'any' in sentences with internal negation. In contrast to children, adults assign a 'not both' interpretation to sentences with internal negation and disjunction, such as (20). This is because disjunction is analysed as a [+PPI] by adults and, thus, is interpreted as taking scope over negation. For children, disjunction is initially analysed as [-PPI], so children generate a conjunctive entailment (the 'neither' interpretation), which is the interpretation that English-speaking adults assign to the corresponding sentences in English.

This difference in interpretation between children and adults is consistent with the Continuity Assumption. Mandarin-speaking children differ from adults in the interpretation of disjunctive sentences with internal negation in ways in which adult speakers of Mandarin differ from adult speakers of English. On the other hand, the observed children's non-adult linguistic behaviours undermine the usage-based approach to language acquisition, which contends that children learn the meanings of logical expressions via adult input.

Another finding is that Mandarin-speaking children generate a negated free choice inference (the 'not both' interpretation) in disjunctive sentences with external negation, which is introduced by the focus adverb *zhiyou* 'only'. Moreover, children know that free choice inferences are cancelled in sentences with internal negation, but are preserved in sentences with external negation. Further investigations are needed to verify whether

Mandarin-speaking children preserve free choice inferences associated with the polarity sensitive expression *renhe* 'any' and in sentences with *wh*-words like *shei* 'who' in the presence of external negation.

Finally, a corpus study revealed that children lack the primary linguistic data of the various entailments and inferences that were reported in this dissertation. This constitutes a *Poverty of the Stimulus Argument*. Due to the paucity of the primary linguistic data, it is unlikely that children acquire the different patterns of entailments and inferences merely via adult input. Rather, the findings support the biolinguistic approach to language acquisition.

**Future Directions**

This thesis looked at Mandarin-speaking children's knowledge of the entailments and inferences associated with ∃-items. To provide a fuller picture of the unified account of the ∃-items, there is still much work to do. First, it remains to be shown whether or not Mandarin-speaking children cancel free choice inferences associated with *wh*-words such as *shei* 'who' and *shenme* 'what' in sentences with internal negation. In addition, studies are needed to see whether or not Mandarin speaking children preserve free choice inferences associated with the polarity sensitive expression *renhe* 'any' and *wh*-words such as *shei* 'who' in sentences with external negation. Future work is needed to provide further evidence supporting the unified account of the ∃-items (Chierchia 2013; Fox 2007). In addition, the present work could be extended from typical development children to children with Specific Language Impairment. A comparison of typical versus atypical children's knowledge of entailments and inferences promises to shed light on the source of the deficits in children with language impairments.

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# Appendices

**Appendix A**

**Test Stimuli for the Experiments in Chapter 2**

**Experiment 1**

**Story 1**

Control sentence:

Xiaogou   keyi  chi chaofan huozhe zhuroutang.

Small dog may eat fried rice  or      pork soup

'The small dog is allowed to eat fried rice or pork soup.'

Test sentence:

Dagou   keyi chi chaofan huozhe zhuroutang.

Big dog may eat fried rice  or      pork soup

'The big dog is allowed to eat fried rice or pork soup.'

**Story 2**

Test sentence:

Xiaobeijixiong   keyi tui    dache   huozhe xiaoche.

Small polar bear may push big car or        small car

'The small polar bear is allowed to push a big car or a small car.'

Control sentence:

Dabeijixiong   keyi tui    dache  huozhe xiaoche.

Big polar bear may push big car or        small car

'The big polar bear is allowed to push a big car or a small car.'

**Story 3**

Control sentence:

Datuzi    keyi mai yi-ge    lanqiu      huozhe yi-ge   zuqiu.

Big rabbit may buy one-CL basketball   or       one-CL football

'The big rabbit is allowed to buy a basketball or a football.'


Test sentence:

Xiaotuzi     keyi mai yi-ge    lanqiu     huozhe yi-ge   zuqiu.

Small rabbit may buy one-CL basketball or       one-CL football

'The small rabbit is allowed to buy a basketball or a football.'


**Story 4**

Test sentence

Dahouzi     keyi na   dahongbao        huozhe xiaohongbao.

Big monkey may take big red packet     or       small red packet

'The big monkey is allowed to take a big red packet or a small red packet.'


Control sentence:

Xiaohouzi     keyi na   dahongbao        huozhe xiaohongbao.

Small monkey may take big red packet    or       small red packet

'The small monkey is allowed to take a big red packet or a small red packet.'


**Experiment 2**

**Story 1**

Test sentence:

Qi e      hui  xuanze fenhongse huozhe huangsede qiqiu.

Penguin will choose pink        or        yellow      balloon

'The penguin will choose a pink balloon or a yellow balloon.'


Filler sentence:

Xiongmao hui xuanze lüsede qiqi.

Panda      will choose green balloon

'The panda will choose a green balloon.'


**Story 2**

Test sentence:

Huangniu    hui  mai lunyi        huozhe qiche.

Yellow cow will buy wheelchair or        car

'The yellow cow will buy a wheelchair or a car.'


Filler sentence:

Huaniu      hui  mai lunyi.

Spotted cow will buy wheelchair

'The spotted cow will buy a wheelchair.'


**Story 3**

Test sentence:

Milaoshu        hui chi pisa    huozhe dangao.

Mickey Mouse will eat pizza   or       cake

'Mickey Mouse will eat a pizza or a cake.'

Filler sentence:

Tanglaoya      hui chi dangao.

 Donald Duck will eat cake

'Donald Duck will eat a cake.'


**Story4**

Test sentence:

Lanjingling hui  shiyong jinhuangse huozhe yinsede xingxing.

Smurf        will use      golden      or      silver    star

'The Smurf will use a golden star or a silver star.'


Filler sentence:

Xiaoairen hui shiyong lüsede xingxing.

Dwarf     will use      green  star

'The Dwarf will use a green star.'

# Appendix B

## Test Stimuli for Experiments in Chapter 3

### Experiment 1

### Internal negation group

### Story 1

Filler sentence

It is true that Mr. Hippo is allowed to eat a cracker

Target sentence

It is true that Mr. Tiger is not allowed to eat sushi or pasta.


### Story 2

Filler sentence

It is true that Tom is allowed to buy a book on how to keep pets

Target sentence

It is true that Jack is not allowed to buy a cat or a dog.


### Story 3

Filler sentence

It is true that the black dog is allowed to watch the training.

Target sentence

It is true that the yellow dog is not allowed to lift the small box or the big box.


### Story 4

Filler sentence

It is true that Small Pig is allowed to watch the tree climbing.

Target sentence

It is true that Small Cat is not allowed to climb the small tree or the big tree.

## External negation condition

### Story 1

Filler sentence

It is true that Mr. Horse is only allowed to eat pasta.

Target sentence

It is not true that Mr. Tiger is allowed to eat sushi or pasta.

### Story 2

Filler sentence

It is true that Mary is only allowed to buy a cat.

Target sentence

It is not true that Jack is allowed to buy a cat or a dog.

### Story 3

Filler sentence

It is true that the spotted dog is only allowed to lift up the small box.

Target sentence

It is not true that the yellow dog is allowed to lift up the small box or the big one.

### Story 4

Filler sentence

It is true that Small Monkey is only allowed to climb the small tree.

Target sentence

It is not true that Small Cat is allowed to climb the small tree or the big tree.

**Experiment 2**

**Story 1**

Filler sentence

Wo zhidao yi-jian shiqing: bainfuxia bei yunxu chi shousi.

I    know   one-CL  thing:  Batman    PM allow eat sushi

'I know one thing: Batman was allowed to eat sushi.'

Test sentence

Bianfuxia mei   bei yunxu chi yidalimian huozhe jirou.

Batman    NEG PM allow eat  pasta          or      chicken

a. Expected Child Interpretation: 'Batman wasn't allowed to eat pasta or chicken.'

b. Expected Adult Interpretation: 'It was pasta or chicken that Batman was not allowed to

eat.'

**Story 2**

Filler sentence

Wo zhidao yi-jian shiqing: xiaoming bei yunxu mai piqiu.

I    know one-CL thing:    xiaoming PM allow buy ball

'I know one thing: Xiaoming was allowed to buy a ball.'

Test sentence

Xiaoming mei beiyunxu    mai qiche huozhe feiji.

Xiaoming NEG PM allow buy car     or        plane.

a. Expected Child Interpretation: 'Xiaoming wasn't allowed to buy the car or the plane.'

b. Expected Adult Interpretation: 'It was the car or the plane that Xiaoming was not allowed to buy.'

**Story 3**

Filler sentence

Wo zhidao yi-jian shiqing: xiaogongzhu bei yunxu-le     chao    jidan.

 I    know one-CL thing:   little princess PM allow-ASP stir-fry egg

 'I know one thing: The little princess was allowed to stir-fry the egg.'

Test sentence

Xiaogongzhu   mei   bei yunxu chao     qiezi     huozhe baocai.

Little princess NEG PM allow stir-fry eggplant    or      cabbage

a. Expected Child Interpretation: 'The little princess wasn't allowed to stir-fry the eggplant or the cabbage.'

b. Expected Adult Interpretation: 'It was the eggplant or the cabbage that the little princess wasn't allowed to stir-fry.'

**Story 4**

Filler sentence

Wo zhidao yijian  shiqing: xiaoniu    bei yunxu-le     tu    xiaohezi.

I    know one-CL thing:    small cow PM allow-ASP paint small box

'I know one thing: The small cow was allowed to paint the small box.'

Test sentence

Xiaoniu    mei  bei  yunxu tu    zhongdengde  hezi huozhe dahezi.

Small cow NEG PM allow paint medium-sized box   or      big box

a.  Expected Child Interpretation: 'The little cow wasn't allowed to paint the medium-sized box or the big box.'

b.  Expected Adult Interpretation: 'It was the medium-sized box or the big box that the little cow wasn't allowed to paint.'


**Experiment 3**

**Pre-test**

**Story 1**

Test sentence 1

 Xiao houzi    keyi  pa    yi-ke   shu.

 Small monkey  may  climb one-CL tree

 'The small monkey is allowed to climb one of the trees.'


Test sentence 2

Xiao  houzi    keyi   pa   renhe yi-ke   shu.

 Small monkey may climb  any   one-CL tree

 'The small monkey is allowed to climb any one of the trees.'


**Story 2**

Test sentence 1

Xiao zhu  keyi  ban   yi-jian   jiaju.

Small pig  may  carry one-CL furniture

'The small pig is allowed to carry one piece of the furniture.'


Test sentence 2

Xiao  zhu     keyi   ban   renhe yi-jian  jiaju.

Small pig     may   carry  any   one-CL furniture

'The small pig is allowed to carry any piece of the furniture.'


**The main test session**

**Story 1**

Filler sentence 1

Meiyangyang keyi chi lanzi   li      de renhe yi-zhong shuiguo.

Beauty Goat  may eat  basket inside DE any   one-CL   fruit

'Beauty Goat is allowed to eat any kind of fruit in the basket.'


Filler sentence 2

San-zhi     yang  dou bu  keyi chi lanzi   li      de  shuiguo.

Three -CL goat   all NEG may eat basket inside DE fruit

'None of the three goats are allowed to eat the fruit in the basket.'


Test sentence 1

Fei yangyang bu    keyi chi lanzi    li     de  renhe yi-zhong shuiguo.

Fit  Goat      NEG may eat basket inside DE any   one-CL   fruit

'Fit Goat is not allowed to eat any kind of fruit in the basket.'

Test sentence 2

Lan  yangyang bu   keyi  chi lanzi   li     de  renhe yi-zhong shuiguo.

Lazy Goat     NEG may eat basket inside DE any   one-CL   fruit

'Lazy Goat is not allowed to eat any kind of fruit in the basket.'


**Story 2**

Filler sentence 1

Housan        keyi mai shangdian li     de renhe yi-zhong wanju.

Monkey three may buy shop       inside DE any   one-CL   toy

'Monkey brother No.3 is allowed to buy any kind of toy in the shop.'


Filler sentence 2

San-zhi   houzi    dou bu  keyi mai shangdian li       de  wanju.

Three-CL monkey all NEG may buy shop        inside DE toy

'None of the three monkeys are allowed to buy the toys in the shop.'


Test sentence 1

Houer        bu    keyi mai  shangdian li de renhe yi-zhong wanju.

Monkey two NEG may buy shop inside  DE any   one-CL    toy.

'Monkey brother No. 2 is not allowed to buy any kind of toy in the shop.'


Test sentence 2

Houda        bu    keyi mai shangdian li       de renhe yi-zhong wanju.

Monkey big NEG may buy shop        inside DE any   one-CL   toy.

'Monkey brother No.1 is not allowed to buy any kind of toy in the shop.'

**Story 3**

Filler sentence 1

Xiongda keyi cai   huayuan li     de renhe yi-zhong hua.

Bear big may pick garden   inside DE any   one-CL   flower

'Bear brother No.1 is allowed to pick any kind of flower in the garden.'


Filler sentence 2

San-zhi     xiong dou bu     keyi cai  huayuan li     de   hua.

Three -CL bear   all NEG    may pick garden inside DE flower

None of the three bears are allowed to pick the flowers in the garden.'


Test sentence 1

Xionger   bu    keyi cai  huayuan li     de   renhe yi-zhong hua.

Bear two NEG may pick garden inside DE any    one-CL    flower

'Bear brother No. 2 is not allowed to pick any kind of flower in the garden.'


Test sentence 2

Xiongsan   bu    keyi cai   huayuan li      de   renhe yi-zhong hua.

Bear three NEG may pick garden   inside DE any    one-CL   flower

'Bear brother No. 3 is not allowed to pick any kind of flower in the garden.'


**Story 4**

Filler sentence 1

Xiaoming keyi kan shufang li       de  renhe yi-zhong shu.

Xiaoming may read study    inside DE any   one-CL   book

'Xiaoming is allowed to read any kind of book in the study.'


Filler sentence 2

San-ge    haizi dou bu    keyi kan shufang li      de  shu.

Three-CL kid   all  NEG may read study   inside DE book

 'None of the three kids are allowed to read the books in the study.'


Test sentence 1

Xiaoqiang bu     keyi kan shufang li      de  renhe yi-zhong shu.

Xiaoqiang NEG may read study   inside DE any    one-CL   book

'Xiaoqiang is not allowed to read any kind of book in the study.'


Test sentence 2

Xiaomei bu     keyi kan shufang li       de renhe yi-zhong shu.

Xiaomei NEG may read study   inside De any   one-CL    book

'Xiaomei is not allowed to read any kind of book in the study.'


**Experiment 4**

**Story 1**

Test sentence

Zhiyou dahaidao zai hongse huozhe lüse   meirenyu bianshang zhong-le   shanhu.

Only big pirate    at red        or       green mermaid side         plant-ASP coral

'Only the big pirate planted corals near the red mermaid or the green mermaid.'

Filler sentence

Dahaidao bi xiaohaidao qiangzhuang.

Big pirate to small pirate strong

'The big pirate is stronger than the small pirate.'


**Story 2**

Test sentence

Zhiyou huanggou   tui-le        dache   huozhe xiaoche.

Only    yellow dog push-ASP big car or        small car

'Only the yellow dog pushed the big car or the small car.'


Filler sentence

Huanggou   bi heigou     qiangzhuang.

Yellow dog to black dog strong

'The yellow dog is stronger than the black dog.'


**Story 3**

Test sentence

Zhiyou baima       tiaoguo-le        gaoliba    huozhe ailiba.

Only    white horse jump over-ASP high fence or        low fence

'Only the white horse jumped over the high fence or the low fence.'


Filler sentence

Baima        bi heima        qiangzhuang.

White horse to black horse strong

'The white horse is stronger than the black horse.'


**Story 4**

Test sentence

Zhiyou baitu          xi-le          dayifu          huozhe xiaoyifu.

Only    white rabbit wash-ASP big clothes  or        small clothes

'Only the white rabbit washed the big clothes or the small clothes.'


 Filler sentence

 Baidu          bi heitu          qiangzhuang.

 White rabbit to black rabbit strong

 'The white rabbit is stronger than the black rabbit.'


**Experiment 5**

**Story 1**

Test sentence

Zhiyou da haidao keyi zai hongse huozhe lüse   meirenyu  bianshang zhong shanhu

Only    big pirate may at   red        or        green mermaid  side          plant   coral

'Only the big pirate is allowed to plant corals near the red mermaid or the green mermaid.'


Filler sentence

Zhiyou dahaidao keyi zai lüse meirenyu bianshang zhong shanhu.

Only    big pirate may at green mermaid side          plant   corals.

'Only the big pirate is allowed to plant corals at the side of the green mermaid.'

**Story 2**

Test sentence

Zhiyou huanggou  keyi tui    dache   huozhe xiaoche.

Only    yellow dog may push big car or        small car

'Only the yellow dog is allowed to push the big car or the small car.'


Filler sentence

Zhiyou heigou      keyi  tui    xiaoche.

Only    black dog  may  push small car

'Only the black dog is allowed to push the small car.'


**Story 3**

Test sentence

Zhiyou baima       keyi tiao   gaoliba    huozhe ailiba.

Only    white horse may jump high fence or        low fence

'Only the white horse is allowed to jump over the high fence or the low fence.'


Filler sentence

Zhiyou heima       keyi tiao   ailiba.

Only    black horse may jump low fence

'Only the black horse is allowed to jump over the low fence.'


**Story 4**

Test sentence

Zhiyou baitu        keyi  xi    dayifu        huozhe xiaoyifu.

Only   white rabbit may wash big clothes or        small clothes

'Only the white rabbit is allowed to wash the big clothes or the small clothes.'


Filler sentence

Zhiyou heitu         keyi  xi    xiaoyifu.

Only    black rabbit may wash  small clothes

'Only the black rabbit is allowed to wash the small clothes.'

## Appendix C

## Test stimuli for the experiments in Chapter 4

**Experiment 1**

**Story 1**

Test sentence1

Shei  chi-le    bingqilin?

Who eat-ASP ice-cream

'Who ate ice-cream?'


Control sentence 1

Shei qingzhu-le      zijide shengru?

Who celebrate-ASP self    birthday

'Who celebrated his/her own birthday?'


Test sentence 2

 Shei  dou chi-le    bingqilin.

 Who  all  eat-ASP ice-cream

 'Everyone ate ice-cream.'


Control sentence 2

Tamen dou zai shengru juhuishang kesou.

They    all  at  birthday party        cough

'They all coughed at the birthday party.'

**Story 2**

Test sentence 1

Shei tiao-le        liba?

Who jump-ASP fence

'Who jumped over the fence?'


Control sentence 1

Shei zhiding-le        xunlian de guiju?

Who establish-ASP training DE rule

'Who established the rules for the training?'


Test sentence 2

Shei dou tiao-le        liba.

Who all  jump-ASP fence

'Everyone jumped over the fence.'


Control sentence 2

Tamen dou zhiding-le        xunliande    guiju.

They   all    establish-ASP training DE rule

'They all established the rules for the training.'


**Story 3**

Test sentence 1

Shei tui-le        dache?

Who push-ASP big car

'Who pushed the big car?'

Control sentence 1

Shei zhiding-le      xunlian de   guiju?

Who establish-ASP training DE rule

'Who established the rules for the training?'

Test sentence 2

Shei dou tui-le      dache.

Who all push-ASP big car

'Everyone pushed the big car.'

Control sentence 2

Tamen dou zhiding-le      xunlian de   guiju.

They   all   establish-ASP training DE rule

'They all established the rules for the training.'

**Story 4**

Test sentence 1

Shei zhai-le     pingguo?

Who pick-ASP apple

'Who picked the apples?'

Control sentence 1

Shei  zhiding-le      zhai pingguo de  guiju?

Who establish-ASP pick apple    DE rule

'Who established the rules for picking the apple?'


Test sentence 2

Shei dou zhai-le    pingguo.

Who all pick-ASP apple

'Everyone picked the apples.'


Control sentence 2

Tamen dou zhidaing-le     zhai pingguo de  guiju.

They    all  establish-ASP pick apple     DE rule

'They all established the rules for picking the apples.'


**Story 5**

Test sentence 1

Shei kan-le      shu?

Who read-ASP book

'Who read the books?'


Control sentence 1

Shei zhiding-le      kan shu de    guiju?

Who establish-ASP read book DE rule

'Who established the rules for reading the books?'

Test sentence 2

Shei dou kan-le      shu.

Who all  read-ASP book

'Everyone read the books.'


Control sentence 2

Tamen dou zhidaing-le     kan shu   de      guiju.

They    all   establish-ASP read book DE rule

'They all established the rules for reading the books.'


**Story 6**

Test sentence 1

Shei zhi-le        shu?

Who plant-ASP tree

'Who planted the trees?'


Control sentence 1

Shei  zhiding-le      zhi   shu  de  guiju?

Who establish-ASP plant tree DE rule

'Who established the rule for planting the trees?'


Test sentence 2

Shei dou zhi-le        shu.

Who all  plant-ASP tree

'Everyone planted the trees.'

Control sentence 2

Tamen dou zhiding-le    zhi   shu  de   guiju.

They    all  establish-ASP plant tree DE rule

'They all established the rules for planting the trees.'


**Experiment 2**

**Story 1**

Test sentence1

Shei  bei yunxu-le    chi  bingqilin?

Who PM allow-ASP eat ice-cream

'Who was allowed to eat ice cream?'


Control sentence 1

Shei  qingzhu-le      zijide shengru?

Who celebrate-ASP self    birthday

'Who celebrated his/her own birthday?'


Test sentence 2

 Shei  dou bei yunxu-le    chi  bingqilin.

 Who all  PM allow-ASP eat   ice-cream

 'Anyone was allowed to eat ice-cream.'


Control sentence 2

Tamen dou zai shengru juhuishang kesou.

They   all   at   birthday party        cough

'They all coughed at the birthday party.'


**Story 2**

Test sentence 1

Shei bei   yunxu-le    tiao   liba

Who PM allow-ASP jump fence

'Who was allowed to jump over the fence?'


Control sentence 1

Shei zhiding-le       xunlian de  guiju?

Who establish-ASP training DE rule

'Who established the rules for the training?'


Test sentence 2

Shei  dou bei yunxu-le     tiao    liba.

Who all   PM allow-ASP jump fence

'Anyone was allowed to jump over the fence.'


Control sentence 2

Tamen dou zhiding-le       xunlian de   guiju.

They   all   establish-ASP training DE rule

'They all established the rules for the training.'


**Story 3**

Test sentence 1

Shei bei   yunxu-le    tui    dache?

Who PM allow-ASP push big car

'Who was allowed to push the big car?'


Control sentence 1

Shei zhiding-le       xunlian de  guiju?

Who establish-ASP training DE rule

'Who established the rules for the training?


Test sentence 2

Shei dou bei yunxu-le     tui   dache.

Who all PM allow-ASP push big car

'Anyone was allowed to push the big car.'


Control sentence 2

Tamen dou zhiding-le      xunlian de  guiju.

They    all  establish-ASP training DE rule

'They all established the rules for the training.'


**Story 4**

Test sentence 1

Shei bei   yunxu-le    zhai pingguo?

Who PM allow-ASP pick apple

'Who was allowed to pick the apples?'

Control sentence 1

Shei zhiding-le      zhai pingguo de guiju?

Who establish-ASP pick apple    DE rule

'Who established the rules for picking the apple?'


Test sentence 2

Shei dou bei  yunxu-le   zhai  pingguo

Who all  PM allow-ASP pick apple

'Anyone was allowed to pick the apples.'


Control sentence 2

Tamen dou zhidaing-le     zhai  pingguo de  guiju.

They    all  establish-ASP pick apple    DE rule

'They all established the rules for picking the apples.'


**Story 5**

Test sentence 1

Shei bei  yunxu-le     kan  shu?

Who PM allow-ASP read book

'Who was allowed to read the books?'


Control sentence 1

Shei zhiding-le      kan shu    de  guiju?

Who establish-ASP read book DE rule

'Who established the rules for reading the books?'

Test sentence 2

Shei dou bei yunxu-le    kan   shu

Who all PM allow-ASP read book

'Anyone was allowed to read the books.'


Control sentence 2

Tamen dou zhiding-le     kan shu    de  guiju.

They    all establish-ASP read book DE rule

'They all established the rules for reading the books.'


**Story 6**

Test sentence 1

Shei bei   yunxu-le   zhi   shu?

Who PM allow-ASP plant tree

'Who was allowed to plant the trees?'


Control sentence 1

Shei zhiding-le      zhishu    de  guiju?

Who establish-ASP plant tree DE rule

'Who established the rule for planting the trees?'


Test sentence 2

Shei dou bei  yunxu-le   zhi   shu.

Who all PM allow-ASP plant tree

'Anyone was allowed to plant the trees.'

Control sentence 2

Tamen dou zhiding-le    zhi   shu  de  guiju.

They   all   establish-ASP plant tree DE rule

'They all established the rules for planting the trees.'


**Experiment 3**

**Story 1**

Test sentence 1

Dou (you) shei mai-le    xiaoqiche?

All (have) who buy-ASP small car

'Who were all the people that bought a small car?'


Control sentence 1

Shei zuo-le    huoche huijia?

Who sit-ASP train    go home

'Who went home by train?'


Test sentence 2

Shei dou mai-le    xiao qiche.

Who all  buy-ASP small car

'Everyone bought a small car.'


Control sentence 2

Tamen dou mai-le yi-ge    wanju.

They all buy-ASP one-CL toy

'They all bought a toy.'


**Story 2**

Test sentence 1

Dou (you) shei xuanze-le   hongsede qiqiu?

All (have) who select-ASP red          balloon

'Who were all the people that selected a red balloon?'


Control sentence 1

Shei mai-le     shengri  dangao?

Who buy-ASP birthday cake

'Who bought the birthday cake?'


Test sentence 2

Shei dou xuanze-le hongsede qiqiu.

Who all select-ASP red          balloon

'Everyone selected a red balloon.'


Control sentence 2

Tamen dou xuanze-le qiqiu.

They   all   select-ASP balloon

'They all selected a red balloon.'


**Story 3**

Test sentence 1

Dou (you) shei qi-le          ma?

All (have) who ride-ASP horse

'Who were all the people that rode the horses?'


Control sentence 1

Shei zuo-le   huoche   huijia?

Who sit-ASP train go home

'Who went home by train?'


Test sentence 2

Shei dou qi-le       ma.

Who all ride-ASP horse

'Everyone rode the horses'


Control sentence 2

Tamen dou laidao-le    saimachang.

They   all   arrive-ASP race track

'They all arrived at the race track.'


**Story 4**

Test sentence 1

Dou (you) shei  zhuadao-le hudie.

All  (have) who catch-ASP butterfly

'Who were all the people that caught a butterfly?'

Control sentence 1

Shei zuo-le    huoche huijia?

Who sit-ASP train go home

'Who went home by train?'


Test sentence 2

Shei dou zhuadao-le hudie

Who all catch-ASP   butterfly

'Everyone caught a butterfly.'


Control sentence 2

Tamen dou canjia-le        zhua hudie      de   bisai.

They   all participate-ASP catch butterfly DE competition

'They all participated in the competition of catching butterflies.'


**Story 5**

Test sentence 1

Dou (you) shei  kan-le      shu?

All  (have) who read-ASP book

'Who were all the people that read the books?'


Control sentence 1

Shei kan-le      shu?

Who read-ASP book

'Who read the books?'

Test sentence 2

Shei dou kan-le      shu

Who all  read-ASP book

'Everyone read the books.'


Control sentence 2

Tamen dou dao-le        tushuguan.

They    all  arrive-ASP library

'They all arrived at the library.'


**Story 6**

Test sentence 1

Dou (you) shei jiandao-le    beike?

All (have) who collect-ASP shell

'Who were all the people that collected a shell?'


Control sentence 1

Shei zuo-le    huoche huijia?

Who sit-ASP train go home

'Who went home by train?


Test sentence 2

Shei dou jiandao-le    beike.

Who all collect-ASP shell

'Everyone collected a shell.'

Control sentence 2

Tamen dou laidao-le    haibian.

They    all  arrive-ASP seaside

'They all arrived at the seaside.'

Appendix D of this thesis has been removed as it may contain sensitive/confidential content