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Downward entailment in child Mandarin*

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ABSTRACT

There are three hallmarks of core linguistic properties. First, they are expected to be manifested in typologically different languages. Second, they should unify superficially unrelated linguistic phenomena. Third, they are expected to emerge early in the course of language development, all things being equal (Crain, 1991). The present study investigates a candidate for a core linguistic property, namely the semantic property of downward entailment. We report the findings of two experimental studies of children's knowledge of downward entailment. These experiments explore two different aspects of downward entailment, in a study with Mandarin-speaking children. Taken together with previous research findings, the results of the present study support the conclusion that downward entailment is a core property of human languages.

INTRODUCTION

Downward entailing expressions (e.g. *not*, *never*) appear in all human languages (Ladusaw, 1979; Horn, 1989; Kadmon & Landman, 1993; Krifka, 1995; Zwarts, 1998). In addition, the semantic property of downward entailment ties together several apparently disparate linguistic phenomena, including the interpretation of disjunctive words (English *or*; Mandarin *huozhe*), and the licensing of negative polarity items like English *any* and Mandarin *renhe* 'any'. In some languages, such as Mandarin Chinese, downward entailing expressions also license the non-interrogative use of *wh*-words, e.g. *shenme* 'what'. These features that are associated with

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downward entailment make it important for theories about language development. If children master a cluster of properties early in the course of language acquisition, this would be evidence that their grammars incorporate a 'deep' linguistic property, and that children do not learn, piecemeal, the various linguistic phenomena associated with that property (Crain, Thornton & Khlentzos, 2009). If empirically confirmed, the joint observations that downward entailment (a) appears in typologically different languages, (b) unifies apparently disparate facts, and (c) emerges early in the course of language development all would lend weight towards counting downward entailment as being a core property of human languages.

This study was designed to obtain empirical data that would be relevant to these hallmarks of core linguistic properties. Specifically, we report the findings of two experimental studies of Mandarin-speaking children. These studies were designed to assess children's knowledge of two properties that are associated with downward entailment. The first experiment investigated children's interpretation of disjunction in downward entailing linguistic contexts. The second experiment investigated children's knowledge of the fact that downward entailing contexts license the non-interrogative use of *wh*-words like *shenme* 'what'. Although previous studies have investigated related linguistic phenomena (mostly with English-speaking children), few studies (if any) have undertaken a joint investigation of more than a single phenomenon using the same downward entailing expression.

Another novel feature of the present study is the focus on Mandarin Chinese. As noted, Mandarin differs from more familiar (and more heavily investigated) languages because downward entailing expressions in Mandarin license the non-interrogative use of question words (e.g. *shenme* 'what' and *shei* 'who'). When the Mandarin question words *shenme* and *shei* appear in the scope of downward entailing expressions, they are interpreted as indefinite NPs (i.e. similar to negative polarity items). Consequently, a sequence of words in which *shenme* or *shei* appears in the scope of a downward entailing expression (e.g. *meiyouren* 'nobody') is typically taken to make a statement, at least by adults. However, when the same question words are used without a downward entailing expression they function as question-markers, so the sequence of words is interpreted as a question, at least by adults.

The main aim of this study is to determine whether three- to five-year-old Mandarin-speaking children exhibit knowledge that downward entailment is associated with these two superficially unrelated linguistic phenomena: (a) how disjunction words are interpreted and (b) how *wh*-words are interpreted. The findings promise to provide critical data in evaluating one putative core property of human languages, and in adjudicating between different models of language acquisition.

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The article is structured as follows. First, we describe the diagnostic criteria for determining what can be counted as 'core' properties of human languages. To illustrate these criteria, we first discuss a core syntactic principle, Principle C of the Binding Theory. Then, we turn our attention to downward entailment, which is a candidate for being a core SEMANTIC property of human languages. Second, we review previous experimental studies of downward entailment in child language. Finally, we report the findings of two experiments on Mandarin-speaking children's knowledge of downward entailment: one experiment examines children's interpretation of disjunction, and the second focuses on their interpretation of *wh*-words.

CORE LINGUISTIC PROPERTIES

Developmental psycholinguists have demonstrated young children's mastery of a variety of linguistic principles. These principles include ones that draw upon core syntactic and semantic properties. For a linguistic property to be a viable candidate to be considered part of core grammar, one expectation is that it should tie together several apparently unrelated linguistic phenomena. We will illustrate this hallmark of core linguistic properties using a syntactic principle, Principle C of the Binding Theory (Chomsky, 1981).

The Binding Theory is a set of three principles that govern the anaphoric relations that can be established between different kinds of noun phrases and their potential antecedents (other noun phrases). Principle C is the third principle of the Binding Theory, which is about the anaphoric relations that pertain to referring expressions. Referring expressions include proper names, such as *Max*, as well as definite descriptions, such as *the director*. Principle C asserts that referring expressions must be 'free', where 'free' means that referring expressions must be distinct in reference from any antecedent noun phrase that bears a particular structural relation with them. The structural relation is called c-command. Roughly, one noun phrase A c-commands another noun phrase B if there is a path (in constituent structure) that proceeds upwards from A to the first branching node, and then downwards to B. Setting details aside, the sentences in (1) can be used to illustrate where Principle C does and does not apply.

(1) a. He said Max was drinking wine.
    b. Max said he was drinking wine.
    c. When he walked in, Max was drinking wine.

Principle C applies in example (1a). Here, Principle C governs the referring expression, *Max*, because the pronoun *he* c-commands the name *Max* in the example. Since Principle C is operative, *he* and *Max* must pick out different individuals. So, the pronoun *he* in (1a) cannot refer to the person named *Max*. Notice that Principle C establishes when a referring expression can

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NOT pick out the same individual as some antecedent noun phrase does. Negative statements like this are often referred to as constraints. Principle C is a constraint that enforces disjoint reference (or non-co-reference).

This means that when Principle C is not operative, as in examples (1b) and (1c), the name *Max* is permitted to be anaphorically linked to the pronoun *he*. In these examples, the pronoun *he* and the name *Max* may be used to pick out the same individual, because the pronoun *he* does not c-command the name *Max* in either of the examples. But, in addition, the pronoun *he* can be used to pick out some male individual who is salient in the context, or who has been introduced earlier. The consequence is that examples (1b) and (1c) are ambiguous. These examples allow two interpretations. On one, the pronoun *he* and the name *Max* are said to be anaphorically linked (or co-referential); on the other, *he* and *Max* are said to have disjoint reference (or non-co-referential). By contrast, example (1a) is unambiguous, due to Principle C. This illustrates the 'constraining' property of Principle C. It eliminates an interpretation that could otherwise be assigned to the sentence (1a), in the absence of Principle C.

As mentioned, one hallmark of a core linguistic property is that it unifies apparently disparate phenomena. Principle C meets this criterion. It is manifested in several diverse constructions. As well as applying to statements, as in (1a), Principle C governs the interpretations that can be assigned to *wh*-questions, as in (2). And it also governs the interpretation of statements with quantificational expressions, as in (3) (these examples are adapted from Chomsky, 1981).

(2) Who did he say Max had criticized (for which x, he said Max had criticized x)

(3) He said Max had criticized everyone (for every x, he said Max had criticized x)

Notice that the pronoun *he* in examples (2) and (3) must refer to a single male individual, and cannot be interpreted as a 'bound' pronoun. By comparison, consider examples (4) and (5). In these examples, the *wh*-word *who* and the quantificational expression *everybody* can be anaphorically linked to the pronoun *he* because Principle C is not operative in these examples.

(4) Who said he had criticized Max (for which x, x said x had criticized Max)

(5) Everybody said he had criticized Max (for every x, x said x had criticized Max)

In short, Principle C provides a unified account of a range of apparently disparate linguistic phenomena. It applies to declaratives, *wh*-questions, and to quantificational expressions.

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Two other hallmarks of core linguistic properties were noted earlier, universality and early emergence. These aspects of Principle C have been investigated in the literature, and Principle C has been found to be operative early in the course of language development, and across languages (see Crain & McKee, 1985; Crain & Thornton, 1998; Conroy & Thornton, 2005; Kazanina & Phillips, 2001; Kiguchi & Thornton, 2004, among others).

The semantic property of downward entailment

Like Principle C, downward entailment is a viable candidate for being a core linguistic property of grammar. The defining feature of downward entailing expressions is that they license inferences from general terms to more specific terms (from sets to their subsets). That is, if a sentence that contains a downward entailing expression and a general term like 'musical instrument' is true, then so is a sentence in which the general term is replaced by one referring to a specific musical instrument, e.g. 'violin' or 'guitar'. Example (6) indicates that the predicate phrase of the negative quantificational expression *nobody* is downward entailing.

(6) Nobody in this class plays a musical instrument.
$\Rightarrow$ Nobody in this class plays the violin.

It is noteworthy that downward entailing operators are sometimes members of a minimal pair, where the other member of the pair contains an operator that is not downward entailing. So, the predicate phrase of the positive quantificational expression *everybody* can be used to form a minimal pair with the negative quantificational expression *nobody*. To see this, note that (6) and (7) form a minimal pair, where (6) but not (7) licenses an inference from the general term 'musical instrument' to the specific term 'violin'.

(7) Everybody in this class plays a musical instrument.
$*\Rightarrow$ Everybody in this class plays the violin.

Downward entailment and the conjunctive entailment of disjunction

Downward entailment unifies several linguistic phenomena that, at first look, appear to be unrelated. We will limit the present discussion to two linguistic phenomena: (a) the generation of conjunctive entailments for disjunction words (Crain, 2008) and (b) the licensing of negative polarity items (Ladusaw, 1979). The first observation is that when a disjunction word, such as English *or*, appears in the scope of a downward entailing expression, then the sentence is true in a restricted set of circumstances, as compared to when disjunction appears in sentences lacking a downward entailing expression. The circumstances associated with disjunction words

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in downward entailing linguistic environments are referred to as the 'conjunctive entailment' of disjunction (see, e.g., Higginbotham, 1991). An example of the conjunctive entailment of disjunction under negation occurs in one of de Morgan's laws of propositional logic: $\neg (A \vee B) \Rightarrow \neg A \wedge \neg B$ (see, e.g., Partee, Meulen & Wall, 1990). The conjunctive entailment of disjunction requires that the disjunction operator is inclusive-*or*, as in classical logic.

This one of de Morgan's laws in negative sentences is validated in many human languages, including English. For example, the English sentence *Amy didn't say that Max plays the violin or the guitar* entails both (a) *Amy didn't say that Max plays the violin* and (b) *Amy didn't say that Max plays the guitar*. Therefore, the conjunction of these statements is entailed by the original statement with *or*.[1] The conjunctive entailment of disjunction extends beyond negation, to all downward entailing expressions. The general schema for the conjunctive entailment of disjunction in the scope of downward entailing expressions is represented in (8), where Δ represents a downward entailing operator (Crain, 2008).

(8) Δ (A or B) $\Rightarrow$ Δ A and Δ B

If we apply the general schema in (8) to human languages, the expectation is that disjunction words will license conjunctive entailments when they appear in the scope of all downward entailing expressions. To illustrate, take the downward entailing expression *nobody*. Example (9) shows that the schema in (8) is satisfied by *nobody*.

(9) Nobody in this class plays the violin or the guitar.
$\Rightarrow$ nobody in this class plays the violin
and
nobody in this class plays the guitar

Disjunction does not generate conjunctive entailments, however, in sentences without a downward entailing expression, as example (10) illustrates.

(10) Everybody in this class plays the violin or the guitar.
* $\Rightarrow$ everybody in this class plays the violin
and
everybody in this class plays the guitar

[1] It should be noted that this de Morgan's law applies only if negation takes scope over disjunction. Across languages, when negation appears in a higher clause than the clause that contains disjunction, it generates a conjunctive entailment, thereby showing that human languages conform to this one of de Morgan's laws. However, when disjunction appears in simple negative sentences, languages are partitioned into two classes. One class, including languages like English, German and Korean, follows this de Morgan's law, and generates the conjunctive entailment when disjunction appears in simple negative statements. By contrast, in languages like Hungarian, Japanese, Chinese, Russian and Polish, disjunction is interpreted as taking scope over local negation in simple negative statements (Szabolcsi, 2002; Goro & Akiba, 2004; Crain, 2009; Notley *et al.*, in press).

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Example (10) contains the quantificational expression *everybody*, which is not downward entailing. Therefore, the conjunctive entailment of disjunction is not enforced. Instead, sentence (10) can be interpreted as *everybody in this class plays the violin or the guitar or possibly both*. Since the sentence can have the full range of truth conditions associated with inclusive-*or*, we call this the 'disjunctive' truth conditions of disjunction in non-downward entailing linguistic contexts.[2]

Downward entailment and the licensing of negative polarity items

Downward entailment has another diagnostic test, which is associated with the distribution of negative polarity items such as English *any*, Mandarin *renhe* and Mandarin *wh*-words such as *shenme* and *shei*. The appearance of such items is sensitive to the presence, in the same sentence, of certain other 'licensing' expressions. Specifically, negative polarity items, as their names suggest, often like being in somewhat 'negative' linguistic contexts (Klima, 1964), and they are more generally licensed by downward entailing expressions (Ladusaw, 1979). For example, the English negative polarity item *any* appears fine in downward entailing contexts. By contrast, non-downward entailing contexts don't allow the presence of *any*. Example (11) provides a minimal pair with *any*. In (11a), the predicate phrase of the quantificational expression *nobody* licenses *any*. Example (11b) shows that *any* is not tolerated in the predicate phrase of *everybody*.

(11) a. Nobody in this class plays any instrument.
b. Everybody in this class plays *any instrument.

To summarize, downward entailing environments unify the dual properties of (a) generating the conjunctive entailment of disjunction and (b) licensing negative polarity items. Moreover, there are further distinctions among downward entailing expressions, as well as various types of negative polarity items. We refer the readers to the 'Appendix' for discussion.

[2] A pragmatic implicature often reduces this range of truth conditions for disjunction words in non-downward entailing contexts. In particular, the implicature excludes circumstances in which both disjuncts are true, by rendering disjunction an exclusive-*or* reading (Horn, 1972). The implicature arises because the expression *or* forms a scale with the expression *and* based on information strength, with *and* being more informative than *or* in non-downward entailing contexts. Language users are compelled by the Principle of Cooperation (Grice, 1975) to use the strongest linguistic expression that is consistent with their state of knowledge, so if speakers know that both statements *A and B* and *A or B* are true, they avoid using the statement with disjunction, because it constitutes a weaker statement. If a speaker uses the weaker statement, hearers infer that the speaker was not in a position to use the stronger statement, so the hearer infers the negation of the stronger statement, i.e. *not* (*A and B*).

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A minimal pair in Mandarin Chinese : meiyouren versus meigeren

As we just saw, downward entailing operators sometimes permit the formation of minimal pairs with linguistic expressions that are not downward entailing. These minimal pairs formed the basis of the experiments we conducted with Mandarin-speaking children.

In Mandarin, the quantificational expression corresponding to English *nobody* is *meiyouren*. As with English *nobody*, the predicate phrase of *meiyouren* is downward entailing. This is shown in example (12).

(12) Ban shang meiyouren PRED [yanzou yueqi].
class PREP not-have-person play musical instrument
'Nobody in this class plays a musical instrument.'
⇒ Ban shang meiyouren PRED [yanzou xiaotiqing].
class PREP not-have-person play violin
'Nobody in this class plays the violin.'

The Mandarin expression corresponding to English *everybody* is *meigeren*. As with English *everybody*, *meigeren* is not downward entailing on its predicate phrase, as illustrated in example (13).

(13) Ban shang meigeren dou PRED [yanzou yueqi].
class PREP every-CL-person all play musical instrument
'Everybody in this class plays a musical instrument.'
* ⇒ Ban shang meigeren dou PRED [yanzou xiaotiqing].
class PREP every-CL-person all play violin
'Everybody in this class plays the violin.'

At this point, we would like to bring to the readers' attention the different morphemes corresponding to Mandarin *mei* in the quantificational expressions *meiyouren* and *meigeren*. In example (12), *mei* (rising/second tone) is the negator in *meiyouren*, which is an allomorph of *bu* 'not', and it is used in conjunction with verbs denoting existence or possession, such as the verb *you* 'have'. This *mei* must be distinguished from the other *mei* (falling-rising/third tone) that appears in *meigeren* in example (13), which is the Mandarin universal quantifier, similar to English *every*.

Let us now examine the two diagnostic properties of downward entailing expressions in Mandarin Chinese. The first observation is that the Mandarin word for disjunction, *huozhe* 'or', yields different truth conditions when it appears in the predicate phrases of *meiyouren* versus *meigeren*, as illustrated in examples (14) and (15).

(14) Ban shang meiyouren PRED [yanzou xiaotiqing huozhe jita].
class PREP not-have-person play violin or guitar
'Nobody in this class plays the violin or the guitar.' = Conjunctive

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(15) Ban shang meigeren dou PRED [yanzou xiaotiqing huozhe jita].
class PREP every-CL-person all play violin or guitar
'Everybody in this class plays the violin or the guitar.' = Disjunctive

When *huozhe* appears in the predicate phrase of *meiyouren*, it generates a more restricted set of truth conditions, namely those truth conditions associated with the conjunctive entailment of disjunction. So, example (14) is true only when *nobody in this class plays the violin and nobody in this class plays the guitar*. By contrast, example (15) indicates that *huozhe* licenses the full range of disjunctive truth conditions when it appears in the predicate phrase of *meigeren*, as did its English counterpart *Everybody in this class plays the violin or the guitar*.

The second diagnostic of downward entailment is the licensing of negative polarity items like English *any* and Mandarin *renhe*. As illustrated in examples (16) and (17), the predicate phrase of the negative quantificational expression *meiyouren* licenses *renhe*, whereas *renhe* is not tolerated in the predicate phrase of the positive quantificational expression *meigeren*.

(16) Ban shang meiyouren PRED [yanzou renhe yueqi].
class PREP not-have-person play any music instrument
'Nobody in this class plays any instrument.'

(17) Ban shang meigeren dou PRED [yanzou *renhe yueqi].
class PREP every-CL-person all play any music instrument
'Everybody in this class plays *any instrument.'

Despite the parallels between English *any* and Mandarin *renhe*, we did not investigate Mandarin *renhe* in the current experimental study. Notice that the distinction between (16) and (17) is one of acceptability, i.e. *renhe* is acceptable in (16) but not in (17). It has been found, however, that children younger than six years old are not able to reliably make judgements about the acceptability of sentences (see, e.g., Saywitz & Cherry-Wilkinson, 1982; Edwards & Kirkpatrick, 1999; Cairns, Schlisselberg, Waltzman & McDaniel, 2006). In view of this finding, we chose to investigate children's interpretation of *wh*-words, rather than *renhe*, in downward entailing versus non-downward entailing contexts. By using Mandarin *wh*-words as the target lexical items, we were able to develop a different kind of meta-linguistic task, called the Question/Statement task (Zhou & Crain, 2011), which will be introduced in the experimental part.

Let us now turn to the specific linguistic properties of Mandarin *wh*-words. In Mandarin, *wh*-words serve dual semantic functions. In many

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ordinary linguistic environments, they serve as question-markers, turning a sequence of words into a question. By contrast, when *wh*-words appear in the scope of downward entailing expressions, they often function as negative polarity items.[3] Consequently, the sequence of words that contains the *wh*-word constitutes a statement, rather than a question (see Huang, 1982; Cheng, 1991; Li, 1992; Cheng, 1994; Lin, 1996; 1998, for a detailed discussion of the interpretation of *wh*-words in Chinese).

Let us apply this distinction to the quantificational expressions *meiyouren* and *meigeren*. When the Mandarin question-word *shenme* appears in the predicate phrase of *meiyouren*, as in (18), the speaker is making a statement.[4] By contrast, when the question word *shenme* is combined with *meigeren*, as in (19), the speaker is posing a question.

(18) Ban shang meiyouren PRED [yanzou shenme yueqi].
class PREP not-have-person play what musical instrument
'Nobody in this class plays any musical instrument.'

(19) Ban shang meigeren dou PRED [yanzou shenme yueqi]?
class PREP every-CL-person all play what musical instrument
'What kind of musical instrument does everybody in this class play?'

To recap, the minimal pairs in the truth conditions of disjunction and in the interpretation of *wh*-words in the predicate phrase of *meiyouren* versus the predicate phrase of *meigeren* are schematically represented in (20) and (21), respectively.

(20) Meiyouren PRED [……huozhe…….] = Conjunctive
Meigeren PRED [……huozhe…….] = Disjunctive

(21) Meiyouren PRED [……wh-words……] = Statement
Meigeren PRED [……wh-words……] = Question

[3] It should be pointed out that the non-interrogative use of *wh*-words is not limited to downward entailing environments. *Wh*-words are also tolerated in 'non-existence' environments, such as in sentences with the epistemic adverb *keneng* 'perhaps' and raising verbs like *haoxiang* 'seem' (Lin, 1996; 1998). However, the conjunctive entailment of the disjunction word *huozhe* is not generated in these environments. We will ignore these cases, where these dual properties fail to co-occur. Instead, we restrict our attention, in the present article, to cases where the dual properties do occur, namely in linguistic contexts with downward entailing expressions (see the 'Appendix').

[4] Although *shenme* is glossed as *any* in the present examples (and in the sentences we tested in the experiments reported below), the non-interrogative interpretation of *wh*-words in Chinese is not identical to *any*, since *wh*-words are also sometimes interpreted as indefinite pronouns, roughly equivalent to English *some* (Li, 1992).

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The following study on child Mandarin investigated whether young Mandarin-speaking children understand these different linguistic properties that are associated with the predicate phrases of *meiyouren* versus *meigeren*. Before we turn to the study, we will review previous literature on children's knowledge of downward entailment.

DOWNWARD ENTAILMENT IN CHILD LANGUAGE: PREVIOUS RESEARCH

Previous child experiments on downward entailment provide separate reports on children's interpretation of disjunction and their understanding of the licensing condition of negative polarity items like *any*. A series of cross-linguistic studies have investigated children's interpretation of disjunction in the scope of downward entailing operators, including *not* (Crain, Gardner, Gualmini & Rabbin, 2002; Goro & Akiba, 2004; Jing, Crain & Hsu, 2005), *none* (Gualmini & Crain, 2002), *before* (Notley, Zhou, Jensen & Crain, in press) and the subject phrase of *every* (Boster & Crain, 1993; Gualmini, Meroni & Crain, 2003; Su & Crain, 2009). It has been found, across typologically different languages, that young children generate the conjunctive entailment when disjunction appears in the scope of downward entailing operators, whereas they assign disjunctive truth conditions to disjunction when it appears in non-downward entailing contexts (see Crain, 2008, for a review).

One source of empirical evidence of children's knowledge of downward entailment comes from studies of three- to five-year-old children's understanding of disjunction words in simple negative sentences. Studies have been conducted in English, Japanese and Mandarin Chinese (Crain *et al.*, 2002; Goro & Akiba, 2004; Jing *et al.*, 2005). Interestingly, in two of these languages, Chinese and Japanese, children's interpretations differed from those of adults. For adult speakers of Japanese and Chinese, words for disjunction are not interpreted as being within the scope of negation in simple negative sentences (see footnote 1). For example, in the Jing *et al.* study (2005), Mandarin-speaking adults were found to accept the sentence *Tanglaoya meiyou juqi zhuozi huozhe dianshi* 'Donald Duck didn't lift the table or the TV' as a description of a situation in which Donald Duck lifted the table but not the TV. That is, adults interpreted the test sentence as if it meant *It is the table or the TV that Donald Duck didn't lift*, where disjunction takes scope over negation. By contrast, twenty out of twenty-one Mandarin-speaking children responded like English-speaking children and English-speaking adults (see Crain *et al.*, 2002, for the English study). They consistently rejected the test sentence by pointing out that Donald Duck had lifted the table. So, for children, the meaning that was assigned to the sentence can be paraphrased as *Donald Duck lifted neither the table nor the TV* (see Goro & Akiba, 2004, for similar results in an earlier Japanese

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study). In short, it appears that, across languages, young children initially adhere to de Morgan's law, sometimes in apparent disregard to the properties of adult language (Crain, Goro & Thornton, 2006; Crain & Khlentzos, 2008; 2010). Findings like these are not expected according to experience-based models of language development, which contend that child language matches the input provided by adult language users (Pullum & Scholz, 2002; Tomasello, 2003).

Recently, Su and Crain (2009) assessed three- to five-year-old Mandarin-speaking children's knowledge of the different truth conditions for the disjunction word *huozhe* in the subject phrase versus the predicate phrase of the universal quantifier *mei* 'every'. On one trial, there were five aliens purchasing vehicles. Two aliens bought airplanes and chose stars as gifts. Two aliens bought cars and chose books as gifts. Finally, one alien bought a boat and chose a suitcase as a gift. The test sentence was *Mei-ge mai-le feiji huozhe xiaoqiche de waixingren dou xuanze-le shu* 'Every alien who bought an airplane or a car chose a book'. It was reported that twenty child subjects rejected such test sentences 91% of the time. Children justified their rejections by pointing out that two aliens who bought airplanes chose stars, not books. This suggests that children assigned a conjunctive entailment to *huozhe* when it appeared in the subject phrase of *mei*. Therefore, they interpreted the test sentence as entailing that *every alien who bought an airplane chose a book and every alien who bought a car chose a book*.

On another condition, *houzhe* appeared in the predicate phrase of the universal quantifier *mei*. In a typical story, there were four princesses with dogs, and one with a bird. Two of the princesses with dogs took some jewels from a witch's house, two other princesses with dogs took rings, and the one princess with a bird took a flower. The same children accepted the test sentence *Mei-ge dai-zhe gou de gongzhu dou tou-le baoshi huozhe jiezhi* 'Every princess who carried a dog stole a jewel or a ring' 95% of the time. This finding provides evidence that children assigned disjunctive truth conditions to *huozhe* in the predicate phrase of *mei*, a non-downward entailing context. These experimental findings resemble those reported in earlier English studies conducted by Boster and Crain (1993) and Gualmini *et al*. (2003).

Taken together, the findings of previous research provide evidence that across typologically different languages, children are aware of the different linguistic properties of the downward entailing subject phrase versus the non-downward entailing predicate phrase of the universal quantifier (e.g. Mandarin *mei* and English *every*). The evidence is that they assign different truth conditions to disjunction in these different structural positions. Despite the compelling evidence that young children generate the conjunctive entailment of disjunction in the scope of several downward entailing operators, to our knowledge no study has tested children's linguistic knowledge of the interpretation of disjunction in the predicate phrase of

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Mandarin *meiyouren*. The present study is designed to supplement the previous findings by examining Mandarin-speaking children's knowledge that the predicate phrase of *meiyouren* is downward entailing and, therefore, licenses the conjunctive entailment of disjunction.

What about children's knowledge of the other diagnostic property of downward entailment – the licensing of negative polarity items? There are only a handful of child studies investigating the development of polarity sensitivity, mainly focusing on children speaking English and Dutch (O'Leary & Crain, 1994; Koster & van der Wal, 1995; van der Wal, 1996). One study by Koster and van der Wal (1995) investigated seven- to fourteen-year-olds, as well as young adults. In this experiment, children and young adults were asked for judgements about the grammaticality of the licensing environments of the German negative polarity item *hoeven* 'have to'. The grammaticality judgement task revealed that children's understanding of these licensing environments improved with age. To our knowledge, however, there have been no studies adopting such grammaticality judgement tasks to assess younger children's knowledge of negative polarity items, because children younger than six have been found to be unable to make reliable meta-linguistic judgements about the grammaticality of sentences (Saywitz & Cherry-Wilkinson, 1982; Edwards & Kirkpatrick, 1999; Cairns *et al*., 2006).

Knowledge of where negative polarity items are and are not licensed has been investigated using other methodologies, when the subjects were younger than six to seven years old. In previous studies, these methodologies include elicited production tasks and act-out tasks (Koster & van der Wal, 1995; O'Leary & Crain, 1994). For example, Koster and van der Wal (1995) conducted an elicitation and acting-out experiment with a group of three-year-olds, testing their knowledge of the licensing situations of *hoeven*. The results showed that even very young children's grammatical knowledge of restrictions on *hoeven* was essentially adult-like, although there were some particular deviations from the adult usage.

Another study conducted by O'Leary and Crain (1994) adopted the Truth Value Judgement task with an elicitation component. In the task, Kermit the frog uttered false descriptions of events that had happened in the stories witnessed by children. After children's rejection of the puppet's assertions, they were asked to explain to Kermit 'what really happened?' It was found that children's negative statements, as in (22), typically contained the negative polarity item *anything*. By contrast, children produced the positive polarity item *something*, rather than *anything*, in the predicate phrase of their statements with pre-subject *every*, as in (23).

(22) KERMIT: Every dinosaur found something to write with.
CHILD: No, this one didn't find anything to write with.

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(23) KERMIT: Only one of the reindeer found anything to eat.
CHILD: No, every reindeer found something to eat.

The findings suggest that four-year-old English-speaking children use the negative polarity item *any* in downward entailing contexts, but refrain from using *any* in non-downward entailing contexts.

There are no studies of children's knowledge of the licensing condition of negative polarity items in Mandarin Chinese. To fill in this gap, the present study investigated whether Mandarin-speaking children know that the predicate phrase of *meiyouren*, a downward entailing context, allows the non-interrogative interpretation of *wh*-words like *shenme*. By contrast, the appearance of *shenme* in the predicate phrase of *meigeren*, a non-downward entailing context, leads to the question reading.

To summarize, although independent investigations have been undertaken on children's knowledge of (a) the interpretation of disjunction and (b) the licensing of negative polarity items, few experimental studies in any language have addressed the 'unification' feature of downward entailment by testing these two linguistic phenomena under the same linguistic contexts. In the following sections, we report two experiments investigating Mandarin-speaking children's knowledge of these two phenomena of downward entailment, using the quantificational expressions *meiyouren* versus *meigeren*. These experiments were conducted to fill a crucial missing link in previous research, i.e. whether or not children have the knowledge that downward entailment unifies several superficially unrelated linguistic phenomena, as a 'core' property in human languages.

EXPERIMENT 1

Experiment 1 investigates children's interpretation of the Mandarin disjunction word *huozhe* in the predicate phrases of *meiyouren* versus *meigeren*. We aim to assess whether children assign different truth conditions to disjunction in these two linguistic contexts. In particular, we address the following two research questions: Do children generate the conjunctive entailment of disjunction in the predicate phrase of *meiyouren*, a downward entailing context? Do they assign the disjunctive truth conditions to disjunction when it appears in the predicate phrase of *meigeren*, a non-downward entailing context?

METHOD

Subjects

The subjects consisted of twenty-six monolingual Mandarin-speaking children (mean age 4;09, range 4;01 to 5;03). The children were recruited from the Second Kindergarten Affiliated with the Education Department of

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Kaifu District in Changsha, China. In addition, sixteen adult native Mandarin speakers served as a control group. These subjects were recruited at Macquarie University in Sydney, Australia.

Procedures

The experiment used the Truth Value Judgement task (Crain & Thornton, 1998). The Truth Value Judgement task was conducted by two experimenters. The first experimenter acted out stories in front of the child subject using props and toys. The second experimenter played the role of a puppet (Kermit the frog) who watched the stories alongside the child. At the end of each story, the puppet produced a sentence which purported to accurately describe what happened in the story. The child's task was to judge whether or not the puppet said the 'right thing or the wrong thing' (i.e. true or false). When a child indicated that the puppet's statement was wrong, the child was asked to explain to the puppet what had really happened in the story. The explanation children produced was subsequently used in the data analysis, to ensure that the child understood the story and therefore produced a legitimate reason for rejecting the puppet's statement.

The child subjects were first introduced to the task as a group. Then they were tested individually in a quiet room. Each child was introduced to the task with two warm-up stories. One of these warm-ups was designed to elicit a 'Yes' answer and the other was designed to elicit a 'No' answer. If children answered both of the warm-up sentences correctly, and produced appropriate justifications for their 'No' response, they were invited to participate in the main test sessions. Otherwise, children were eliminated from further testing. Two children said 'Yes' to both warm-up sentences and did not participate further. Altogether, twenty-four children participated in the two main sessions of the experiment.

The sixteen adults in the control group were also tested individually, but only by the main experimenter, who told the stories and played the role of the puppet. Unlike the child subjects, adults only participated in one session in which all of the test sentences were combined (i.e. the 'warm-up' sentences, filler sentences and control sentences were deleted). These adult subjects were also instructed to indicate whether the puppet was right or wrong, following each of the target assertions. As with the child subjects, whenever the adult subjects judged the puppet to be wrong, they were asked to justify their answers.

Materials

The experiment used a within-subject design. Each child subject was tested using the same non-linguistic contexts, both for test sentences with

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meiyouren and ones with *meigeren*. In each main session, there were four test trials consisting of two types of test sentences: two trials with the disjunction word *huozhe* appearing in the predicate phrase of *meiyouren* and the other two with *huozhe* appearing in the predicate phrase of *meigeren*. The stories were designed to make the test sentences false if *houzhe* appeared in the predicate phrase of *meiyouren*, but true if it appeared in the predicate phrase of *meigeren*.

To illustrate, the following represents a typical story: 'This story is about Superman and four of his car friends, who were visiting Superman's house. Superman wanted to show his friends about how strong he was. He led his car friends to his backyard where he raised a lot of animals, including a bear, four kangaroos, four cats and four dogs. ''My muscle gets stronger by lifting up these animals every day! Look at how strong I am!'' He lifted up the big bear. The cars admired Superman very much and they also wanted to try. ''Let's have a competition!'' Superman said. Each of the cars tried to lift the heaviest animal it could. Two cars boasted, ''We can lift the kangaroos!'' But these cars failed to lift the kangaroos and, in the end, each of them could only lift a cat. Superman asked the two smaller cars if they wanted to lift the baby dogs, which were the easiest to lift up. But these two cars refused. Surprisingly, they each lifted a big kangaroo.'

When the story concluded, the puppet either produced the test sentence with negation, as in (24) or the test sentence with the universal quantifier, as in (25).

(24) Meiyou xiaoche juqi daishu huozhe xiaogou.
not-have car lift kangaroo or dog
'No car lifted a kangaroo or a dog.'

(25) Mei-liang xiaoche dou juqi-le daishu huozhe xiaomao.
every-CL car all lift-ASP kangaroo or cat
'Every car lifted a kangaroo or a cat.'

The subjects were divided into two groups for the main session. The first group of subjects (twelve children and eight adults) heard the test sentence (24). The second group of subjects (twelve children and eight adults) was tested with the test sentence (25). These two types of test sentences were mixed and counterbalanced across the two groups of subjects, so that each group was presented with both types of test sentences and there were an equal number of both types of sentences for each group.

Notice that (24) is false if the subjects know that the predicate phrase of *meiyouren* is downward entailing. This generates the conjunctive entailment of *huozhe* (i.e. *no car lifted a kangaroo and no car lifted a dog*) and, consequently, they should reject the test sentence on the grounds that two cars

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lifted a kangaroo. However, if children fail to generate the conjunctive entailment for *huozhe*, then they should accept (24), since the sentence would mean that *no car lifted a kangaroo or no car lifted a dog*. This reading would make the test sentence true in the context, because none of the cars lifted a dog.[5]

By contrast, we anticipated that children would assign a different truth value to target sentences like (25), i.e. by saying 'Yes' if they understand the predicate phrase of *meigeren* as non-downward entailing and thus assign the disjunctive truth conditions to *huozhe*. However, if children fail to distinguish the predicate phrase of *meigeren* from the predicate phrase of *meiyouren*, they could reject test sentence (25). This could happen, for example, if children analyzed these two similar linguistic structures to be downward entailing, thereby licensing the conjunctive entailment of disjunction in both structures. If so, children's interpretation of (25) would be true only if every car lifted both a kangaroo and a cat. At the same time, if children misinterpreted *huozhe* as meaning *he* 'and', as has been suggested in the literature (Paris, 1973), they would also produce a negative response. If so, then children would have taken sentence (25) to mean that every car lifted a kangaroo and a cat, so they would have rejected it on the grounds that each of the cars lifted only one thing.

In addition to the target sentence, the puppet also produced a filler sentence on each trial, which preceded the test sentence. Filler sentences were designed to hold the child subjects' attention, and to provide an equal number of 'Yes' and 'No' responses from the child subjects. Moreover, they obscured the purpose of the experiment. The filler sentence was either obviously true or obviously false and the truth value of the filler sentence was different from the test sentence. For example, the first group of subjects who were tested with sentence (24) heard the filler sentence *dalishi juqi-le xiaoxiong* 'Superman lifted a bear', which was clearly true; whereas the second group of subjects who were tested with sentence (25) heard the filler sentence *dalishi juqi-le xiaogou* 'Superman lifted a dog', which was clearly false.

In addition to the four test trials, there were two control trials in each session. The control sentences (one true and one false) were similar to the test sentences, but they were presented in a different situational context and, thus, were expected to evoke different true or false responses from the corresponding test sentences. For example, on one control trial, a fairy and four mermaids went to purchase things for their new house. At the end of the story, the fairy had purchased a treasure box, two mermaids had

[5] An additional precaution was taken to remove a possible order effect. For half of the test sentences, the sentences were false in virtue of the first disjunct and, for the other half, the test sentences were false because of the second disjunct.

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purchased a mirror, two mermaids had purchased a wardrobe, but no one had purchased either a bed or a chair. Following the story, the puppet produced either sentence (26) or sentence (27).

(26) Meiyou meirenyu mai-guo chuang huozhe dengzi.
not-have mermaid buy-ASP bed or chair
'No mermaid bought a bed or a chair.'

(27) Mei-tiao meirenyu dou mai-le dengzi huozhe jingzi.
every-CL mermaid all buy-ASP chair or mirror
'Every mermaid bought a chair or a mirror.'

For adults, the control sentence (26) with *huozhe* in the predicate phrase of *meiyouren* was true. By contrast, sentence (27) with *huozhe* in the predicate phrase of *meigeren* was false in the same context. Each group of subjects was presented with both types of control sentences once in each session. As with test trials, each control sentence was preceded by a filler sentence (with a different truth value from the control sentence). The first group of subjects who were tested with control sentence (26) heard the filler sentence *Xiannü mai-le jingzi* 'Fairy bought a mirror', which was clearly false; whereas the second group of subjects who were tested with control sentence (27) heard the filler sentence *Xiannü mai-le baohe* 'Fairy bought a treasure box', which was obviously true.

Finally, in each session, each group of children was also tested with two identical filler trials (one true and one false), which contained simple positive sentences in the past tense, e.g. *Xiaonü zhaodao-le tanglaoya* 'The Donkey found the Donald Duck'. So, in addition to the six filler sentences introduced in the four test trials and the two control trials, children were tested with a total of eight filler sentences per session.

RESULTS AND DISCUSSION

Before we report the findings, let us review the main experimental predictions. The experimental hypothesis was that children would make a distinction between the downward entailing predicate phrase of *meiyouren* and the non-downward entailing predicate phrase of *meigeren*, such that they would be expected to access the different truth conditions of disjunction in these two structures. So, children would reject test sentences like (24), with *huozhe* in the predicate phrase of *meiyouren*. On the other hand, children were expected to accept test sentences like (25), with *huozhe* appearing in the predicate phrase of *meigeren*. The results confirmed the experimental hypothesis. When *huozhe* was in the predicate phrase of *meiyouren*, children rejected the test sentences 94% of the time (90/96). By contrast, when *huozhe* was in the predicate phrase of *meigeren*, children accepted the test

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sentences 90% of the time (86/96).[6] Children also justified their negative judgements of the test sentences for the right reasons. For example, in justifying their rejections of (24), children consistently pointed out that two of the cars lifted kangaroos. The control group of sixteen Mandarin-speaking adults correctly rejected the test sentences with disjunction in the predicate phrase of *meiyouren* 98% of the time (63/64), and they accepted the test sentences with disjunction in the predicate phrase of *meigeren* 95% of the time (61/64). Moreover, children accepted the control sentences with *huozhe* in the predicate phrase of *meiyouren* (e.g. (26)) 96% of the time (46/48) and they rejected the control sentences with *huozhe* in the predicate phrase of *meigeren* (e.g. (27)) 98% of the time (47/48). In addition, children made correct judgements for the filler sentences 99·5% of the time (382/384).

A comparison of the adult data between the previous Jing *et al.* (2005) study and our study reveals two different interpretive patterns for the disjunction word *huozhe*. Although both studies tested disjunction in negative contexts, adult subjects in the Jing *et al.* (2005) study did not appear to adhere to de Morgan's law, whereas adults in our study did show adherence to it. We attribute this discrepancy to the two different negative structures under investigation, i.e. (i) negation and disjunction appearing as clause mates (as in the Jing *et al.* (2005) study) versus (ii) negation appearing in higher clauses than disjunction (as in our study). As noted, in the Jing *et al.* (2005) study, the adult interpretation of disjunction in simple negative sentences is subject to cross-linguistic variation (Szabolcsi, 2002; Goro & Akiba, 2004; Crain, 2009; Notley *et al.*, in press). Consequently, Mandarin-speaking adults allowed disjunction to take scope over negation and failed to follow de Morgan's law. However, in our study, when the negative operator *meiyouren* appeared in the subject position, disjunction was not able to take scope over *meiyouren*. It is not surprising that adults always assigned the conjunctive entailment to *huozhe* in our study, because in this case disjunction remains in the scope of a downward entailing operator (Gualmini & Crain, 2005).

No matter how complicated adults' interpretations might be, young children across languages are found to follow the similar interpretive pattern of assigning the conjunctive entailment to disjunction in the scope of downward entailing operators (Crain, 2008). In the Jing *et al.* (2005) study, children observe de Morgan's law despite abundant counter-examples from adult data. In our study, the findings clearly demonstrated that Mandarin-speaking children are aware of the different truth conditions of *huozhe* in the

[6] Only one boy consistently rejected all four test sentences with *huozhe* in the predicate phrase of *meigeren*. For instance, for the test sentence (25) *Mei-liang xiaoche dou juqi-le daishu huozhe xiaomao* 'every car lifted a kangaroo or a cat', he expected that either every car could lift a kangaroo or every car could lift a cat. This phenomenon is also found in the Boster and Crain (1993) study of English-speaking children.

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predicate phrases of *meiyouren* versus *meigeren*. The four- to five-year-old Mandarin-speaking children we tested demonstrated understanding that *huozhe* generated a conjunctive entailment when it appeared in the predicate phrase of *meiyouren*, a downward entailing context. The same children assigned disjunctive truth conditions to *huozhe* when it appeared in the predicate phrase of *meigeren*, a non-downward entailing context. In combination with previous cross-linguistic child studies (see, e.g., Crain *et al*., 2002; Gualmini & Crain, 2002; Gualmini *et al*., 2003; Goro & Akiba, 2004; Jing *et al*., 2005; Su & Crain, 2009; Notley *et al*., in press), these results provide additional support for the conclusion that young children master one of the diagnostic properties of downward entailment, i.e. the conjunctive entailment of disjunction, at an early age, and across languages.

EXPERIMENT 2

Experiment 2 examines Mandarin-speaking children's interpretation of the *wh*-word *shenme* in the predicate phrases of *meiyouren* versus *meigeren*. The purpose is to test whether children understand that *shenme* is interpreted differently in these two linguistic contexts. More precisely, we address the following two research questions: Do children access the non-interrogative use of *shenme* when it appears in the predicate phrase of *meiyouren*, a downward entailing context? Do children assign the normal question reading to *shenme*, when it appears in the predicate phrase of *meigeren*, a non-downward entailing context?

METHOD

Subjects

This study involved another twenty-eight monolingual Mandarin-speaking children (mean age 4;2, range 3;5 to 4;9) from the Kindergarten Affiliated with Beijing Language and Culture University. In addition, twenty Mandarin-speaking adults served as controls, all postgraduates at Beijing Language and Culture University.

Procedures

To determine children's understanding of *shenme*, we developed a new methodology called the Question–Statement task (Zhou & Crain, 2011). This task involved two experimenters. One experimenter acted out stories using toy characters and props, and the other played the role of a puppet who watched the stories alongside the subject. At the end of each story, the puppet attempted to tell the subject what had happened in the story, using one of the test sentences. However, sometimes the puppet didn't pay close

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attention to the story and thus was not sure about what happened in the story. If this was the case, then the puppet asked the child a question. Whenever the subject understood the puppet to be asking a question, the subject was instructed to answer the question and then asked the puppet to pay closer attention to the next story. In the other task, instead of asking a question, the puppet produced a statement about what had happened in the story. In this case, the subject's task was to decide whether the puppet accurately described the events that were unfolded in the story.

The child subjects were introduced to the task individually and then tested individually. In order to familiarize the subjects with the task, they were given two practice trials before the main test session. On one of the practice trials, the puppet informed the subject about what happened in the story, and on the other trial the puppet asked the subject a question. Only those children who correctly judged whether the puppet made a statement about the story and asked a question about the story in the practice trials were included in the actual test. In this study, all of the twenty-eight children succeeded in the two practice trials.

Materials

During the main test session, six test stories were presented to each child. Three of the test sentences contained *shenme* in the predicate phrase of *meiyouren*, and three contained *shenme* in the predicate phrase of *meigeren*. The test sentences would be expected to evoke a statement when *shenme* appeared in the predicate phrase of *meiyouren* and to evoke a question when *shenme* appeared in the predicate phrase of *meigeren*.

To illustrate, here is a typical story: 'This story is about three pandas that went to have breakfast. They had four choices, including three types of fruit (lemons, pears and strawberries) and eggs. They came to the lemons first. None of them picked one, because they were too sour. Then they came to the eggs and each of them took one. Then they came to the pears. Two of them didn't like pears but the third panda chose one big pear. Finally, they came to the strawberries. They all liked strawberries, so each panda took one.'

As soon as the story ended, the puppet either produced test sentence (28) or test sentence (29). Subjects were divided into two groups for the presentation of the test trials. The first group of subjects (fourteen children and ten adults) was tested with sentence (28). The second group of subjects (fourteen children and ten adults) was tested with sentence (29). These two types of test sentences were counterbalanced for each group of subjects.

(28) Meiyou xiongmao chi shenme shuiguo.
not-have panda eat what fruit
'No panda ate any fruit.'

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(29) Mei-zhi xiongmao dou chi-le shenme shuiguo?
every-CL panda all eat-ASP what fruit
'What kind of fruit did every panda eat?'

At this point, it is important to clarify two research strategies in the experimental design, which were cautiously undertaken to ensure that the subjects would make a judgement of the test sentences on the basis of the linguistic structures, rather than depending on several other linguistic features specific to Mandarin Chinese. First, it should be noted that no Mandarin sentential final particle was attached to the end of the test sentences. In Mandarin Chinese, sentential final particles such as the modal particles *a*, *o* and question particles *ne*, *ma* are often used in statements and questions, performing pragmatic functions (e.g. the modal particle *a* indicates affirmation, approval or consent) or grammatical functions (e.g. the question particle *ma* changes declarative sentences to interrogative ones). We made sure that the subjects would not rely on the occurrence of these particles to judge whether the test sentences were interrogative or non-interrogative. Second, it is crucial to point out that we have controlled the prosodic features of the test sentences, by using the same intonation pattern, i.e. level intonation, with *shenme* unstressed. To be specific, the experimenter who played the role of the puppet was required to utter both types of test sentences with level intonation. Moreover, this experimenter was not informed about the purpose of the experiment, so that she wouldn't be unintentionally biased towards supporting either of the interpretive patterns of the target sentences via prosodic cues. This is because Mandarin Chinese is famously known as a tone language that uses intonation to distinguish between making a statement (i.e. using level intonation) and asking a question (i.e. using rising intonation). With this manoeuvre of adopting the same level intonation for all the test sentences with *shenme*, children are less likely to resolve the different speech acts of the two types of test sentences by simply relying on prosodic cues. We will have more comments on the prosodic features of the test sentences in the next section.

In addition to the six test trials, there were four control trials. These included two statements with the universal quantifier *mei*, as in (30) and two questions with *wh*-words, as in (31).

(30) Mei-zhi xiongmao dou chi-le caomei.
every-CL panda all eat-ASP strawberry.
'Every panda ate a strawberry.'

(31) Shei cong qiao-shang diaoxiaqu-le?
Who from bridge-top fall-ASP
'Who fell off the bridge?'

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These control trials were included to investigate children's understanding of the universal quantifier *mei* and their understanding of *wh*-words in simple sentences, so that it would be clear whether or not any children might be expected to experience difficulty understanding the universal quantifier *mei* or a *wh*-word when it appeared in the test sentences. At the same time, the control trials were used to verify that children could understand the Question–Statement task. If so, children were expected to provide an answer to a question and to make a truth-value judgement in response to a statement, whenever appropriate.

RESULTS AND DISCUSSION

Here are the experimental hypotheses. If children know that downward entailing contexts license *wh*-words as negative polarity items, then they would be expected to interpret ones with *shenme* in the predicate phrase of *meiyouren* as negative statements; and they would be expected to interpret ones with *shenme* in the predicate phrase of *meigeren* as questions. To illustrate, children should reject the puppet's statement for (28), and to justify their 'No' response by pointing out that every panda ate some fruit. Moreover, if children interpret the question word *shenme* as a question word in (29), then they should produce the answer 'strawberry', because every panda ate a strawberry. On the other hand, if children do not understand that the predicate phrase of *meiyouren* licenses *shenme* as a negative polarity item in (28), then they would be expected to interpret *shenme* in the predicate phrase of *meiyouren* as making a *wh*-question. In short, children would be expected to provide answers to both (28) and (29). Besides, if children don't interpret sentence (29) with *shenme* in the predicate phrase of *meigeren* as a question, then they would be expected to say either 'Yes' or 'No' to the puppet's utterance. This could happen, for example, when children merely associate the level intonation of all the test sentences with the statement reading.

The main finding was that children and adults analyzed *shenme* as a negative polarity item in the predicate phrase of *meiyouren* 100% of the time, so they interpreted (28) as a statement, and rejected it on the grounds that every panda ate some fruit. By contrast, the same children, as well as adults, interpreted *shenme* in the predicate phrase of *meigeren* (e.g. (29)) as a question-marker 100% of the time, so they provided answers to this type of test sentences.[7] It should be pointed out that neither children nor adults

[7] However, we also observed some non-adult responses in children's answers to the test sentences like (29). Unlike adults who produced the answer 'strawberry', all child subjects pointed out the fruit eaten by each panda separately. For example, they pointed out that the first panda ate a strawberry, the second panda ate a strawberry and the third panda ate a pear and a strawberry.

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interpreted *shenme* as having scope over the negative subject *meiyouren*. That is, for sentences like (28), children did not assign a non-adult interpretation such as *what fruit did no panda eat?* This is further evidence that *meiyouren* is a strong negative quantifier in the subject position, which blocks the movement of both *huozhe* (in Experiment 1) and *shenme* (in Experiment 2) to take scope over *meiyouren*.

Recall that all the test sentences were uttered by using level intonation. It becomes important to ask whether or not the subjects depended on this intonation pattern in reaching the statement interpretation for *shenme* in sentences with *meiyouren*, as in (28). The concern is that children might treat *shenme* differently just on the basis of the intonation of a sentence. More precisely, one strategy children might take is to treat a sentence with a rising intonation as a question and so they interpret *shenme* as 'what'; whereas when children encounter a sentence with a level intonation, they know that *shenme* can't be 'what' and they might ignore *shenme* in the sentence. Following this strategy, if *shenme* in (28) is omitted, then the sentence would be 'No panda ate fruit', which shares the same truth value as the sentence with *shenme* in the present task. Hence, an alternative explanation of the data we need to consider is that children might offer their replies to (28) by simply omitting *shenme* and drawing upon the association between the level intonation and the statement reading. As for this explanation, we admit that it may be possible that the level intonation has assisted children in reaching the statement reading of *shenme* in sentences with *meiyouren*. So, as one reviewer suggests, a better way to remove the subjects' intonation strategy is to utter both sentences with rising intonation, so that the subjects wouldn't use the level intonation to access the statement reading of *shenme* in the predicate phrase of *meiyouren*. However, we would like to raise two other relevant questions: Do children always assign the statement reading to a sentence with level intonation? Do children simply ignore *shenme* in sentences with level intonation? We hold a more conservative view towards these questions. To present a counter-example, let us take a close look at sentence (29) with level intonation, in which *shenme* appears in the predicate phrase of *meigeren*. Suppose that children ignore *shenme* in (29) and interpret this sentence with level intonation as a statement (i.e. *every panda ate fruits*), then they should say 'Yes' to (29). This type of response, however, was not observed in the experiment, because all the subjects provided answers indicating the fruits that each panda had eaten. The data seem to suggest that children don't just associate the level intonation of a sentence with the statement reading, nor do they ignore *shenme* in the test sentences. So, it is highly likely that children also processed the *wh*-word *shenme* when it appeared in the predicate phrase of *meiyouren*, as in (28). This indicates that children made a distinction between the predicate phrases of *meiyouren* vs. *meigeren*,

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when they assigned different interpretations to *shenme* in these two structures.

Therefore, we contend that these experimental findings provide supporting evidence that three- to five-year-old Mandarin-speaking children are aware that downward entailing contexts license *wh*-words as negative polarity items. Whereas children treated the *wh*-word *shenme* as a negative polarity item in the predicate phrase of *meiyouren*, a downward entailing expression, the same children analyzed *shenme* as a question word in the predicate phrase of *meigeren*, a non-downward entailing context. Taken together, the findings clearly demonstrate that Mandarin-speaking children master one of the diagnostic properties of downward entailment, which underlies the appropriate appearance of negative polarity items.

GENERAL DISCUSSION

This study investigated children's knowledge of downward entailment from a cross-linguistic perspective. Specifically, we tested children's knowledge of two diagnostic properties of downward entailment: first, the conjunctive entailment of disjunction, and second, the licensing of negative polarity items. We conclude that, by four years old, Mandarin-speaking children are sensitive to the different truth conditions associated with disjunction in the predicate phrases of *meiyouren* versus *meigeren*. In particular, Mandarin-speaking children assigned a conjunctive entailment to disjunction when it appeared in the predicate phrase of *meiyouren*, which is downward entailing; and they assigned the disjunctive truth conditions of disjunction when it appeared in the predicate phrase of the non-downward entailing quantifier *meigeren*. Moreover, Mandarin-speaking children interpreted *shenme* as a negative polarity item in the downward entailing predicate phrase of *meiyouren*, whereas they interpreted the *wh*-word *shenme* as a question-marker in the non-downward entailing predicate phrase of *meigeren*. Taken together with the results of previous cross-linguistic studies (Boster & Crain, 1993; O'Leary & Crain, 1994; Crain *et al*., 2002; Gualmini & Crain, 2002; Gualmini *et al*., 2003; Goro & Akiba, 2004; Jing *et al*., 2005; Su & Crain, 2009; Notley *et al*., in press), the present findings invite the conclusion that the semantic property of downward entailment applies across languages and appears early in the course of language development. In addition, our study invites the inference that Mandarin-speaking children understand that the semantic property of downward entailment unifies two superficially unrelated linguistic phenomena, i.e. the conjunctive entailment of disjunction and the licensing of *wh*-words as negative polarity items. Altogether, these features make downward entailment a viable candidate to be considered as a 'core' linguistic property in human languages.

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There are two competing accounts of how young children demonstrate competence of these 'core' linguistic properties in the initial stage of language development. According to one account, children extract linguistic knowledge from the linguistic environment, using domain-general strategies. These strategies are used by children to form statistical generalizations based on distributional cues. This is the experience-dependent account (Pullum & Scholz, 2002; Tomasello, 2003, Goldberg, 2003; 2006). According to the experience-dependent account, core properties are ones with 'maximal generality' (Tomasello, 2003), which are in fact more general, regular and frequent within a given language, as compared to peripheral phenomena. Hence, language learners are expected to have an even easier time learning these core properties (Goldberg, 2003; 2006; Tomasello, 2003). On the alternative account, based on Universal Grammar (UG), the core linguistic properties are shared by all human languages and these properties express regularities. But different from the experience-dependent account, such regularities are 'deep-seated' (Chomsky, 1965), rather than simply occurring with greater frequency than other linguistic phenomena. More precisely, these core properties run 'deep' because they tie together a number of linguistic phenomena which, on the surface, appear to be unrelated. For instance, advocates of UG ask the question: How do children across languages understand that the linguistic environments governing the conjunctive entailment of disjunction appear to track other features of natural languages, such as the appearance of negative polarity items? To answer this question, proponents of UG contend that human children come to the task of language acquisition already equipped with the core principles of human languages (such as downward entailment), and they draw upon a priori knowledge of these universal principles as part of the human genome (Crain & Pietroski 2001; Crain, Gualmini & Pietroski, 2005; Crain & Thornton, 2006; Crain *et al.*, 2009; Pietroski & Crain, in press).

The linguistic phenomena under investigation (i.e. the interpretations of *huozhe* and *shenme* in the predicate phrases of *meiyouren* versus *meigeren*) support the account of language development offered by the theory of UG, and they seemingly pose a serious challenge for the experience-dependent account. The experience-dependent account focuses on how children use statistical learning mechanisms to learn distributional patterns of morphological items. Based on such patterns, it might be possible to account for how children acquire the licensing conditions for negative polarity items such as English *any* or Mandarin *renhe*. For example, if children are extremely good record keepers, they might keep track of the fact that *renhe* appears in the predicate phrase of *meiyouren* (e.g. *Ban shang meiyouren yanzou renhe yueqi* 'Nobody in this class plays any musical instrument'), but not in the predicate phrase of *meigeren* (e.g. *Ban shang*

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*meigeren dou yanzou *renhe yueqi* 'Everybody in this class plays *any musical instrument'). However, in learning the interpretation of disjunction, what children learn is not a distributional property. Rather, what they learn is that disjunction is assigned different truth conditions when it appears in different linguistic environments. Similarly, in learning the interpretation of the Mandarin *wh*-word *shenme*, what Mandarin-speaking children learn is that the same word, e.g. *shenme*, is interpreted as a negative polarity item in downward entailing linguistic contexts, but it functions as a *wh*-marker in other linguistic contexts. It is not the distribution of *shenme* that is at issue for learners, but its interpretive properties. So, even children who had learned the distribution of other negative polarity items, such as English *any* or Mandarin *renhe*, based on distributional facts, would be hard-pressed to use the same learning algorithms to establish the connection between downward entailing expressions and the functions of the *wh*-word *shenme*. Even if children are excellent record keepers, distributional learning will not suffice. To elaborate this point, our next step is to investigate whether the input does provide decisive evidence for the facts that children must acquire.

As we have seen, children master the different truth conditions of disjunction in the predicate phrases of *meiyouren* versus *meigeren*. It turns out, however, that there is a great paucity for the disjunction word *huozhe* in the input, making these two interpretations rarely accessible for Mandarin-speaking children. In a survey of total 43 289 Mandarin adult utterances in the CHILDES database (MacWhinney, 2000),[8] we only found eleven adult utterances with *huozhe*. None of these utterances resemble the test sentences. Moreover, among these few cases that contain *huozhe*, adult utterances generally suggest alternative choices or express mutual exclusivity. Here are two examples from the input to children in the CHILDES database: *Jiang waiyu gei ma ma ting huozhe lai ge feiwen ba* 'Speak a foreign language to mum or give (me) a kiss'; *Shuo hao huozhe buhao* 'Say good or not good'. These examples suggest that adults' daily usage of disjunction often carries an implicature of exclusivity, by assigning disjunction an exclusive-*or* interpretation in non-downward entailing contexts (see footnote 2). It is hence difficult for language learners to observe the conjunctive entailment of disjunction in the input, which only occurs in downward entailing structures. Moreover, if children construct their grammars solely on the

[8] We examined three Mandarin Chinese corpora in the CHILDES database, i.e. the Chinese Beijing (2) corpus and the Zhou (1) and Zhou (2) corpora, all containing files of conversations between adults and individual child subjects between the ages of one to six. The CLAN programme (MacWhinney, 2000) was used to determine the number of utterances and the number of target words, and to identify the immediate context of the target words (i.e. four utterances before and after the words).

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basis of the adult input, they are likely to erroneously conclude that disjunction is exclusive-*or* (Morris, 2008). As a consequence, language learners could easily fail to capture the relationship between the property of downward entailment and the conjunctive entailment of disjunction, which holds only if disjunction is interpreted inclusively. In short, on the experience-dependent account, we are owed an explanation of how children master the different truth conditions of disjunction, and especially the conjunctive entailment of disjunction, given that the relevant linguistic evidence is not readily attested in the primary linguistic data.

Our next concern is whether statements containing *shenme* in the predicate phrases of *meiyouren* vs. *meigeren* are available in sufficient quantity in the input to ensure that every child converges on a grammar that allows these different readings of *shenme*. The transcripts of adult input reveal that there is no exact match with *shenme* in the predicate phrase of a negative quantificational expression like *meiyouren*, which takes the subject position. At the same time, we found only two critical examples with *shenme* in the predicate phrase of the universal quantifier *mei*, e.g. *shuaya yihou, meigeren dou zai mang shenme ne?* 'What is everybody doing, after brushing his teeth?' Such low frequencies of relevant input make it unlikely that every child encounters the requisite evidence by the age at which they are found to know the different interpretations of *shenme* in corresponding linguistic contexts.

The experience-based approach might come up with other hypotheses to account for children's knowledge of the two interpretive patterns of *shenme*. For instance, one might ask whether there is a correlation between (i) *meiyouren* and declaratives and (ii) *meigeren* and questions, so that children could just pick up the frequency bias of the interpretive patterns of these two linguistic expressions, without considering the interpretation of *shenme*. With this concern, we searched the Mandarin corpora with the target words *meiyouren* and *meigeren* (without the combination of *shenme*), and the adult data only revealed three instances of *meiyouren* (two statements and one question) and seven matches with *meigeren* (four statements and three questions), suggesting no such hypothesized correlation between these two expressions and the corresponding interpretive patterns in the input. We then took the investigation further by searching the negator *meiyou* and the universal quantifier *mei* as the target words. This time, the results reveal a reverse pattern from the hypothesized correlation, i.e. the presence of *meiyou* is associated with more cases of questions, whereas the occurrence of *mei* is associated with more cases of statements. To be specific, out of a total of 472 adult utterances with the negator *meiyou*, we found 278 questions and 194 statements; and out of a total of 60 adult utterances with the universal quantifier *mei*, there are 45 statements and 15 questions. So, it is unlikely that children interpret the test sentences with *shenme* by simply depending

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on the statistical regulation of expressions like *meiyouren* or *meigeren*. Instead, children must adhere to specific linguistic structures (i.e. *shenme* in the predicate phrases of *meiyouren* versus *meigeren*) and observe the exact ways different linguistic expressions interact with each other (Gulamini & Crain, 2005).

It remains to be determined whether or not both interrogative and non-interrogative usages of *shenme* are abundant in children's linguistic experience, such that children could learn to master these different interpretations of *shenme* based on the input. As for this question, because it seems impossible for us to sort out the exact number of these two readings out of 8452 adult utterances with *shenme* in the database, we would like to assume that both these two readings are available in the adult input. However, our research question is how children make a distinction between these two interpretations and how they recognize the relevant linguistic environments for each reading. Exacerbating the problem of learnability is the fact that different licensing situations for the non-interrogative use of *shenme* differ in their frequency of occurrence in the adult input. For instance, in the database, we found 170 adult utterances with the non-interrogative use of *shenme* in the antecedent of the Mandarin conditional clauses with *jiu* 'then', 46 utterances with *shenme* in bare conditionals, 34 utterances with *shenme* in the restrictor of the Mandarin universal quantifier *dou* 'all' and 8 utterances with *shenme* co-occurring with the Mandarin licensor *ye* 'also'. In our case, however, there is not a single instance of *shenme* in the predicate phrase of *meiyouren*. As a consequence, on the experience-based account, children would be expected to master those more frequent linguistic contexts earlier than the other contexts, or they might easily fail in assigning the correct interpretations in linguistic contexts they don't usually encounter. For example, some (perhaps many) children might commit errors, such as interpreting *shenme* in the predicate phrase of *meiyouren* as following its normal function as a question, but this is contrary to the findings of our experimental research.

Even given the most optimist assumptions about children's capacities to form and test generalizations, and supposing that children successfully discern (all of) the apparently subtle distinctions amidst the buzzing bloom of conversation, and supposing that they remember all the distributional facts about where the same lexical item *shenme* is assigned a statement reading and where it functions as a normal question word, it still seems highly unlikely that children could draw upon their knowledge of the two readings of *shenme* to understand when disjunction generates a conjunctive entailment, and when it does not. Of course, linguists 'discovered' the cross-linguistic connection between these and other linguistic phenomena by considering a vast array of data, both positive and negative, and they had access to a vast array of cross-linguistic data, all of which could be examined

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at once. By contrast, the language learner must master these phenomena in the absence of negative evidence and without any cross-linguistic data. Moreover, as we noted earlier, it is difficult for the language learner to keep detailed records of when disjunction words do and do not generate conjunctive entailment, since the relevant distinction is not readily accessible in the input. Therefore, it seems highly implausible that every biologically normal child, across the globe, has the requisite skills to make an observation of the input data and draw the description of the evidence that 'the conjunctive entailment is assigned to disjunctive statements if and only if the non-interrogative use of *shenme* appears in that linguistic environment'.

However, these problems of learnability are circumvented on the account advanced by advocates of UG. From the UG perspective, human children are innately endowed with substantive core principles of grammar. Guided by these principles, children can effortlessly 'cognize' seemingly complicated linguistic phenomena, including the semantic properties that are associated with downward entailing expressions. Therefore, on the UG approach, children should demonstrate knowledge of these core linguistic principles from the earliest stages of language development. Mandarin-speaking children's early emergence of knowledge of two apparently disparate linguistic phenomena associated with downward entailment therefore lends credibility to the theory of Universal Grammar.

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APPENDIX: Different Types of Downward Entailing Expressions

There are distinctions to be drawn among the class of downward entailing operators. These distinctions involve their degree of 'negativity', where one downward entailing expression is more negative than another if it satisfies a greater number of de Morgan's laws (van der Wouden, 1994; Zwarts, 1998). We can call the most basic downward entailing expressions 'merely' downward entailing expressions. The merely downward entailing expressions license the de Morgan's law that generates the conjunctive entailment of disjunction: $\neg(A \vee B) \Rightarrow \neg A \wedge \neg B$. This is the pattern of entailment that we focus on in the present study. It is the pattern of entailment that has been investigated in much research on child language. The 'merely' downward entailing expressions also conform to another de Morgan's law: $\neg(A \wedge B) \Rightarrow \neg A \vee \neg B$.

In addition to merely downward entailing expressions, there are even more NEGATIVE expressions called antiadditive and antimorphic downward entailing expressions. These adhere to the same de Morgan's laws as merely downward entailing expressions, including the entailment $\neg(A \vee B) \Rightarrow \neg A \wedge \neg B$ but in addition, antiadditive expressions generate the reverse entailment $\neg A \wedge \neg B \Rightarrow \neg(A \vee B)$. Antimorphic expressions generate the same bidirectional entailments as antiadditive expressions, but these expressions also generate the bidirectional entailment of another de Morgan's law: $\neg(A \wedge B) \Leftrightarrow \neg A \vee \neg B$.

These distinctions among downward entailing expressions have been used to partition negative polarity items into classes (van der Wouden, 1994; Zwarts, 1998). Negative polarity items that are only licensed by antimorphic expression are called 'superstrong' negative polarity items (e.g. *one bite*). Next come 'strong' negative polarity items (e.g. *either, until*), which are licensed by both antimorphic and antiadditive expressions. Finally, 'weak' negative polarity items (e.g. *any, ever*) are licensed by antimorporhic, antiadditive, and also by merely downward entailing expressions. Recently, the class of licensors for 'weak' negative polarity items like *any* has been extended to include what are called non-veridical functions (Zwarts, 1995; Giannakidou, 2011). Non-veridicality is not defined in terms of de Morgan's laws. Rather it is an epistemic concept that characterizes expressions that do not commit individuals to the truth of a proposition. Although non-veridical operators license 'weak' negative polarity items like *any*, not all non-veridical operators generate the conjunctive entailment of

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disjunction. Since our primary focus is on cases with the dual linguistic properties, namely the generation of the conjunctive entailment of disjunction as in the de Morgan's law: $\neg(A \vee B) \Rightarrow \neg A \wedge \neg B$, and the licensing of negative polarity items like English *any*, Mandarin *renhe* and *wh*-word *shenme*, we will limit the present discussion to downward entailment.

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