The Scope of Logical Expressions in Child Language

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DECLARATION

The work in this thesis is an original piece of research and has not been previously submitted for a higher degree to any other institution. I certify that all information sources and literature used are indicated in the thesis, and that appropriate Macquarie University Ethics approval was granted for all the experiments (HE23MAR2007-RO5076, HE02MAY2008-D05799, HE27MAR2009-D06391HS, HE24OCT2008-D06146L&P). I further certify that the thesis has been written by me. The following chapters in this thesis are based on articles that have either been published, or will be submitted for publication, as joint authored work:

Chapter 2: Notley, A., Zhou, P., Jensen, B. & Crain, S. (2012). Children's interpretation of disjunction in the scope of 'before': A comparison of English and Mandarin. *Journal of Child Language 39*(3), 482-522.

Chapter 3: Notley, A., Zhou, P., Crain, S, & Thornton, R. (2009). Children's interpretation of focus expressions in English and Mandarin. *Language Acquisition*, 16, 240-282.

Chapter 4: Notley, A., Zhou, P., Goro, T., & Crain, S. (to be submitted). Children's interpretation of conjunction in the scope of negation in English and Mandarin: new evidence for the Semantic Subset Maxim.

Chapter 5: Notley, A., Jensen, B., & Ursini, F. (2008). The early stages of universal quantification. In Y. Otsu (Ed.), *The Proceedings of the Ninth Tokyo Conference on Psycholinguistics* (pp. 273-300). Tokyo: Hituzi Syobo Publishing.

Chapter 6: Notley, A., Thornton, R., & Crain, S. 2012. English-speaking children's interpretation of disjunction in the scope of 'not every'. *Biolinguistics 6*(1), 32-69.

As the first author in each case I was responsible for all of the writing. Chapters 2, 3 and 4 include data from Mandarin experiments run by my colleague Peng Zhou. I was responsible for the corresponding English-language experiments and for writing up the results in both languages. The role of other authors is appropriately acknowledged at the start of each chapter. Please note that each of the articles has been included in this thesis by publication in an unchanged format and thus there is a degree of repetition across the Introduction and Method sections of these chapters.

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THESIS SUMMARY

This thesis explores the way children choose to resolve certain kinds of semantic scope ambiguities. The aim is to answer two main questions:

(i) which reading of scopally ambiguous sentences do children favour, if either?

(ii) if children favour one reading, why do they do so?

Several hypotheses have been put forward to account for what we currently know about children's scope preferences, suggesting different answers to (i) and (ii) above. The main contribution of this thesis is to reformulate one of these hypotheses to address some of its observed shortcomings, and to test the predictions of the new formulation on three sentence types that have not yet been investigated in the previous literature. These are sentences containing (a) the temporal conjunction *before* and disjunction (e.g. *The dog reached the finish line before the turtle or the bunny*), (b) negation and conjunction (e.g. *The elephant did not eat both the carrot and the capsicum*), and (c) the compound quantifier *not every* and disjunction (e.g. *Not every princess took a star or a shell*). Each of these sentence types gives rise to two possible scope interpretations, although languages can vary as to which of these readings is preferred. We present the results of three major studies (and two supporting studies) to determine which of the possible scope interpretations children prefer for each of these sentence types.

Chapter 1 provides an introduction to the scope preference hypotheses. Chapter 2 looks at English- and Mandarin-speaking children's interpretative preferences for sentence type (a). Chapter 3 investigates children's interpretation of the pre-subject focus operator *only*. These findings inform our experimental design in Chapter 4, which examines English- and Mandarin-speaking children's interpretative preferences for sentence type (b). Chapter 5 investigates children's interpretation of the universal quantifier *every*. These findings inform our experimental design in Chapter 6, which examines English-speaking children's interpretative preferences for sentence type (c). Chapter 6 also explores how logical principles underpin the scope interpretations available in sentences (a)-(c), and whether children are sensitive to these principles. In Chapter 7, we discuss the implications of the findings for current accounts of children's scope preference and we offer answers to the two main questions of this thesis.

For my mum and dad

CHAPTER 1
Introduction

"Les grandes personnes ne comprennent jamais rien toutes seules, et c'est fatigant, pour les enfants, de toujours leur donner des explications."

Grown-ups never understand anything by themselves, and it is tiresome for children to be always and forever explaining things to them.

— Antoine de St. Exupéry, Le Petit Prince

1. Introduction

Ambiguity is one of the hallmarks of human language. Words often have more than one meaning; whole sentences can too. This ambiguity is part of what makes language creative, entertaining, and downright fun. Ambiguity gives us riddles, word-play, metaphor, and poetry. However, ambiguity can also be a useful tool in the area of linguistic research. When two possible readings of a sentence are available in a given context (or when two possible readings of a sentence are available across different languages), we can ask whether language-users have an underlying preference to assign one meaning over another? If so, which reading is it, and why is it preferred? The answers to these kinds of questions can inform our theories of the underlying structure of language, of the factors involved in the online processing of language , and even of the way humans acquire a language in the first place. In this thesis I will explore, in particular, the way children resolve certain kinds of semantic scope ambiguity, and discuss the implications of my findings for theories of language acquisition.

Semantic scope can be defined as follows:

> "The scope of an operator is the domain within which it has the ability to affect the interpretation of other expressions." (Szabolcsi, 2001: 607)

Scope ambiguity can arise when a sentence contains two (or more) scope-bearing operators, and these operators must be interpreted in relation to one another. Scope-bearing operators are typically logical expressions like quantifiers, negation, disjunction and conjunction. For example, sentence (1) has two possible meanings, depending on the scope that is assigned to the universally quantified noun phrase *every horse* in relation to the negation operator *not*.

(1) Every horse did not jump over the fence

a. None of the horses jumped over the fence (every > not)

b. Not all of the horses jumped over the fence (not > every)

If *every horse* takes scope over negation, then the resulting sentence interpretation is that all the horses failed to jump over the fence. This meaning is given in 1(a). If, on the other hand, negation is assigned wide scope over *every horse*, then the resulting sentence interpretation is that it is not the case that every horse jumped over the fence (in other words, some horses probably did jump over the fence, but some definitely did not). This meaning is given in 1(b).

This thesis will investigate three different types of scopally ambiguous sentences, similar to (1), in the aim of answering two main questions:

(i) which reading of scopally ambiguous sentences do children favour, if either?

(ii) if children do favour one reading, why do they do so?

In Chapter 2, we examine children's interpretation of sentences like (2) containing the temporal conjunction *before* and disjunction. The two possible readings of (2) are given in 2(a) and 2(b).

(2) The dog reached the finish line before the turtle or the bunny

a. The dog reached the finish line before the turtle and before the bunny
(before > or)

b. It was before the turtle or the bunny that the dog reached the finish line
(or > before)

In Chapter 4, we examine children's interpretation of sentences like (3) containing the negation operator and conjunction. The two possible readings of (3) are given in 3(a) and 3(b).

(3) The elephant didn't eat both the carrot and the capsicum

a. The elephant didn't eat both vegetables, but may have eaten one or neither
(not > and)

b. It was both the vegetables that the elephant didn't eat
(and > not)

Finally, in Chapter 6, we examine children's interpretation of sentences like (4) containing the compound quantifier *not every* and disjunction. The two possible readings of (4) are given in 4(a) and 4(b). Note that, in each case, the two scopal readings given are hypothetically possible, although languages can vary as to which of these readings is preferred.

(4) Not every princess took a star or a shell

a. There is some princess who did not take a star and who did not take a shell (not every > or)

b. It was either a star or a shell that some princess didn't take (or > not every)

None of the sentence types in (2)-(4) has been previously investigated in the literature on child language. The present work therefore provides original data to add to the body of research investigating children's interpretations of scopally ambiguous sentences. Moreover, in the case of sentences like (2) and (3), we present data from both English-speaking children and from Mandarin-speaking children. These particular cross-linguistic comparisons are also new to the literature, and add to current findings from separate investigations in English and Mandarin (e.g. Crain, Gardner, Gualmini, & Rabbin, 2002; Fan, 2010; Gualmini, 2005; Musolino & Lidz, 2006; Zhou & Crain, 2009), as well as from investigations in other languages like Italian, Dutch, Kannada, Korean, and Japanese (e.g. Goro & Akiba, 2004; Kramer, 2000; Kwak, 2010; Lidz & Musolino, 2005/2006; Moscati & Gualmini, 2007).

Three main hypotheses have been put forward to account for the findings across languages. These hypotheses currently suggest three different possible sets of answers to questions (i) and (ii) above. The next section reviews the three hypotheses. Currently, however, each of these hypotheses has some shortcomings. The main contribution of this thesis is to adapt one of these hypotheses to address its shortcomings. I will present this new proposal and outline the specific predictions made about children's scope preferences for each of the sentence types in (2)-(4). I will then explain how the experiments presented in subsequent chapters test these predictions.

2. Current Child Scope Interpretation Hypotheses

2.1 The Isomorphism Account

The first major observation about children's scope assignment preferences was the Observation of Isomorphism introduced by Musolino, Crain, & Thornton (2000). These researchers noted that when interpreting ambiguous sentences containing two logical operators, children seemed to display a marked preference for assigning an isomorphic mapping between surface syntax and semantic interpretation. It was subsequently suggested that children prefer for the structurally dominant (c-commanding) logical operator to take scope over the operator it dominates (Lidz & Musolino, 2002). This account drew on research with 5- and 6-year-old English-speaking children who were tested using sentences like (1) *Every horse didn't jump over the fence*. This particular test sentence was presented in a context in which two horses managed to jump a fence, and one failed to make it over. The isomorphic reading is the 'every > not' (or 'none') reading, since the universal quantifier c-commands negation in the sentence. The context made the test sentence false on this isomorphic interpretation, since two horses did jump over the fence. At the same time, the contexts made the test sentence true on the non-isomorphic 'not > every' (or 'not all') reading, since not all of the horses managed to jump over the fence. Adults accepted the test sentences in such contexts 100% of the time, showing they preferred to access a non-isomorphic reading. In contrast to adults, the 5-year-old children rejected the same sentences 100% of the time and the 6-year-old children rejected them 85% of the time (Musolino, Crain, & Thornton, 2000). Thus, English-speaking children appeared to have a strong preference to initially assign an isomorphic interpretation to scopally ambiguous sentences like *Every horse didn't jump over the fence*, even if this interpretation was not modeled in the input for them.

Subsequent research showed, however, that contextual manipulations could facilitate children's access to the non-isomorphic reading of sentences like (1). In a ground-breaking study, Gualmini (2005) demonstrated that English-speaking children who ranged in aged from 3;0 to 5;7 accessed the non-isomorphic interpretation of the same sentences 81% of the time when the experimental conditions made it more felicitous to interpret negation as taking scope over the universal quantifier. Essentially, to satisfy the felicity conditions for negation, there needs to be a mismatch between the final outcome of the story and the expected outcome. In the modified context of

Gualmini's study, the focus of the test stories was clearly set up to be whether or not all of the horses could make it over the fence. Similar results have been obtained for English-speaking children aged 4;5–5;2, (Conroy, Lidz, & Musolino, 2009) and for Mandarin-speaking children aged 3;4-4;3 (Zhou & Crain, 2009). The same result has also been found for sentences containing negation and an existential quantifier, such as *The troll didn't deliver some pizzas.* In this case, the non-isomorphic 'some > not' reading is that there were some pizzas that the troll did not deliver. Gualmini (2005) found that 15 English-speaking children (aged 4;01-5;06) were able to access this non-isomorphic reading 90% of the time in contexts in which an expected outcome was introduced that the troll would deliver all the pizzas, but the final outcome was that the troll delivered some, but not all of the pizzas. These studies show that children are not LIMITED to an isomorphic reading of scopally ambiguous sentences.

To reconcile these two sets of findings (on the one hand that children display a marked preference for the isomorphic reading in some contexts, and on the other hand that they are able to access the non-isomorphic reading), it has been suggested that children might apply an isomorphic interpretation by default, when a context supporting a non-isomorphic reading is absent. It is clearly not the case that children lack the grammatical capacity to process a non-isomorphic scope interpretation, so it remains to be explained why children behave in this way. One answer that has been suggested is that children may differ from adults in their parsing abilities. That is, children might arrive at an isomorphic parse of the sentences first since this involves identity between the syntactic and semantic levels of representations, and they subsequently have more difficulty than adults do in recovering from this parse, perhaps because they lack the requisite computational resources to reanalyse the sentence structure when information is encountered which indicates that the initial analysis is not intended (Lidz & Musolino, 2005/2006).[1] Another possibility is that children are less sensitive than adults to the conversational principle of charity, which encourages hearers to give speakers credit for speaking truthfully whenever possible. Perhaps there is a trade-off between relative processing difficulty of an interpretation and the application of the principle of charity. It could be that for children the greater the processing difficulty of an interpretation (presumably a non-isomorphic interpretation requires a greater processing load than an isomorphic one), the more likely it is that this difficulty will override the application of the principle of charity (Musolino & Lidz, 2003).

2.2 The Question-Answer Requirement (QAR) Model

An alternative proposal has been advanced about children's preferences for resolving scope ambiguities, based on the findings showing that children are capable of accessing non-isomorphic readings of scopally ambiguous sentences. This is the Question-Answer Requirement model (Gualmini, 2007a, 2007b, 2008; Hulsey, Hacquard, Fox, & Gualmini, 2004). This model predicts that children base their preferred interpretation of a scopally ambiguous sentence on whether it is a good answer to the 'question-under-discussion' (QUD). Further, only if both interpretations address the relevant question will children choose the interpretation that makes the sentence true in the context. For example, in the original studies investigating children's interpretation of sentences like (1), the question under discussion was presumably whether or not any of the horses would succeed in jumping over the fence, as in (5).

(5) QUD: Will any of the horses jump over the fence?

(6) Every horse didn't jump over the fence

a. None of the horses jumped over the fence (every > not)

b. Not all of the horses jumped over the fence (not > every)

If the statement *Every horse didn't jump over the fence* is the speaker's attempt to answer this unspoken question, then assigning the universal quantifier wide scope over negation results in the best answer, along the lines of 6(a). Assigning negation wide scope over the universal quantifier, on the other hand, results in a fairly circuitous answer to the question, along the lines of 6(b). According to this model, 6(a) therefore represents the best answer to the question under discussion. However, in the contexts tested by Musolino et al. (2000), 6(a) was false (because some horses had, indeed, jumped over the fence). This is thought to explain why children rejected test sentences like (6) in the original studies. In subsequent studies, the question under discussion was clearly set up to be whether or not all of the horses would succeed in jumping over the fence, as in (7).

(7) QUD: Will all of the horses jump over the fence?

If the same answer (6) is given to this question, both scope interpretations 6(a) and 6(b) constitute acceptable answers to the question. Now, children are expected to choose the scope interpretation that makes (6) true. In a context in which some horses did not jump over the fence, and some did, this is interpretation 6(b), the non-isomorphic interpretation. This is thought to explain why children accepted test sentences like (6) in the studies designed to satisfy the felicity conditions of negation.

The QAR model has something in common with the Isomorphism by Default hypothesis. On both models, a child is better situated to apply the principle of charity, and thereby to assign the scope interpretation that makes a sentence true, when processing demands are minimised (e.g., by providing contextual support for the non-isomorphic reading as an answer to the question under discussion). The QAR model differs from the Isomorphism by Default hypothesis in the mechanism that is invoked to explain children's scope interpretations in the absence of context supporting a non-isomorphic interpretation, for example when the question under discussion is one like (5). The Isomorphism by Default hypothesis predicts that children prefer the isomorphic interpretation 6(a) because it is easier to process an isomorphic mapping between surface syntax and semantic interpretation. The QAR model, on the other hand, assigns no special status to the isomorphic interpretation 6(a). Rather, it is the proposition expressed by 6(a) that is important, and the fact that it represents a good answer to the question under discussion. Children are seen to violate the principle of charity in order to address the question under discussion. Although adults are assumed to be driven by the same parsing considerations as children, adults are thought to be better able to accommodate a question that differs from the one made salient by the context, a question more like (7). This then leads adults to select 6(b) as their interpretation of (6).

To begin to tease apart these two accounts, we need to know how children interpret a sentence in which the isomorphic interpretation is not the best answer to the question under discussion. A study by Hulsey et al. (2004) has done just that, by investigating children's interpretations of sentences like (8) and (9) in a context in which a dwarf delivered two of four available pizzas, and the question-under-discussion was set up to be whether the dwarf could deliver all the pizzas.

(8) Some pizzas were not delivered

a. There were some pizzas that were not delivered (some > not)

b. No pizzas were delivered (not > some)

(9) Some pizzas were not lost

a. There were some pizzas that were not lost (some > not)

b. No pizzas were lost (not > some)

Sentence (8) is a felicitous statement in the context and, therefore, both the Isomorphism Account and the QAR Model would expect children to adhere to the principle of charity and select the scope interpretation that makes (8) true. This is indeed what was observed, with 12 children aged 2;10-5;3 (mean 4;7) accepting sentences like (8) 94% of the time. In other words, children accessed the isomorphic 'some > not' reading given in 8(a) when the context supported this reading. On the other hand, sentence (9) is infelicitous in the same context. In this case, the Isomorphism Account would predict that children should prefer the isomorphic reading, given in 9(a), in which the existential quantifier takes scope over negation. This reading was true in the context (since the dwarf did deliver two pizzas, so those pizzas were not lost). On the other hand, the QAR Model would predict that children should select the scope interpretation that constitutes the best answer to the question under discussion. This is the non-isomorphic 'not > some' interpretation given in 9(b), which was false in the context. It was found that 15 children aged 2;10-6;01 (mean 4;9) accepted test sentences like (9) only 43% of the time, compared to adults who accepted them 93% of the time. These data have been put forward in support of the Question-Answer Requirement model over the Isomorphism Account.

There is, however, a third hypothesis that should be considered. This hypothesis is more specific than the two previous ones, in that it only applies to certain kinds of scopally ambiguous sentences. These are sentences in which one reading asymmetrically entails the other. For example, sentences like (1) *Every horse didn't jump over the fence* fall into this category. In this case, it is reading 1(a), the 'none' reading, that asymmetrically entails reading 1(b), the 'not all' reading. In other words, if none of the horses jumped over the fence, then it is certainly true that not all of them did. However, if not all of them did, it is not necessarily true that none of them did. That is, whenever the 'none' reading is true, the 'not all' reading is necessarily also true.

Not all scope ambiguities have this entailment relation. Consider sentence (10). If negation is assigned wide scope over the quantified noun phrase *two apples*, then the resulting sentence interpretation is that it is not the case that the horse ate two apples. If *two apples* is assigned wide scope over negation, then the resulting sentence interpretation is that there were two apples that the horse did not eat.

(10) The horse did not eat two apples

a. It is not the case that the horse ate two apples (not > two)

b. There are two apples that the horse did not eat (two > not)

If an entailment relation existed between these meanings we should see that whenever one of the two meanings is true, the other is necessarily also true. We can show this is not the case by testing contexts in which either one meaning is true or the other meaning is true. First, consider a context in which the horse had two apples to eat, and only ate one. In this context, the sentence is true on reading 10(a), because it is, indeed, not the case that the horse ate two apples, he only ate one. However, the wide scope numeral reading, 10(b), is false in this context (because there is only one apple that the horse did not eat). Now, consider a context in which the horse had four apples to eat, and only ate two. In this context, reading 10(b) is true, because there are two apples the horse did not eat. However, the reading on which negation takes wide scope, 10(a), is false (because the horse did, in fact, eat two apples). So it is not the case for sentences like (10) that one reading asymmetrically entails the other. Each reading can be true or false independent of the other.

For the subset of scopally ambiguous sentences in which one reading does asymmetrically entail the other, however, a potential learnability problem arises for children. The hypothesis we will now consider is designed to address this problem.

2.3 The Semantic Subset Principle

The Semantic Subset Principle (SSP) was originally introduced to solve the learnability problem that could arise for children if the same kind of sentence is assigned more than one meaning in some language, but only a single meaning in another language (Crain, Ni, & Conway, 1994). For example, suppose that adult speakers of some language only assign the 'none' reading to negative statements with a universal quantifier (assigning the universal quantifier wide scope over negation). Further suppose that children initially hypothesise that negative statements with a universal quantifier are assigned a 'not all' reading (assigning negation wide scope over the universal quantifier).

Then, for children, statements like *Every horse didn't jump over the fence* will be true in contexts in which some, but not all of the horses jumped over the fence, as well as in contexts in which none of the horses jumped over the fence. The problem is: How will children find out that such negative statements are only true, for adult speakers, in one of these circumstance, the one in which none of the horses jumped over the fence? All of the evidence children encounter will be consistent with their hypothesised reading. In order to revert to the more restricted adult 'none' reading, children would have to record the fact that adults do not use negative statements in certain circumstances, where these sentences are acceptable for children. But observing and mentally recording what does not happen is likely to be beyond the cognitive capacities of most adults, much less children. Moreover, we know that even when negative evidence of this type is made explicit to adults, only a small percentage of them actually manage to make use of such information in learning scenarios (Hovland & Weiss, 1953).

One possible way out of the dilemma would be for a child to produce a negative statement in one of the circumstances that makes the sentence true on the 'not all' reading, but false on the 'none' reading. The adult could then come to the rescue, and provide feedback informing the child that they had said something that was false, because in the circumstance at least one horse had jumped over the fence. Although conceivable, it seems farfetched to believe that every child who hypothesized the 'not all' reading could count on input from adults to provide such corrective feedback. Any child who was not fortunate enough to have such parental interactions, in sufficient quantities, would not converge on a grammar equivalent to that of adult speakers of the local language. Since all children do in fact converge on grammars that are equivalent to those of adults, children are clearly able to circumvent this learnability problem. But how?

The proposal advanced by Crain et al. (1994) is that children circumvent the learnability problem by initially favouring the reading that asymmetrically entails the other reading. We will call this reading the strong reading. The entailed reading will be called the weak reading. By initially favouring the strong reading, children will be positioned to converge on the grammar of the local language, regardless of which reading is favoured by adults.

Suppose, on the one hand, that adult speakers of a language assign the strong reading to negative statements with the universal quantifier. Then a child who has hypothesized the strong reading has already successfully converged on the adult language. Suppose, on the other hand, that adult speakers of a language assign both strong and weak readings.[2] Then a child who initially favours the strong reading will witness such statements being used in circumstances that are inconsistent with the strong reading. This will constitute positive evidence that adults allow the weak reading in addition to the strong reading. In view of these observations, Crain et al. (1994) proposed that children adhere to the Semantic Subset Principle, which was defined as follows:

> "The principle orders children's semantic hypotheses in advance, as follows: Default hypotheses are ones that will not subsequently need to be revised (they are realized universally), and additional (language-particular) hypotheses are added on the basis of positive evidence in the input…if the interpretative component of Universal Grammar makes two interpretations, A and B, available for a sentence S, and if interpretation A makes S true in a narrower range of circumstances than interpretation B does, then interpretation A is hypothesized before B in the course of language development" (Crain et al., 1994, pp. 455-455)

The Semantic Subset Principle was inspired by the more familiar subset problem described by Berwick (1985) and by Pinker (1984). Both of these researchers observed that a learnability problem could arise for children when one language generates a subset of the grammatically acceptable sentences generated by another language. In the absence of negative evidence, children are compelled to initially adopt the 'subset' language. Data to support the Semantic Subset Principle was again taken from children's interpretation of sentences like (1) *Every horse didn't jump over the fence* in English and Mandarin. English sentences of this form can receive both a strong and weak reading. By contrast, when such sentences are translated into other languages (e.g. Mandarin Chinese, or German), it is often claimed that only the strong reading is possible. One reason for this, it has been argued, is that languages like Mandarin Chinese have a structural constraint on scope relations that enforces an isomorphism between surface syntax and semantic interpretation.

In view of the potential learnability problem that could confront children acquiring languages like Mandarin, the Semantic Subset Principle predicts that children acquiring all languages should initially assign the strong 'every > not' interpretation to the sentences under consideration, such that *Every horse didn't jump over the fence* should initially be judged to be true only in the circumstance in which no horse jumped over the fence. Children would then be able to add the weak reading in languages like

English, where the sentence is also true on the weak reading, when not all horses jumped over the fence. Adult input could provide the evidence for the existence of the 'not > every' reading in the local language. As we have already discussed, when English-speaking children's interpretation of sentences like *Every horse didn't jump over the fence* were first reported on, it appeared that children only accessed the strong 'none' reading, even though adults actually prefer the weak 'not all' reading (Musolino et al., 2000). These data were expected under the SSP, which contends that children's scope assignment hypotheses are the result of a necessary logical constraint on learning processes. Adherence to the SSP (hypothesising the strong reading first) prevents children from making an error from which they could not recover in the absence of negative evidence.

Of course, the SSP has had to contend with the same findings that the Isomorphism Account and the QAR Model have had to deal with. That is, we know now that contextual manipulations can facilitate children's access to the weak reading of sentences like *Every horse didn't jump over the fence* in English (Gualmini, 2005) and in Mandarin (Zhou & Crain, 2009). These findings can be reconciled with the SSP if, across languages, negative sentences with a universal quantifier are actually not defined as being in a superset-subset relationship. Pursuing this possibility, Zhou & Crain (2009) argue that the Mandarin sentences in question contain an additional focus operator that is lacking in the corresponding English sentences, and they contend that this operator is responsible for eliminating the weak interpretation in Mandarin. On this scenario, both children acquiring English and children acquiring Mandarin initially hypothesise both strong and weak readings for negative statements with a universal quantifier. However, once children acquiring Mandarin master the semantics of the focus operator in Mandarin, the weak reading of the critical sentences is jettisoned from their grammars. On the other hand, because English lacks this focus operator, both readings remain intact.

Although this explanation rescues the Semantic Subset Principle in this one case, it is reasonable to ask whether the learnability problems that the SSP is designed to solve do ever arise. This question was posed by Musolino (2006), who concluded that it is unlikely that semantic subset problems exist. He proposed that children's independent knowledge of the syntax of their language allows them to determine whether or not various sentences are ambiguous, as was suggested to be the case in the study of Mandarin versus English reported in Zhou & Crain (2009). In response, Gualmini & Schwarz (2009) point out, however, that until an exhaustive search of ambiguities across all the world's languages has been conducted, it is premature to conclude that semantic subset problems do not exist. Gualmini & Schwarz (2009) argue, nonetheless, that the SSP is not the only solution to the kind of learnability problem that was introduced by Crain et al. (1994). Instead, they explore other kinds of evidence children might exploit to eventually arrive at a strong reading of a sentence in cases where they have initially hypothesised a weak reading.

In fact, the solutions advanced by Gualmini & Schwarz (2009) are compatible with a reformulation of the Semantic Subset Principle. This reformulation forms the crux of this thesis. According to the reformulation offered here, the principle is recast as a maxim for assigning preferences to alternative interpretative options, rather than as a categorical constraint on children's initial hypotheses in the course of language acquisition. This reformulation of the SSP is dubbed the Semantic Subset Maxim.

3. The Semantic Subset Maxim

The Semantic Subset Maxim (SSM) is proposed to apply to cases of scope ambiguity that occur whenever two logical operators interact in a sentence, such that one reading asymmetrically entails the other. We assume that, in such cases, there probably is no language that only allows a strong scope interpretation of such sentences. Instead, we assume that BOTH hypothetically possible scope readings are available for such sentences in all languages, and at all stages of acquisition. This assumption is made in view of the evidence from research showing that context can be manipulated to allow both children and adults to access either scope relation in such sentences, even if one is highly preferred (e.g. Musolino & Lidz, 2003). This is the crucial difference with the SSP, which reasons that children's default hypotheses will correspond to ones realised universally, while additional hypotheses will only be realised in some languages of the world. The SSM instead reformulates the driving idea behind the SSP to assign default PREFERENCES for certain interpretive options that are available WITHIN all languages, but where, often, opposite preferences are found ACROSS languages. In order to communicate most efficiently with adult language users, the child's task is to determine which of the scope interpretations is preferred in the local language. Faced with this ambiguity, and if the two interpretations available form a subset-superset relationship, then the Semantic Subset Maxim enjoins children to initially favour the subset reading, i.e., the strong reading. Following the same logic as the SSP, children who subsequently witness circumstances in which the sentence is true on the superset reading, i.e., the weak reading, can add these circumstances to the truth conditions they associate with the ambiguous sentences in their grammars.

As formulated, the SSM anticipates a specific trend in children's scope assignment, rather than a categorical presence or absence of a reading. The SSM predicts that children who are presented with a scope ambiguity in which one reading asymmetrically entails the other will have a strong tendency to initially assign the strong (subset) meaning first. Proceeding in this way ensures that children follow the most efficient path in aligning their grammatical system with that of other members of the linguistic community, including preferences for resolving scope ambiguities. If children initially favour the subset interpretation, then if it turns out that adult speakers favour the superset interpretation, children will receive compelling evidence from the linguistic input informing them that the subset reading is not operative in most circumstances. Based on the evidence, children can move quickly to align their preferences with those of adult speakers. Suppose, instead, that children initially favour the superset reading. Then the majority of the evidence they receive will be consistent with that interpretation, including evidence from speakers who strongly prefer the subset reading. It would therefore take children considerably longer to align their preferences with those of the adults around them on this scenario.

We have chosen the word 'maxim' to replace 'principle' since what is represented is a default preference for the subset reading, not the absolute presence or absence of an interpretation. A principle prevents a child from making an error from which he or she could not recover in the absence of negative evidence. A maxim, as we are using the term, merely encourages children to proceed in a certain way to allow them to converge on the adult preferences as rapidly and effortlessly as possible. The maxim encourages children to adopt the scopal interpretation that provides them with the most efficient means for aligning their preferences with those of adults for various semantic interpretations of sentences during the language acquisition process.

To recap, the SSM brings two major (and related) changes to the original formulation of the SSP. The SSP proposes that when a sentence is ambiguous, and one reading asymmetrically entails the other, then the strong reading will be found universally, and this will be the reading that children hypothesise first in the course of language development. If a weak reading occurs in some languages of the world, children acquiring those languages can then add the weak reading to their language model on the basis of positive evidence. The SSP can only be invoked as an explanatory principle in cases where some relevant sentence carries both a strong and weak reading in one language, and only a strong reading in another. So far, unequivocally identifying such a situation has been controversial. The first change the SSM brings to the SSP is thus to propose that sentences of this type always carry two hypothetically possible meanings in all languages of the world (even if one is heavily preferred by adult speakers). This means children are expected to have both readings available to them at an initial stage, rather than only hypothesising the strong reading. Recall that this has, indeed, been found to be the case, for example, in children's interpretation of sentences like *Every horse didn't jump over the fence* in both English and Mandarin. On this view, children will still be faced with a semantic subset problem. However, this problem is slightly different to the one the SSP is designed to solve. The task for children is now to determine which of the available readings, if either, is preferred by adult speakers of their language. The second change the SSM brings to the SSP is thus to predict a default PREFERENCE for the strong reading of such sentences initially, rather than predicting the categorical presence or absence of a reading in the child's grammar. Favouring the strong reading will allow the child to converge on adult-like scope preferences in the most efficient manner. Together, these two changes allow the driving ideas behind the SSP to continue to be applied to situations from which they have currently been excluded in the literature (like the acquisition of the meanings associated with sentences like *Every horse didn't jump over the fence*).

In this thesis I will present the results of three main studies (and two supporting studies) providing evidence in line with the Semantic Subset Maxim. In one of these three studies, the predictions of the SSM are also tested against those of the Isomorphism Account, and the Isomorphism Account is found to be lacking. In another study, the role of the QAR Model is explored, but its ability to explain children's underlying default preferences is questioned. I turn now to a presentation of the three major studies, and the specific predictions of the SSM in each case.

4. Children's Interpretation of Scope Relations

4.1 Children's Interpretation of the Scope Relation between BEFORE and OR

The first major study of this thesis investigates children's interpretation of sentences like (2), repeated here as (11).

(11) The dog reached the finish line before the turtle or the bunny

a. The dog reached the finish line before the turtle and before the bunny (before > or)

b. It was before the turtle or the bunny that the dog reached the finish line (or > before)

One of the possible interpretations of (11), 11(a), asymmetrically entails the other, 11(b). In 11(a), *before* takes scope over disjunction. The temporal conjunction *before* is called a downward entailing operator. When a downward entailing operator takes scope over disjunction, disjunction is assigned a conjunctive interpretation.[3] For example, the interpretation in 11(a) is that the dog must have reached the finish line before the turtle AND before the bunny. This conjunctive interpretation of disjunction makes (11) true in a narrower range of circumstances than the interpretation in which disjunction scopes over *before*. On the conjunctive interpretation the only circumstance that will make the sentence true is if the dog reaches the finish line before both other animals. On the alternative interpretation, 11(b), there are three logical circumstances which will make the sentence true: (i) if the dog reaches the finish line before the turtle, but after the bunny, or (ii) if the dog reaches the finish line before the bunny, but after the turtle, or (iii) if the dog reaches the finish line before both other animals. 11(a) is thus the strong subset reading, while 11(b) is the weak superset reading. In addition, it turns out that adult speakers of English strongly prefer to assign reading 11(a) to (11), while adult speakers of Mandarin often prefer reading 11(b).

Despite these language differences, the SSM predicts that all children will initially prefer to interpret a sentence like (11) to mean 11(a), that the dog reached the finish line before both other animals. This means that at an initial stage, we would actually expect Mandarin-speaking children to behave more like English-speaking children and adults than like Mandarin-speaking adults. At a later stage, Mandarin-speaking children who hear sentences like (11) in situations in which the dog came before only one of the other animals can then easily expand their scope preferences to include the wider interpretation, 11(b).

To test this prediction we used a truth value judgement task, a research technique designed to investigate which meanings children can and cannot assign to sentences (Crain & Thornton, 1998). The task involves two experimenters. One acts out stories with toy characters and props, and the other plays the role of a puppet who watches the stories alongside the child. At the end of each story, the puppet explains to the child subject what he thinks happened in the story. The child's task is to decide whether the puppet said the right thing or not. If the child informs the puppet that he was wrong, then the child is asked to explain to the puppet what really happened.

We tested 3- to 5-year-old English- and Mandarin-speaking children on their interpretation of sentences like (11), uttered by the puppet, in two contexts. In the first condition, the dog had reached the finish line before both other animals in question. In the second condition, he had only reached the finish line before one of the other animals in question. The SSM would predict that children acquiring English or Mandarin should accept the test sentences in the first condition, and crucially reject them in the second. The results of this study are reported in Chapter 2.

4.2 Children's Interpretation of the Scope Relation between NOT and AND

The second major study of this thesis investigates children's interpretation of sentences like (3), repeated here as (12).

(12) The elephant didn't eat both the carrot and the capsicum
   a. The elephant didn't eat both vegetables, but may have eaten one or neither
      (not > and)
   b. It was both the vegetables that the elephant didn't eat
      (and > not)

Here again, one of the possible interpretations of (12), 12(b), asymmetrically entails the other, 12(a). In 12(a), negation takes scope over conjunction, and the resulting interpretation is that the elephant didn't eat both vegetables. On this interpretation there are three circumstances which could make the sentence true: (i) if the elephant ate the carrot, but not the capsicum, or (ii) if the elephant ate the capsicum, but not the carrot, or (iii) if the elephant ate neither vegetable. In 12(b), on the other hand, in which conjunction takes scope over negation, there is only one circumstance that makes the sentence true: if the elephant ate neither vegetable. Interpretation 12(b) is thus the strong subset reading, while interpretation 12(a) is the weak superset reading. In addition, it turns out that adult speakers of English prefer to assign reading 12(a) to (12), while adult speakers of Mandarin strongly prefer reading 12(b).

Again, despite these cross-language differences, the SSM predicts that all children will initially prefer to interpret a sentence like (12) to mean 12(b), that the elephant ate neither vegetable. In this case, we would expect just the opposite pattern to that expected in our Chapter 2 study. That is, we are led by the SSM to expect English-speaking children to behave more like Mandarin-speaking children and adults than like English-speaking adults at an initial stage. At a later stage, English-speaking children who hear sentences like (12) in situations in which the elephant did eat one of the vegetables in question can then easily expand their scope preferences to include the wider interpretation, 12(a).

To test this prediction we used another truth value judgement task. We tested 3- to 5-year-old English- and Mandarin-speaking children on their interpretation of sentences like (12), uttered by a puppet, in a context in which an elephant had eaten a carrot, but not a capsicum. The SSM predicts that children acquiring English or Mandarin will reject the test sentences in this context, because the elephant ate one of the vegetables. However, in this case, note that the Isomorphism Account would actually make the opposite prediction. The isomorphic scope interpretation of (12) in English and in its Mandarin counterpart is actually the weak 'not > and' interpretation, 12(a), because negation structurally dominates conjunction. The Isomorphism Account would thus predict that children acquiring English or Mandarin should accept the test sentences in this context, because the elephant did not eat both vegetables, just one of them. Therefore, any evidence from this study in favour of the SSM will also be evidence against the Isomorphism Account.

These predictions rely on children interpreting conjunction in the scope of negation in a Boolean way. This Boolean relationship makes a statement like 'not (P and Q)' true in three circumstances (one of which is if the elephant ate the carrot, but not the capsicum). However, it might be possible to argue that, even if children assign an isomorphic 'not > and' scope relation to (12), their interpretation of a statement like 'not

(P and Q)’ is one which is true in only one circumstance, namely when neither P nor Q is true. It has been suggested that this kind of interpretation of conjunction can arise across languages when the conjuncts involved are definite noun phrases (rather than sentences, predicates, or quantified phrases), because the conjoined noun phrase can be interpreted as denoting a set or plurality (Hoeksema, 1988; Szabolcsi & Haddican, 2004). If children interpret the conjoined noun phrase *both the carrot and the capsicum* in our test sentences as denoting a plural, then regardless of what scope relations they assign to negation and conjunction, they will interpret a test sentence like (12) to mean that the elephant ate neither of the vegetables. On this view our data would fail to distinguish between the predictions of the SSM and the Isomorphism Account.

To rule out the possibility that children might assign a non-Boolean interpretation to negated conjunction, we need to further demonstrate that children have a Boolean ‘not both’ interpretation of conjunction under negation in some other linguistic context, when it combines definite noun phrases of the type used in (12). This can be accomplished by testing children’s interpretation of sentences in which the wide scope reading of conjunction with respect to negation is cancelled. One environment that cancels scope effects is in what is called the assertion of a sentence with a focus expression such as *only*.

For example, consider (13) below. The meaning of (13) can be divided into two propositions. One proposition is about the individual in focus, the dwarf – the dwarf bought some oranges. This proposition is called the presupposition. The second proposition is about a set of individuals in the conversational context that are being contrasted with the individual in focus. This second proposition is called the assertion. The assertion states that everyone in the contrast set lacks the property being attributed to the focus element, the dwarf. So the assertion is that everyone else did not buy any oranges.

(13) Only the dwarf bought some oranges

a. The dwarf bought some oranges

b. For all individuals x such that x is not the dwarf, x did not buy some (=any) oranges

For the sentence under consideration to be true, both 13(a) and 13(b) must be true. The property being attributed to the dwarf is *bought some oranges*. This property uses the existential quantifier *some*. In the assertion, therefore, the negation of this property, *didn't buy some oranges*, must be true of everyone being contrasted with the dwarf. Notice, however, that despite the fact that English-speaking adults assign *some* scope over negation in negative statements like *The dwarf didn't buy some oranges,* when *some* appears in the assertion of a sentence with a focus expression, such as (13), the meaning of *some* reduces to that of the negative polarity item, *any*. That is, it must be true that nobody else (being contrasted with the dwarf) bought any oranges. Crucially, the sentence *Only the dwarf bought some oranges* is false if anyone other than the dwarf bought some oranges, even if they also failed to buy some.

This example illustrates that the assertion of a focus expression requires the elements within it to be interpreted within the scope of negation. We can thus use this linguistic environment to find out the exact meaning that children assign to conjunction, by placing conjunction in the scope of a focus expression, and then examining the assertion that is derived. To do this, we designed another truth-value judgement task. We tested another group of 3- to 5-year-old English- and Mandarin-speaking children on their interpretation of sentences like (14), uttered by a puppet, in a context in which Mickey Mouse ate a strawberry and a banana, Tigger ate a strawberry, and Rabbit ate a banana.

(14) Only Mickey Mouse ate both a strawberry and a banana

a. Mickey Mouse ate both a strawberry and a banana

b. All those who are not Mickey Mouse, i.e. {Tigger, Rabbit}, did not eat both a strawberry and a banana

If the interpretation of conjunction in the scope of negation in 14(b) is Boolean, then sentence (14) will be true in the context under consideration, since Mickey Mouse did eat both a strawberry and a banana, and neither Rabbit nor Tigger ate both food items; they each ate just one of the items. If, on the other hand, the conjoined noun phrase *both a strawberry and a banana* denotes a plural set, then sentence (14) will only be true if Mickey Mouse ate both a strawberry and a banana, and Rabbit and Tigger ate neither item. In the context under consideration, sentence (14) would thus be false. If children accept test sentences like (14) in the context given, then we have independent evidence that they assign Boolean truth conditions to conjunction in the scope of negation.[4] We can therefore be sure that any rejections of sentences like (12), *The elephant didn't eat both the carrot and the capsicum*, in our original experiment will be due to children assigning these sentences a strong 'and > not' scope interpretation (and not due to them interpreting 'not > and' to mean 'not either'). The results of these two experiments, investigating children's interpretation of sentences like (12) and (14), are reported on in Chapter 4.

As a preface to Chapter 4, however, we first present the results of a supporting study investigating English-speaking and Mandarin-speaking children's interpretation of focus sentences without conjunction. The results of this study are reported on in Chapter 3. Establishing the kinds of child errors that can surface in interpreting focus expressions like *only* in simple contexts then informs our study design in Chapter 4. Briefly, in Chapter 3, we are concerned with children's interpretation of sentences like (15) in a context in which, for example, a cat ate a carrot, a duck ate a carrot and an apple, and a horse ate an apple.

(15) Only the cat ate a carrot

It has been observed that children often accept a sentence like (15) in these contexts, whereas adults reject them because the duck also ate a carrot, in addition to the cat. There has been a debate in the literature about whether these non-adult responses are due to children only processing the presupposition meaning component of (17) (i.e. the cat ate a carrot), or due to children erroneously assigning scope of the pre-subject focus operator to the verb phrase, thereby attaining a meaning along the lines of 'The cat only ate a carrot' (Crain et al., 1994; Paterson, Liversedge, Rowland, & Filik, 2003; Paterson, Liversedge, White, Filik, & Jaz, 2005/2006). We address this debate in our supporting study.

The results of this study highlight another kind of scope preference in children. We collect data showing that children, across languages, appear to pass through a stage in which they prefer to assign scope of a pre-subject focus operator to the verb phrase rather than to the subject noun phrase. We offer an explanation as to why this particular focus expression scope preference might surface for children in Chapter 3. This explanation is necessarily separate to the hypotheses we are considering in the rest of this thesis, as the scope preference we observed cannot be cast in terms of differing structural relations (isomorphic vs. non-isomorphic), nor in terms of a strong vs. a weak reading. In addition, although we show that the question under discussion does play a role in guiding children towards assigning focus to either the subject phrase or the verb phrase, there still appears to be a default interpretative preference for assigning focus to the verb phrase.

4.3 Children's Interpretation of the Scope Relation between NOT EVERY and OR

The third major study of this thesis investigates children's interpretation of sentences like (4), repeated here as (16).

(16) Not every princess took a star or a shell

a. There is some princess who did not take a star and who did not take a shell (not every > or)

b. It was either a star or a shell that some princess didn't take (or > not every)

Once again, one of the possible interpretations of (16), 16(a) asymmetrically entails the other, 16(b). In 16(a), the compound quantifier *not every* takes scope over disjunction. Because *not every* is logically equivalent to 'some not', the resulting interpretation is that there is some princess who did not take a star or a shell. Negation, like the conjunction *before*, is a downward entailing operator. This means that when disjunction is interpreted within the scope of negation, a conjunctive interpretation arises. So the interpretation in 16(a) is that there is some princess who didn't take either object. This conjunctive interpretation of disjunction makes (16) true in a narrower range of circumstances than an interpretation in which disjunction scopes over *not every*, as in 16(b). On interpretation 16(b) there are three circumstances which could make the sentence true: (i) if some princess didn't take a star, but did take a shell, or (ii) if some princess didn't take a shell, but did take a star, or (iii) if some princess didn't take either object. Interpretation 16(a) is thus the strong subset reading, while interpretation 16(b) is the weak superset reading.

The SSM predicts that English-speaking children will initially prefer to interpret a sentence like (16) to mean 16(a), that there is some princess who took neither object. It turns out this is also the interpretation favoured by English-speaking adults (although our data do show they also assign an interpretation like 16(b) some of the time). Nonetheless, even if 16(a) is the preferred interpretation for adults, it is extremely unlikely that children hear many sentences demonstrating how negation, the universal quantifier, and negation are interpreted in combination. In a survey of all adult utterances in the MacWhinney and Brown corpora on the CHILDES database (a total of 130,337 utterances), we found just two instances of disjunction occurring in the predicate phrase of *every*, and none in the predicate phrase of *not every*. In fact, we found no instances of the use of the compound quantifier *not every* at all. There were 40 utterances in which *not* preceded the quantifier *all*, either as two separate operators or as the compound quantifier *not all*, but none of these utterances also included the disjunction operator. If children cannot learn what sentences like (16) mean directly from the input, then it is reasonable to assume that they are, indeed, faced with an ambiguity between interpretation 16(a) and interpretation 16(b) of sentence (16). This means it could be possible to see some English-speaking children assigning interpretation 16(a) to (16), and some interpretation 16(b). If, on the other hand, they are guided by the SSM, then we would expect to see a marked preference for interpretation 16(a).

In this study, we were also concerned with a further issue. If children apply the SSM as a maxim guiding their scope preferences, then they must draw upon certain logical principles. These logical principles, taken together, define the strong and weak meanings of the sentences we have been considering in the major studies of this thesis. The first of these principles is that disjunction is always assigned an inclusive interpretation. This means that a statement of the form 'P or Q' in natural language has three circumstances which make it true: (i) if P is true, but Q is not, (ii) if Q is true, not P is not, (iii) if both P and Q are true. The second principle is that certain operators are naturally classed together as downward entailing operators. The defining characteristic of downward entailing operators is that they license inferences from sets to subsets. The three logical expressions interacting with disjunction and conjunction in the major studies of this thesis (*before*, *not*, and *not every*) are all downward entailing operators. For example, we can truthfully infer from the statement *Not every animal is a mammal*, that *Not every animal is a fox.* It turns out that these two logical principles result in disjunction being assigned a strong conjunctive interpretation whenever it is interpreted in the scope of a downward entailing operator. We see this conjunctive meaning in interpretation 16(a) of *Not every princess took a star or a shell.* The conjunctive interpretation makes 16(a) the strong reading, and creates ambiguity with the other hypothetically possible interpretation of the sentence, the one in which disjunction is interpreted outside the scope of the downward entailing operator as in 16(b). If the logical principles affecting the interpretation of disjunction in downward entailing environments were not applied, there would be no ambiguity in interpreting (16). Whether disjunction was interpreted inside or outside the scope of *not every* would amount to the same thing. In fact, exactly this occurs when disjunction occurs in the noun phrase restricted by *not every*, which is not a downward entailing environment, as in (17).

(17) Not every girl or boy bought a ball

Sentence (17) can only mean that there is some girl or some boy who did not buy a ball. On this interpretation, there are always three circumstances that make the sentence true: (i) if some girl did not buy a ball, but all the boys did (ii) if some boy did not buy a ball, but all the girls did (iii) if some girl and some boy did not buy a ball. This is because the noun phrase restricted by *not every* (or restrictor) is not a downward entailing environment. In other words, the compound quantifier *not every* is only downward entailing in its predicate phrase (or nuclear scope). This difference allows us to make an interesting within-language comparison. In sentence (16) a strong reading is available, while in (17) no strong reading is available. If children are guided both by the SSM, and by logical principles determining for them the set of possible downward entailing environments and the interpretation of disjunction in the scope of these downward entailing environments, then we should see children assign a strong meaning to (16), and not to (17).

If, on the other hand, children have to learn piecemeal about each downward entailing environment, it is possible they might try to assign a strong meaning to (17), one in which some boy and some girl did not buy a ball. They might do this because they do not distinguish between the nuclear scope and the restrictor of *not every*, or, because they associate the behaviour of disjunction in sentences like (17) with sentences like (18), in which disjunction appears in the restrictor of the universal quantifier, 'every'. The restrictor of the universal quantifier is a downward entailing environment, and accordingly sentence (18) only has a strong meaning, on which every girl and every boy bought a ball.

(18) Every girl or boy bought a ball

To test these predictions we used another truth value judgement task. We tested 4- to 5-year-old English-speaking children on their interpretation of sentences like (16) and (17) in two specific contexts. Sentences like (16), *Not every princess took a star or a shell*, were produced in a context in which two princesses had taken shells and stars, and two princesses had taken stars only. Contexts like this made the test sentences false on a strong interpretation, but true on a weak one. If the logical principles outlined underpin natural language, and if, further, children are guided by these principles during the language acquisition process, then they should correctly identify the nuclear scope of *not every* as a downward entailing environment, and calculate a possible strong interpretation for the sentence, in addition to a weak one. The SSM predicts that children should show an initial preference to reject the test sentences on their strong interpretation, because there was no princess who had taken neither a shell nor a star.

Sentences like (17), *Not every girl or boy bought a ball*, were presented to children in a context in which two boys and one girl had bought a ball, and one girl had not bought a ball. Contexts like this made the test sentences true on their weak interpretation, but false on a possibly strong interpretation for children (i.e. that some boy and some girl had not bought a ball). These sentences allowed us to conduct a control on our results with sentences like (16). Here, if children correctly identify the restrictor of *not every* as a non-downward entailing environment, then they should automatically access the only interpretation available for this sentence, the one in which disjunction can be assigned three possible truth conditions (one of which is if just one girl does not buy a ball), and accept the test sentences. The results of this study are reported in Chapter 6.

As a preface to Chapter 6, however, we first present the results of a study investigating young children's interpretation of the universal quantifier in sentences without disjunction. The results of this supporting study are reported on in Chapter 5. Establishing the kinds of child errors that can surface in interpreting the universal quantifier *every* in simple contexts informs our study design in Chapter 6. Briefly, in Chapter 5, we are concerned with children's interpretation of sentences like (19) in a context in which three boys are riding elephants, and one extra elephant is riderless.

(19) Every boy is riding an elephant

It has been observed that children often reject a sentence like (19) in these contexts, pointing out that no boy is riding the extra elephant. Adults, on the other hand, accept them. There has been a debate in the literature about whether these non-adult responses demonstrate that children possess a non-adult semantic interpretation of *every*, in which they allow *every* to quantify over elephants (Geurts, 2003; Philip, 1995), or whether they have difficulty interpreting *every* when it is used in infelicitous discourse contexts (Crain et al., 1996; Drozd, 1996; Drozd & van Loosbroek, 2006). We address this debate in our supporting study from a new angle, by collecting data from very young 2-year-old English-speaking children. The aim of this study was to uncover children's earliest hypothesis about universal quantification, as, if they do entertain a non-adult reading at some point during their development, it is most likely to appear at an early age. Our data support the view that even very young children initially interpret *every* in an adult-like manner, so long as the contexts presented to them are felicitous. Felicity can be achieved by satisfying the presuppositionality demands of the universal quantifier by making the set corresponding to the restrictor set clear in the context, as well as by satisfying the condition of plausible dissent. The condition of plausible dissent states that when asking someone to judge the truth or falsity of a sentence, a different possible outcome from the actual outcome should have been under consideration at some point (Crain et al., 1996). For example, a felicitous context for the question *Is every boy riding an elephant*? would require the possibility that, at some point, not every boy is riding an elephant. This can be achieved by providing an additional different animal in the context that the boys might have ridden. These aspects of the context were taken into consideration when designing our Chapter 6 study.

5. Thesis Organisation

This thesis investigates which reading children may favour when presented with scopally ambiguous sentences in which one reading asymmetrically entails the other. Three major hypotheses about children's scope preferences (the Isomorphism Account, the Question-Answer Requirement Model, and a modified version of the Semantic Subset Principle, the Semantic Subset Maxim) will be considered in explaining the reason behind children's scope preferences. Chapter 2 reports the results of a study of children's interpretation of sentences containing *before* and *or*. Chapter 3 reports the results of a supporting study investigating children's interpretation of pre-subject *only*. Chapter 4 reports the results of a study of children's interpretation of sentences containing *not* and *and*, as well as a control study of children's interpretation of sentences containing pre-subject *only* and *and*. Chapter 5 presents the results of the second supporting study investigating very young children's interpretation of *every*. Chapter 6 reports the findings of a study investigating children's interpretation of sentences containing the compound quantifier *not every* and *or*. Finally, in Chapter 7, I will discuss the implications of the findings for the three child scope preference accounts. Based on the new data presented here, I will offer an answer to the two main questions of this thesis, and make some suggestions for further work.

Endnotes

[1] For a similar idea invoking computational efficiency as the only factor responsible for scope preferences in both children and adults, see also (O'Grady & Lee, 2008)

[2] It is hard to see how there could be languages that lack the strong reading, and only accept negative statements with the universal quantifier on the weak reading, since the weak reading makes sentences true in circumstances associated with the strong reading.

[3] The meaning of disjunction does not differ when it is assigned a conjunctive interpretation versus when it is not, but the truth conditions associated with disjunction do differ. Disjunction has three logical truth conditions. So, a statement like ‘P or Q’ can be true if (i) P is true, but Q is not, (ii) Q is true, but P is not, or (iii) P and Q are true. When disjunction is interpreted in the scope of a downward entailing operator like ‘before’, all three of these truth conditions must hold for the sentence as a whole to be true. This results in a conjunctive interpretation (both P and Q must be true). When disjunction is interpreted outside the scope of a downward entailing operator, only one of the three possible truth conditions must hold for the sentence as a whole to be true.

[4] Two slightly different interpretations of sentence (14) might arise if children consider characters other than Mickey Mouse in the context (i.e. Tigger and Rabbit) to be acting together, as a couple. As we shall see, in either case, children would then have to reject sentence (14) in the context given. First, suppose children do not assign Boolean truth conditions to conjunction in the scope of negation. Sentence (14) would then be true if Mickey Mouse ate both a strawberry and a banana, and Tigger and Rabbit together ate neither. Because in the context Tigger and Rabbit together did eat both food items, (14) would be false on this reading. Now, suppose children do assign Boolean truth conditions to conjunction in the scope of negation. Sentence (14) would then be true if Mickey Mouse ate both a strawberry and a banana, and Tigger and Rabbit together did not eat both. Because in the context Tigger and Rabbit together did eat both food items (Tigger ate a strawberry and Rabbit ate a banana), (14) would also be false on this reading. In other words, it might be possible for children who treat conjunction in a Boolean way to nonetheless reject our test sentences. These responses would be false negatives. However, to err on the side of caution, we will only treat acceptances of our test sentences as evidence in support of children’s Boolean interpretation of conjunction.

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CHAPTER 2
Children's interpretation of disjunction in the scope of 'before': a comparison of English and Mandarin

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Abstract

This study investigates 3- to 5-year-old children's interpretation of disjunction in sentences like 'The dog reached the finish line before the turtle or the bunny'. English disjunction has a conjunctive interpretation in such sentences ('The dog reached the finish line before the turtle AND before the bunny'). This interpretation conforms with classical logic. Mandarin disjunction ('huozhe') can take scope over 'before' ('zai…zhiqian'), so the same sentence can mean 'The dog reached the finish line before the turtle OR before the bunny (I don't know which)'. If children are guided by adult input in the acquisition of sentence meanings, English- and Mandarin-speaking children should assign different interpretations to such sentences. If children are guided by logical principles, then children acquiring either language should initially assign the conjunctive interpretation of disjunction. A truth value judgment task was used to test this prediction and English- and Mandarin-speaking children were found to behave similarly.

1. Introduction

This study is a cross-linguistic investigation of children's interpretation of disjunction (English 'or', Mandarin 'huozhe') in sentences with the temporal conjunction BEFORE (English 'before', Mandarin 'zai…zhiqian'). The interpretation of disjunction in sentences with this temporal conjunction differs in English and Mandarin, at least for adult speakers. Therefore, a comparison of child learners of these languages provides an interesting testing ground for theories about the emergence of meaning in language acquisition. If children are uniquely guided by the adult input, then English-speaking children and Mandarin-speaking children should assign different interpretations to sentences in which disjunction appears with the temporal conjunction BEFORE, since adult speakers of these languages assign different interpretations to such sentences. On the other hand, if children acquiring both languages are guided by both a learnability constraint on the acquisition of semantic representations and by logical principles, then they should initially assign a conjunctive interpretation to disjunction in sentences with the temporal conjunction BEFORE regardless of the interpretation assigned by adults. On this scenario, Mandarin-speaking children are expected to differ from Mandarin-speaking adults in interpreting the relevant sentences. Instead, they are expected to adopt the same interpretation that is characteristic of English-speaking children (and adults).

To frame the present study, we begin with a discussion of the interpretation of disjunction in sentences containing certain negative logical words like 'not' and 'none'. This is followed by a discussion of the interpretation of disjunction in sentences with the words 'every' and 'before' which do not have a negative cast. We then introduce the relevant cross-linguistic differences in how sentences with 'before' and disjunction are interpreted, and we present the learnability constraint, the Semantic Subset Maxim, we believe may be operative for children as they are acquiring the meanings of these sentences. We review previous research on children's interpretation of disjunction in various languages. The findings of previous studies indicate that children are guided by both the Semantic Subset Maxim and by logical principles in their interpretation of disjunction in sentences with negative operators like 'not' and 'none', and with the universal quantifier 'every'. However, the present study is the first cross-linguistic investigation of the acquisition of the interpretation of disjunction in sentences with BEFORE. This study assesses the extent to which children across languages adhere to the same learnability constraint and logical principles in interpreting such sentences.

1.1 Downward Entailment and the Conjunctive Interpretation of Disjunction

The class of expressions called DOWNWARD ENTAILING (DE) operators encompasses a wide range of parts of speech in human languages. For example, the negative operator ‘not’, the determiner ‘none’, and the preposition ‘without’ are all downward entailing operators. They are also all negative expressions. However, the class of DE expressions also includes non-negative expressions like the universal quantifier ‘every’ and the temporal conjunction ‘before’. Despite syntactic and semantic differences among these expressions, they form a natural class in human languages because they have several properties in common. First, they license inferences from general terms (e.g. ‘Romance language’) to more specific terms (e.g. ‘French’). Consider the statement ‘John did not learn a Romance language’. This statement contains negation (‘not’) and the general term ‘Romance language’. If this statement is true, then it logically follows that the statement ‘John did not learn French’ is also true, where the general term ‘Romance language’ has been replaced by the specific term ‘French’. The temporal conjunction ‘before’ also validates inferences from general terms to specific terms, so if the statement ‘Dinosaurs lived before modern mammals’ is true, then it must also be true that ‘Dinosaurs lived before foxes’. Most words, even those which appear to form a natural class with downward entailing operators in terms of their semantic class or part of speech, do not license inferences from sets to their subsets. For example, although ‘every’ licenses an inference from a set to a subset (e.g. ‘Every Romance language is easy to learn’ licenses the inference ‘French is easy to learn’), other quantifiers like ‘some’, ‘most’, or ‘few’ do not (‘Some Romance languages are easy to learn’ does not necessarily mean that ‘French is easy to learn’). The licensing of inferences from sets to their subsets is the defining property of downward entailing operators.

A second diagnostic property of downward entailing operators is that they license the conjunctive interpretation of disjunction (English ‘or’). Consider the English sentence ‘John does not like broccoli or cauliflower’. This sentence contains the downward entailing operator ‘not’ and the disjunction operator ‘or’. The sentence is understood to entail that John does not like broccoli AND that John does not like cauliflower. The conjunctive interpretation of disjunction arises because the English disjunction operator ‘or’ is assigned the truth conditions associated with inclusive disjunction (inclusive-or). Ordinary statements with inclusive-or are true in three circumstances, just as in classical logic. In classical logic, a statement of the form ‘P or Q’ is true if (i) P is true (but Q is not), or (ii) Q is true (but P is not), or (iii) both P and Q are true. This means that 'P or Q' is false in just one circumstance: when neither P nor Q is true.

When 'or' is negated, the truth conditions for inclusive-or are reversed. So 'not (P or Q)' is true in the one circumstance in which 'P or Q' is false, namely when neither P nor Q is true. This relationship is captured in one of de Morgan's laws of propositional logic, where the symbol '$\neg$' stands for 'not', the symbol '$\vee$' stands for 'or', and the symbol '$\wedge$' stands for 'and':

(1) $\neg(P \vee Q) \Rightarrow \neg P \wedge \neg Q$

In natural languages, as in logic, the conjunctive interpretation of disjunction is assigned when disjunction is negated. Even more generally, the conjunctive interpretation of disjunction is assigned whenever disjunction appears in the scope of a downward entailing operator. For example, 'or' generates a conjunctive interpretation in sentences with 'none' and 'without', as illustrated in (2).

(2) a. None of the students took maths or biology
$\Rightarrow$ None of the students took maths and none of the students took biology

b. I left the restaurant without my purse or my camera
$\Rightarrow$ I left the restaurant without my purse and I left the restaurant without my camera

The expressions 'none' and 'without' clearly contain negation as part of their meanings. In view of the logical relationship between negation and disjunction, it makes sense that these operators trigger the conjunctive interpretation of disjunction. However, other downward entailing operators do not require a negative meaning in order to license the conjunctive interpretation of disjunction. The expressions 'every' and 'before' are two such cases. Example (3) illustrates that 'every' licenses the conjunctive interpretation of disjunction. For this downward entailing expression, a different logical process is responsible for the conjunctive interpretation of disjunction, as compared to negative expressions like 'none' and 'without'.

(3) Every passenger who ate chicken or beef became ill
⇒ Every passenger who ate chicken became ill and every passenger who ate beef became ill

The expression 'every' yields the conjunctive interpretation of disjunction because of the set relations that it creates when it is in construction with a noun phrase that contains disjunction, such as 'every passenger who ate chicken or beef'. In this noun phrase, 'or' is used to partition the universally quantified superset 'every passenger' into two subsets 'passengers who ate chicken' and 'passengers who ate beef'. The quantificational expression 'every passenger who ate chicken or beef' refers to the entirety of the partitioned superset of passengers. This superset necessarily includes (i) passengers who ate chicken, (ii) passengers who ate beef, and (iii) any passengers who ate both chicken and beef. In other words, the conjunctive interpretation of disjunction arises in (3) because all three circumstances associated with inclusive-or must be true in order to guarantee the truth of the universally quantified statement. The linguistic behavior of 'every' contrasts with the negative downward entailing expressions 'not', 'none' and 'without'. When 'or' appears in the scope of these expressions, a statement is true only in the event that both of the disjuncts are false.

The conjunctive interpretation of disjunction also arises in sentences with 'before', as in (4).

(4) Jane arrived at the pool before Mary or Sue
⇒ Jane arrived at the pool before Mary and Jane arrived at the pool before Sue

This interpretation arises for reasons similar to the ones just outlined for the universal quantifier. This is because the temporal concept BEFORE introduces a 'covert' universal quantifier which quantifies over the points-in-time that make up events (Anscombe, 1964; Heinamaki, 1972). That is, if an event A is said to occur BEFORE an event B, then at least one point-in-time in event A must have taken place before EVERY point-in-time in event B. The 'covert' universal quantifier in the semantics of BEFORE is the source of the conjunctive interpretation of disjunction. Example (4) can be used to illustrate. Event A is expressed in the main clause 'Jane arrived at the pool'. Event B is expressed in the BEFORE-clause 'Mary arrived at the pool or Sue arrived at the pool'. Since event B is a disjunction of events, event B contains two sub-events, one denoting Mary's arrival and the other denoting Sue's arrival. For (4) to be true, some point-in-time in event A must have preceded every point-in-time in the sub-events that comprise event B. So, Jane's arrival must have preceded every point-in-time in the sub-event of Mary's arrival, AND Jane's arrival must have preceded every point-in-time in the sub-event of Sue's arrival. This is why the temporal conjunction BEFORE licenses the conjunctive entailment of disjunction.[1]

1.2 Cross-Linguistic Differences in Downward Entailment Properties

For the conjunctive interpretation of disjunction to arise in a sentence containing a downward entailing (DE) operator and disjunction, disjunction must be interpreted WITHIN the scope of the DE operator. In natural languages, as opposed to classical logic, assigning scope to two logical operators can be ambiguous. This gives rise to some interesting cross-linguistic differences in scope assignment. To illustrate, let us again use the example of negation.

In some languages, like English, disjunction is interpreted within the scope of negation in both simple negative sentences, such as (5a) and in complex negative sentences, as in (5b). As a consequence of this uniform scope relationship, disjunction receives a conjunctive interpretation in both simple and complex sentences.

(5) a. John does not like broccoli or cauliflower
$\Rightarrow$ 'John does not like broccoli and John does not like cauliflower'

b. I do not think John likes broccoli or cauliflower
$\Rightarrow$ 'I do not think John likes broccoli and I do not think John likes cauliflower'

Languages which behave like English in this respect include German, French, Greek, Romanian, Bulgarian, and Korean (Szabolcsi, 2002).

In other languages, including Mandarin, the conjunctive interpretation of disjunction only arises in complex sentences, where negation appears in a higher clause than the clause that contains disjunction, as illustrated in (6).

(6)	Wo	bu	renwei	ta	xihuan	xilanhua	huozhe	huayecai
	I	not	think	he	like	broccoli	or	cauliflower

‘I do not think he likes broccoli or cauliflower’

⇒ ‘I do not think he likes broccoli and I do not think he likes cauliflower’

When negation and disjunction appear in the same clause, however, as in (7) below, the disjunction operator tends to be interpreted as taking scope over negation. So in Mandarin, the translation of ‘John does not like broccoli or cauliflower’ can mean ‘It is broccoli or cauliflower that John doesn’t like (I’m not sure which one)’. Note that the notion of scope under consideration does not refer to the linear order of words in sentences. Negation precedes disjunction in the Mandarin example (7), but disjunction is interpreted as taking scope over negation.

(7)	Ta	bu	xihuan	xilanhua	huozhe	huayecai
	He	not	like	broccoli	or	cauliflower

‘He does not like broccoli or cauliflower’

⇒ ‘It is broccoli or cauliflower that he doesn’t like (I’m not sure which one)’

Languages which allow disjunction to be interpreted as taking scope over negation in simple negative sentences include Hungarian, Japanese, Russian, Serbo-Croatian, Slovak, and Polish (Goro & Akiba, 2004a, 2004b; Szabolcsi, 2002).

Due to the ‘inverse scope’ relation allowed between disjunction and negation in languages like Mandarin, disjunction typically implies exclusivity (e.g. ‘It is either broccoli or cauliflower (but not both) that he doesn’t like’). This interpretation of disjunction arises because hearers compute an implicature. Briefly, the implicature arises because the operator ‘or’ and the operator ‘and’ form a scale based on information strength. On the scale containing ‘and’ and ‘or’, statements with ‘and’ are stronger than the corresponding statements with ‘or’, where a term α is ‘stronger’ than another term β if α asymmetrically entails β. Since the truth conditions assigned to ‘P and Q’ are a subset of the truth conditions of ‘P or Q’, statements with ‘and’ asymmetrically entail the corresponding statements with ‘or’, which are true in a wider range of circumstances. Following the Gricean conversational maxim of quantity (which entreats speakers to make their contributions as informative as possible), hearers generally assume that if a speaker uses ‘or’, he or she is not in a position to use the stronger term ‘and’ to describe the situation under consideration (Grice, 1975). Hearers therefore remove the truth conditions associated with ‘and’ from the meaning of ‘or’, yielding the exclusive-or reading of disjunctive statements (Horn, 1996).

This account of the interpretive differences between languages supposes that the basic meaning of disjunction in all human languages is inclusive-or. In languages in which disjunction takes scope over negation, the exclusive-or reading of disjunction is derived by a pragmatic implicature. On the other hand, in languages in which negation takes scope over disjunction, the entailment relations are reversed, such that statements with ‘or’, e.g. ‘not (P or Q)’ are stronger than the corresponding statements with ‘and’, ‘not (P and Q)’. So in these languages there is no implicature of exclusivity. To recap, the behaviour of disjunction in simple negative sentences differs across languages because the scope relations between disjunction and negation differ across languages. When negation takes scope over disjunction, as in English, the interpretation that is assigned conforms to de Morgan’s laws. When disjunction takes scope over negation, as in Mandarin, the interpretation of disjunction includes an implicature of exclusivity. As noted, English and Mandarin do not differ in the interpretation of disjunction when negation appears in a higher clause than the clause that contains disjunction. It seems that when negation and disjunction are separated by a clause boundary disjunction is prevented from taking scope over negation in human languages.

We can now ask whether languages differ in the behavior of disjunction in sentences with the universal quantifier. In answering this question it is important to point out that the conjunctive interpretation of disjunction only arises in the restrictor of the universal quantifier, the noun phrase it is in construction with (e.g. ‘Every [passenger who ate chicken or beef]$_{\text{Restrictor}}$ became ill’).[2] When disjunction occurs in the restrictor, it is part of the constituent headed by ‘every’. There do not seem to be differences in how sentences of this kind are interpreted in English-type and Mandarin-type languages (at least in the Mandarin-type languages we have reviewed: Mandarin, Japanese, and Hungarian). In the restrictor of ‘every’, the conjunctive interpretation of disjunction arises in both types of languages.

This brings us to the issue underpinning the present study: how disjunction is interpreted across languages in sentences with BEFORE. As we discussed earlier, the conjunctive interpretation of disjunction arises in sentences with BEFORE because BEFORE generates a covert universal quantifier. It turns out that there are cross-linguistic differences in how disjunction is interpreted in relation to this covert universal quantifier.

In languages like English, the universal quantifier introduced by BEFORE takes scope over disjunction, so that at least one point-in-time in the event mentioned in the main clause must precede every point-in-time in both events mentioned in the 'before' clause. However, in some other languages, including Mandarin, disjunction is interpreted as taking scope over the universal quantifier introduced by BEFORE. So, the truth conditions are such that at least one point-in-time in the event mentioned in the main clause must precede every point-in-time in at least one of the sub-events mentioned in the 'before' clause. To illustrate, consider the Mandarin example in (8), where disjunction ('huozhe') can scope over 'zai...zhiqian' ('before').

(8)	Jian	zai	Mali	huozhe	Su	zhiqian	dao-le
	Jane	at	Mary	or	Sue	before	arrive-ASP
	shuichibian						
	pool-side						

'Jane arrived at the pool before Mary or Sue'
⇒ 'It is before Mary or Sue that Jane arrived at the pool'

The cross-linguistic differences between English and Mandarin are reminiscent of the observation that languages differ in scope relations between negation and disjunction. In short, due to scope ambiguities, languages can differ in the interpretation of disjunction in sentences with two different downward entailing expressions, negation and BEFORE. Cross-linguistic differences like these provide a prime testing ground for theories of language acquisition, and in particular for a model of language acquisition based on the theory of Universal Grammar (UG).

We can ask how children interpret disjunction in simple sentences with downward entailing operators in languages like English and Mandarin, in which the interpretations of logical expressions differ for adults. If children's interpretations are the same as those of adults, then children learning English would be expected to assign the conjunctive interpretation to disjunction in simple sentences with a DE operator, whereas children learning Mandarin would be expected to allow disjunction to scope over a DE operator in simple sentences. However, a UG-based model of language acquisition anticipates that differences can arise between children's grammatical hypotheses and those of adults. On the UG-based model children are thought to draw on innate logical concepts in assigning meanings to expressions in the local language. For example, the meaning of disjunction (inclusive-or), as well as knowledge that certain expressions are downward entailing are thought to be innate logical concepts that children bring to the task of language development (Crain, Goro, & Thornton, 2006; Crain, Gualmini, & Pietroski, 2005; Crain & Thornton, 2006). It is possible on this model that children may be constrained to making a single hypothesis about how to interpret two logical expressions at the earliest stages of development. If this is the case then children learning English and Mandarin would be expected to make similar semantic hypotheses to each other, and possibly different hypotheses to those made by adults speaking their respective languages.

1.3 Hypothesised Constraint on Children's Acquisition of Semantic Interpretations

It is possible that when presented with sentences in which two scope assignments are available, children adhere to a learnability maxim on the acquisition of semantic representations. We will call this the SEMANTIC SUBSET MAXIM (SSM). This maxim is based on a learnability principle, the SEMANTIC SUBSET PRINCIPLE (SSP) introduced by Crain, Ni, & Conway (1994) to solve the learnability problem that would arise if the same kind of sentence is assigned more than one meaning in some languages, but only a single meaning in other languages. When first introduced, the principle was defined as follows:

> "if the interpretative component of Universal Grammar makes two interpretations, A and B, available for a sentence S, and if interpretation A makes S true in a narrower range of circumstances than interpretation B does, then interpretation A is hypothesized before B in the course of language development" (Crain et al., 1994, p. 455)

We will adopt the Semantic Subset Maxim (SSM) to explain children's default preferences among interpretive options, rather than using the more categorical terminology of the Semantic Subset Principle (SSP). Differences between languages in the scope assignments they give to logical operators are difficult to define categorically. That is, even if a language displays a preference for a particular scope assignment between two operators (like negation and disjunction), the reverse scope assignment remains theoretically available to speakers (and can normally be elicited with enough contextual or prosodic manipulation). Nonetheless, we believe the SSP can be adapted to the study of scope phenomena, as the SSM.

We suggest that when languages differ in the preferred scope assignment between two operators, it is not necessary to conclude that one class of languages allows only interpretation A, and another class of languages allows both interpretations A and B. Rather, WITHIN any given language, a sentence S containing two logical operators will always have two available interpretations, A and B. The child's task is to determine which of these interpretations is preferred in the local language. Faced with this ambiguity, the Semantic Subset Maxim enjoins children to initially favour the scope relationship that makes the sentence true in the narrowest range of circumstances, the subset reading. Children who then witness cases in which the sentence is true on a wider set of interpretations, the superset reading, can easily add these interpretations to their grammar. Proceeding in this way ensures that children follow the most efficient path in aligning their grammatical system with that of other members of the linguistic community, including preferences for resolving scope ambiguities. That is, if children initially favour the subset interpretation, and their language favours the superset interpretation, then children will receive clear and compelling evidence from the linguistic input informing them that the subset reading is not operative in most circumstances. Based on the evidence, children can move quickly to align their preferences with those of adult speakers. On the other hand, if children initially favour the superset reading, then the majority of the input they receive will be consistent with that interpretation, including input from speakers who strongly prefer the subset reading. It would therefore take children considerably longer to align their preferences with those of the adults around them on this scenario.

We have chosen the word 'maxim' to replace 'principle' since what is represented is a default preference for the subset reading, not the absolute presence or absence of an interpretation. A principle prevents a child from making an error from which he or she could not recover in the absence of negative evidence. A maxim, as we are using it, merely encourages children to proceed in a certain way to allow them to converge on the correct adult preferences as rapidly and effortlessly as possible. The maxim encourages children to adopt the scopal interpretation that provides them with the most efficient means for aligning their preferences with those of adults for various semantic interpretations of sentences.

Let's consider how the SSM would work in the case of sentences containing disjunction and a DE operator like negation. As we have seen, if negation takes scope over disjunction, then a conjunctive interpretation of disjunction arises. This interpretation will make a sentence like 'John does not like broccoli or cauliflower' true in a narrower range of circumstances than an interpretation in which disjunction scopes over negation. That is, on the conjunctive interpretation the only circumstance that will make the sentence true is if John likes neither vegetable in question. On the alternative interpretation, in which disjunction takes scope over negation, there are three logical circumstances which will make the sentence true: (i) if John does not like broccoli, but likes cauliflower, (ii) if John does not like cauliflower, but likes broccoli, (iii) if John likes neither vegetable (although, as previously discussed, circumstance (iii) is usually discarded by hearers through the application of a pragmatic implicature). The SSM would thus predict that children across languages will initially interpret a sentence like 'John does not like broccoli or cauliflower' to mean John likes neither vegetable, regardless of the adult scope preferences in that language. Children who hear sentences like 'John does not like broccoli or cauliflower' in situations in which John ate one of the vegetables in question can then expand their scope preferences to include the wider interpretation.

Note that this prediction can only be made if we also assume that children possess certain logical concepts. That is, children must assign disjunction the meaning of inclusive-or, and they must know that negation is a downward entailing operator that triggers a conjunctive interpretation of disjunction in its scope. Consequently, evidence in support of the prediction is also evidence that children do indeed possess these logical concepts. We turn now to a brief review of previous research in this area to see how the predictions of the SSM bear out.

1.4 Previous Child Research on Downward Entailment Relations

In 2002, Crain, Gardner, Gualmini, & Rabbin showed that three- to five-year-old English-speaking children, like adults, consistently assign a conjunctive interpretation to disjunction when it appears in the scope of negation. They presented two types of test sentences to 30 children. In both, negation preceded disjunction. However, in one sentence type negation was in a structurally 'higher' position than disjunction (e.g. 'The girl who stayed up late will not get a dime or a jewel'). This results in a conjunctive interpretation for adult speakers, so the meaning is 'The girl who stayed up late will not get a dime AND the girl who stayed up late will not get a jewel'. In the second sentence type, negation appeared in an embedded clause such that it was not structurally 'higher' than disjunction (e.g. 'The girl who did not go to sleep will get a dime or a jewel'). This type of sentence does not result in a conjunctive interpretation for adults, so the meaning is 'The girl who did not go to sleep will get a dime OR the girl who did not go to sleep will get a jewel'. Children were tested using a truth value judgment task, in which a story was acted out in front of them and then one of the two types of test sentence was used to describe the events of the story. Children were asked whether they agreed or disagreed with the test sentence. In the story corresponding to the two test sentences above, two girls were waiting for the tooth fairy. At the end of the story, it turned out that the girl who stayed up late (i.e. the girl who did not go to sleep) got a jewel. This context made the test sentences false if disjunction was assigned the conjunctive interpretation, but it made them true if disjunction was assigned 'disjunctive' truth conditions. The child subjects were sensitive to this feature of the context. They judged sentences like 'The girl who stayed up late will not get a dime or a jewel' to be false 92% of the time, and they judged sentences like 'The girl who did not go to sleep will get a dime or a jewel' to be true 87% of the time. This result was replicated by Gualmini & Crain in 2005 (Gualmini, 2005; Gualmini & Crain, 2005), and has also been shown to hold in child English for the operator 'none' (Gualmini & Crain, 2002).

What about children learning a language in which disjunction can be interpreted as taking scope over negation in simple negative statements? Goro & Akiba (2004a, 2004b) tested 30 three- to six-year-old Japanese-speaking children on sentences like 'The pig did not eat the carrot or the pepper' in contexts in which it turned out that the pig in question did not eat a carrot, but did eat a pepper. Whereas English speakers judge such sentences to be false in this context, Japanese adults judged the corresponding Japanese sentences to be true. This is because the interpretation of the sentence by Japanese-speakers allows disjunction to take scope over negation. So the sentence corresponding to 'The pig did not eat the carrot or the pepper' can be paraphrased as 'It is either a carrot or a pepper that the pig did not eat'. Since the pig did not eat a carrot, Japanese-speaking adults judged the sentence to be true. However, the Japanese-speaking children that were tested by Goro and Akiba differed markedly from adults. Children judged such sentences to be false 75% of the time. Four of the oldest children were effectively adults and consistently accepted the test sentences. When the results of these four children were removed, the rejection rate for the remaining 26 children was 87%. It appears then that

Japanese-speaking children initially compute a conjunctive interpretation for disjunction in simple negative sentences, unlike Japanese-speaking adults.

These findings support the prediction of the SSM that when presented with sentences containing negation and disjunction, children across languages initially compute the conjunctive interpretation of disjunction (the narrower interpretation). The findings also support the hypothesis that children across languages draw upon possibly innate universal logical concepts about the meaning of disjunction and its interaction with downward entailing operators. To further test this hypothesis, other studies have looked at how children learning different languages respond to disjunction in sentences with downward entailing operators other than negation. Some work has been done in English and Mandarin on children's interpretation of disjunction in the restrictor of the universal quantifier, which, as we have discussed, gives rise to a conjunctive interpretation in both languages. For example, a sentence like 'Every troll who ordered French fries or onion rings got mustard' entails that 'Every troll who ordered French fries got mustard AND every troll who ordered onion rings got mustard'. It has been shown that three- to five-year-old English-speaking and Mandarin-speaking children consistently reject sentences of this type in contexts in which, for example, only trolls who ordered French fries got mustard. Moreover, children learning both languages distinguish between sentences in which disjunction occurs in the downward entailing restrictor of 'every' and sentences in which it occurs outside the restrictor like 'Every ghostbuster will choose a cat or a pig'. Both English-speaking and Mandarin-speaking children consistently accept sentences like this in contexts in which, for example, ghostbusters choose cats or pigs, but not both (Boster & Crain, 1993; Chierchia et al., 2004; Gualmini, Meroni, & Crain, 2003; Su & Crain, 2009). These findings are in line with the hypothesis that children across languages draw upon innate universal logical concepts about the meaning of disjunction and its interaction with downward entailing operators.

Even stronger support for the innateness hypothesis could come from investigations of children's interpretation of disjunction in sentences with a non-negative downward entailing operator where there are cross-linguistic differences in interpretation. This is the case for the temporal conjunction BEFORE. Therefore, the present study investigates how English-speaking and Mandarin-speaking children interpret 'or' and 'huozhe' in the scope of 'before' and 'zai…zhiqian' respectively.

2. Predictions

Recall that in an English sentence, the downward entailing operator ‘before’ licenses a conjunctive interpretation of disjunction, as in (4), repeated here as (9).

(9) Jane arrived at the pool before Mary or Sue
⇒ Jane arrived at the pool before Mary and Jane arrived at the pool before Sue

By contrast, in Mandarin, disjunction can take scope over a downward entailing operator like ‘zai…zhiqian’ so that a conjunctive interpretation does not arise, as in (8), repeated here as (10).[3]

(10)

Jian	zai	Mali	huozhe	Su	zhiqian	dao-le
Jane	at	Mary	or	Sue	before	arrive-ASP

shuichibian
pool-side

'Jane arrived at the pool before Mary or Sue'
⇒ ‘It is before Mary or Sue that Jane arrived at the pool’

The difference between the two languages is, however, not as clear-cut as in the case of negation and disjunction. That is, a Mandarin speaker may also compute the conjunctive interpretation of disjunction in the scope of ‘zai…zhiqian’, just as in English. Nonetheless, the interpretation with disjunction taking scope over ‘zai…zhiqian’ is much more accessible to Mandarin-speakers in sentences like (10) than the corresponding reading for English speakers in sentences like (9). This is shown in our results section where we present a comparison of Mandarin- and English-speaking adults’ rates of acceptance of sentences like (9) and (10) in different contexts. When disjunction is interpreted as taking scope over ‘zai…zhiqian’ in sentences like (10), the reading that results for Mandarin-speakers engages an implicature of exclusivity (e.g. ‘It is either before Mary or before Sue (but not before both) that Jane arrived at the pool’). Such a reading is, at best, a faint possibility in English, and requires a particularly marked prosodic contour in which there is a long pause before disjunction.

In spite of the differences in adult usage between the two languages in question, on a UG-based account of language acquisition we expect children learning either English or Mandarin to draw upon innate universal logical concepts about the meaning of disjunction and its interaction with downward entailing operators, and to be guided in their scope assignment by the SSM. Similarly to the case of negation, when disjunction appears in a sentence with the DE operator BEFORE, a conjunctive interpretation of disjunction will make the sentence true in a narrower range of circumstances than a reading in which disjunction takes scope over BEFORE. So if children adhere to the SSM they should initially hypothesise that a sentence like 'Jane arrived at the pool before Mary or Sue' means Jane arrived before both other girls. This model predicts that, across languages, children will initially assign wide scope to BEFORE, and adhere to the logical set relation principle dictated by the covert universal quantifier in its semantics. We should thus see children computing the conjunctive interpretation of disjunction in sentences with 'before' in English, AND in sentences with 'zai…zhiqian' in Mandarin. The present study was designed to evaluate this prediction.

There are several caveats to this prediction. As we have seen, the conjunctive interpretation of disjunction in the scope of a downward entailing operator like BEFORE arises for two reasons. First, the basic meaning of disjunction must be inclusive-or. The truth conditions associated with inclusive disjunction are then considered simultaneously in assessing the truth of the BEFORE statement. Second, the conjunctive interpretation of disjunction is due to the fact that the semantics of the temporal conjunction BEFORE includes a covert universal quantifier. For children to compute the conjunctive interpretation of disjunction, therefore, they must first have grasped the semantics of BEFORE.

Previous research indicates that 3- to 5-year-old children should be able to meet these two requirements. Although it was once debated whether children might only interpret disjunction exclusively (e.g. Braine & Rumain, 1981), recent studies have shown that 3- to 6-year-old children do access an inclusive reading of 'or' when it is presented in a context that is felicitous to this reading, such as the prediction mode, in which a test sentence is presented to children before events play out (Chierchia et al., 2004; Crain, Gualmini, & Meroni, 2000; Gualmini, Crain, & Meroni, 2000). An example of the prediction mode would be a story in which a mouse visits a fruit shop and a puppet has to guess what the mouse will buy. The puppet predicts 'I think the mouse will buy the apple or the grapes'. The child is asked to reward the puppet if the puppet's prediction turns out to be correct. When disjunction is used in the prediction mode, it is easier for language users to access the inclusive reading (the one in which, if the mouse buys both the apple and the grapes, the puppet is right).

We also know from previous research that children tend to start using juxtaposition to indicate temporal relations around age two, and begin using conjunctions like ‘before’ around age 2;6-3;0, although not consistently in the correct contexts (Clark, 2003). Previous studies in this area have mainly focused on how clause ordering affects children’s processing of ‘before’, as opposed to their processing of ‘after’. This issue is not relevant to our study; however, the results of this work can give us an indication of when children grasp the semantics of ‘before’. The results reported in the literature vary dependent on the task used and the type of test sentences, and in some cases children have been shown to have problems accessing the full meaning of ‘before’ between ages 3-4. However, by 4;6 they tend to perform various comprehension tasks quite well (Amidon & Carey, 1972; Clark, 1971, 2003; Crain, 1982; French & Brown, 1977; Johnson, 1975; Kavanaugh, 1979; Stevenson & Pollitt, 1987; Trosborg, 1982). We turn now to our study, which was designed to assess our prediction, while controlling for each child’s grasp of the semantics of disjunction and the conjunction ‘before’ or ‘zai…zhiqian’.

3. Study

3.1 Participants

We tested 24 English-speaking children between the ages of 3;4 and 5;1 (13 boys, 11 girls, mean age 4;4) and 20 Mandarin-speaking children between the ages of 4;6 and 5;4 (8 boys, 12 girls, mean age 4;7). The English-speaking children were recruited from two daycare centres at Macquarie University in Australia and all had English as their sole home language. The Mandarin-speaking children were recruited from the kindergarten at Beijing Language and Culture University in China and all had Mandarin as their sole home language. In addition we tested 20 English-speaking undergraduate students at Macquarie University (aged 18-27, mean age 21), and 20 Mandarin-speaking postgraduate students at Beijing Language and Culture University (aged 25-30, mean age 27).

3.2 Methodology

The children performed three tasks. The first was a pre-test assessing their knowledge of the meaning of the word BEFORE in isolation. We call this the Before Pre-Test. The second was a control task assessing their knowledge of the meaning of disjunction in isolation. We call this the Disjunction Control task. The third was a test task assessing their knowledge of the semantics of sentences in which BEFORE and disjunction occur together. We call this the Before-Or Test task. The adults were only given the Disjunction Control task and the Before-Or Test task. We outline the three tasks below.

3.2.1 Before Pre-Test

To check the children's comprehension of 'before' (Mandarin 'zai…zhiqian') as a conjunction we used an act-out task similar to those used in previous studies in this area (e.g. Amidon & Carey, 1972; Crain, 1982; Johnson, 1975). We introduced the children to a felt picture board and a number of felt animals, and explained they could make a picture by placing the animals on the board. We established that the children knew the names of all the animals by presenting them with each felt object and asking them to name it. We used the name the children gave us for each animal in the rest of the task. Once the animals had been named, we directed the children's actions by asking them to put on one animal before another one. There were four test sentences in English with clause ordering (main vs. subordinate) counterbalanced so that each child was given two directives in which the correct order of actions was also the order of mention as in (11) and two directives in which the correct order of actions was the reverse of the order of mention as in (12a). In Mandarin, subordinate clauses must always precede main clauses so children were only tested on two directives in which the correct order of actions was the reverse of the order of mention as in (12b).

(11) 'Could you put on the elephant (Y) before you put on the tiger (X)?'

(12) a. 'Before you put on the giraffe (X), could you put on the butterfly (Y)?'

b.	Zai	fang	changjinglu	zhiqian,	ni	neng	ba
	at	put	giraffe	before	you	can	BA

hudie	fangshangqu	ma?
butterfly	put-on	PART

'Before you put on the giraffe, could you put on the butterfly?'

Children were also given two filler directives using the temporal conjunction 'after'. These 'after' fillers were included to provide variety in the task and to break up patterns of response to the 'before' test sentences. In Mandarin, in both of the 'after' directives the correct order of actions was also the order of mention: 'After you put on the X, could you put on the Y?'. In English, one 'after' directive was like this, while in the other the correct order of actions was the reverse of the order of mention: 'Could you put on the Y after you put on the X?'. It should be noted that this study was not designed to assess how children respond to temporal conjunctions in sentences in which order of mention mirrors order of actions versus those in which it does not. The different possible orders in English were simply included to present a balanced range of 'before' and 'after' sentences to the children.

Temporal conjunctions like 'before' and 'after' trigger a discourse presupposition, a background belief that must be shared by both the speaker and hearer for the utterance to be considered appropriate in context. For example, in the sentence 'Before he had breakfast, Frank worked for an hour', it is presupposed that Frank did have breakfast. In this discussion we are setting aside non-veridical uses of 'before' like 'The firemen arrived before the house burned down', in which the event in the before-clause does not actually occur. Non-veridical uses of 'before' are not relvant here as all test sentences we used were presented in veridical contexts. That is, in the Before-Or Test task (presented later in our Methodology section) children were asked to respond after the fact to events in the 'before' clause that had already clearly taken place. Because it has been shown that children's non-adult responses in some tasks can be due to difficulty processing discourse presuppositions that are not adequately supported by the context (Crain, 1982; Gualmini, 2005), we aimed to satisfy pragmatic felicity requirements on the use of 'before' and 'after' in our task by always establishing with the child their intention to move an object before issuing a command to do so. We did this by asking the child what animal they would like to put on the board before each directive. The object they intended to move was then incorporated into the subordinate clause of the following test sentence (i.e. the clause containing 'before'). For example, for a child who expressed a desire to move the giraffe, (12a) would be felicitous. This is because we have satisfied the presupposition triggered by the use of 'before' (in this case, the presupposition that the child does in fact intend to put the giraffe on the board). The directives using a temporal conjunction were interspersed with other filler directives without temporal conjunctions (e.g. 'Put the flamingo next to the tree'). In total English-speaking children responded to 12 items in this task (4 test directives using 'before', 2 filler directives using 'after', and 6 filler directives without temporal conjunctions), while Mandarin-speaking children responded to 8 items (2 test directives using 'before', 2 filler directives using 'after', and 4 filler directives without temporal conjunctions).

3.2.2 Disjunction Control Task

The Disjunction Control task was designed to test whether children had an inclusive reading of disjunction. This was important for two reasons. Firstly, as discussed, children could only be expected to access the conjunctive interpretation of disjunction in sentences with BEFORE in the Before-Or Test task (presented below) if their underlying interpretation of disjunction were inclusive. Secondly, if children showed an exclusive interpretation of disjunction in sentences with BEFORE in the Before-Or Test task, we would know whether this was because the children were allowing disjunction to scope over BEFORE or whether this was because they interpreted disjunction exclusively. To administer this control we used a truth value judgement task. This research technique is designed to investigate which meanings children can and cannot assign to sentences (Crain & Thornton, 1998). The task involves two experimenters – one acting out stories with toy characters and props, and the other playing the role of a puppet who watches the stories alongside the child. At the end of each story, the puppet explains to the child subject what he thinks happened in the story. The child's task is to decide whether the puppet said the right thing or not. If the child informs the puppet that he was wrong, then the child is asked to explain to the puppet what really happened.

Because disjunction can be subject to a scalar implicature in many positive sentential contexts, its reading often appears to be exclusive-or. However, the inclusive reading of disjunction is demonstrated when a conjunctive interpretation arises in negative sentences. As discussed, this occurs across languages when negation occurs in a higher clause to disjunction. This task thus consisted of four test sentences containing negation in a higher clause to disjunction. Four guessing game stories for our puppet were devised. In these stories, the puppet made a prediction about what he thought would happen in the story before the events played out. He was then asked to hide his eyes. After the events of the story, the puppet repeated his prediction and the child was asked to tell the puppet whether he had been right or not. Because our test sentences contained negation, a positive lead-in to the test sentence was used to satisfy felicity conditions on the use of negation (Gualmini, 2005; Musolino & Lidz, 2006). An example story is given below with the relevant test sentence in English and Mandarin given in (13).

Lifting Competition Story

Experimenter: Here are four things to lift – a shoe, a feather, a flower pot, and a truck – and two animals - a lion and a lamb - who would like to try to lift these things. [To the Puppet]: What do you think the lion will lift?

Puppet:

(13) a. We might see the lion lifting the shoe, but we won't see him lifting the feather or the truck

b.

Women		keneng		hui	kandao		shizi	juqi	
we		possibly		will	see		lion	lift	
xiezi,	danshi	women		bu	hui	kanda	ta	juqi	shoe
but	we		not	will	see	he	lift		
yumao		huozhe		kache					
feather		or		truck					

'We might see the lion lifting the shoe, but we won't see him lifting the feather or the truck'

Experimenter: [To the Puppet]: Ok, hide your eyes. [To the child]: Let's see what happens. [The lion lifts the shoe and the truck]

Puppet: Was I right? I said maybe we would see the lion lifting the shoe, but we wouldn't see him lifting the feather or the truck.

In two of our four stories, the puppet's prediction was correct. In the other two, the puppet's prediction was incorrect. To balance the stimulus set, one of these incorrect predictions was false because the character in question did in fact act on the first disjunct mentioned in the test sentence. We will call this the '1st disjunct false' sentence. The other incorrect prediction was false because the character in question acted on the second disjunct (e.g. in the story outlined above, the lion did lift the truck). We will call this the '2nd disjunct false' sentence. Each test sentence was followed by a filler sentence which did not contain negation or disjunction. For example in the lifting competition, the puppet was asked to make a prediction about the lamb ('Maybe we'll see the lamb lifting the feather'). In total, the children responded to 8 items in this task. The test sentences and fillers were administered in a fixed pseudo-random order.

3.2.3 Before-Or Test Task

For the Before-Or Test task, we also used a truth value judgement task. The task consisted of four test stories and one control story. Each story was about a race with three participants. In each race, one participant came first, one second, and one last. At the end of the race, the participants were placed on a three-tiered podium to reflect the order in which they had come (first, second, or third), serving as a reminder to the child of the events of the story. After each of the four test stories, the puppet produced a test sentence, such as (14). We will call these the 'before-or test sentences'. The before-or test sentences were delivered using a natural prosodic contour without pausing before disjunction.

(14) a. The dog reached the finish line before the turtle or the bunny

b. Xiaogou zai wugui huozhe tuzi zhiqian paodao-le zhongdian
dog at turtle or rabbit before reach-ASP finish line

'The dog reached the finish line before the turtle or the bunny'

Two of the four before-or test sentences described contexts in which the referent of the subject NP (e.g. the dog) came first. We will call this the First-Place condition. The other two test sentences described contexts in which the referent of the subject NP came second. We will call this the Second-Place condition. We expected that if children computed a conjunctive interpretation of disjunction, they should judge (14) to be a true description of stories in the First-Place condition, but a false description of stories in the Second-Place condition. On the other hand, if children allowed disjunction to take scope over BEFORE, then they should judge (14) to be a true description of stories in both conditions (i.e. when the dog came first, before both other participants, as well as when the dog came second, before only one other participant).

It was important to ensure that child subjects were actually processing both disjuncts when judging the before-or test sentences. To verify this, we ordered the disjuncts so that if the children made a false judgement in the Second-Place condition we could be sure they were responding to the full test sentence. That is, the first disjunct always referred to the participant who had come last, while the second disjunct referred to the participant who had come first. For example, in our swimming race story, a horse, a duck and a dolphin each had to swim to a shell at the end of a pool. The dolphin came first in this race, the duck second, and the horse last. After the story, the puppet said: '[The duck]$_{\text{2nd place}}$ got his shell before [the horse]$_{\text{3rd place}}$ or [the dolphin]$_{\text{1st place}}$'. Children could only reject this statement if they processed both disjuncts, and they computed a conjunctive interpretation: it was not true that the duck got his shell before the horse AND before the dolphin. On the flip side, children might agree with the puppet's statement for two reasons – either they allowed disjunction to take scope over 'before' (it was true that the duck either came before the horse OR before the dolphin), or they simply only processed the first disjunct (it was also true that the duck got his shell before the horse). Our fifth control story was used to make sure that any 'true' judgements in the Second-Place condition stories were genuinely due to children allowing disjunction to take scope over BEFORE. The control story was identical to the test stories in that three participants took part in a race, but at the end of the story the control sentence uttered by the puppet contained 'and' instead of 'or' as given in (15). We will call this the 'before-and control sentence'. In the relevant story, Tigger came first, followed by a pig, and then an elephant.

To successfully reject the before-and control sentence, children had to be processing both disjuncts. This control item introduces a new operator ('and') to the testing paradigm. Although this may be seen as a drawback, using 'and' allowed us to determine whether or not children were processing both disjuncts by eliciting a rejection from the child subjects. That is, if children were processing both disjuncts, they were expected to reject the control item. Children's rejections are stronger evidence of knowledge than their acceptances, as children can also accept test sentences if they are confused, or don't understand a sentence. It was important to administer a control trial requiring rejection, in the event that a child allowed 'or' to scope over 'before' and, therefore, accepted all the before-or test sentences.

(15) a. The pig jumped to the finish line before the elephant and Tigger

b.

Xiaozhu	zai	daxiang	he	tiaotiaohu	zhiqian
pig	at	elephant	and	Tigger	before

tiaodao-le	zhongdian
jump-to-ASP	finish line

'The pig jumped to the finish line before the elephant and Tigger'

The four before-or test sentences and the one before-and control sentence were each followed by a filler sentence which contained neither BEFORE nor disjunction or conjunction (e.g. 'In that race, the turtle fell over'). So, in total, the children responded to 10 items in this task. The fillers allowed us to balance the total number of true and false statements, and check whether the children had been paying attention to the stories. The order of before-or test sentences was counter-balanced for English-speaking children: half the children heard the stories in the First-Place condition first, and half heard the stories in the Second-Place condition first. However, this was found to have no effect on their answers, so the order of test sentences was fixed for the Mandarin-speaking children. These children all heard the stories in the First-Place condition first, followed by the ones in the Second-Place condition. The before-and control sentence was always administered last.

3.3 Testing Procedure

The children were tested individually over two sessions in a quiet corner of their daycare centre or kindergarten. In the first session, each child began with the Before Pre-Test, followed by a truth value judgement warm-up task, in which our puppet made several statements about a story which were obviously true or obviously false. This let the children know the puppet could say something wrong and familiarised them with the task. After the warm-up story, the children were given the Before-Or Test task. In the second session, children were given the Disjunction Control task. The full order of presentation (without filler sentences) is given, using English as an example, in Table 1.

	Task	**Sentence Type**	**Sentence**
Session 1	**Before Pre-Test**	Reverse OM*	Before you put on X, could you put on Y?
		After filler (Reverse OM)	Could you put on Y after you put on X?
		Reverse OM	Before you put on X, could you put on Y?
		OM	Could you put on Y before you put on X?
		After filler (OM)	After you put on X, could you put on Y?
		OM	Could you put on Y before you put on X?
	TVJT† Warm-Up	Warm-Up True	The cat chose a car to drive
		Warm-Up False	The cow drove his plane very slowly
	Before-Or Test	First Place before-or test sentence	The dog reached the finish line before the turtle or the bunny
		First Place before-or test sentence	The monkey picked his strawberry before the frog or the koala
		Second Place before-or test sentence	The duck got his shell before the horse or the dolphin
		Second Place before-or test sentence	The giraffe found his ball before Winnie-the-Pooh or the mouse
		Before-and control sentence	The pig jumped to the finish line before the elephant and Tigger

Session 2	**Disjunction Control**	2nd disjunct false	Maybe we'll see the lion lifting the shoe, but we won't see him lifting the feather or the truck
		True	Maybe we'll see the princess eating the ice cream, but we won't see her eating the watermelon or the grapes
		1st disjunct false	Maybe we'll see the boy jumping on the bed, but we won't see him jumping on the table or the bathtub
		True	Maybe we'll see Eeyore find the star, but we won't see him find the ball or the flowers

Table 1: Order of Presentation of Task Sentences in English
(*OM = Order of Mention, †TVJT = Truth Value Judgement Task)

4. Results

We coded each subject's initial response to the test sentences. Self-corrections were accepted only if the test sentence had not been repeated. If children changed their answer after the test sentence was repeated, this was coded as a 'mis-match' answer. Nine English-speaking children were excluded from the final analysis because they failed more than one test item in the Before Pre-Test (2 children), they failed more than one filler item in either the Before-Or Test task or Disjunction Control task (2 children), they failed the before-and control sentence in the Before-Or test task (2 children), or they gave a mis-matched answer to this control item (3 children). The remaining 15 children ranged in age from 3;4 to 5;1 (9 girls, 6 boys, mean age 4;4). All 20 Mandarin-speaking children (who were slightly older than the English-speaking children) successfully passed the Before Pre-Test, as well as all fillers and the before-and control sentence in the Before-Or test task.

4.1 Before Pre-Test Results

In English the Before Pre-Test consisted of four 'before' trials for each child (a total of 60 trials over the 15 children). The fifteen English-speaking children retained in the data set made no errors on any 'before' trial (although six of these children did make one or more errors on the 'after' filler sentences).

In total, the percentage of correct responses to 'before' trials on this task in English was 100 % (60/60 trials). We took this as evidence that the English-speaking children had an adequate knowledge of the semantics of ‘before’ to perform the test task. The fact that six children made errors on the ‘after’ fillers in this task was not considered grounds to exclude them from analysis of the Before-Or Test task, as this task relies on an understanding of the semantics of ‘before’, not ‘after’. It is possible that the greater number of ‘before’ trials in the English version of the Before Pre-Test biased some children to responding to all trials as a request to perform one action ‘before’ another one. There was no noticeable divide in ages between the children who made errors on the ‘after’ fillers and those who did not (the children who made ‘after’ errors were mostly younger children, 3;4-4;3, but also included some older children 4;8-4;10), and the errors were equally spread over the two types of filler (those in which the correct order of actions was also the order of mention, and those in which it was the reverse of the order of mention).[4]

In Mandarin this task consisted of two ‘before’ trials for each child (a total of 40 trials over 20 children). None of the Mandarin-speaking children made any errors on this task, either on the ‘before’ trials or the ‘after’ fillers. In total, the percentage of correct responses to ‘before’ trials on this task was 100% (40/40 trials). We took this as evidence that the Mandarin-speaking children had an adequate knowledge of the semantics of ‘zai…zhiqian’ to perform the test task. Table 2 summarises these results across languages. Rates of error for the different ‘before’ trial types and ‘after’ filler types are given for completeness, however, as previously noted, this study was not designed to compare children’s responses to these different orderings. Rather, we were interested in overall correct responses to ‘before’ trials.

		English N=15	**Mandarin N=20**
Before Trials	**Correct (%)**	100 (60/60 trials)	100 (40/40 trials)
	Incorrect on OM* trial (%)	0	NA
	Incorrect on Reverse OM trial (%)	0	0
After Fillers	**Correct (%)**	70 (21/30 trials)	100 (40/40 trials)
	Incorrect on OM filler (%)	17 (5/30 trials)	0
	Incorrect on Reverse OM filler (%)	13 (4/30 trials)	NA

Table 2: Before Pre-Test Results Across Languages (*OM = Order of Mention)

4.2 Disjunction Control Task Results

The Disjunction Control task consisted of 2 true trials and 2 false trials for each child and adult subject in both languages. In English this resulted in a total of 30 true trials and 30 false trials for the 15 children, and 40 true trials and 40 false trials for the 20 adults. The English-speaking children responded correctly to their true trials 100% (30/30 trials) of the time, and they rejected their false trials 83% (25/30 trials) of the time. The reasons the children gave for their rejections were always clearly related to the conjunctive interpretation of disjunction under negation. For example, in response to the test sentence 'We might see the lion lifting the shoe, but we won't see him lifting the feather or the truck', a representative justification from a child aged 4;6 is given in (16):

(16)	Child:	look, he lifted these [showing shoe and truck]
	Puppet:	was I right or was I wrong?
	Child:	wrong
	Puppet:	can you tell me why?
	Child:	cause he lifted the truck

Only one child (4;1) accepted both false trials and was thus potentially not computing a conjunctive interpretation of disjunction under negation. However, in examining this child's answers more closely, it is clear he was correcting the puppet on these trials, but was incapable of then making a judgement about whether the puppet had been right or wrong. This was most likely due to some confusion over the positive lead-in used in this task (in which the puppet was always right). An example of this child's answer to the sentence 'We might see the lion lifting the shoe, but we won't see him lifting the feather or the truck' is given in (17).

(17)	Child:	yes, I saw him lifting the truck AND the shoe
	Puppet:	I guessed maybe we'd see the lion lifting the shoe but we wouldn't see him lifting the feather or the truck
	Child:	but he lifted the truck too
	Puppet:	so did I get it right or wrong?
	Child:	I don't know... maybe right

This child had no problem judging the puppet right or wrong in the Before-Or Test task (in which no positive lead-in was used), and thus was not excluded from analysis in the Before-Or Test task. However, if this child's answers are removed from the analysis of the Disjunction Control task (reducing the total number of trials to 28 true and 28 false over the 14 remaining children), the child rejection rate of false trial sentences rises to 89% (25/28 trials). The few errors the English-speaking children did make on false trials were made by 3 separate children, and occurred on both '1st disjunct false' and '2nd disjunct false' trials. There was thus no noticeable pattern of errors in response to the different types of false trial. The disjunction control task was included to check that children had an inclusive reading of disjunction, in the event that a child accepted the Second-Place before-or test sentences. However, the 3 children in question rejected all their Second-place before-or test sentences. So, their incorrect responses in the disjunction control task were probably due to a lapse in concentration, rather than being indicative of an underlying exclusive meaning of disjunction. A Wilcoxon Signed Ranks test showed the children's response patterns across the true and false trials in this task to be significantly different ($Z = 3.6$, $p < 0.001$).

The English-speaking adults accepted their true test sentences 95% of the time (38/40 trials), and rejected their false test sentences 97.5% of the time (39/40 trials). The rates in this task are thus highly comparable between children and adults.

		English		**Mandarin**		
		Children (N=15)	**Adults (N=20)**	**Younger Children 4;6-4;7 (N=14)**	**Older Children 5;0-5;4 (N=6)**	**Adults (N=20)**
True Trials	**Correct (%)**	100 (28/28)	95 (38/40)	100 (28/28)	100 (12/12)	90 (36/40)
	Incorrect (%)	0	5 (2/40)	0	0	10 (4/40)
False Trials	**Correct (%)**	89.3 (25/28)	97.5 (39/40)	100 (28/28)	50 (6/12)	70 (28/40)
	Incorrect 1st D* (%)	3.6 (1/28)	0	0	16.7 (2/12)	15 (6/40)
	Incorrect 2nd D† (%)	7.1 (2/28)	2.5 (1/40)	0	33.3 (4/12)	15 (6/40)

Table 3: Disjunction Control Results Across Languages
(*1st D = 1st disjunct false; †2nd D = 2nd disjunct false)

A Mann-Whitney test showed no significant difference between children's and adult's responses in this task to true trials ($Z = 1.2$, $p = 0.633$) or false trials ($Z = 1.4$, $p = 0.458$). We take this as evidence that the English-speaking children had an inclusive reading of disjunction. The English-speaking child and adult responses in this task are given in the two left-hand columns of Table 3.

In Mandarin, both the 20 children and the 20 adults responded to a total of 40 true trials and 40 false trials in this task. The Mandarin-speaking children correctly accepted their true trials 100% (40/40 trials) of the time, and they rejected their false trials 85% (34/40 trials) of the time. The reasons the children gave for their rejections were always clearly related to the conjunctive interpretation of disjunction under negation. For example, in response to the test sentence *Women keneng hui kandao tuzi chi baicai, danshi women bu hui kandao ta chi qingjiao huozhe caomei* 'We might see the bunny eating the cabbage, but we won't see him eating the green pepper or the strawberry', in a context in which the bunny ate the cabbage and the strawberry, a representative justification from a child aged 4;7 is given in (18):

(18) Puppet:	Wo shuodui-le ma?	
	'Am I right?	
Child:	Budui	
	'No'	
Puppet:	Weishenme?	
	'Why?'	
Child:	Yinwei tuzi chi-le caomei [pointing to the strawberry]	
	'Because the bunny ate the strawberry'	

The six acceptances of false trials all came from older children, aged 5 or over (5;0-5;4). This would seem to reflect development towards a possibly more adult-like interpretation of these sentences, as the 20 Mandarin-speaking adults who performed this task showed unexpected variability in their interpretation of the false test sentences: they only rejected these 70% of the time (28/40 trials), while they only accepted the true test sentences 90% of the time (36/40 trials). It would seem that though the majority of Mandarin-speaking adults typically access the conjunctive interpretation of disjunction under negation in a higher clause, others continue to interpret disjunction as they would when it occurs with negation in the same clause (i.e. they allow disjunction to scope over negation). This result is somewhat puzzling given that we expect negation in a higher clause to trigger a conjunctive interpretation of disjunction across the world's languages. We think that the variability in the Mandarin adults' responses in the Disjunction Control task could be due to our use of the verb 'see' (Mandarin 'kandao') in the higher clause of the relevant test sentences. The adults may have interpreted the verb 'see' as forming a single complex with the verb of the lower clause (e.g. 'see lift'). This could have happened because Mandarin does not use complementisers or mark nominative and accusative case, so the cues to clause boundaries are greatly reduced for Mandarin speakers. When other verbs, such as 'think' (Mandarin 'renwei'), occur in the higher clause, the Mandarin speakers we have questioned do access the conjunctive interpretation of disjunction in a lower clause (see example sentence (6)).[5]

Given the clear-cut difference in the Chinese children's data by age in this task, we decided to divide the children into two groups: a younger group of 14 children (4;6-4;7) who responded to 28 true trials and 28 false trials in total, and an older group of 6 children (5;0-5;4) who responded to 12 true and 12 false trials in total. The younger group correctly accepted their true trials 100% (28/28 trials) of the time, and they rejected their false trials 100% (28/28 trials) of the time. The older group accepted their true trials 100% of the time (12/12 trials), but only rejected their false trials 50% of the time (6/12 trials). For the other 50% of the time (6/12 trials), they accepted their false trials. These acceptances occurred on both '1st disjunct false' and '2nd disjunct false' trials, so was not due to a difficulty with a single type of false trial. A Wilcoxon Signed Ranks test showed the younger Mandarin children's response patterns across the true and false trials in this task to be significantly different ($Z = 3.7$, $p < 0.001$), providing clear evidence that these children had an inclusive reading of disjunction. The younger children's responses were also compared to adult responses in this task using a Mann-Whitney test. No significant difference was found between the two group's responses to true trials ($Z = 1.76$, $p = 0.341$) or false trials ($Z = 2.64$, $p = 0.051$), although the difference in the two group's responses to false trials approaches significance due to the unexpected acceptances of false trials by Mandarin adults. The results are given in the three right-hand columns of Table 3.

4.3 Before-Or Test Results

The Before-Or Test task consisted of 2 First-Place before-or test sentences and 2 Second-Place before-or test sentences for each child and adult subject, as well as 1 before-and control sentence for each child. The before-and control sentence was designed to check that children were listening to the end of the puppet's statements and processing both disjuncts. Any child who failed to correct the puppet on the before-and control sentence was excluded from analysis, as we could not be sure these children were responding to both disjuncts in the before-or test sentences. All results reported below are for children who successfully rejected the before-and control sentence.

To code the children's answers to the before-or test sentences, a number of response categories were identified. In addition to clear true or false judgements of the puppet's statements (i.e. in which the children's first answer was to say 'yes' or 'no' in agreement or disagreement with the puppet's statement), children also occasionally responded to First-Place before-or test sentences by identifying the character whom the winner of the race had come immediately before. This answer was classified as 'Immediate Before'. It was further classified as being accompanied by a true or false judgement, or by no judgement at all. In response to the Second-Place before-or test sentences, children also occasionally gave an 'Immediate Before' answer, or they answered by identifying the character who had won the race. This answer was classified as 'First Place', and again was further classified as being accompanied by a true or false judgement, or no judgement at all. To calculate the overall rates of true and false judgements, we combined the following answer categories. For the First-Place before-or test sentences, true judgements comprised true answers, and 'Immediate Before' answers accompanied by a true judgement. A representative 'Immediate Before' answer from an English-speaking child aged 4;10 in response to the First-Place before-or test sentence 'The dog reached the finish line before the turtle or the bunny' is given in (19):

(19)	Child:	um, the bunny rabbit.
	Puppet:	did I get it right?
	Child:	yeah

For the Second-Place before-or test sentences, false judgements comprised false answers, 'First Place' answers accompanied by a false judgement, as well as one 'Immediate

Before' answer accompanied by a false judgement (as these answers were considered corrections of the puppet's original statement either by telling the puppet who had actually come first in the story or by telling him who the character in question had actually come before). A representative 'First Place' answer from an English-speaking child aged 3;10 in response to the Second-Place before-or test sentence '[The giraffe]$_{2nd\ place}$ found his ball before [Winnie-the-Pooh]$_{3nd\ place}$ or [the mouse]$_{1st\ place}$', is given in (20):

(20)	Child:	um the mouse
	Puppet:	do you think I'm right or I'm wrong?
	Child:	wrong
	Puppet:	wrong? What happened?
	Child:	um the mouse, the mouse found the green ball

In English there were 30 First-Place trials and 30 Second-Place trials over the 15 children, and 40 First-Place trials and 40 Second-Place trials over the 20 adults. Using the coding categories outlined above, the English-speaking children accepted their First-Place before-or test sentences 90% of the time (27/30 trials), and rejected their Second-Place before-or test sentences 93% of the time (28/30 trials). Two children did fail to reject a Second-Place before-or test sentence on one of their two Second-Place trials. One gave an 'Immediate Before' answer, but no judgement could be elicited. The other gave a 'First Place' answer, accompanied by a true judgement. Both of these children correctly answered all items in the Disjunction Control task, so it is perhaps possible that these two children were allowing disjunction to scope over 'before' on one of their two trials. However, the overall pattern of results across children clearly shows that English-speaking children have a preference to assign 'before' wide scope and compute the conjunctive interpretation of disjunction. A Wilcoxon Signed Ranks test showed the difference between the children's responses in the two conditions to be significant ($Z = 3.49$, $p < .001$). The children's justifications for their rejections typically showed they understood the test sentences as meaning that the referent of the subject NP had come first. For example, one child aged 4;4 responded as follows to the Second-Place before-or test sentence '[The giraffe]$_{2nd\ place}$ found his ball before [Winnie-the-Pooh]$_{3nd\ place}$ or [the mouse]$_{1st\ place}$':

(21) Child: no

Puppet: no? can you help me?

Child: the mouse found his ball first

The 20 English-speaking adults tested accepted their First-Place before-or test sentences 100% of the time (40/40 trials) and rejected their Second-place before-or test sentences 97.5% of the time (39/40 trials). A Mann-Whitney test comparing child and adult responses in this task showed no significant differences in either the First-Place condition ($Z = 1.66$, $p = 0.521$) or the Second-Place condition ($z = 0.859$, $p = 0.681$). The comparison of English-speaking child and adult acceptance rates to the two types of trial is given in Figure 1.

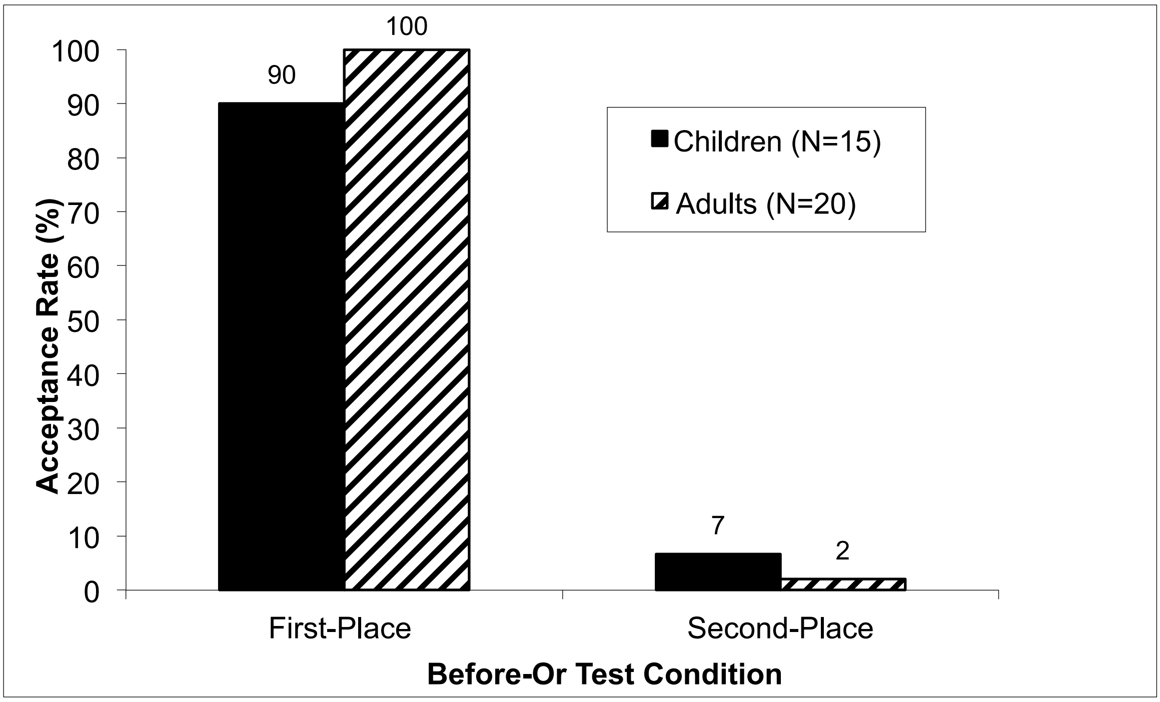

Figure 1: Child and Adult Acceptance Rates in English Before-Or Test Task

In Mandarin, there were 40 First-Place trials and 40 Second-Place trials over the 20 children and over the 20 adults. Overall, the Mandarin-speaking children accepted their First-Place before-or test sentences 100% of the time (40/40 trials), and rejected their Second-Place before-or test sentences 70% of the time (28/40 trials). Looking at the results by group, the 14 younger Mandarin-speaking children accepted their First-Place before-or test sentences 100% of the time (28/28 trials), and rejected their Second-Place before-or test sentences 100% of the time (28/28 trials). A Wilcoxon Signed Ranks test showed the difference between these younger children's responses in the two conditions to be significant ($Z = 3.74$, $p < .001$). These children's justifications for their rejections typically showed they understood the test sentences as meaning that the referent of the subject NP had come first. For example, the response of one child aged 4;6 to the Second-Place before-or test sentence *Wugui zai xiaoma huozhe yu zhiqian nadao-le beike* '[The turtle]$_{\text{2nd place}}$ got his shell before [the horse] $_{\text{3rd place}}$ or [the fish] $_{\text{1st place}}$' is given in (22):

(22) Puppet: Wo shuodui-le ma?
'Am I right?'
Child: Budui
'No'
Puppet: Weishenme?
'Why?'
Child: Yinwei yu xian nadao-le beike
'Because the fish got his shell first'

The six older Mandarin-speaking children, on the other hand, accepted their First-Place before-or test sentences 100% of the time (12/12 trials), and also accepted their Second-Place before-or test sentences 100% of the time (12/12 trials). This was the pattern we anticipated if children allowed disjunction to take scope over 'zai…zhiqian'. The older children's results need to be considered alongside their responses to false trials in the Disjunction Control task. This task was designed to check whether our child subjects had an inclusive reading of disjunction. A child with an inclusive reading of disjunction should have rejected the false trials in the Disjunction Control task, showing that they accessed the conjunctive interpretation of disjunction under negation in a higher clause. Recall that the older group of Mandarin-speaking children only rejected their false trials in the Disjunction Control task 50% of the time (6/12 trials), and accepted these trials the other 50% of the time (6/12 trials); and their acceptances were not linked to one particular type of false trial. This pattern of results appears random, which could suggest that the six older children simply did not understand the disjunction control sentences. However we feel this is unlikely given the fact that the younger children had no difficulty in responding to exactly the same sentences in the Disjunction Control task, and very consistently correctly accessed the conjunctive interpretation of disjunction under negation. Rather, we feel that the older children's pattern of results suggests a transition phase to a more adult-like interpretation of these sentences, in which disjunction can sometimes scope over negation, even in a higher clause.[6] So this data, combined with the fact that the older children accepted the First-Place before-or test sentences in the Before-Or Test task, is taken as evidence that these children did have an underlyingly inclusive reading of disjunction. In other words, their performance on the Second-Place before-or test sentences cannot be attributed to them simply interpreting disjunction exclusively. If this were the case they should have accepted the false test sentences in the Disjunction Control task more consistently, and they should have rejected the First-Place test sentences in the Before-Or Test task.

The 20 Mandarin-speaking adults tested accepted their First-Place before-or test sentences 60% of the time (24/40 trials) and rejected their Second-Place before-or test sentences 75% of the time (30/40 trials). These results for Mandarin-speaking adults contrast clearly with English-speaking adults (as can be seen in Figure 3 below). In Mandarin, the conjunctive interpretation of disjunction is not the only reading in sentences with 'zai…zhiqian'. Disjunction can also take scope over 'zai…zhiqian' for adult speakers, making a Second-Place condition sentence true. In addition, for Mandarin adults, First-Place condition sentences may be false if a scalar implicature is computed. That is, when a speaker allows disjunction to scope over BEFORE then there are three truth conditions that make a sentence like 'A came BEFORE B or C' true: (i) if A came before B, but not C; (ii) if A came before C, but not B; (iii) if A came before B and C. First-Place condition sentences were presented in context (iii) and were thus logically true. However, as discussed in the introduction, hearers who calculate a scalar implicature will assume that if a speaker uses 'or', he or she is not in a position to use the stronger term 'and' to describe the situation under consideration. Hearers therefore remove the truth conditions associated with 'and' from the meaning of 'or'. That is, they remove condition (iii) from the truth conditions under consideration, and will thus reject a First-Place condition sentence. Indeed, the Mandarin-speaking adults who accepted the before-or test sentences in the Second-Place condition, rejected them in the First-Place condition and justified their rejection by saying that the puppet should have used a conjunctive statement (e.g. The dog reached the finish line before the turtle AND the bunny) rather than a disjunctive one. An example of a Mandarin-speaking adult's response to a before-or test sentence in the First-Place condition (in which the dog reached the finish line first) is given in (23):

(23) Puppet: Xiaogou zai wugui huozhe tuzi zhiqian paodao-le zhongdian
'The dog reached the finish line before the turtle or the bunny'

Adult: Budui, xiaogou shi zai wugui he tuzi zhiqian paodao zhongdian de, suoyi yao yong 'he'
'No, the dog actually reached the finish line before both the turtle and the bunny, so 'and' should be used here'

As we have seen, the older group of Mandarin-speaking children behaved much like these Mandarin-speaking adults in that they judged the Second-Place before-or test sentences to be true. The fact that the older children also accepted the First-Place before-or test sentences is not surprising, as it has been shown that children are less likely than adults to compute scalar implicatures, especially in certain tasks like the truth value judgement task (Gualmini, Crain, Meroni, Chierchia, & Guasti, 2001; Guasti et al., 2005). It is thought this is not because children lack the notion of information strength, but because they lack the computational resources needed to mentally construct an alternative representation of the sentence under consideration and then compare the relative information strength of this alternative sentence to the test sentence (Gualmini et al., 2001).

A Mann-Whitney test comparing the younger Mandarin-speaking children's responses with adult responses in this task showed a significant difference in the First-Place condition ($Z = 3.06$, $p < 0.05$), although not in the Second-Place condition ($Z = 2.43$, $p = 0.09$). The comparison of the younger Mandarin-speaking children's and adult acceptance rates to the two before-or test sentence conditions is given in Figure 2.

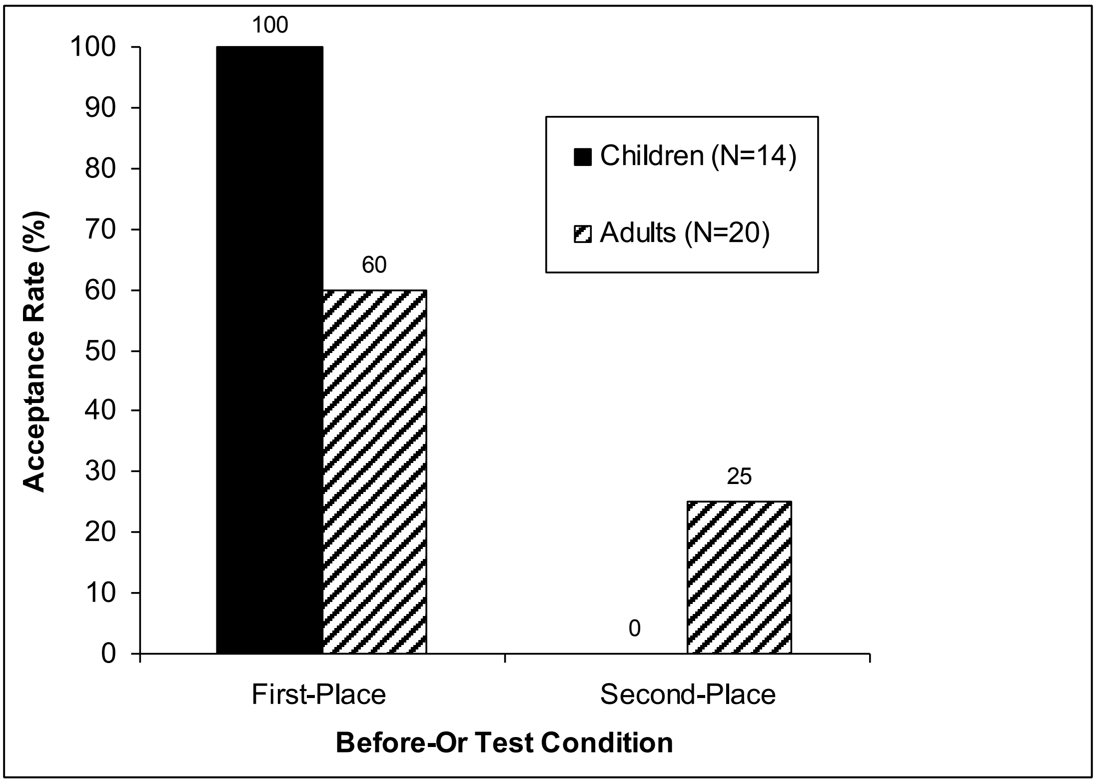

Figure 2: Younger Child and Adult Acceptance Rates in Mandarin Before-Or Test Task

4.4 Comparing the English and Mandarin Results

The comparison of the English-speaking and younger Mandarin-speaking children's and adults' results across languages is given in Figure 3. The crucial finding was that the English-speaking children and the younger Mandarin-speaking children overwhelmingly accepted First-Place condition before-or test sentences (90% of the time in English, 100% of the time in Mandarin), and rejected Second-Place condition before-or test sentences (93% of the time in English, 100% of the time in Mandarin). This shows that both groups of children were computing a conjunctive interpretation for disjunction in the scope of 'before' and 'zai…zhiqian' respectively. A multivariate ANOVA comparing the effect of age and language on acceptance rates in the two test conditions shows a significant age by language interaction for both the First-Place condition ($F = 13.93$, $p < 0.001$) and the Second-Place condition ($F = 6.79$, $p < 0.05$). In other words, children across both language groups behaved similarly to each other, while adults differed. Strikingly, younger Mandarin-speaking children's responses were more like the responses of English-speaking children and adults than like those of Mandarin-speaking adults. At age 5, Mandarin-speaking children begin to adopt more adult-like interpretations of the sentences tested.

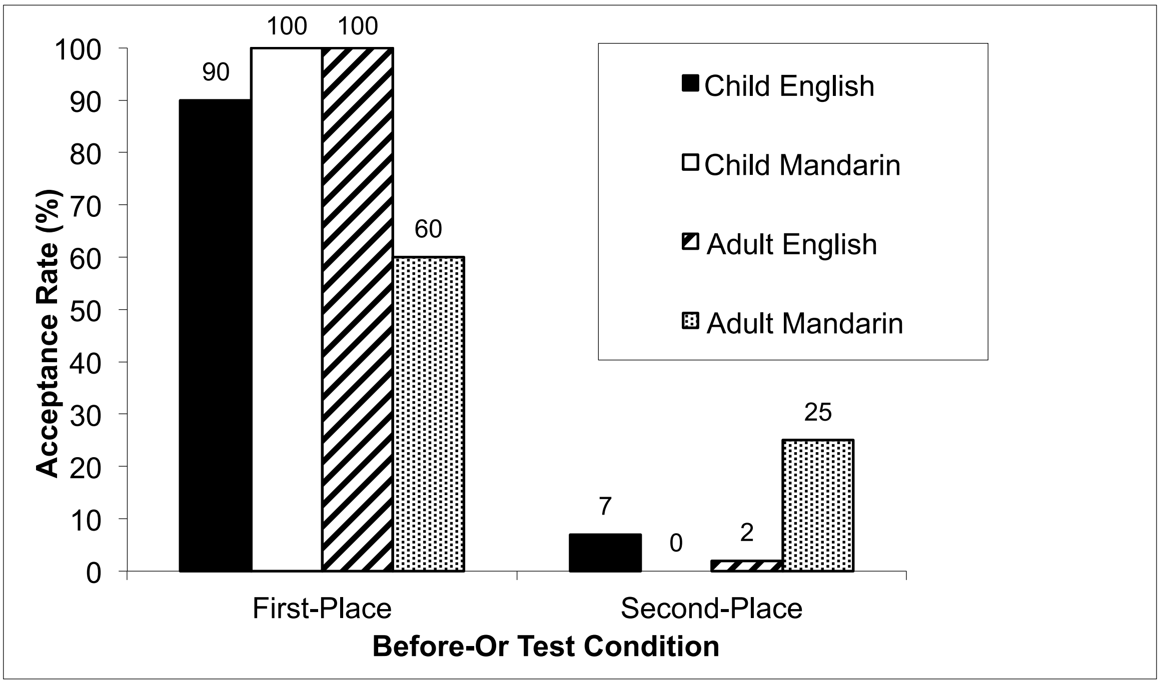

Figure 3: Child and Adult Acceptance Rates Across Languages in the Before-Or Test Task

5. Discussion

The present study asked how children interpret disjunction in the downward entailing environment of the temporal conjunction BEFORE. In particular, our interest was to see whether the same cross-linguistic patterns of interpretation that have been observed in negative DE environments would also be found in sentences with BEFORE. We identified a cross-linguistic difference in how disjunction is interpreted in sentences with 'before' in English and with 'zai…zhiqian' in Mandarin. In English a conjunctive interpretation of disjunction arises in sentences like 'The dog reached the finish line before the bunny or the turtle', because disjunction is interpreted in the scope of 'before'. We suggested that this interpretation is triggered by the presence of a covert universal quantifier in the semantics of BEFORE. The universal quantifier establishes the logical set relations from which the conjunctive interpretation of disjunction is derived. In an English sentence of the form A BEFORE B, disjunction splits event B into two sub-events. For event A to have occurred before event B, it must have occurred before every point-in-time in event B which includes every point-in-time in both of the sub-events.

In Mandarin Chinese, by contrast, disjunction takes scope over BEFORE. This means the logical relation between the subsets of event B and event A are different. In Mandarin, for event A to have occurred before event B all that is required is for A to have occurred before every point-in-time in at least one of the sub-events of B, but not necessarily before both of these sub-events. Hence, the conjunctive interpretation of disjunction is not the unique reading that is assigned in adult Mandarin.

In view of the observed differences between adult English and adult Mandarin, we sought to determine whether or not English- and Mandarin-speaking children assign the same scope relations that are attested by adult speakers. If so, then English-speaking children would be expected to compute the conjunctive interpretation of disjunction in sentences with 'before', while Mandarin-speaking children would be expected to show a mix of both the conjunctive and non-conjunctive interpretation of disjunction in sentences with 'zai…zhiqian'. By contrast, if children across languages are guided in their assignment of scope relations by the Semantic Subset Maxim, and adhere to the basic logical relation dictated by the semantics of BEFORE (essentially universal quantification), then they would be expected to compute the conjunctive interpretation of disjunction in sentences with BEFORE across languages, disregarding the scope relations used by adult speakers of the target language, at least initially.

Our data support the hypothesis that children adhere to the SSM and are guided by universal logical principles governing the interpretation of disjunction in the scope of downward entailing operators such as BEFORE. That is, when children are presented with a sentence containing two logical operators, hypothetically there are always two available interpretations. The SSM predicts that when faced with this ambiguity, children will initially prefer the interpretation that makes the sentence true in the narrowest range of circumstances, the subset reading. Proceeding in this way allows children to align their scope preferences with those of adults as quickly as possible. Children are presented with exactly this kind of situation when acquiring the semantic representations of sentences like 'The dog reached the finish line before the turtle or the bunny'. Interpretation A of such a sentence would be 'The dog reached the finish line before the turtle and before the bunny'. This makes the sentence true in a narrower range of circumstances than interpretation B 'The dog reached the finish line before the turtle or before the bunny' (which could be true if the dog reached the finish line before one other participant or before both other participants). The SSM thus predicts that both English-speaking and Mandarin-speaking children should start with interpretation A, the conjunctive interpretation of disjunction. When Mandarin-speaking children realise that their language does allow a wider set of interpretations for sentences like ‘The dog reached the finish line before the turtle or the bunny’, they can easily add interpretation B to their grammar.

As we have seen, both English-speaking and younger Mandarin-speaking children do clearly and consistently interpret sentences like ‘The dog reached the finish line before the turtle or the bunny’ to mean that the dog reached the finish line first (before the turtle AND before the bunny). They accepted such before-or sentences as descriptions of First-Place condition stories, and they rejected the same sentences as descriptions of Second-Place condition stories. They normally corrected the puppet in the Second-Place condition by pointing out who really had come first. This behaviour was in line with how English-speaking adults interpret such sentences, but was quite different to how Mandarin-speaking adults interpret such sentences. When Mandarin-speaking children reach age 5 they begin to allow disjunction (‘huozhe’) to take scope over ‘zai…zhiqian’ like Mandarin adults. It is likely that the evidence required to switch the children’s interpretation of these sentences does not come from exposure to before-or sentences in the input alone, as these sentences are very rare, as far as corpus counts indicate. For example, in a survey of 224,797 parental utterances in 7 English corpuses on the CHILDES database (the MacWhinney corpus, the Brown corpus (Adam, Eve and Sarah), and the New England corpus (Folders 14, 20, and 32)), we found only 2 instances of the requisite construction (e.g. from the MacWhinney corpus). In a survey of 80,625 adult utterances in 4 Chinese corpuses (the Beijing 1 corpus, the Beijing 2 corpus (Folders F2 and F3), and the Chang corpus) we found no instances of the requisite construction. It is possible, however, that Mandarin children accumulate the evidence for a reading in which disjunction scopes over ‘zai…zhiqian’ from other construction types in which disjunction scopes over a downward entailing operator like negation. We are not committed to a particular type of evidence from the input triggering the observed change in scope interpretations for children. What is indisputable is that eventually Mandarin children do switch from their initial scope assignment.

Before adopting our interpretation of the findings, we will discuss several alternative ways to account for the data we found. One possibility that deserves consideration is that young children merely fail to distinguish between the meanings of ‘or’ and ‘and’. Suppose that the English-speaking and younger Mandarin-speaking children in our study interpreted the before-or test sentence ‘The dog reached the finish line before the turtle or the bunny' as equivalent in meaning to 'The dog reached the finish line before the turtle and the bunny.' If so, then they would also be expected to accept such sentences in the First-Place condition and reject them in the Second-Place condition. Although we did not control directly for children's understanding of 'or' as opposed to 'and', it has been shown that English-speaking children aged 3;2-5;9 do distinguish between these two logical connectives. In a study by Gualmini, Crain & Meroni (2000), children consistently rewarded a puppet with a coin 86% (24/28 trials) of the time following the puppet's statement 'If a giraffe OR a penguin is on the stage, then I get a coin' in contexts in which only a giraffe or only a penguin appeared on the stage in question. Adult controls rewarded the puppet 90% of the time. By contrast, in the same contexts, the children did not reward the puppet 76% (32/42 trials) of the time when it said 'If a giraffe AND a penguin are on the stage, then I get a coin'. Adult controls did not reward the puppet 92% of the time in the same contexts. Given these results, it is reasonable to infer that the children in our study, too, knew the difference between 'or' and 'and'.

Another possible explanation of our results should be considered. This alternative account maintains that young children are simply incapable of assigning inverse scope to two logical operators. This could arise either because they lack the grammatical competence to compute the inverse scope reading, or because they lack the requisite computational resources. In either case, if children are initially incapable of assigning inverse scope to two logical operators, then we would also expect both English-speaking and Mandarin-speaking children to interpret BEFORE as taking scope over disjunction, and thus to accept our before-or test sentences in the First-Place condition and reject them in the Second-Place condition.

Children's preference for assigning scope in line with the surface syntactic position of two logical operators has been dubbed the ISOMORPHISM EFFECT in the literature (e.g. Musolino, Crain, & Thornton, 2000). The isomorphism effect has typically been investigated using sentences with operators like 'not' and 'every' (e.g. Every horse didn't jump over the fence). These sentences can have two readings. The first reading is referred to as the 'surface scope' reading, according to which none of the horses in question jumped over the fence. The second reading is referred to as the inverse scope reading, according to which at least one horse fails to jump over the fence. The term surface scope is unfortunate, however, as it does not make clear whether scope is being assigned on the basis of the linear order of the logical operators or on the basis of the hierarchical precedence of these operators. In English, which is the language in which most of the work on children's scope preferences has been done, linear and hierarchical precedence are simply confounded. For example, the universal quantifier 'every' both precedes negation in linear order in the sentence 'Every horse didn't jump over the fence', and it is 'higher' in the syntactic structure. However, a study done comparing English with Kannada, in which linear and hierarchical precedence are not confounded, has shown that children tend to assign scope based on structural considerations, and not on the basis of linear order (Lidz & Musolino, 2002). We will thus use the term 'structural scope' rather than surface scope in our discussion.

Early work investigating children's scope preferences showed that 4- to 5-year-old children experience difficulty accessing the inverse scope reading of sentences like 'Every horse didn't jump over the fence' (Lidz & Musolino, 2002; Musolino et al., 2000). However, later work on the isomorphism effect raised the possibility that children assigned structural scope in earlier studies because they were unable to accommodate certain pragmatic infelicities in the stories they were presented with. Gualmini (2005) demonstrated that, when experimental conditions were modified to make it more felicitous to use negation with the universal quantifier (by clearly setting up the focus of the test stories to be whether, for example, all of the horses could make it over the fence), English-speaking children aged 3;0-5;7 were able to access the inverse scope interpretation of sentences like 'Every horse didn't jump over the fence'. These results have been replicated by Conroy, Lidz, & Musolino (2009) for English-speaking children aged 4;5-5;2, and Mandarin-speaking children have also been shown to access the inverse scope reading of similar sentences in Mandarin (Zhou & Crain, 2009). Given these more recent results on the isomorphism effect it is unlikely that the younger children in our study were simply incapable of accessing the inverse scope readings of our test sentences. Therefore, to account for our data showing that children around age 4, across languages, initially assign wide scope to BEFORE in our before-or sentences, we need to identify a mechanism that initially guides children in their scope assignment preferences.

We have suggested here that the necessary mechanism is provided by the Semantic Subset Maxim. The SSM accounts nicely for our data, and avoids the criticism that has been levied against its precursor, the Semantic Subset Principle. In its original formulation, the SSP required there to exist two classes of languages, one class of languages with a unique 'narrow' interpretation of some sentence-type, and another class of languages with both the 'narrow' interpretation and another 'wide' interpretation of the same sentence. It has been questioned whether this type of learnability problem arises across languages (Musolino, 2006). The SSM avoids this controversy, since it applies to cases of scope ambiguities that occur whenever two logical operators interact in a sentence. We assume that, in such cases, there probably is no language that ONLY allows a 'narrow' scope interpretation, and that both scope readings are available at all stages of acquisition, in view of the evidence from research showing that context can be manipulated to allow even young children to access either scope relation, even if one is highly preferred. The SSM instead reformulates the driving idea behind the SSP to assign default preferences for certain interpretive options that are available WITHIN all languages, but preferences that are found to differ ACROSS languages. Sentences containing two logical operators are ambiguous. In order to communicate most efficiently with adult language users, the child's task is to determine which of these interpretations is preferred in the local language. As formulated, the SSM anticipates a specific trend in children's scope assignment, rather than a categorical presence or absence of a reading. Nevertheless, the SSM predicts that children who are presented with a scope ambiguity will have a strong tendency to initially assign the 'narrower', 'stronger' meaning first.

The SSM should also apply to sentences containing the logical operators 'every' and 'not'. In the case of a sentence like 'Every horse didn't jump over the fence', the narrow interpretation is 'None of the horses jumped over the fence' and the wider interpretation is 'Not every horse jumped over the fence' (which could be true if only one horse failed to jump over the fence or if all the horses failed to jump over the fence). The prediction would thus be that children across languages should initially assign a 'none' interpretation to such sentences. However, as we have seen, studies have shown that children do not only initially access the narrow interpretation of such sentences. Rather, both English- and Mandarin-speaking children have been shown to access both interpretations of sentences like 'Every horse didn't jump over the fence' in felicitous contexts (Gualmini, 2005; Zhou & Crain, 2009). We would like to suggest that the data collected on these sentences to date has, nonetheless, shown that children do have a PREFERENCE for assigning the 'none' interpretation. It is only if measures are taken to modify the context in which the sentences are presented to favour the wider interpretation that children are pushed to access this reading.

In conclusion, our cross-linguistic data provide clear evidence that, regardless of adult preferences, children prefer to initially assign a 'narrow' scope reading to sentences with two logical operators. In addition, the data clearly show, that once scope has been assigned, children conform to logical principles, by computing a conjunctive interpretation of disjunction in the scope of the covert universal quantifier contained in the semantics of BEFORE. This work extends previous work in the domain of children's interpretation of disjunction in the scope of negative downward entailing environments to a wider cross-section of downward entailing operators. It appears that even in universally quantified downward entailing linguistic environments, children adhere to logical principles. This suggests that there may exist a deep semantic relationship between disjunction and downward entailing operators in general, and that children exploit this relationship as a linguistic universal during the language acquisition process. Further child acquisition evidence from languages in which disjunction can take scope over DE operators like BEFORE (e.g. Hungarian, Japanese, or Danish) will serve to clarify this hypothesis.

Endnotes

[1] The meaning of BEFORE differs from that of its conceptual twin AFTER. For an event A to occur AFTER an event B, then all that is required is for at least one point-in-time in event A to follow at least one point-in-time in event B (Anscombe, 1964; Heinamaki, 1972). There is no covert universal quantification. This means that when event B contains a disjunction of sub-events, then at least one point-in-time in event A has to follow at least one point-in-time in either of the sub-events. Consider the sentence 'Jane arrived at the pool after Mary or Sue'. Event A is Jane's arrival, and event B is a disjunction of sub-events, Mary's arrival and Sue's arrival. The sentence is true if there is a point-in-time in event A, Jane's arrival, that follows one of these sub-events, or a point-in-time in event A that follows them both. So, the sentence is true if Jane arrived after Mary (but not after Sue), or if Jane arrived after Sue (but not after Mary), or if Jane arrived after both Mary and Sue. Hence the temporal conjunction AFTER does not license the conjunctive entailment of disjunction.

[2] By contrast, when disjunction occurs outside the restrictor (e.g. 'Every [passenger who was ill]$_{\text{Restrictor}}$ ate chicken or beef'), any of the range of truth conditions of disjunction will make the sentence true. That is, the sentence 'Every passenger who was ill ate chicken or beef' is true if every passenger who was ill ate chicken, OR if every passenger who was ill ate beef, OR if some of the ill passengers ate chicken and some ate beef. Only one of these scenarios need be true for the whole sentence to be true.

[3] Additional note not appearing in published version of this article: A short note on the means of expressing the temporal concept BEFORE in Mandarin is in order. For this study, we have chosen the Mandarin expression 'zai…zhiqian' as being the closest equivalent to the English conjunction 'before'. Both English 'before' and the morpheme 'qian' in Mandarin are used to express temporal sequencing, as well as horizontal spatial location (e.g. 'The boy stood before the house'; *Zai zhuozi qian-bian zhan-zhe yi ge xuesheng*, 'There is a student standing before/in front of the desk'). Another way for Mandarin to express the concept BEFORE is by using 'shang', which, otherwise, is used to expresses vertical spatial location (e.g. *Zhuozi-shang you deng*, 'There is a light over/on top of the table'). 'Shang' can occasionally be used when discussing the sequencing of one time context with respect to another (e.g. *Hu nian de shang yi nian shi shenme nian?* 'What is the year before the year of the tiger?'), but this is not common. Instead, 'shang' is used most naturally when discussing time contexts described relative to the time of speaking (e.g. *Shang yi ban che wudianzhong kai-zou le,* 'The previous bus (i.e. before now) left at 5 o'clock') (Scott, 1989). Although 'shang' is perhaps more morphologically similar to English 'before' compared to the compound expression 'zai…zhiqian', it was not appropriate to use 'shang' in our study because our test sentences did not express temporal location relative to the speaker. In any case, the results of our Before Control task show that the morphological complexity of

‘zai…zhiqian’ had no effect on Mandarin-speaking children’s ability to interpret this term as compared to English-speaking children’s ability to interpret ‘before’.

[4] Additional note not appearing in published version of this article: Another possible explanation for children’s lower accuracy with ‘after’ might be that children are being requested to perform their preferred action first, while holding in memory a subsequent action chosen by the experimenter. On ‘before’ trials, by contrast, the action they must hold in memory would be more salient to them, being the action they have selected themselves. I am grateful to Kamil Ud Deen for this suggestion.

[5] Additional note not appearing in published version of this article: We suggest that adult Mandarin speakers may have treated the verbs ‘renwei’ (‘think’) and ‘kandao’ (‘see’) differently because these verbs fall into different aspectual classes (as described by Vendler (1957)), and because they differ in the kinds of syntactic argument they can take. On the one hand, ‘thinking’ is an atelic event, while ‘seeing’ is a telic event. On the other hand, ‘think’ almost always takes a full clausal complement, while ‘see’ can take either a full clausal or simple NP complement. To know whether our choice of the verb ‘kandao’ (‘see’) in our test sentences was, indeed, responsible for the small percentage of unexpected responses from Mandarin-speaking adults, a study devoted to comparing adult judgements of disjunction in a range of sentences used in similar contexts, and differing only by verb type, is required. We leave this for future research.

[6] Additional note not appearing in published version of this article: An analysis of the older children’s individual data further reveals that 3 older children consistently rejected the false Disjunction Control trials, like younger children, while 3 other older children consistently accepted them, like some adults. This supports our characterisation of the results as a transition phase (in which some children are adult-like and others not).

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Moving from Chapter 2 to Chapter 3

In Chapter 2, we presented evidence showing that both English- and Mandarin-speaking children have an initial preference to assign a strong scope interpretation to sentences containing the downward entailing operator BEFORE and disjunction. This data supports the predictions of the Semantic Subset Maxim. However, because English 'before' and Mandarin 'zai…zhiqian' structurally dominate disjunction in the English and Mandarin sentences we tested, it could be argued that these data are also in line with the Isomorphism Account. To more clearly distinguish between these two accounts, our second major study examines a sentence type in which the isomorphic reading is actually the weak reading, not the strong one. The results of this study are presented in Chapter 4.

Before moving on to the Chapter 4 study, however, we need to lay some groundwork in Chapter 3. We thus diverge here from our major line of investigation, to examine children's understanding of the focus operator ONLY in English and Mandarin. The findings of this investigation inform the design of a control study associated with our Chapter 4 enquiry.

CHAPTER 3

Children's interpretation of focus expressions in English and Mandarin

This paper is presented in its original published format:

Notley, A., Zhou, P., Crain, S, & Thornton, R., (2009). Children's interpretation of focus expressions in English and Mandarin. *Language Acquisition*, 16, 240-282.

I would like to acknowledge the roles of my co-authors. Peng Zhou ran the Mandarin-language experiments; Stephen Crain and Rosalind Thornton collected the English-language longitudinal database that I transcribed and analysed. They also provided feedback on drafts of the paper. I was otherwise responsible for all other aspects of testing and writing.

Abstract

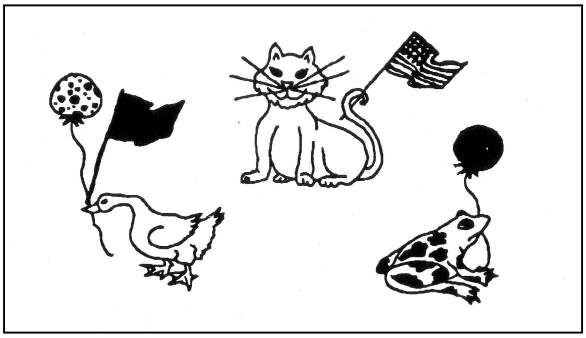
Children often produce non-adult responses to sentences with the focus operator *only,* such as *Only the cat is holding a flag*. For example, children often accept this sentence as a description of a situation in which a cat holds a flag and a duck holds both a flag and a balloon. One proposed analysis, by Paterson et al. (2003), contends that children disregard *only* in such sentences, yielding *The cat is holding a flag.* An alternative proposal, by Crain et al. (1994), maintains that children mis-assign *only* to the VP, yielding *The cat is only holding a flag.* The findings of experimental studies with two typologically distinct languages, English and Mandarin Chinese, support Crain et al.'s analysis. We propose, further, that children pass through a stage at which *only* is analysed as a sentential adverb taking scope over both the subject NP and the VP. We address the questions of why children initially adopt this analysis, and how they converge on the adult grammars of these languages.

1. Introduction

Only is an adverbial quantificational expression, a focus operator. The meaning of sentences containing *only* (e.g. *Only John ran the marathon*) can be partitioned into two conjoined propositions (Horn, 1969, 2002). The first proposition, called the presupposition, says something about the element associated with *only*, the focus element (in this case *John*). The second proposition associated with *only* is called the assertion.[1] The assertion is a negative proposition about a contextually determined contrast set, a set of alternatives to the element in focus. Typically, the contrast set has already been established in the domain of discourse before the utterance of the sentence. Consider the sentence *Only John ran the marathon* produced in a conversational context in which John, Sue and Bill have all signed up for different events in an athletic competition. For the sentence with *only* to be true, it must be true that John ran the marathon, and it must be false that Sue ran the marathon and Bill ran the marathon. The first proposition (John ran the marathon) is the presupposition, and the assertion is comprised of the negations of the propositions in which members of the contrast set have replaced the element in focus {*It's not the case that Sue ran the marathon, It's not the case that Bill ran the marathon*}. So, the assertion entails that every member of the contrast set fails to have the property being attributed to the element in focus.

Over the past 15 years, it has been shown that children make some interesting non–adult responses to sentences containing the focus operator *only*. In 1994, Crain, Ni, & Conway reported on an earlier study by Crain, Philip, Drozd, Roeper, and Matsuoka (1992), in which English–speaking children aged 3–6 years were presented with a picture similar to that in Figure 1. They found that over half of the children (21/38) consistently accepted the sentence *Only the cat is holding a flag* as an accurate description of the picture. Similar findings have since been obtained in other studies of English–speaking children (Paterson, Liversedge, Rowland, & Filik, 2003; Philip & Lynch, 2000). One possibility is that these children are only able to process the presupposition of sentences with *only* (i.e., *the cat is holding a flag*), and fail to process the assertion involving the contrast set, presumably because of a limitation on computational resources (Paterson et al., 2003). An alternative is that children process both the presupposition and the assertion, but associate the focus operator with the object of the VP (*a flag*), rather than with the subject NP (*the cat*) as adults do (Crain, Ni, & Conway, 1994). Both of these positions have been advanced in the literature. One of the main aims of the present paper is to adjudicate between these alternative accounts of children's non–adult responses.

As things stand, the overall picture of results in this research domain is far from clear. In this study we attempt to extend the current findings in two ways. First, we address the question of whether or not English–speaking children's non–adult responses of the type depicted in Figure 1 arise because they fail to process the assertion, or because they interpret the assertion based on an association between the focus operator and a different focus element, as compared to adults. Once this question is answered, we take up the question of whether or not children's non–adult responses could be indicative of a universal stage of language development. We will address this second question by investigating children’s responses to sentences with focus expressions in two typologically distinct languages: English and Mandarin Chinese.



Test sentence:
Only the cat is holding a flag
Non–adult child response:
yes

Figure 1:
***Only* picture verification task**

Languages can differ in the way they mark focus syntactically, so it is of considerable interest to see if children are sensitive to these cross-linguistic differences. If they are, then children acquiring some languages may make different errors than children learning other languages, or, alternatively, children learning some languages may not make errors at all, in contrast to children learning other languages. On the other hand, if the same kind of non–adult behaviour, as documented in Figure 1, is witnessed in children acquiring typologically different languages, then this would raise the possibility that all children proceed through a stage of language development at which they interpret focus in a similar, albeit non–adult manner.

As the previous literature points out, the origin of children's non–adult behaviour could be due either to a failure to compute contrast sets, or it could be due to a failure to associate the focus operator with the same focus element as adults do. The experimental findings of the present paper support the conclusion that children across languages do compute contrast sets. When children differ from adults, it is because they associate the focus operator with different focus elements than adults do. Following the description of the experiments and the presentation of the findings, we propose an analysis of children's non–adult behaviour that is consistent with the theory of Universal Grammar, and one that explains how children converge on the target grammar of the local language based on readily available positive evidence.

The next sections spell out in more detail the meaning components of the focus operator *only* and how this adverbial quantifier operates in English and in Mandarin Chinese. We then review the results from previous research in this domain, before turning to new experimental investigations of children's understanding of focus expressions in these two languages. In the discussion, we will draw together the findings to suggest that, across languages, children initially analyse *only* as a sentential adverb, but one that is positioned differently than it is in the adult grammars of the languages under consideration. Finally, the implications of this proposal for language learnability will be discussed.

1.1 The Meaning of Only and the Focus Systems of English and Mandarin

Various semantic representations have been proposed in the literature to capture the meaning of *only* (e.g. Atlas, 1993; Beaver & Clark, 2003; Horn, 1969; Rooth, 1996). Some of these meaning representations make reference to a set of alternatives previously introduced in the domain of discourse, but others do not. The jury is still out on which of these analyses is correct. However, generalizing across analyses, there is a consensus that there are two meaning components, and that one of these meaning components involves the universal quantifier. In this paper, we will assume that the meaning of focus expressions in human languages involves the computation of a contrast, at least in adult grammars. For expository purposes, we adopt the analysis used by Crain et al. (1994), originally advanced by Krifka (1991). As (1) illustrates, the analysis enables *only* to quantify either over individual variables (x, y, z…) or to quantify over properties (P, Q, R…). So, the formal meaning relations corresponding to sentences with *only* can be stated using either properties of individuals, or individuals themselves, depending on whether the element in focus is a property or an individual. Earlier we introduced an example where *only* was associated with an individual: *Only John ran the marathon*. An example of a sentence where *only* quantifies over properties is *John only danced*. Here the assertion is that John did nothing else besides dancing, i.e., he did not sing or play guitar and so forth, where {*sing*, *play guitar…*} are properties contained in the contrast set.

(1) a. B(X)

'The background B holds of a focus element represented by the set of properties X' AND

b. $\forall(Y)\ [\{Y \in \mathrm{CONX}) \ \&\ B\ (Y)\} \rightarrow Y = X]$

'For every Y, if Y is a member of the contrast set to X and the background applies to Y, then Y is X'

The meaning rule in (1) indicates that language users must go through two steps to evaluate the truth or falsity of an *only* statement. First of all, they must identify the focus element, and this will determine what kind of variable (individual–level or property–level) corresponds to the meta–variable X. The background information must apply to the element in focus (1a). The next step is to mentally construct a set of the same type as the element in focus, and to ensure that the background does not hold for any member of this set (1b).

The first part of the meaning rule for *only* draws both on information encoded in the syntactic representation of the sentence, and on information contributed by pragmatic factors. In English, when *only* occurs before the subject (as in *Only John ran the marathon*), the only appropriate candidate for the element in focus is the denotation of the Subject NP (in this case *John*). The focus element in this example could never be taken to be the VP (*run the marathon*) or any constituent within the VP (*the marathon*). That is, the sentence cannot mean that the only thing John did was run the marathon, or the only event John ran in was the marathon. These prohibitions are indicated in (2b, c). On the other hand, if *only* appears pre–verbally, focus can only be assigned to the VP or a constituent within the VP, and cannot be assigned to the subject, as illustrated in (3).

(2) a. Only [John]$_F$ ran the marathon

b. *Only John [ran the marathon]$_F$

c. *Only John ran [the marathon]$_F$

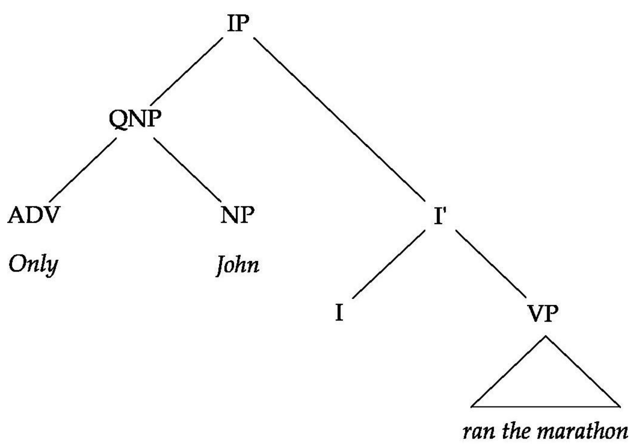
(3) a. John only [ran the marathon]$_F$

b. John only ran [the marathon]$_F$

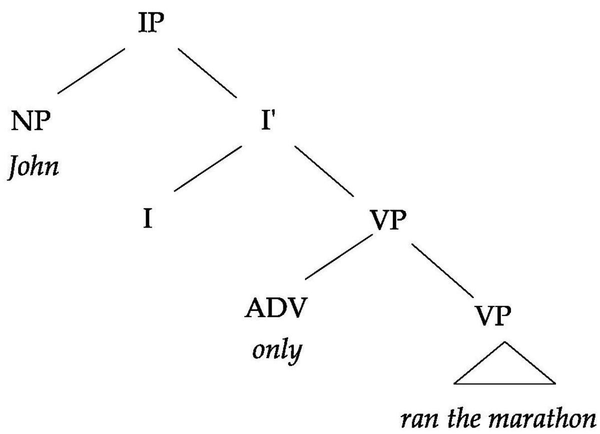
c. *[John]$_F$ only ran the marathon

This linguistic behaviour can be explained in terms of a c–command constraint on the association of the focus operator with some expression in the sentence. To implement the constraint, we posit different tree structures for pre–subject *only* and pre–VP *only*. When *only* immediately precedes the subject NP, it forms a quantificational noun phrase in construction with the subject NP, with *only* c–commanding the subject, but not the VP, as in (4).[2] When *only* immediately precedes the verb phrase, as in (5), it is positioned as an adjunct which c–commands the VP, but does not c-command the subject NP.[3] We will refer to the phrase that is c–commanded by *only* as the focus phrase.

(4)



(5)



Focus in English is not determined solely by the structural configuration of the sentence, however. Either an entire focus phrase or individual constituents within it can serve as the element in focus and which it is depends largely on pragmatic factors, with prosody often serving to reinforce the selection of the focus element. For example, when pre–subject *only* occurs before a complex subject NP as in *Only the children who ate their vegetables had dessert*, the entire subject NP is the focus phrase (*the children who ate their vegetables*). Within this phrase, focus can be assigned to *children* (in contrast to adults in the context who ate their vegetables) or to *vegetables* (in contrast to children who ate their meat, but not their vegetables) or to *eat*, or to *eat their vegetables* (in contrast to children who threw their vegetables on the floor). Once the focus element has been identified through a combination of syntactic and contextual constraints, the product is then run through the semantic rule in (1).[4]

We now turn to the focus system of Mandarin Chinese. Although typologically distinct from English, the focus system in Mandarin is similar to English in many respects. One adverbial particle corresponding to English *only* is *zhiyou*. Like English *only*, *zhiyou* must c–command the focus phrase it associates with, and the particular focus element is further determined by the pragmatic context. So, when *zhiyou* appears in pre–subject position, as in (6), it is only able to associate with the subject NP *Yuehan*, since *Yuehan* is the unique element in its c–command domain. It cannot associate with the entire VP *chi–le pingguo* or with the object NP within the VP *pingguo*. When the (phonologically shortened) focus operator *zhi*[5] occurs in preverbal position, as in (7), it is able to associate with the entire VP or with an element within the VP. However, it cannot associate with the subject NP.

(6)	*Zhiyou*	*Yuehan*	*chi–le*	*pingguo*
	FOC	John	eat–ASP	apple

‘Only John ate an apple’

a. Only $[\text{John}]_F$ ate an apple

b. *Only John $[\text{ate an apple}]_F$

c. *Only John ate $[\text{an apple}]_F$

(7) *Yuehan* *zhi* *chi–le* *pingguo*

John FOC eat–ASP apple

‘John only ate an apple’

a. John only [ate an apple]$_F$

b. John only ate [an apple]$_F$

c. *[John]$_F$ only ate an apple

Another focus construction in Mandarin is *shi…de*. In this construction, *shi* can be analysed as a focus operator and *de* as a functional particle (e.g. Huang, 1982; Lee, 2005; Teng, 1979; Shi, 1994; Zhou & Crain, to appear). *Shi…de* constructions are typically translated along the lines of cleft constructions in English but, unlike English cleft constructions, the Mandarin particle *shi* does not require the overt displacement of the focus element in the syntax (such as *It is John who…*). Rather, *shi* directly precedes the focus phrase, just as *zhiyou* does. Also as in English, both *shi…de* and *zhiyou* can only be associated with a focus element in their c–command domain.[6] The similarities between *zhiyou* and *shi…de* can be seen by comparing the examples with *zhiyou* in (6) and (7) to the corresponding sentences with *shi…de* in (8) and (9).

(8) *Shi* *Yuehan* *chi-de* *pingguo*

FOC John eat-DE apple

‘It is John who ate an apple’

a. *Shi* [John]$_F$ ate an apple

b. **Shi* John [ate an apple]$_F$

c. **Shi* John ate [an apple]$_F$

(9) *Yuehan* *shi* *chi-de* *pingguo*

John FOC eat- DE apple

‘It is an apple that John ate’

a. John *shi* [ate an apple]$_F$

b. John *shi* ate [an apple]$_F$

c. *[John]$_F$ *shi* ate an apple

The research question of the present study asks whether or not children's acquisition of focus in English differs from children's acquisition of focus in Mandarin. If children learning typologically distinct languages show the same type of non-adult behaviour in response to test sentences containing a focus operator like *only* this could suggest that all children pass through a stage in which they analyse focus differently from the way focus is analysed by adults. We now review what is already known about how children respond to sentences with focus operators in these languages.

1.2 Data from Child Acquisition

As mentioned earlier, it has been found that English–speaking children produce non–adult responses in certain tasks, such as the picture verification task depicted in Figure 1, in responding to sentences with pre–subject *only* (e.g. *Only the cat is holding a flag*). Many young children accept this sentence as a description of a situation, as in Figure 1, where the cat is holding a flag but nothing else, but where another character, the duck, is also holding a flag. For adults, *Only the cat is holding a flag* is not an accurate description of this situation, since adults require that no member of the set of alternatives to the focus element (*the cat*) has the property being attributed to the focus element. That is, no member of the contrast set can be holding a flag. Based on their experimental findings, Crain et al. (1994) conclude that children can initially associate pre–subject *only* with the VP, in apparent violation of the c–command constraint on the association of the focus operator with a focus element. Later we discuss how Crain et al.'s analysis of children's non–adult responses can be maintained without violating the c–command constraint.

An alternative account of children's non–adult responses has been advanced by Paterson et al. (2003), who suggest that children are able to process the presupposition of sentences with *only* (e.g. *the cat is holding a flag*), but not the assertion (e.g. *no–one else in the context is holding a flag*). In short, the conclusion by Paterson and colleagues is that young children fail to mentally represent contrast set information. To support this conclusion, Paterson et al. (2003) conducted several experiments aimed at controlling for what they call the 'VP Scope' analysis, according to which children erroneously assign focus of pre–subject *only* to the VP. They contrast the 'VP Scope' analysis with their own proposal that children fail to process the assertion, which they call the 'No Scope' analysis. They found that in response to test sentences with pre–subject *only* (e.g. *Only the fireman is holding a hose*), 4–5–year–old children produced a pattern of responses to 6 pictures that was uniquely consistent with the 'No Scope' analysis 25% of the time, whereas children produced a pattern of responses uniquely consistent with the 'VP Scope' analysis only 5% of the time.[7] In response to test sentences with pre–verbal *only* (e.g. *The fireman is only holding a hose*), the children again produced a high percentage (38%) of 'No Scope' responses. Similar patterns of results were obtained for older children. Paterson et al. thus argue that the primary reason that children produced non–adult responses to sentences with *only* in previous studies was because they had also failed to process the assertion.

It is indeed likely that non–adult responses to *only* sentences were evoked from children due to a failure to compute the assertion in the Patterson et al. study. However, it is unlikely that this was the source of children's non–adult responses in other research. In retrospect, it seems that Paterson et al.'s task (artificially) induced an abnormally high proportion of 'No Scope' responses, as well as other kinds of erroneous responses. A closer examination of the results reveals that, for the most part, there was no recognisable pattern of correct or incorrect responses by any of the child groups that were tested (up to age 12) or even by the adult control group. This suggests that the task was quite confusing both for children and for adults. Moreover, both child and adult subjects showed relatively high proportions of another type of unexpected response, an 'NP Scope' response, in which pre–verbal *only* was associated with the subject NP. The youngest children (4–5 years) produced this response 12.5% of the time and adults produced this response 9% of the time, which was as often as 6–7–year–old children.

These relatively high levels of 'NP Scope' responses provide a clue as to why subjects found the task confusing. Namely, the pictures that were used were more pragmatically felicitous for associating the focus operator with the subject rather than with the object. Two characters (e.g. a fireman and a policeman) were in every picture, and these characters were holding some object (e.g. a hose or a ladder), but there were never any 'extra' objects in the background.[8] This context apparently led to erroneous subject–focused responses from children and adults, regardless of the surface position of *only*. It is noteworthy that, even in these contexts favouring the selection of the subject as the focus element, some children still showed a pattern of responses uniquely consistent with the 'VP Scope' analysis, though adults never showed this non–adult behaviour.[9] In sum, we certainly do not deny that the 'No Scope' response is a possible response pattern from children, however the relative levels of this type of response, as opposed to a 'VP Scope' response, were not accurately represented in the Paterson et al. study, due to task demands.

In later work, Paterson et al. (2005/2006) acknowledged that the pictures they used in the 2003 study were pragmatically infelicitous. Consequently, they changed the task demands in their 2005/2006 study, and far fewer 'No Scope' responses were elicited than had been reported in their 2003 experiments. Other recent research also invites the conclusion that children are able to construct contrast sets when processing sentences with *only.* For example, Goro, Minai & Crain (2005, 2006) investigated children's understanding of the logical entailments of disjunction, *or,* and conjunction, *and,* in the assertion of the focus operator *only*. To illustrate, the assertion of the sentence *Only Bunny Rabbit will eat a carrot or a pepper* generates the 'conjunctive' entailment that no one else in the context will eat a carrot and nobody else in the context will eat a pepper. They documented that English–speaking children aged 3;6–5;8 accepted sentences like *Only Bunny Rabbit will eat a carrot or a pepper* 93% of the time in contexts where nobody else chose a carrot or a pepper but, more importantly for present purposes, the same children rejected these sentences 90% of the time in contexts in which another character chose a pepper. Similar results were found in studies with 3– to 6–year–old Japanese–speaking children using test sentences involving disjunction or conjunction in the scope of the focus operator *–dake* in Japanese. This is clear evidence that children at this stage of language development compute contrast sets (Crain, Goro & Minai 2007). These findings provide evidence that children's non–adult responses with focus operators are not likely to be due to a failure to compute contrast sets, at least not after the age of 3;6.

Furthermore, one study of Mandarin-speaking children also provides evidence of a possible 'VP Scope' response from 3– to 6–year–old Mandarin–speaking children (Jing, Crain, & Hsu, 2005). In this study, children were presented with sentences with *dou–shi* in Mandarin, such as (10), which corresponds to the English sentence *Only workers that are wearing hats took a hammer or a pair of pliers.* In the context, there were 3 workers wearing hard hats and one without a hat. The workers with hard hats had a hammer or pliers (and one also had a wrench), and the worker without a hat had a hammer. These sentences were therefore false for adults, because the worker who was not wearing a hat had a hammer.

(10) *Dou–shi* *dai–zhe* *maozi* *de* *gongren* *na–le*
FOC–COP wear–PROG hat RCM worker take–PERF
chuizi *huozhe qianzi*
hammer or pliers
'Only workers that are wearing hats took a hammer or a pair of pliers'

The children in the study rejected the test sentences 87% of the time. However, on 60% of the trials, children did not justify their rejections with any reference to the worker who was not wearing a hat. Rather, children justified their rejections on the grounds that one of the workers wearing a hat was also in possession of a wrench, not just a hammer or a pair of pliers. In other words, these Mandarin-speaking children appeared to be constructing a contrast set based on the content of the VP rather than being based on the content of the subject NP, as in adult Mandarin.

1.3 The Present Study: Research Questions

Where does this leave us? First, it seems that children's non–adult responses to sentences with *only* are not due to a failure to compute contrast sets, at least not after age 3;6. However, the possibility that children fail to compute contrast sets before age 3;6 still remains to be empirically investigated. To this end, we collected experimental data from English–speaking children aged 2–3, which we report in Experiment 1. Second, there seems to be a 'VP Scope' response from children to sentences with *only* in both English and Mandarin. Since the 'VP scope' response is not characteristic of the final state of these languages, four research questions arise, which we will attempt to answer through our experimental investigations:

(i) Do all children pass through a stage in which they assign 'VP Scope', or is this language–specific?
(ii) Assuming that children assign a 'VP Scope' analysis to sentences with focus operators, at least in some languages, do children's initial non–adult analyses violate the c–command constraint exhibited in adult grammars, or do children initially adopt structural representations that are not subject to the c–command constraint?

(iii) What leads children to initially formulate a non–adult analysis of focus expressions?
(iv) How do children who hypothesise a non–adult linguistic analysis converge on the grammar of the local language?

Following a report of the findings of our new experimental investigations of child speakers of English and Mandarin, we will propose answers to these four research questions. At this point, we move to the laboratory, beginning with a study investigating the early stages of the acquisition of the focus system by young English–speaking children.

2. Experiment 1

The first experiment reports on an investigation of child English. This study was designed to explore very young English–speaking children's interpretation of *only* and, if possible, to identify the lower bound at which children successfully compute contrast sets. At the same time, the study was designed to explore the origins of the 'VP Scope' response observed in previous research.

Even where more than one possible assignment of scope is supported by the pragmatic context, adults are guided by the c–command constraint to uniquely associate a pre–subject focus operator with the subject NP. By contrast, English–speaking children have been found to produce the 'VP Scope' response for pre–subject *only* in pragmatically ambiguous situations. So, for example, when the question under consideration might well be either 'what is everybody doing?' or 'who is doing what?' children tend to assign focus to the object regardless of the surface position of the focus operator. However, when the question under consideration clearly calls for an answer pertaining to the subject NP, such as 'who ate what?' as in Goro et al.'s (2005, 2006) experiments, children successfully associate the focus operator with the subject NP. Another way in which focus on the subject NP can be made more prominent is by using intransitive verb phrases or locative clauses, i.e., by creating sentences where the only available focus element is the subject NP (in the case of locatives, it is difficult to envisage a situation in which a contrast set could be constructed for something only being in one place as opposed to being in two or more places at once). Donaldson & Lloyd showed as early as 1974 that 3;7– to 5;0–year–old English-speaking children had no problem processing pre–subject *only* in sentences with these types of syntactic structure (e.g. *Only the red car is in the garage*).

Given these observations, three experimental contexts were used to evaluate young English–speaking children's sensitivity to syntactic and pragmatic constraints on focus assignment. In one condition (i) *only* had surface scope over the VP. We will refer to this as: NP–Only–VP. In the second condition (ii) *only* had scope over the subject NP with a locative predicate phrase, so we dub this condition: Only–NP–VP_{LOC}. In the third condition (iii) *only* had scope over the subject NP with a transitive predicate phrase, so this will be referred to as: Only–NP–VP_{TRANS}. Here is an example of each condition.

(i)	NP–Only–VP	(*Tigger only has a yo–yo*)
(ii)	Only–NP–VP_{LOC}	(*Only Tigger is under the blanket*)[10]
(iii)	Only–NP–VP_{TRANS}	(*Only Tigger has a yo–yo*).

Based on the findings of prior research, we expected that, once children showed the capacity to construct contrast sets, they would produce adult–like responses in condition (ii): Only–NP–VP_{LOC}. Because of the locative verb phrase, there is only one contextually relevant set over which to construct a contrast set, the subject NP. However, in conditions (i) and (iii), we were interested in seeing whether children would assign focus to the object or the subject. We did not purposefully manipulate context to favour an association of the focus expression with either the object or the subject, so the question under consideration in both of these conditions could potentially have been either 'who has what?' (favouring a subject focus interpretation) or 'what does everyone have?' (favouring an object focus interpretation).

2.1 Subjects

Two English–speaking children from different families were recruited by word of mouth to attend our lab fortnightly for 1–hour experimental sessions until they reached their 3rd birthday. The children, Ian and Pam, came to the lab over a period of 6–12 months (the number of sessions they each participated in was dependent on how old they were at the start of testing). Ian started testing at age 2;4 and participated in 15 sessions until age 3;1 (relevant trials began at age 2;5). Pam started testing at 2;1 and participated in 21 sessions until age 2;11 (relevant trials began at age 2;2).

2.2 Methodology

There were three experimental tasks: an act–out task and two judgement tasks, a Yes/No–question task and a Wh–question task. These tasks were used across the three experimental conditions outlined above. The children were first introduced to different sets of toys making up possible subjects and objects (e.g. subject sets included turtles, frogs or Winnie–the–Pooh friends; object sets included strawberries, balls or yo–yos). On an act–out trial, children were instructed to perform an action restricted by *only*. A representative example is given in (11).

(11) [Context: 3 baby animals and 3 mother animals introduced; toy farm]
EXP: *Only put the baby animals into the farm*

The act–out task was easy for very young children to perform, and children's responses can be revealing if a child produces non–adult responses (for example by putting both baby animals and mother animals into the farm). However, if a child performs in an adult–like way, trials of this kind do not allow us to draw the conclusion that the child has processed *only* and has constructed a contrast set, because it is possible to produce an adult–like response by processing the presupposition alone (e.g. *Put the baby animals into the farm*). Therefore, such trials were only used sparingly, during the children's earliest sessions.

By contrast, the judgement tasks were designed so that adult–like responses could only result if children processed both the presupposition and the assertion of the test sentences with *only*. Arrays of toys were set up by the experimenter (sometimes with the child) before the experimenter asked the child a Wh–question, such as (12), or a Yes/No–question, such as (13). In a typical trial, three of Winnie–the–Pooh's friends were having a tea party. One of the friends was given strawberries and bananas but two others were only given strawberries. Then, the test question was posed:

(12) Who only has a strawberry?

(13) Does only Piglet have a strawberry?[11]

If a child answered test questions like the one in (12) in an adult–like manner by naming or pointing to the two friends who only have strawberries, then this constitutes evidence that he/she has processed the relevant contrast set in the assertion. If the child processed the presupposition alone, then he/she should point to or name all the characters who have strawberries, not just those who only have strawberries. Test questions like (13) require a control (as pointed out by Paterson et al. 2003). This is because if a child answers 'yes', there is no way of knowing if he/she is responding to the presupposition alone (e.g. *Does Piglet have a strawberry?*) or to the sentence with *only.* Judgement questions like (13) were primarily used in Only–NP–VP_{TRANS} trials where children might respond 'yes' in contexts in which Piglet only had a strawberry, but some other characters also had strawberries. Control trials were carried out for one child, Pam.[12]

The play sessions were video recorded and transcribed in full. The relevant trials were then isolated for scoring. The data for Ian consisted of 66 trials. Of these, 60 trials (10 act–out trials, and 50 judgement trials) were scored, and 6 were experimentally flawed and therefore discarded (for example, if the possible contrast sets were not clearly introduced in the preceding context, or if the array could not be seen clearly on the video record of the trial).[13] The data for Pam consisted of 120 trials. Of these, 105 trials (7 act–out trials, and 98 judgement trials) were scored, and 15 were discarded. For each trial, the child's first response was recorded, as well as any subsequent response or justification for their response that they may have given upon repetition of the trial sentence. Their responses were then assigned to one of four categories. Trials in which the child's first response was adult–like (and any subsequent response matched their first response) were classified as (i) 'Right'. Trials in which the child's first response was non adult–like (and any subsequent response was also non adult–like) were classified as 'Wrong'. Two different incorrect response patterns were coded. If the child's response showed processing of the presupposition, but <u>not</u> the assertion of a test sentence, the response was classified as (ii) 'Wrong (No Scope)'. If the child's response was consistent with processing the incorrect contrast set in Only–NP–VP_{TRANS} trials, the response was classified as (iii) 'Wrong (Possible VP Scope)'. If the child was distracted and gave no response, or gave a response that was not related to the test trial, this was classified as (iv) 'Other'.[14] Approximately 24% of each child's data set was selected at random to be scored by a second coder (16 trials for Ian, 25 trials for Pam). Overall inter–rater reliability was high (.87). Cases in which there was disagreement were discussed with a third coder and a consensus was reached.

2.3 Results

2.3.1 Ian

Ian's responses in the three test conditions are presented in Figures 1 and 2. His responses are partitioned into 'Right', 'Wrong (No Scope)', 'Wrong (Possible VP Scope)' and 'Other' answer categories. 'Right' answers are further broken down into act–out and judgement trial types (since correct act-out answers cannot be taken as evidence that the child has processed the assertion of an *only* test sentence). 'Wrong' answers include both act-out and judgement trials (since an incorrect answer on either of these tasks reflects a non-adult response). The breakdown of act-out and judgement trials in all test conditions is given in Appendix A.

Figure 1 presents Ian's responses between the ages of 2;5 and 2;8. In the Only–NP–VP_{LOC} condition (6 trials) and in the NP–Only–VP condition (5 trials), Ian produced 'Wrong (No Scope)' responses to both judgement and act-out trials, along with some 'Right (Act)' answers to act-out trials. Ian was not presented with any trials in the Only–NP–VP_{TRANS} condition at this time. We will call this period Stage I. Stage I is characterised by a majority of answers that show the child is not processing the assertion of the test sentences.

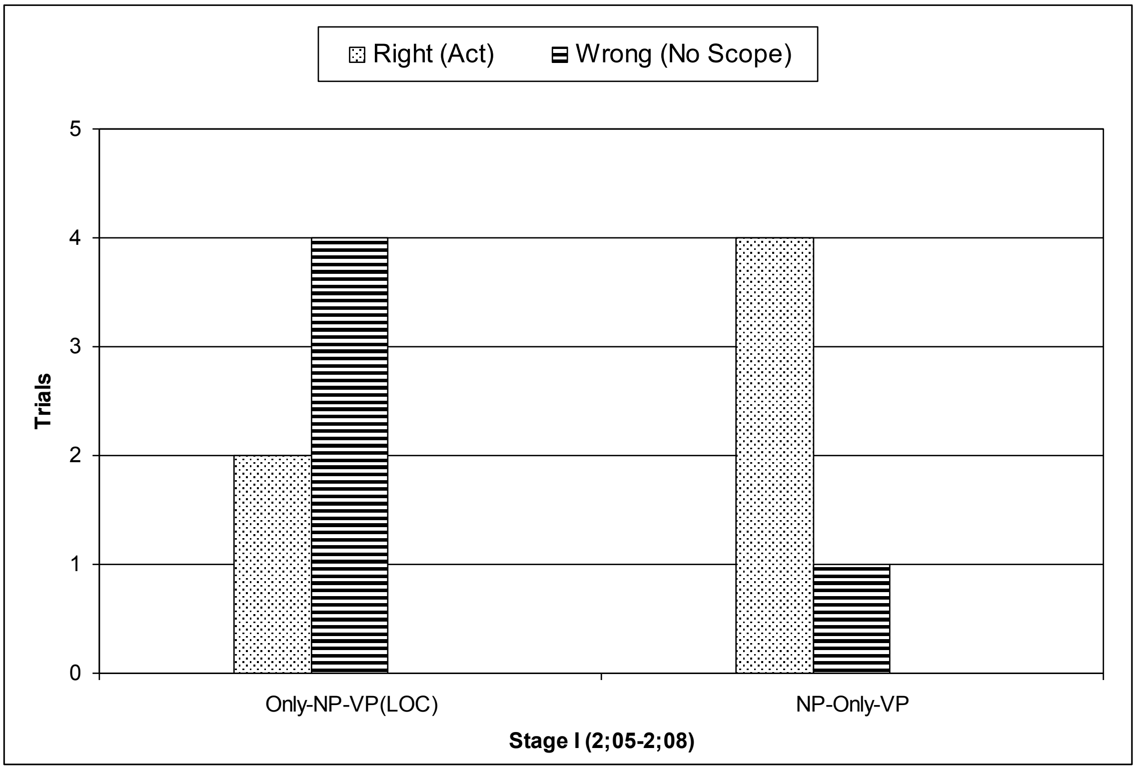


Figure 1: *Only* Responses Across Conditions in Stage I: Ian

Figure 2 presents a second stage in Ian's development, which we call Stage II. Stage II is characterised by a marked increase in answers indicating that the child in question has started processing the assertion of the test sentences. For Ian, this stage began at age 2;9 and lasted to the end of testing at 3;1. During Stage II, Ian gave many 'Right (Judge)' responses to the trials in the Only–NP–VP_{LOC} condition (9 trials) and in the NP–Only–VP condition (23 trials). An example of a correct judgement to one of the NP–Only–VP trials, at age 2;8 is given in (14).

(14) [Context: Winnie–the–Pooh, Piglet and Eeyore have balls and toy dogs; Tigger and Donald Duck only have toy dogs]
EXP: *Who only has a dog*?
IAN: … *Not Piglet, he has a ball. Donald has only a dog, and Tigger*!

Note that Ian should have named every character if he had been responding to the presupposition of trial (14) alone. Instead, Ian explicitly showed that he had constructed a contrast set, not only by naming Donald and Tigger, but by denying that Piglet was a suitable answer, because Piglet had a ball. Because of the high number of correct trials of this type in Stage II in response to sentences in the NP–Only–VP condition and in the Only–NP–VP_{LOC} conditions, we concluded that Ian was consistently constructing contrast sets by 2;9.

At Stage II, however, Ian also produced many 'Wrong (Possible VP Scope)' responses to sentences in the Only–NP–VP_{TRANS} condition (*Only Tigger has a yo–yo*). He was given 17 trials of this type. An example of an incorrect response in this condition at age 2;10 is given in (15).

(15) [Context: Eeyore and Tigger have yo-yos; Winnie-the-Pooh, Donald Duck, and Piglet have yo-yos and balls]
EXP: *Only Eeyore has a yo-yo, is that right?*
IAN: *yes, he has a yo-, only yo-yo*

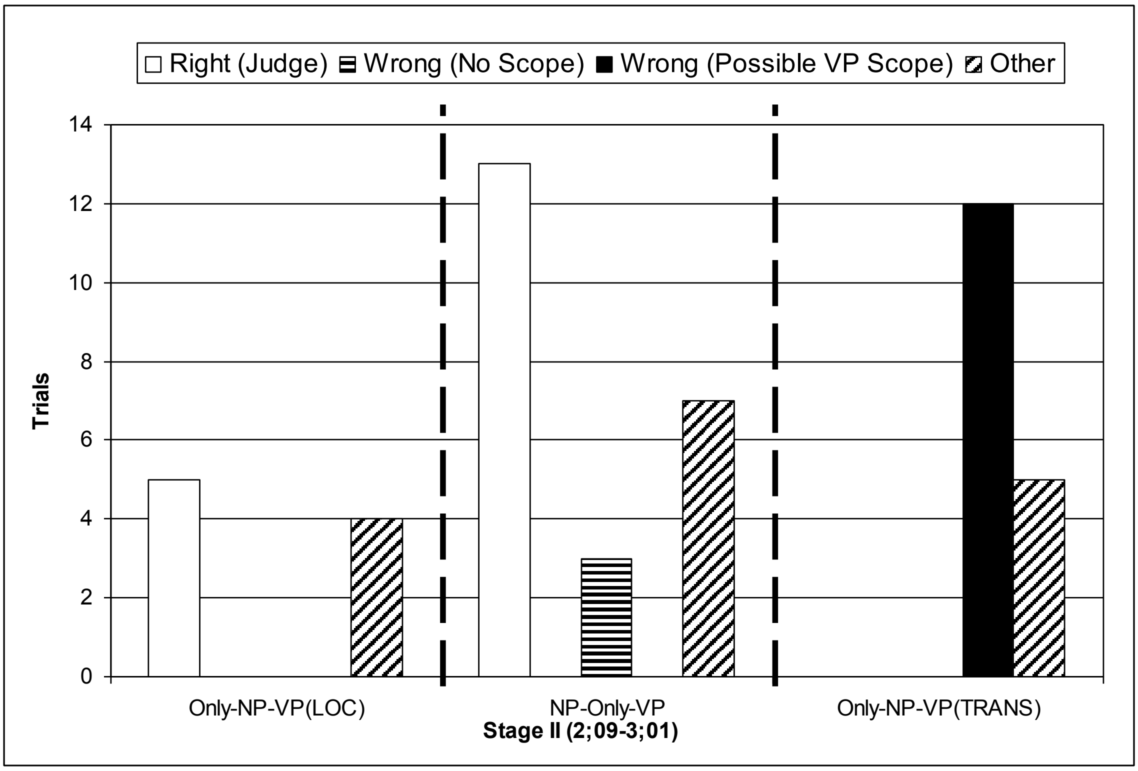


Figure 2: *Only* Responses Across Conditions in Stage II: Ian

During Stage II, there were only three trials in which Ian seemed to ignore *only* and processed the presupposition alone in the NP–Only–VP type condition. There is no reason to think that, in trials of the type Only–NP–VP_{TRANS}, Ian suddenly reverted to an earlier stage of processing at which he did not construct contrast sets (especially given that he clearly could construct contrast sets on locative trials in which *only* took scope over the subject). For example, at 2;9, Ian was presented with a context in which a black dog and a brown dog were hidden under a blanket. The experimenter then asked "Is this right, only a black dog is under there?" and revealed what was hidden under the blanket. Ian said "no, a brown dog and a black". This suggests that Ian's responses in the Only–NP–VP_{TRANS} condition which were categorised as 'Possible VP Scope' responses (and which are, in fact, the only response Ian produced for this trial type), were indeed 'VP Scope' responses, and not instances of Ian failing to construct a contrast set.

2.3.2 Pam

Pam's responses in the three test conditions are presented in Figures 3 and 4. 'Right' answers are again broken down into act–out and judgement trials,[15] while 'Wrong' answers include both act-out and judgement trials. Again, the full breakdown of act-out and judgement trials in all test conditions is given in Appendix A. Figure 3 presents Pam's Stage I responses. Recall that Stage I is characterised by a majority of answers which show the child is not processing the assertion of the test sentences. For Pam, this stage occurred between the ages of 2;2 and 2;4. Like Ian, at this stage Pam's responses were primarily 'Right (Act)' responses to act-out trials, along with some 'Wrong (No Scope)' responses to both judgement and act-out trials, in the Only–NP–VP_{LOC} condition (13 trials) and in the NP–Only–VP condition (3 trials). Pam was not given any trials in the Only–NP–VP_{TRANS} condition during this period.

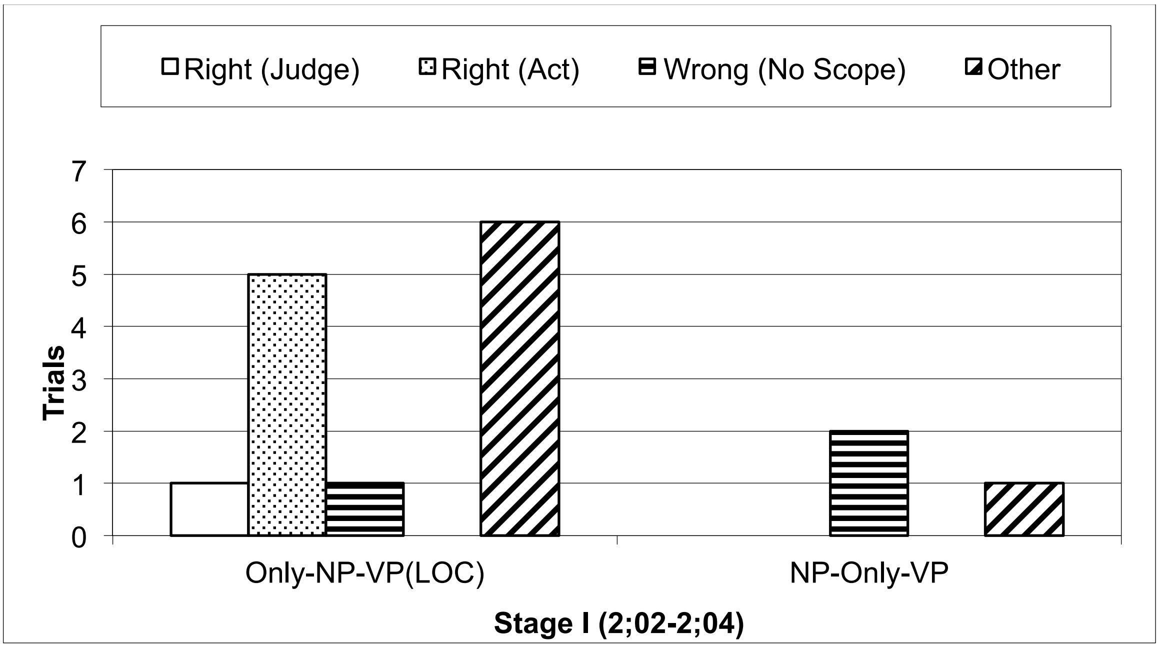


Figure 3: *Only* Responses Across Conditions in Stage I: Pam

Pam entered Stage II at 2;5, which is 3 months earlier than Ian did. Recall that Stage II is characterised by a marked increase in answers indicating that a child has started processing the assertion of the test sentences. Figure 4 presents Pam's Stage II responses, from 2;5 to the end of testing at 2;11. During Stage II, Pam produced many 'Right (Judge)' responses to sentences in the Only–NP–VP_{LOC} condition (18 trials) and in the NP–Only–VP condition (47 trials), as compared to her 'No Scope' responses.

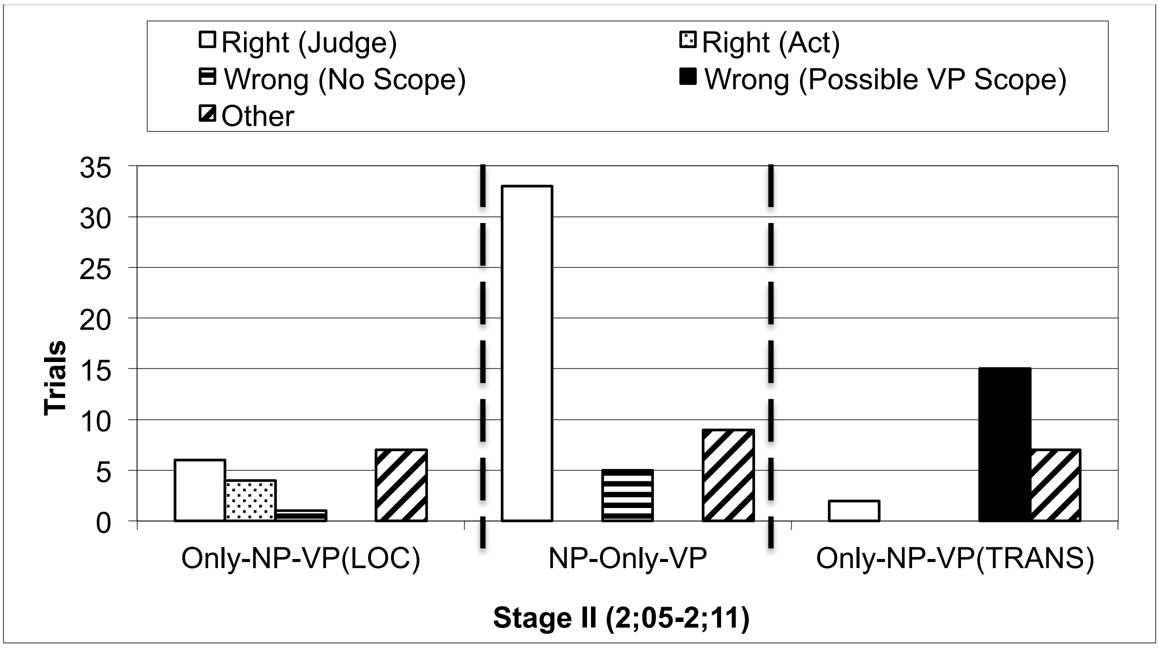


Figure 4: *Only* Responses Across Conditions in Stage II: Pam

An example of a correct judgement response from Pam to an NP–Only–VP trial in Stage II, at age 2;7, is given in (16).

(16) [Context: Eeyore and Piglet have balls, books and yo–yos; Tigger has a ball and a yo–yo; Donald Duck and Winnie–the–Pooh have yo–yos only]

EXP: *Who only has a yo–yo*?

PAM: [points to Piglet, then shakes head 'no', points to Donald Duck and Winnie–the–Pooh]

EXP: *What about Tigger?*

PAM: *no he has a ball*

If Pam had been responding to the presupposition alone in (16), she should have named every character. In fact, she explicitly shows she has constructed a contrast set here, by denying that one of the other characters, Tigger, is a suitable answer because he has a ball. Because of the high number of correct trials of this type in Stage II in response in the NP–Only–VP condition, and the relatively high proportion of correct responses in the Only–NP–VP_{LOC} condition (compared to 'No Scope' or 'Right (Act)' responses), we feel that it is reasonable to conclude that Pam was consistently constructing contrast sets by 2;5. In fact, at

Stage II, there were only 5 trials (out of 47) in which Pam may be deemed to have ignored *only* and processed the presupposition alone in the NP–Only–VP condition.

However, like Ian, Pam made many 'Wrong (Possible VP Scope)' responses in the Only–NP–VP_{TRANS} condition (*Only Tigger has a yo–yo*) at this stage. She was given 24 trials of this type. In view of Pam's consistent processing of contrast sets on other trials, we take Pam's 'Possible VP Scope' responses in the Only–NP–VP_{TRANS} condition to represent VP contrast set responses, and not instances in which she failed to construct a contrast set. This is confirmed in Pam's case by 9 control Only–NP–VP_{TRANS} trials. On 7 of these, she answered 'no' and gave a justification that referred to an object mentioned in the VP. This clearly shows that she is indeed assigning scope of *only* to the VP. An example at age 2;9 is given in (17).

(17) [Context: Eeyore has 3 presents; Tigger and Piglet have 1 present; Winnie–the–Pooh has a ball; Donald Duck has a ball and a yo–yo]
EXP: *Only Donald Duck has a ball.*
PAM: *no, he's got a yo–yo and a ball*

It is interesting to note that Pam did produce two correct responses to control Only–NP–VP_{TRANS} trials. These were in contexts that, it could be argued, were more felicitous if the focus expression was associated with the subject NP than with the object NP. In (18), we have given an example that occurred when Pam was 2;10.

(18) [Context: 4 Pooh characters have shells; Tigger has a shell and a yo–yo][16]
EXP: *Does only Tigger have a yo–yo?*
PAM: *yeah*

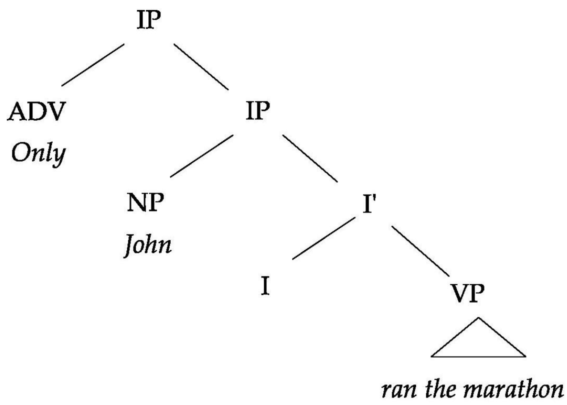
This example adds to the general picture for both children. There was no stage in which either child systematically failed to assign focus to the subject NP in pre–subject *only* trials. They were able to assign focus to the subject NP when the context was felicitous with this interpretation, (i) when pre–subject *only* occurred in locative clauses, and (ii) even in transitive clauses, when the context favoured a subject focus interpretation.

2.4 Discussion of Experiment 1

The results of Experiment 1 show that the ‘Wrong (No Scope)’ response to sentences with *only* is abandoned very early by English–speaking children, and is replaced by a semantic representation that includes the assertion with its calculation based on a contrast set, well before age 3. The fact that these data were obtained from children far younger than those that have ever been studied before makes it all the more unlikely that a failure to compute contrast sets is the reason for older children’s reported non–adult responses with *only* in previous comprehension studies.

Moreover, the present study shows that as soon as children begin to successfully construct contrast sets, at around age 2;6, they consistently make non–adult ‘VP Scope’ responses to pre–subject *only* in sentences with transitive predicate phrases. To explain children's non–adult ‘VP Scope’ responses, we advance the following proposal. We propose that, at Stage II, children differ from adults in that children process *only* as a sentential adverbial that c–commands both the subject NP and the VP. The analysis we attribute to children is graphically depicted in (19).

(19)



Many English adverbs of quantification (e.g. *always, sometimes*) tend to take sentential scope, regardless of their syntactic position (e.g. *(Sometimes) a man who owns a donkey (sometimes) beats it*), and this phenomenon is witnessed across the world’s languages. The claim that children initially analyse focus adverbs such as *only* as taking sentential scope is therefore compatible with the Continuity Assumption – the proposal that children's linguistic analyses are restricted to ones that characterise adult languages (e.g., Crain 1991; Pinker 1984).

Here is our proposal. Following the analysis of Lewis (1975), we take it that adverbs of quantification quantify over both the antecedent and the consequent clauses of conditionals, e.g. ***Sometimes*** + {if x is a man, and y is a donkey, and x owns y}, x beats y. We propose that this analysis of adverbial quantificational expressions extends to *only* in early child language. For children, then, both sentences with pre–subject and with pre–verbal *only* are interpreted in the same way. For example, *Only Tigger has a ball* and *Tigger only has a ball* receive the same interpretation: ***Only*** + {if x is Tigger, and y is a ball}, x has y. Then because *only* must be associated with a focus element, children can choose either x (*Tigger*) or y (*a ball*) to fill this slot. Both are c–commanded by *only* at the sentential level. This analysis can account for children's correct assignment of focus to the subject NP in locative clauses, when the VP presents no felicitous alternative set on which to construct a contrast set (it is physically impossible for someone to be in only one location as opposed to two or more locations at one time). However, when there are two possible focus phrases (as in NP–Only–VP_{TRANS} and Only–NP–VP_{TRANS} cases), it seems English–speaking children favour the VP. This occurs when the question under consideration in the discourse is possibly ambiguous between "What does everybody have?" and "Who has what?" However, this study hints at the possibility that in other contexts where a subject–focus interpretation is made more felicitous, children can correctly assign focus to the subject in Only–NP–VP_{TRANS} (*Only Tigger has a ball*) cases.

According to the proposed analysis, English-speaking children's grammars differ from those of adults at one stage in the acquisition of the meaning of *only*. It is important to investigate whether this phenomenon is limited to English, or is found across human languages. Evidence of a 'VP Scope' response in languages other than English would lend weight to our analysis. We also need to address the question of why children appear to preferentially select an element of the VP as the focus element in pragmatically ambiguous situations. Is this a default response (and if so why?), or can this response be over–ridden by contextual factors? We turn now to two studies in Mandarin Chinese that were designed to address these questions.

3. Experiment 2

The findings from Experiment 1 demonstrate that the 'No Scope' response to *only* sentences is abandoned very early by English–speaking children. However, these findings have also confirmed that children have difficulty in associating pre–subject *only* with the subject NP when the context is not uniquely felicitous for assigning focus to the subject. We now present results from two experiments in Mandarin designed to probe pre–subject *only* responses further in a language other than English. These experiments were designed both to address the question of whether the 'VP Scope' response is seen cross–linguistically, and the question of whether older children (aged 4– to 5–years–old) continue to show such a response to pre–subject *only*. In addition, these experiments were designed to determine whether modifying the context to be subject–oriented is a sufficient condition to improve responses to pre–subject *only* test questions. Testing contexts systematically controlled for the 'No Scope' response.

3.1 Subjects

We tested 20 Mandarin–speaking children between the ages of 4;5 and 4;10 (11 girls and 9 boys with a mean age of 4;7). The child subjects were recruited from the kindergarten at Beijing Language and Culture University. In addition, 20 Mandarin–speaking adults were tested as controls. All were postgraduate students at Beijing Language and Culture University.

3.2 Methodology

The children were tested individually using a Truth Value Judgement Task. This research technique is designed to investigate which meanings children can and cannot assign to sentences (Crain & Thornton, 1998). The task involves two experimenters – one acting out stories with toy characters and props, and the other playing the role of a puppet who watches the stories alongside the child. At the end of each story, the puppet explains to the child subject what he thinks happened in the story. The child's task is to decide whether the puppet said the right thing or not. If the child informs the puppet that he was wrong, then the child is asked to explain to the puppet what really happened. Each child was given two practice items before the actual test, one in which the puppet's statement was obviously true and one in which it was obviously false, so that children knew that the puppet could say something wrong. These practice items were also used to familiarize children with the task. The full test was only administered to those children who correctly rejected the puppet's statement in the practice item.

There were two test conditions: one in which the test sentence was predicted to be a true description of the story for adults; and one in which the test sentence was predicted to be a false description of the story. We will refer to these conditions as 'Adult–True' and 'Adult–False'. Each condition had 3 trials, yielding 6 different test items. The following two examples are used to illustrate.

<u>Example of an 'Adult–True' Condition Story</u>

"Mr. Horse and Mr. Pig are having a running race. At the far end of the track, there are three coins – two gold coins and one silver coin. They look very shiny, but only the one who runs the fastest can get these coins. Mr. Pig is not very fast. Mr. Horse is a fast runner, but he goes to eat a cake in the middle of the race. After eating a cake, he eats a banana. The food makes him sleepy so he decides to take a nap. When he wakes up, Mr. Pig has finished the race. Mr. Horse feels so sad that he cannot help crying. But Mr. Pig is a nice guy. He takes a gold coin and a silver coin for himself, and leaves the other gold coin for Mr. Horse."

Figure 5, which corresponds to the scene at the end of the story, illustrates this condition. After the story, the puppet watching alongside the child utters test sentence (20) to describe what he thinks happened in the story.

(20)	*Zhiyou*	*zhu*	*xiansheng*	*nadao–le*	*yinse*	*yingbi*
	FOC	pig	sir	get–ASP	silver	coin
	'Only Mr. Pig got a silver coin'					

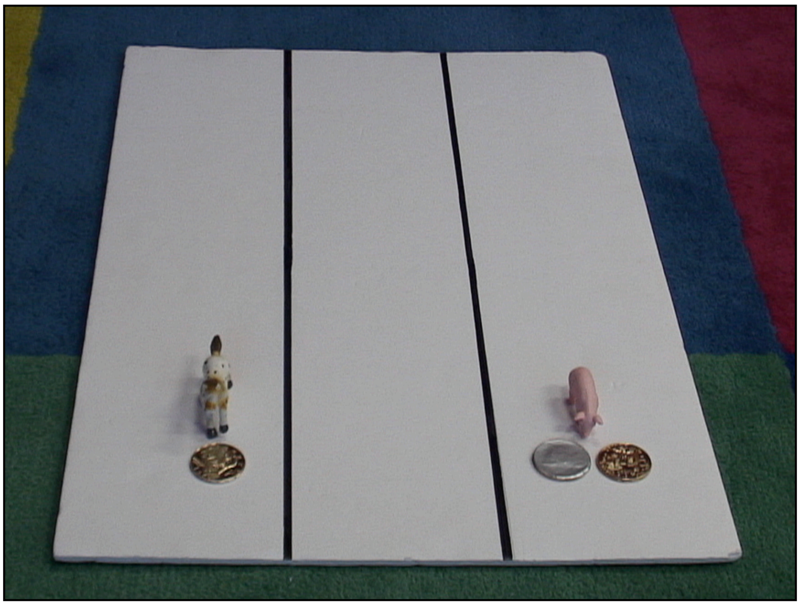


Figure 5: ‘Adult–True’ Condition

<u>Example of ‘Adult–False’ Condition Story</u>

“Mr. Cat and Mr. Rabbit are having lunch at Mr. Owl’s restaurant. Two kinds of food are served here, fish and carrots. Mr. Cat orders a fish and Mr. Rabbit orders a carrot. They soon eat them up. But Mr. Rabbit feels like having one more carrot, so he orders another one. When he is about to eat it, he smells a fish–flavour from the carrot and realises it is a fishy carrot. He doesn’t like the taste of fish, so he gives the fishy carrot to Mr. Cat. Mr. Cat likes this fishy carrot, and he soon finishes eating it.”

Figure 6, which corresponds to the scene at the end of the story, illustrates this condition. After the story, the puppet watching alongside the child utters test sentence (21) to describe what he thinks happened in the story.

(21)	*Zhiyou*	*mao*	*xiansheng*	*chi–le*	*huluobo*
	FOC	cat	sir	eat–ASP	carrot
	‘Only Mr. Cat ate a carrot’				

Figure 6: ‘Adult–False’ Condition

Note that these contexts control for the ‘VP Scope’ response vs. a ‘No Scope’ response. In both cases, the presupposition of the test sentence is true (e.g. *Mr. Pig got a silver coin, Mr. Cat ate a carrot*). So if children are not processing the assertion at all, we expect them to accept the test sentences in both conditions. If, on the other hand, children assign ‘VP Scope’ then we expect them to reject the test sentences in both conditions. This is because, in both cases, an assertion based on the VP is false (e.g. *Mr Pig did not get anything other than a silver coin, Mr. Cat did not eat anything other than a carrot*). Children’s justifications for their rejections will show whether they are indeed assigning ‘VP Scope’. Finally, if children are adult–like, they should accept the test sentences in the ‘Adult–True’ condition and reject them in the ‘Adult–False’ condition, giving a reason for their rejection related to the subject.

Four filler items were also included. On these items, the puppet produced statements like (22) and (23), which were either obviously true or obviously false.

(22)	*Tiaotiaohu*	*zhaodao–le*	*zhu,*	*danshi*	*meiyou*	*zhaodao*	*tuzi*
	Tigger	find– ASP	pig	but	not	find	rabbit

‘Tigger found the pig, but he didn’t find the rabbit’

(23) *Nanhai*	*he*	*nühai*	*qizhe*	*ma*	*qu*	*mai*	*dongxi*	*le*
Boy	and	girl	ride	horse	go	buy	thing	ASP

‘The boy and the girl rode a horse to go shopping’

These filler items were included to check that the children could answer both ‘yes’ and ‘no’ correctly, as well as to obscure the purpose of the experiment. Test and filler items were presented in a pseudo–random order. All test materials are given in Appendix B.

The 20 adult subjects were tested on the same stories, but using a questionnaire. All the stories were written out and they were asked to indicate, for each story, whether the puppet was right or wrong; if they judged the puppet to be wrong, they were also asked to justify their answers.

3.3 Results

Both children and adults gave correct responses on filler items 100% of the time. The dependent measure in the study was the proportion of ‘yes’ responses to the puppet’s statements in each condition. As expected, Mandarin–speaking adults accepted pre–subject *zhiyou* constructions 100% of the time in the ‘Adult–True’ condition; Mandarin–speaking children, by contrast, only accepted them 10% of the time and rejected them 90% of the time. A Mann–Whitney Test showed this difference to be significant ($Z = 5.65$, $p < .001$). When children were asked why the puppet was wrong, they justified their answers by saying that the character in question performed another action besides the one mentioned in the test sentences. For example, they rejected a sentence like (20), saying Mr. Pig also got a gold coin.

In the ‘Adult–False’ condition, there was no significant difference in the acceptance rates of the test sentences by adults (0%) vs. children (13.30%) ($Z = 2.08$, $p = .11$). Both children and adults rejected the test sentences to a high degree (adults: 100% vs. children: 86.70%), however they rejected them for different reasons. For example, adults rejected sentence (21) by making reference to the fact that Mr. Rabbit also ate a carrot, whereas children rejected the sentence by pointing out that Mr. Cat also ate a fish.

Within each group, a Wilcoxon Signed Ranks Test was used to compare the response patterns across the two conditions. For children, no significantly different patterns were observed in the ‘Adult–True’ condition vs. the ‘Adult–False’ condition (Z = 1.41, p = .50); adults, by contrast, exhibited distinct patterns in these two conditions (Z = 4.47, p < .001), as illustrated in Figure 7.

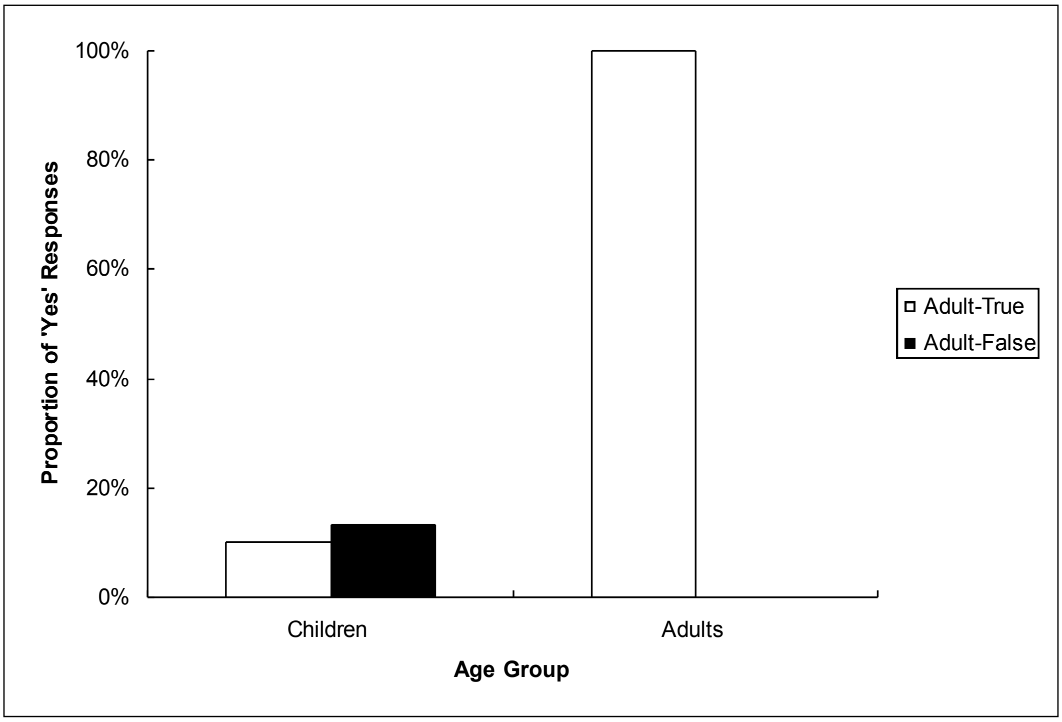


Figure 7: Exp. 2 Child and Adult Acceptance Rates Across Conditions

3.4 Discussion of Experiment 2

The results from this experiment reinforce those of our English study. The findings show that Mandarin–speaking children rejected pre–subject *zhiyou* constructions in both ‘Adult–True’ and ‘Adult–False’ conditions for the same reason: because the character in question performed another action besides the one mentioned in the test sentences. This is evidence that Mandarin–speaking children are producing ‘VP Scope’ responses to test sentences with *zhiyou*, similarly to English–speaking children's response to sentences with *only*; moreover, this response is attested in children up to age 5. At the same time, the findings provide compelling evidence that children’s difficulty with focus sentences cannot be linked to a failure to process the assertion. If this had been the source of their difficulty, then they should have accepted the test sentences in both conditions. In fact, children's justifications for their rejections in both conditions serve as a clear indication that they were computing a contrast set, just not the same contrast set as computed by adults.

These results bolster our proposal that children may initially analyse focus adverbs as having sentential scope. However, it is still not clear why children appear to prefer assigning pre–subject focus expressions to the VP, rather than to the subject NP. If this response is purely context–driven, then we should be able to over–ride it by modifying the context to be overtly felicitous with subject focus. If, on the other hand, changing the context cannot completely over–ride the response, we may have grounds for arguing that children's non–adult VP orientation represents a default interpretation, based either on syntax or semantics. In Experiment 3, we put this to a test by presenting children with contexts in which focus on the subject was emphasised in the experimental context.

4. Experiment 3

4.1 Subjects

Fourteen children participated in this experiment (9 girls and 5 boys with a mean age of 4;6). The children were all participants in Experiment 2 and all exhibited very strong 'VP Scope' responses in that experiment.

4.2 Methodology

As in Experiment 2, we tested children using a Truth Value Judgement Task. They were tested on sentences in both 'Adult–True' and 'Adult–False' conditions, as in Experiment 2. The plots of the stories were similar to those in Experiment 2, but different characters were used so that they would seem different to the children. The crucial difference between Experiment 2 and Experiment 3 lies in the way the test stories were presented. In order to assist the children in accessing the adult–like interpretation, associating the focus operator with the subject NP, we tried to present the test stories biased towards the question '*who did something?*' in two ways. Firstly, before the story started, we asked the child and the puppet who they thought would do something in the story. Secondly, at the end of the story, we framed the question to the puppet as '*who did something?'* rather than '*what* *happened in the story?*'. The following example is used to illustrate, with elements of the story focusing on the subject NP underlined.

Example of 'Adult-False' Subject Focused Story

"This is a story about Tigger and Winnie the Pooh. They are going to have a jumping game to see who the better jumper is. They are going to jump over two things, a fence and a house. (Child's name), who do you think can jump over the two things? [Child answers] Kermit, who do you think can jump over the two things? [Kermit answers: Hmm, I have no idea. Maybe Tigger, or maybe Winnie the Pooh]. Ok. Now let's see who can jump over them."

"Winnie the Pooh comes to compete first. He thinks that the fence is too easy for him, so he wants to try the house first. He starts running towards the house, but as he gets closer, he realises that it is much too high for him. So he decides to jump over the fence instead of the house. And finally he makes it. Now it's Tigger's turn. He starts with the difficult one, the house. He is now doing some warm–ups. Ready, go! Wow, what a great jump. He succeeded. What follows is just a piece of cake, he jumps over the fence easily. We know who the better jumper is – Tigger. Ok, now the story is over. Kermit, could you tell me who jumped over the fence?"

At this point Kermit uttered a test sentence like (24).

(24)	*Shi*	*Tiaotiaohu*	*tiaoguo–de*	*liba*
	FOC	Tigger	jump–over–DE	fence

'It was Tigger who jumped over the fence'

The contexts in Experiment 3 were designed to emphasise subject focus. For this reason we chose to use the focus construction *shi…de* instead of *zhiyou.* The *shi…de* construction is judged by adult Mandarin speakers to be pragmatically more felicitous in this situation. As discussed in the introduction, the focus particle *shi* does not require any overt dislocation of the focused element in the syntax. That is, syntactically *shi…de* constructions behave like English *only* and Mandarin *zhiyou* rather than English cleft constructions. It has been shown that Mandarin-speaking children aged 4;5-4;10 respond similarly to test sentences which only vary in their use of *zhiyou* or *shi…de* to mark focus (Zhou & Crain, to appear).[17] Altogether there were 6 test items (3 in an 'Adult–True' condition, and 3 in an 'Adult–False' condition) plus 4 filler items. Test and filler items were arranged in a pseudo–random order. All test materials are given in Appendix C.

4.3 Results

All 14 children consistently responded correctly to the filler items. The dependent measure was again the proportion of 'yes' responses to the puppet's statements in each condition. In the 'Adult–True' condition, the children accepted the test sentences 76.2% of the time and rejected them 23.8% of the time. When they rejected the test sentences they pointed out that the character in question performed another action besides the one mentioned in the test sentences. In other words, some children were still assigning 'VP Scope' to pre-subject *shi*. In the 'Adult–False' condition, the children accepted the test sentences 0% of the time and rejected them 100% of the time. Children justified their rejections by giving adult–like reasons 61.9% of the time; and they rejected the test sentences for 'VP Scope' reasons 38.1% of the time.

A Wilcoxon Signed Ranks Test was used to compare the response patterns of these 14 children in Experiment 2 (Type 1 contexts: non-subject focused) and Experiment 3 (Type 2 contexts: subject-focused). It was found that in the 'Adult–True' condition, the acceptance rates of the test sentences significantly increased from Type 1 contexts to Type 2 contexts (0% vs. 76.20%, $Z = 3.21$, $p = .001$), as indicated in Figure 8. In the 'Adult–False' condition, there was a significant increase of adult–like rejections from Type 1 to Type 2 contexts (0% vs. 61.9%, $Z = 2.89$, $p < .01$), and a significant reduction of 'VP–Scope' rejections (100% vs. 38.1%, $Z = 2.89$, $p < .01$), as displayed in Figure 9.

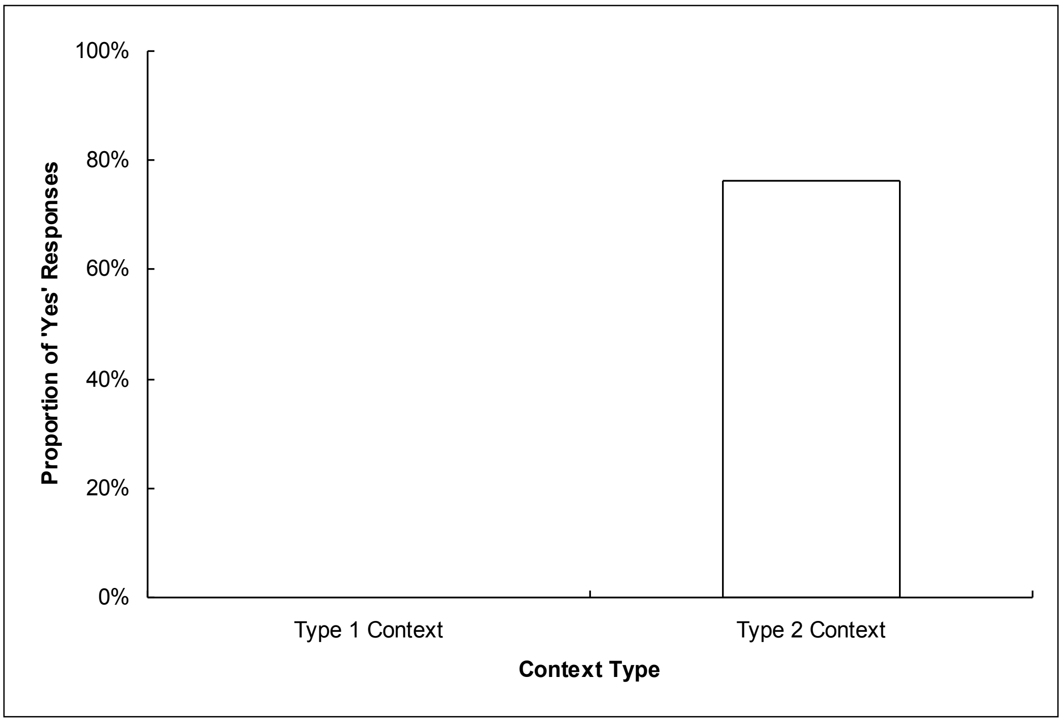


Figure 8: Exp. 3 Acceptance Rate in 'Adult–True' Condition Across Context Types

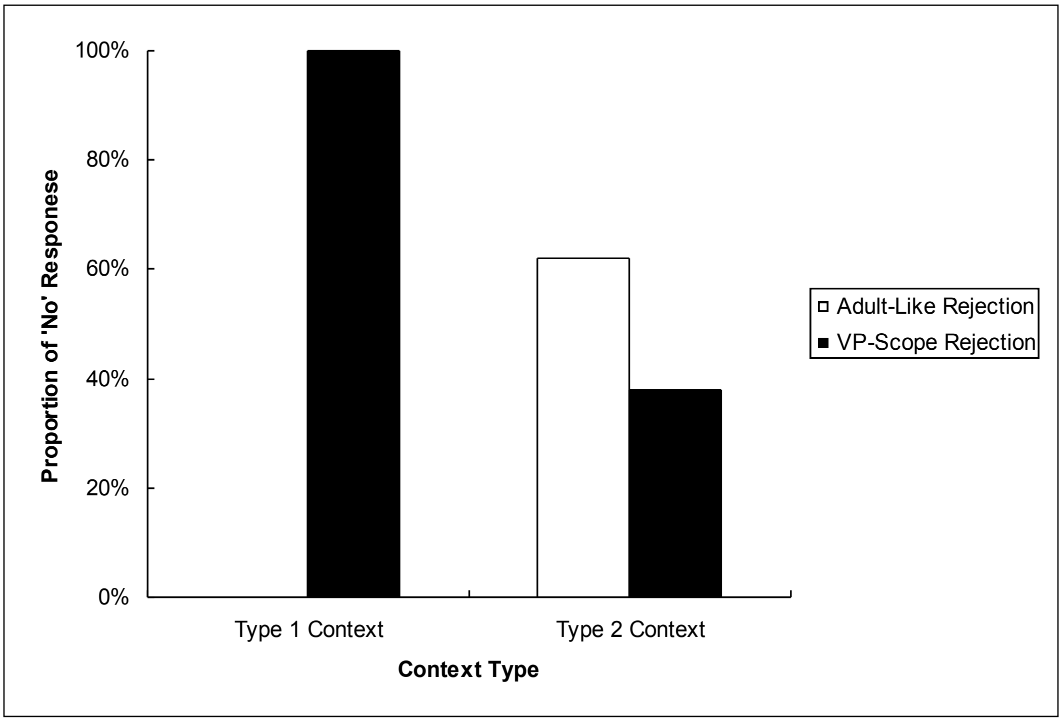


Figure 9: Exp. 3 'Adult–Like' and 'VP Scope' Rejections in 'Adult–False' Condition Across Context Types

4.4 Discussion of Experiment 3

The results show that children behaved more like adults when the test scenarios were biased towards the question '*who did something?*', which indicates that the subject–biased stories assisted the children in accessing the adult–like reading, associating the focus operator with the subject NP. However, some children continued to give 'VP Scope' responses even in these very strong subject–oriented contexts. This is reminiscent of Paterson et al.'s (2003) findings where 4– to 5–year–old English–speaking children gave 'VP Scope' responses 5% of the time, even though the pictures they were tested with were more felicitous for subject focus. Since the 'VP Scope' response cannot be completely over–ridden by contextual cues, these findings suggest that the syntax of the focus operator in child language makes its association with the VP as a default value. We will now turn to why this may be the case. We will also offer some suggestions as to how children may attain the adult interpretation.

5. General Discussion

The aim of this paper was to address several questions about children's acquisition of the meaning of focus expressions. We began by noting that sentences containing focus expressions can be partitioned into two propositions: a positive proposition called the presupposition, and a negative one called the assertion. Children need to process both of these propositions to access the full meaning of a focus expression such as English *only*. One proposal in the previous literature was that the source of children's non–adult understanding of sentences with *only* stems from a failure to process the assertion associated with focus expressions, presumably due to a limitation in computational resources (Paterson et al. 2003, but also see Paterson et al. 2005/2006). An alternative proposal has also been advanced to explain children's non–adult understanding of sentences with *only*. On this account, children tend to produce non–adult responses to sentences with *only* because they associate this focus expression with the predicate phrase in constructions where adults associate it with the subject phrase (e.g., Crain et al. 1994). We have called this type of response a 'VP Scope' response. In this general discussion, we argue that children's non-adult responses to subject-restricted focus sentences are indeed evidence of 'VP Scope' responses. We offer an account of why children differ from adults in analysing sentences with focus expressions, and how children jettison the non–adult analysis from their grammars. To recap, four questions need to be answered:

(i) Do all children pass through a stage in which they assign ‘VP Scope’, or is this assignment of focus restricted to English-speaking children?
(ii) Assuming that children assign a ‘VP Scope’ analysis to sentences with focus operators, at least in some languages, do children's initial non–adult analyses violate the c–command constraint exhibited in adult grammars?
(iii) What leads children to initially formulate a non–adult analysis of focus expressions?
(iv) How do children who hypothesise non–adult linguistic analyses converge on the grammar of the local language?

To answer these questions, we conducted three experimental studies of children's responses to sentences with focus expressions, in two languages. Our cross–linguistic experiments in English and Mandarin disconfirmed the proposal that children initially fail to generate contrast sets, and therefore do not compute the assertion meaning component of focus expressions.

The alternative account of children's non-adult behavior was confirmed in the present experimental investigations. Experiment 1 tested very young English–speaking children. The main finding was that the child subjects had abandoned ‘No Scope’ responses to sentences with *only* by around age 2;6. These children consistently produced ‘VP Scope’ responses, however, to sentences with pre–subject *only* in transitive clauses up to the end of testing, at around age 3. Experiment 2 tested child speakers of Mandarin Chinese. The main finding was that children produced non–adult ‘VP Scope’ responses up to age 5. Experiment 3 was a follow–up study designed to establish that the contexts used in Experiment 2, which we designed to be as neutral as possible, did not inadvertently favour an association of the focus expression with the object of the predicate phrase. The main finding was that, when contexts were heavily biased towards a subject reading of focus, Mandarin–speaking children’s non–adult behaviour rates dropped significantly. However, children's non–adult responses did not disappear entirely in Experiment 3, so we concluded that pragmatic factors alone were not the sole driving force behind children's non–adult behaviour. Based on the findings of these experiments, together with the findings from the previous literature in English and Mandarin, we concluded that the 'VP Scope' was indeed a common response by children acquiring these languages.

Moreover, research undertaken in yet another language, Japanese, also suggests that children's 'VP Scope' response may result from a 'universal tendency' for children to initially assign a non-adult analysis to focus expression across languages. Japanese has two different focus particles corresponding (roughly) to English *only*. These expressions are *–dake* and –*shika*. Both of these expressions are directly attached to the element in focus (i.e., as affixes). An investigation was undertaken by Endo (2004) with 32 3– to 6–year–old Japanese–speaking children. The child subjects were tested on both the *–dake* and *–shika* Japanese counterparts of English *only* sentences in two conditions. One condition tested the Japanese counterparts to English sentences like *The rabbit only took a yellow fish,* where the Japanese focus particles were attached to the object NP. The other condition tested the Japanese counterparts to English sentences like *Only the pig got an apple,* where the Japanese focus particles were attached to the subject NP. Examples of the subject focus sentences Endo used are given in (25) and (26) for *–dake* and *–shika* respectively. Sentences like (25) and (26) were presented in contexts which were either true or false for adults, but would always be false for children on a 'VP Scope' reading. For example, a true context for (25) was one in which a pig and another animal, say a cow, were picking fruit in a garden. The pig took an apple and some other fruit (say a banana), while the cow took two bananas. A false context for (25) was one in which the pig still took an apple and a banana, but the cow took two apples. In either of these contexts, if children erroneously assign focus to the VP, then they should reject (25) because the pig did not only take an apple, he also took a banana.

(25)	*Buta–san–dake–ga*	*ringo–o*	*tot–ta*
	pig–Mr–FOC–NOM	apple–ACC	get–PAST
	'Only the pig got an apple'		

(26)	*Panda–san–shika*	*ringo–o*	*tora–nakat–ta*
	panda–Mr– FOC	apple– ACC	get–NEG– PAST
	'Only the panda got an apple'		

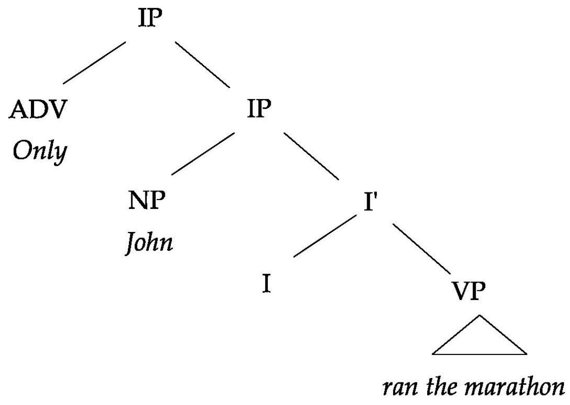
The main finding was that the child subjects responded correctly for the most part in response to sentences with *–shika* and *–dake* attached to the object NP (78–84% of the time, respectively). However, the same children often produced non–adult responses to sentences like (25) and (26) in which the focus particle was attached to the subject NP. In these cases, they rejected the sentences 60–68% of the time. Children justified their rejections on the grounds that the pig also got a banana, showing that children were assigning 'VP Scope' in the Endo study. These non–adult responses were spread evenly across *–dake* and *–shika* sentences, and across the three age groups that were studied (3, 4, and 5– to 6–year–olds).

In a review of the findings of the Endo study, Matsuoka et al. (2006) suggested that the presence of the nominative case marker in the Japanese *–dake* test sentences may have influenced the results, because the case marker encourages an 'exhaustive list' reading. These researchers reported the findings of an experiment showing that, when test sentences did not include the nominative case marker, Japanese–speaking children aged 4;7–6;10 produced adult–like responses to sentences in which *–dake* was attached to the subject NP. Twenty-nine of the 60 children in the experiment (evenly spread across the ages tested) successfully associated the focus operator with the subject NP 94% of the time. However, these researchers also found a fairly high percentage of erroneous 'NP Scope' responses to sentences where *–dake* was attached to the object. In responding to such sentences, 18 of the 60 children erroneously assigned focus to the subject NP 76% of the time. No adult data were given for comparison, nor were the test scenarios described in detail, so it is difficult to know whether or not the contexts may have favoured a subject focus interpretation (as in Paterson et al.'s 2003 study). Even taking the data at face value, it is not clear that the lack of the nominative case marker was responsible for children's high rate of success. Before it can be concluded that case marking influenced children's responses to sentences with *–dake,* control sentences without *–dake* would be needed to determine whether responses by children <u>and</u> adults to the presence and absence of the nominative case marker have the effect of promoting or demoting an exhaustive list reading. Moreover, accepting the conclusion that the case marker causes children to experience difficulty in processing *–dake* is tantamount to accepting that children do not process contrast sets, and accepting the conclusion that the children in Endo's (2004) study were responding to the declarative content of the presupposition (*The pig got an apple*), and rejecting the sentences because they did not provide an exhaustive description of the situation (e.g. *The pig got an apple and* *a banana*). This seems unlikely, however, given the converging evidence across languages demonstrating children's ability to process contrast sets from an early age. Matsuoka et al.'s line of reasoning also offers no explanation for Endo's (2004) *–shika* data, where the nominative case marker never appeared on the element marked by *–shika* because the subject of the sentence was a covert universal quantifier. For these reasons we do not find Matsuoka et al.'s objections to Endo's study entirely convincing.

We are therefore led to ask what these typologically different languages (English, Mandarin, and perhaps also Japanese) have in common, that could lead children to adopt a common non–adult response to sentences with subject-restricted focus expressions. One common feature is that these languages all have Subject–VP word order: SVO in the case of English and Mandarin Chinese (and SOV in the case of Japanese). In answer to the first question (i), then, we propose on the basis of our findings in English and Mandarin Chinese, that the 'VP Scope' response is not language–specific, but will appear at least in any SVO language. Moreover, we have presented some evidence from the literature to suggest the 'VP Scope' response appears in SOV languages like Japanese too, and it may well appear in other languages as well. This answer can, of course, be challenged by investigating languages with other properties, and this is a necessary next step in the development of our proposal.

This brings us to the second question. The 'VP Scope' non–adult behaviour was observed to occur in our experiments in English and Mandarin in pragmatically ambiguous contexts, i.e., in situations in which the association of focus with the subject and the object are both supported by the pragmatic context. Nonetheless, such responses continue to occur, albeit at reduced levels, when the pragmatic context encourages the association of the focus expression with the subject NP. Based on these observations, we proposed that the syntactic component of children's grammars contributes to these non–adult responses. In formulating an answer to the second question, our proposal is that children initially analyse focus adverbs as having sentential scope, as illustrated in (19), repeated here as (27).

(27)



Although our experiments were not specifically designed to probe this analysis of children's grammars, this proposal is consistent with our results. One motivation for this analysis is based on the observation that many other adverbs of quantification take sentential scope. It seems reasonable to hypothesise, therefore, that children could initially analyse a quantificational focus adverb like *only* in the same way as these other adverbs of quantification. It is pertinent to note that this proposal is consistent with the Continuity Hypothesis. According to the Continuity Hypothesis, child grammars are restricted to ones that are compatible with the class of possible adult grammars, as attested in the world's languages (e.g. Crain, 1991; Pinker, 1984).[18]

Because *only* c–commands both the Subject NP and the VP on the analysis we attribute to children, this analysis accounts for both the adult–like behaviour observed in certain experimental contexts, as well as for both types of non–adult behaviour that have been reported in the literature; (i) the 'VP Scope' behaviour of pre–subject focus expressions, and (ii) the occasional non–adult association of pre–VP focus expressions with the subject NP. Crucially, on our analysis, children's non–adult behaviour does not violate the c–command constraint on the association of focus operators. The c-command constraint governs both child and adult grammars.[19]

Of the non–adult behaviours reported, the 'VP Scope' response by children is attested far more often than the 'NP Scope' response (associating pre–VP focus with the subject NP). Moreover, the 'VP Scope' response occurs both in contexts that are neutral with respect to focus and in contexts that encourage children to access the adult–like reading, by strongly biasing the association of focus with the subject NP. Association with an element of the VP is thus a viable candidate as the default interpretive strategy for children, at least in SVO languages (and possibly in SOV languages too).

It is worth pointing out that in recent work with Mandarin–speaking children, Zhou & Crain (to appear) demonstrate that the presence of negation in the predicate phrase establishes a barrier to children's assignment of 'VP Scope' to the pre–subject focus expression *zhiyou*. For example, in negative constructions like *Zhiyou bai gou meiyou pa–shang da shu* ('Only the white dog didn't climb up the big tree'), children do not associate the focus element *zhiyou* with the object NP *da shu* ('big tree'). The explanation of this 'intervention effect' advanced by Zhou and Crain invokes the same analysis of focus expressions by children which we are advocating in the present paper, namely as sentential adverbs. The explanation advanced by Zhou and Crain draws upon Rizzi's (1990, 2001) Relativized Minimality Condition which states that local relations between two elements (in this case, the sentential adverb *zhiyou* and the object NP) are blocked if a third element (in this case, negation) intervenes. Crucially, the third element has the potential to intervene only if it is of the same structural type as the first element. On the present analysis, focus expressions initially reside in an A' position in child grammars. In Mandarin Chinese, negation also appears in an A' position, so it is expected to block the association between the focus particle and object of the VP in sentences like *Zhiyou bai gou meiyou pa–shang da shu* ('Only the white dog didn't climb up the big tree'). This explains why children do not associate the focus element *zhiyou* with the object NP *da shu* ('big tree') in such sentences.

We are now left to answer the third question, namely what leads children to formulate such an analysis with a default interpretive strategy of associating focus with the VP? There are several possibilities. One possibility is that children might attempt to align focus expressions with focus elements using the default prosodic structure of the local language or the default information structure of the language. Although the prosodic and information structure of clauses coincide in many languages, it is a matter of debate whether some languages use prosody to mark focus or not. This debate is beyond the scope of this paper so, in what follows, we will consider the prosodic and information structure of the clause as coinciding. We wish to note, however, that our proposal could be framed using information structure alone for some languages.

For this discussion, we adopt some terminology from Kiss (1998). We will refer to new information in a clause (as opposed to given information) as *information focus*. We will refer to a focus element singled out by a focus operator as *identity focus.* According to Reinhart's (2006) Interface Theory, both information focus and identity focus are marked prosodically across languages. That is, focus must bear the nuclear stress of the clause. Syntactic movement occurs in some languages precisely in order to place a focused constituent in the position where nuclear stress falls. However, if the syntax of the language prohibits focus movement, then stress shift is required. Adopting this perspective, it may be suggested that children initially associate focus operators like *only* with the canonical locus for information focus, which is typically expressed by the bearer of the intonation centre of the sentence. In the case of declarative sentences like the ones tested here (e.g. *Tigger only has a yo–yo*), the intonation centre is the final falling (or rising–falling) cadence of the sentence (Sgall, 1999), which corresponds to the VP in SVO and SOV languages. Marking the subject as the focus of an SVO or SOV language involves stress–shift (e.g. *Only TIGGER has a yo–yo*). In this case, we are suggesting some children may be able to over–ride their default preference for identity focus to coincide with the canonical locus for information focus if the context strongly encourages them to consider another interpretation, but other children may persist with their default interpretation, assigning focus to the VP.

Another area of research in which children's interpretation of focus marked by stress-shift has been investigated is in di-transitive structures like *John only gave SUPERMAN a banana*. Studies in English, Dutch, and Portuguese have shown that children can fail to interpret focus correctly within the VP when it is marked by stress–shift (Halbert, Crain, Shankweiler, & Woodams, 1995; Gualmini, Maciukaite & Crain, 2002; Szendröi, 2004; Costa & Szendröi, 2006). It was suggested by Reinhart (2004) that children are aware of the stress-shift in these cases, but are unable to carry out what she terms the *reference set computation* required to obtain the correct focus. According to Reinhart, the focus set of an utterance is defined as all the possible constituents of an utterance which also contain the main stress of the utterance. The possible focus set may be further restricted structurally by a focus operator like *only* which must c-command the element in focus. So, in a di-transitive construction like *John only gave Superman A BANANA* with neutral right-most stress, the focus set contains the direct object DP and the full VP. When focus is marked by stress-shift, as in *John only gave SUPERMAN a banana* the focus set contains the indirect object DP and the full VP. When adults interpret an *only* utterance with focus marked by stress-shift in this way, Reinhart suggests they compare the focus set of the stress-shift utterance {VP, indirect object NP} with a reference focus set of the same utterance pronounced with neutral stress {VP, direct object NP}. Any constituent which is available as a focus with neutral stress is then filtered out (because otherwise this focus could have been obtained without using stress-shift). In the case of the utterance *John only gave SUPERMAN a banana* this means the VP is filtered out of the stress-shift focus set, leaving only one option for the focus of the sentence: the indirect object IP, *Superman*.

The proposal advanced by Reinhart (2004) is that children have difficulty identifying the focus of stress-shift utterances of this type because children's working memory is not resourced well enough to hold two focus sets in memory, so as to execute the necessary checking operations. Faced with this memory limitation, children either resort to guessing or select some arbitrary default element from the stress-shift focus set {VP, indirect object NP}. In either case the result will manifest itself as a 50% adult-like response rate to sentences like *John only gave SUPERMAN a banana*. This kind of half-right/half-wrong behaviour has been found in several studies (Halbert, Crain, Shankweiler, & Woodams, 1995; Gualmini, Maciukaite & Crain, 2002). However, it is not always due to guessing, as Szendroi (2004) has shown. When data were examined by individual subjects, children were found to fall into two groups: (a) those who produced adult-like responses and (b) those who produced non-adult responses. Thus, it appears that, rather than guessing, children tend to adopt a default strategy in determining the focus in utterances involving stress-shift. In *John only gave SUPERMAN a banana*, the default might be revealed in children's responses as a strong tendency by some children to pick the indirect object NP as the focus (*Superman*), and so to appear adult-like, and for other children to pick the full VP as the focus (*gave Superman a banana*), and so to appear non-adult-like.

The hypothesis of reference set computation by Reinhart (2004) accounts nicely for children's non-adult responses to pre-VP *only* sentences with more than one choice of focus. However, it cannot be directly applied to the pre-subject *only* sentences tested in the present set of experiments, simply because the sentences we tested do not involve reference set computation. That is, utterances like *Only TIGGER has a yo-yo* in which stress-shift is involved have no possible counterpart with right-most neutral stress like *Only Tigger has a YO-YO*.[20] For adults, pre-subject *only* does not induce ambiguity in such sentences, because the only constituent c-commanded by *only* is *Tigger*. However, if children initially analyse *only* as a sentential adverb, then such sentences are ambiguous for children (as are sentences like *Tigger only has a yo-yo*). In both cases, children are faced with the possible focus set {full IP, subject NP, full VP, object NP}.[21] Moreover, the findings we reported reveal that children adopt a non-arbitrary strategy in resolving this focus set ambiguity, such that children choose to assign focus to the VP (or object NP) as a default[22], rather than to the subject NP (unless subject focus is strongly favoured by the context). We suggest that, at least in the case of pre-subject *only*, children assign focus to the VP because this aligns identity focus (focus marked explicitly by a focus adverb) with the neutral information structure of the sentence (in which focused information is typically expressed by the neutral intonation centre of the clause).[23]

It is pertinent to note that the analysis we have advanced entails that the default interpretation will not always associate the focus expression with the VP or an object within the VP. This will depend on the word order of the local language, and on the locus of nuclear stress in declarative sentences. For example, in European Portuguese, sentences with intransitive clauses have VS order, and such sentences are ambiguous for adults between focus on the subject or focus on the predicate, as illustrated in (28).

(28)	*Só*	*caio*	*o*	*Pooh*
	FOC	fell		Pooh
	'Only Pooh fell' or 'Pooh only fell'			

In this case, the subject is positioned at the end of the sentence, which is the locus of nuclear stress. Adult speakers show evidence of the ambiguity in a context in which only Pooh fell, but also did something other than fall: adults accept the sentence 67% of the time (also showing a preference for focus which coincides with nuclear stress), and reject it 33% of the time. Children, on the other hand, accept the same sentence 84% of the time in the same context (Costa & Szendröi, 2006). So in this case, although European Portuguese–speaking children are not assigning focus to the predicate, they are obeying the same prosodic principles which we are suggesting may lead English–speaking and Mandarin–speaking children to assign focus to the VP.

It would be interesting to test children acquiring a strictly SVO language like English with similar intransitive clauses (e.g. *Only Pooh fell*). Unlike Portuguese children, we might expect English–speaking children to preferentially assign focus to the VP in these cases.[24] To further explore this issue, research is also needed on children's acquisition of focus systems in subject–final languages. In these cases, we may find that the default value is actually the Subject NP rather than the VP.

A second possible explanation for children's default interpretive strategy to associate focus expressions with the VP is simply a generalization based on the fact that they analyse focus adverbs as sentential adverbs. Typically, sentential adverbs do not associate with the subject of a clause, so children may be led to initially analyse focus expressions as having the properties that are typical of the majority of sentential adverbs, namely as having scope over the verb phrase.[25] Of course, another possibility is that there is no universal pattern. Some children may choose to associate focus more frequently with the VP, while others choose to associate it with the Subject NP. We lack sufficient data to adjudicate between these possibilities, but there are some intriguing predictions to be tested.

The final question concerns language learnability. If children begin with a focus structure like that in (27), how do they converge on the adult grammar? Children require evidence that quantificational noun phrases (QNP) form a structural unit, distinct from a quantificational adverb modifying a VP. Here we stand on firmer ground. The evidence that children require for convergence on the adult grammar is simple and abundant. The requisite evidence is present, for example, in fragment answers to Wh–questions, as illustrated in (29) and (30) for English. Fragment QNP answers are acceptable, whereas fragment Q–VP answers are not. The same source of evidence is available in Mandarin Chinese, although fragments containing a focus adverb and a VP are also permissible in Mandarin, because understood subjects can be dropped, as illustrated in (31) and (32).

(29) Who ran the marathon?
Only John

(30) What did John do?
*Only ran the marathon

(31) *Shei* *pao–le* *malasong?*
Who run–ASP marathon?
'Who ran the marathon?'
Zhiyou Yuehan
FOC John
'Only John'

(32) *Yuehan* *zuo–le* *shenme?*
John do–ASP what?
'What did John do?'
Zhi *pao–le* *malasong*
FOC run–ASP marathon
'Only ran the marathon'

Since fragment answers are used as a linguistic test case for constituency, the acceptability of fragment answers, as in (29) and (31), constitutes positive evidence for children informing them that, when the adverb *only* occurs with a noun, it forms a constituent, similar to other constituents like DP or VP already in their phrase structure analyses. In English, this also contrasts directly with *only* in combination with a VP. We propose that children combine the use of positive evidence, such as fragment answers, with a uniqueness constraint on form/meaning correspondence. This uniqueness constraint is needed to purge children's grammars of the illicit (and unattested) default analysis, so as to converge on a grammar that is equivalent to that of adults. According to the uniqueness assumption, faced with a set of alternative structures (including children's initial hypothesis in which the focus particle occupies a sentential adjunct position, and an alternative hypothesis in which it occupies the Spec position of a quantificational NP), a child accepts only one of the structures, the one that is attested in the input, unless there is direct evidence that more than one structure is necessary (Berwick, 1985; Pinker, 1984; Wexler 1979).[26]

To conclude, we have presented new data from three cross–linguistic studies of children's acquisition of focus operators. We have offered an account of how children's grammars initially differ from those of adults, and why. The analysis we have advanced awaits confirmation or disconfirmation from the study of children acquiring other languages, especially ones that differ in word order from English and Mandarin Chinese. Until this research is conducted, we cannot determine whether the pattern we have witnessed in English and Mandarin is, in fact, universal. At this point, it seems that children initially associate focus with the canonical locus for new information in SVO languages, namely the VP (which is also typically the bearer of nuclear stress). We have proposed that children generate this analysis without threat of violating the c–command constraint on the assignment of focus, because they initially analyse the focus adverb *only* and its counterparts as a sentential adverb. Once children change their structural representations, in response to readily available positive evidence, they are able to converge on the adult grammar.

Endnotes

[1] We intend no theoretical commitments by adopting this terminology. We are simply borrowing terms that are in common usage, for discursive purposes.

[2] A constituent A c-commands another constituent B if there is a path from A that extends upward to the first branching node above A, and then downward to B. In (4), for example, a path can be traced upward from *only* to the branching node QNP, and then downward to *John*. Thus, *only* c-commands *John*. On the other hand, *only* does not c-command any material in the VP in (4), whereas it c-commands the entire VP in (5).

[3] Additional note not appearing in published version of this article: Some (but not all) English speakers also accept sentences like *John ran the marathon only* in which 'only' appears clause-finally. Although we will not discuss such constructions in the remainder of this paper, we wish to point out that such behaviour is in line with the broad syntactic analysis we are sketching here. For example, when 'only' takes the VP as its focus set, it can be seen as falling into Jackendoff's (1972) VP class of adverbs. One characteristic of this class of adverbs is that they either surface to the left of the main verb or clause-finally (e.g. John [$_{VP}$ easily ran the marathon]; John [$_{VP}$ ran the marathon easily]). Potsdam (1998) has proposed that this behaviour can be accounted for by assuming that VP-adverbs adjoin either to the left or right of V'. In our discussion we have sketched pre-verbal 'only' as adjoining to the left of VP, because this suffices for our purposes in demonstrating the difference between pre-subject and pre-verbal 'only'. However, the discussion still stands if the reader wishes to take pre-verbal 'only' as adjoining to the left (or right) of V'. These fine-grained syntactic issues are not critical here.

[4] To explain how the focus element X becomes available to the semantics, Chomsky (1976) proposes that the focus is assigned scope, such that X moves to the head of a focus phrase at logical form and a variable left behind at the original position is bound by a lambda operator.

[5] *Zhiyou* and *zhi* are two variants of the same focus operator, with the choice between them depending on the position of the focused element. *Zhiyou* is typically used to modify focused elements in subject position, whereas *zhi* is used to modify focused elements in the predicate phrase.

[6] Additional note not appearing in published version of this article: we are referring to the c-command domain of *shi*, which is the critical scope-bearing element in the *shi…de* construction.

[7] Additional note not appearing in published version of this article: The six pictures used were: (A) a fireman holding a hose and a policeman holding nothing, (B) a fireman holding nothing and a policeman holding a hose, (C) both a fireman and a policeman holding hoses, (D) a fireman holding a hose and a ladder and a policeman holding nothing, (E) a fireman holding a hose and a ladder and a policeman holding a hose, and (F) both a fireman and a policeman holding nothing. Reponses

uniquely consistent with a 'No Scope' analysis of the sentence 'Only the fireman is holding a hose' were ones in which participants erroneously judged pictures (C) and (E) to be true (as well as judging (A) and (D) true and (B) and (F) false), because it was true in pictures (C) and (E) that a fireman was holding a hose, even though it was false that only a fireman was holding a hose. Responses uniquely consistent with a 'VP Scope' analysis were ones in which participants erroneously judged picture (C) to be true and picture (D) to be false (as well as judging (A) true and (B), (E), and (F) false), because it was true in (C) and false in (D) that the only thing the fireman was holding was a hose, even though it was actually false in (C) and true in (D) that only a fireman was holding a hose. The rates of uniquely consistent response types were low, however, because many children (40-45%) gave response patterns across the 6 picture types that did not match any one kind of interpretation strategy.

[8] Additional note not appearing in published version of this article: Extra objects in the background would have provided a contrast set for associating focus with the object in the test sentences.

[9] Thanks to the careful controls introduced by Paterson et al., it is clear that these responses (5% from 4–5–year–old children) show an association of pre–subject *only* with the VP.

[10] This condition also included some intransitive predicate phrases like 'Only the mermaid is sleeping'.

[11] Additional note not appearing in the published version of this article: y/n-judgement questions were also sometimes posed in the form: 'Piglet only has a strawberry, is that right?'

[12] A control here was to ask a similar question in a context in which Piglet had a strawberry and a banana. Children who associate *only* with the VP should answer 'no' in this context and would be expected to justify this answer by mentioning the content of the VP. If so, this is evidence of an early 'VP scope' analysis of *only*.

[13] An example of a discarded trial from Ian's data set at age 2;8 involved five baby dolls. Two babies were given a strawberry and some lettuce, two were only given strawberries, and one was given a banana. The experimenter then asked "Who only has a banana?". This trial was discarded because no contrast set was present in the context. That is, there was no other baby with a banana and some other food in the array, so this trial does not allow us to determine whether Ian processed a contrast set or not in responding.

[14] Trials in which the child's first and subsequent responses differed were classified as 'Mismatch'. Since there were only 4 'Mismatch' responses across all data sets, these responses were added to the final category 'Other'.

[15] For Pam, we also included some inconclusive answers to Y/N–judgement questions in the category of 'Right' answers to act–out trials. These were ones in which she did not explicitly deny the test sentence (e.g. [Context: baby and doggy under a blanket], Exp: I think there's only a baby under

this blanket [uncovering blanket] Child: and a doggy). Similarly to correct act–out trials, such answers do not show us clearly whether or not Pam had constructed a contrast set (or was merely adding information to the experimenter's description of the situation). This step was taken so that the total number of correct judgement responses in Pam's graphs just represents cases in which she was processing the assertion.

[16] This type of context was not typical. Generally, there were always at least two characters with two kinds of object in each array. We explore the issue of context in a more controlled fashion in Experiment 3.

[17] Additional note not appearing in published version of this article: Zhou & Crain's study compares our results from Experiment 2 with the results of a new group of 20 children, who watched exactly the same stories as in Experiment 2, but then heard test sentences using *shi…de* instead of *zhiyou*. For example:

Shi	zhu	xiansheng	nadao-de	yinse	yingbi
FOC	pig	sir	get-DE	silver	coin

'It is Mr. Pig who got a silver coin.'

The group of children who heard these *shi…de* sentences behaved just like the group of children in Experiment 2, who heard the original *zhiyou* sentences. They rejected sentences like the one given, by pointing out that Mr. Pig also had a gold coin, showing a bias to associate focus with the VP. Statistical analyses further confirmed that there was no significant difference between the responses of children in the *shi…de* group (in either test condition) and the *zhiyou* group.

[18] Further support for this proposal would come from a demonstration that some sentential adverbs among the world's languages exhibit the meaning of *only*.

[19] Additional note not appearing in published version of this article: Kamil Ud Deen (personal communication) has suggested that an alternative explanation for children's responses to our test sentences might be that children treat 'only' as an adverb adjoined to the VP, which has floated to subject position in sentences like 'Only John ran the marathon'. We are grateful to him for this suggestion, which we believe to be a more syntactically specific variant of ours. We have proposed that children treat 'only' as a sentential adverb. We know that sentential adverbs like 'sometimes' can appear either clause-initially or before the VP (e.g. 'Sometimes John runs the marathon'; 'John sometimes runs the marathon'). In the syntax, it has thus been suggested that sentential adverbs can adjoin either at the level of the IP or the VP (Potsdam, 1998). In (27), we presented the syntactic analysis relevant to sentences like 'Only John ran the marathon' showing 'only' adjoining at the level

of the IP. Of course, if we are proposing that children misanalyse 'only' as a sentential adverb on par with an adverb like 'sometimes', then we would also expect 'only' to be adjoined at the level of the VP in sentences like 'John only ran the marathon'. Crucially, however, at a semantic level of analysis, both of these syntactic representations would correspond to an interpretation in which 'only' takes scope over the whole sentence, meaning either the subject NP 'John' or an element in the VP, like 'marathon' represent potential focus elements (although the interaction of the syntax and semantics might limit which of these is more likely for children in sentences in which 'only' occurs before the VP like 'John only ran the marathon'). A question we did not address is whether children might base-generate 'only' in a position adjoined to IP in sentences like 'Only John ran the marathon', or whether 'only' is first base-generated in a position adjoined to VP, and then moves to IP. One reason to favour a movement account would be to provide a possible syntactic explanation for why children seem to have an underlying bias to assign focus of pre-subject 'only' to the VP. Future work could look at trying to tease apart this explanation from one based on prosodic or information structure, which is the possibility that we pursue in the remainder of this discussion.

[20] A stress-shifted pre-subject *only* sentence that would involve a reference set computation is one like *Only the CHILDREN who ate their vegetables had any dessert*, in which the focus set could be compared to the focus set of an utterance like *Only the children who ate their VEGETABLES had any dessert*.

[21] It could be argued that if children are sensitive to stress-shift as Reinhart maintains, then, even with their non-adult syntactic analysis of *only*, they could still use the prosodic information in the test sentences to restrict the pre-subject *only* focus set to {full IP, subject NP}, whereas the pre-VP *only* focus set would be {full IP, full VP, object NP} (at least in English where we know stress-shift is used to mark focus). The data, however, do not support this view. We therefore suggest that in the case of focus marked both structurally by a focus adverb like *only* and prosodically, and where no reference set computation is involved, children and adults bypass using prosodic information, and construct their focus set based on structural cues.

[22] Our experiments were not aimed at determining whether children assign focus to the full VP or to an element within it.

[23] Additional note not appearing in published version of this article: According to our suggestion, we would expect children to respond to di-transitive sentences like 'Only John gave Superman a banana' in much the same way they have been shown to respond to sentences like 'John only gave Superman a banana' (e.g. Gualmini et al., 2002). The prediction would be that children could erroneously assign focus of pre-subject 'only' to the VP, and preferentially to the direct object 'a banana', which coincides with nuclear stress in the sentence. They could, of course, also correctly

assign focus of pre-subject 'only' to the subject (and this response should be strengthened in contexts designed to provide extra pragmatic support for this reading). What we might not expect to see is children choosing to assign focus to the indirect object 'Superman' within the VP (although this would also be a possibility for them given the grammatical analysis we are proposing). Testing children on these types of sentences could prove to be an interesting way to test our proposal.

[24] The locative clauses tested in the current English study, and in previous research (e.g. Donaldson & Llyod, 1974) made it very difficult to associate focus with the VP (e.g. *Only the red car is in the garage, Only the black dog is under the blanket*). In these cases there is no possible contrast set that could be constructed for something only being under the blanket, as opposed to being in two or more places at once.

[25] It might be argued that the data from VS sentences in Portuguese stand in conflict with this possibility, as there children clearly associated focus with the subject. However, structures such as the one cited in (31) are typically called unaccusative constructions. These occur for certain verbs, in which the logical subject of the sentence (e.g. Pooh) is thought to remain in the VP, rather than moving up to a Subject NP position. This is what yields the VS order. So, in such a case, when children associate the focus operator *só* with the logical subject, it could be argued that they are, in fact, still assigning focus to the structural VP.

[26] This analysis does not rule out the possibility that some children may use the evidence available in fragment answers to immediately access an adult-like grammar for *only*.

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Appendix A: Full Data-Sets for Experiment 1 by Trial Condition and Task Type

Ian – Stage I (2;5-2;8)

		Right (Judge)	Right (Act)	Wrong (No Scope)	Wrong (Possible VP Scope)	Other	Total Trials
Only-NP-VP_{LOC}	Act-Out		2	2			4
	Wh-Judge			2			2
	Y/N-Judge						
NP-Only-VP	Act-Out		4				4
	Wh-Judge			1			1
	Y/N-Judge						
							11

Ian - Stage II (2;9-3;1)

		Right (Judge)	Right (Act)	Wrong (No Scope)	Wrong (Possible VP Scope)	Other	Total Trials
Only-NP-VP_{LOC}	Act-Out					2	2
	Wh-Judge						
	Y/N-Judge	5				2	7
NP-Only-VP	Act-Out						
	Wh-Judge	12		1		5	18
	Y/N-Judge	1		2		2	5
Only-NP-VP_{TRANS}	Act-Out						
	Wh-Judge						
	Y/N-Judge				12	5	17
							49

Pam – Stage I (2;2-2;4)

		Right (Judge)	Right (Act)	Wrong (No Scope)	Wrong (Possible VP Scope)	Other	Total Trials
Only-NP-VP_{LOC}	Act-Out		2			1	3
	Wh-Judge						
	Y/N-Judge	1	3	1		5	10
NP-Only-VP	Act-Out			1		1	2
	Wh-Judge			1			1
	Y/N-Judge						
							16

Pam - Stage II (2;5-2;11)

		Right (Judge)	Right (Act)	Wrong (No Scope)	Wrong (Possible VP Scope)	Other	Total Trials
Only-NP-VP_{LOC}	Act-Out						
	Wh-Judge	1					1
	Y/N-Judge	5	4	1		7	17
NP-Only-VP	Act-Out					2	2
	Wh-Judge	29		4		4	37
	Y/N-Judge	4		1		3	8
Only-NP-VP_{TRANS}	Act-Out						
	Wh-Judge						
	Y/N-Judge	2			15	7	24
							88

Appendix B: Test Stimuli for Experiment 2

Test Stories

Story 1

Plot: This is a story about Piglet and Donald Duck. They are going to compete in a weight–lifting contest to see who is the stronger. They have to try and lift a banana and a car. Mr. Elephant is the winner of last year's competition, so this year he gets to be the judge. Now Piglet and Donald Duck are ready to try and lift the two things. Donald Duck comes to compete first. He thinks he is strong, so he starts with the heavier, the car. He goes to the car, stretches his wings and tries to lift the car. But he fails. Too bad. He must have slept too much this year. Then he tries the banana. This time he succeeds. Now it is Piglet's turn. He stretches all his muscles and comes directly to the car. Heave ho, heave ho. He makes a big effort to pick up the car. Oh, great job. He is now holding the car in the air. He made it. Then he goes to the banana and lifts it with one hand. Mr. Elephant declares that the winner is Piglet.

Test sentence:	*Zhiyou*	*Piglet*	*juqi–le*	*xiaoqiche*
	FOC	Piglet	lift–ASP	car
	'Only Piglet lifted the car'			

Story 2

Plot: This is a story about Mr. Turtle and Mr. Goat. They are going to have a swimming competition. At the far end of the pool there are three shells – two purple and one blue. They look so shiny. But only the one who swims faster can get these shells. Now Mr. Turtle and Mr. Goat are lined up at the start. Ready go! Mr. Turtle slips easily into the pool. Mr. Goat jumps into the pool too. Mr. Turtle is swimming really fast. Mr. Goat is not bad. He is right behind Mr. Turtle. But Mr. Turtle is really a good swimmer and now he is very close to the end of the pool. Mr. Turtle is so excited that he starts to sing (I am going to get all these shells…). But bad luck. When he is about to get to the finish line, he has a cramp. So he has to slow down. Just at this moment, Mr. Goat catches up to him and wins the game. Mr. Turtle is so sad. But Mr. Goat is really a good guy. He takes a blue shell and a purple shell, and leaves the other purple shell for Mr. Turtle. Mr. Turtle is now moved to tears.

Test sentence: *Zhiyou shanyan xiansheng nadao–le lanse beike*
FOC goat sir get–ASP blue shell
'Only Mr. Goat got a blue shell'

Story 3

Plot: This is a story about Mr. Horse and Mr. Pig. They are going to have a running race. At the far end of the track, there are three coins – two gold and one silver. They look so shiny. But only the one who runs faster can get these coins. Ready go! Mr. Horse and Mr. Pig start running. Mr. Horse is really a fast runner. He leaves Mr. Pig far behind him. But Mr. Pig is running really hard (Mr. Pig ate too much this morning and now he is too fat). Mr. Horse almost gets to the finish line. Now he feels kind of hungry and he thinks that Mr. Pig moves like a turtle, so he will have plenty of time. He goes to buy a cake without finishing the race. After eating a cake, Mr. Horse eats a banana. Now the food makes him sleepy and he decides to take a nap. When he wakes up, Mr. Pig has finished the race. Mr. Horse feels so sad that he can't help crying. But Mr. Pig is always a nice guy. He takes a gold coin and a silver coin, and leaves the other gold coin for Mr. Horse. Now a happy smile is on Mr. Horse's face.

Test sentence: *Zhiyou zhu xiansheng nadao–le yinse yingbi*
FOC pig sir get–ASP silver coin
'Only Mr Pig got a silver coin'

Story 4

Plot: This is a story about Mr. Monkey and Mr. Dog. Look. There are two oranges and one pear on this tree. They are now ripe and look tasty. Mr. Monkey and Mr. Dog are now under the tree. They are going to climb up the tree to pick these fruits. They start climbing. Mr. Monkey swings easily into the tree. He is really going fast. When he touches the top of the tree, Mr. Dog is still under the tree. He is having trouble getting into the branches. He has too many legs to think about. Every time he lifts his front paws up, his back paws slide off the branches. Mr. Monkey has already got a pear and an orange. When he is reaching for the other orange with his right foot, Mr. Dog suddenly has an idea. He is now shaking the tree very hard. Before long, the last orange drops off the tree and right into Mr. Dog's front paws. He has now got something to eat too.

Test sentence:	*Zhiyou*	*houzi*	*xiansheng*	*nadao–le*	*juzi*
	FOC	monkey	sir	get– ASP	orange
	'Only Mr. Monkey got an orange'				

Story 5

Plot: This is a story about two dwarfs. They are going to have a jumping game to see who is better. They have to jump over two things, a fence and a house. Dwarf 1 comes to compete first. He thinks that the fence would be too easy for him. So he starts with the house. He is now running towards the house. But as he gets closer, he realizes that it is much too high for him. He gives up. Then he tries the fence. It is easy. He clears the fence. Now comes Dwarf 2. He starts with the house too. He is doing some warm–ups. Ready go! He is getting closer. Wow, what a great jump! He made it. The fence is easy for him. He jumps over it without any effort. Dwarf 2 is a better jumper.

Test sentence:	*Zhiyou*	*dier–ge*	*xiaoairen*	*tiao–guo–le*	*liba*
	FOC	second– CL	dwarf	jump–over– ASP	fence
	'Only Dwarf 2 jumped over the fence'				

Story 6

Plot: This is a story about Mr. Cat and Mr. Rabbit. It is lunch time now. Mr. Cat and Mr. Rabbit come to Mr. Owl's restaurant. Two kinds of food are served here, fish and carrot. They are now ready to order. Mr. Cat wants a fish and Mr. Rabbit wants a carrot. These food are their favourites. They soon eat them up. But Mr. Rabbit feels like one more carrot. So he orders another one. When he is about to eat, he smells a fish–flavour from the carrot. He hates fish and he always thinks that fish will taste yucky. So he gives it to Mr. Cat. Mr. Cat likes this fish–flavoured carrot. He soon finishes it. Poor Mr. Rabbit. He is still hungry.

Test sentence:	*Zhiyou*	*mao*	*xiansheng*	*chi–le*	*huluobo*
	FOC	cat	sir	eat– ASP	carrot
	'Only Mr Cat ate a carrot'				

Filler stories

Story 1

Plot: This is a story about two rats (a white rat and a black rat). They both are very good at car racing. Today they are going to have a car racing game. Look. There is a big carrot on the way to the finish line. If someone hits the carrot, then he is out. Only the one who avoids the carrot and reaches the finish line will win the game. Now they are ready. Go! Their cars start running. The white rat is so excited that he doesn't see the carrot is right in front of him and his car bumps into the carrot directly. He is out. Too bad. He should have been more careful. The black cat is really good at this game. His car doesn't hit the big carrot. In a few minutes, he reaches the finish line. Good job. He is the winner.

Filler:	*Bai*	*laoshu*	*zhuangdao–le*	*huluobo,*	*hei*	*laoshu*	*meiyou*	*zhuangdao*
	white	rat	hit– ASP	carrot	black	rat	not	hit

'The white rat hit the carrot, but the black rat didn't hit the carrot'

Story 2

Plot: This is a story about Tigger and his two friends, the rabbit and the pig. They are going to play hide and seek. Tigger is very good at this game. He is always a good seeker. So this time he gets to be the seeker. Game starts. Tigger covers his eyes and starts counting to a hundred while the rabbit and the pig go hide. The rabbit hides himself under the tree. The pig tries to climb up the tree. But he is too fat. He has to give up. Then he tries to get into the house, but the door is too small for him. He sticks himself in the door. Now Tigger starts seeking. He first inspects the small tree, but he finds no one. Then he sees a tail in the door. It is the Pig. He found him. Now Tigger tries to find the rabbit. He examines the big tree, top of it, behind it, but he fails to find the rabbit. The rabbit is really well hidden. Tigger has to give up.

Filler:	*Tiaotiaohu*	*zhaodao–le*	*zhu,*	*danshi*	*meiyou*	*zhaodao*	*tuizi*
	Tigger	find– ASP	pig	but	not	find	rabbit

'Tigger found the pig, but he didn't find the rabbit'

Story 3

Plot: This is a story about three girls (G1, G2 and G3). They live in a small village. This morning their mother needs to work. When she leaves the house, she tells her three girls to remember to feed the dog and the cat. After G1 gets up, she feeds the cat a fish. When she is about to feed the dog, she feels hungry, so she goes to eat a cake, and then forgets to feed the dog. G2 feeds the cat after eating a cake, and when she is ready to feed the dog, her friend comes and they go out to play, and of course she forgets to feed the dog. G3 also feeds the cat a fish, and then she feels so sleepy that she forgets to feed the dog and goes to bed. Poor doggie. He is now hungry and needs a bone. So he walks into G3's bed and tries to make some noises. It works. G3 wakes up and sees the poor doggie. She then feeds the dog a bone. The dog is now enjoying his meal.

Filler:	*San–ge*	*nühai*	*dou*	*wei–le*	*gou,*	*danshi*	*dou*	*wang–le*
	three–CL	girl	all	feed– ASP	dog	but	all	forget–ASP
	wei	*mao*						
	feed	cat						

'The three girls fed the dog, but they forgot to feed the cat.'

Story 4

Plot: This is a story about a boy and a girl. They want to go shopping. But the shopping centre is far away from their home. So they decide to ride an animal to go there. They have two animals, a horse and a turtle. They want to ride the horse, because it runs much faster than the turtle. They try to get on the horse's back, but the horse is too tall. They try for several times, but all attempts fail. Now they decide to ride the turtle. This time it is much easier. They get on the turtle's back with no effort. The turtle starts moving towards the shopping centre slowly.

Filler:	*Nanhai*	*he*	*nühai*	*qizhe*	*ma*	*qu*	*mai*	*dongxi*	*le*
	boy	and	girl	ride	horse	go	buy	thing	ASP

'The boy and the girl rode a horse to go shopping.

Appendix C: Test Stimuli for Experiment 3

The stories used in Experiment 3 were similar to those used in Experiment 2. We changed the characters of the stories and the way of presenting them as outlined in the text. The test sentences are as follows. Fillers were similar to those used in Experiment 2.

Story 1

Test sentence:	*Shi*	*Chaoren*	*juqi–de*	*xiaoqiche*		
	FOC	Superman	lift–DE	car		
	'It is Superman who lifted the car.'					

Story 2

Test sentence:	*Shi*	*houzi*	*xiansheng*	*nadao–de*	*lanse*	*beike*
	FOC	monkey	sir	get– DE	blue	shell
	'It is Mr Monkey who got a blue shell'					

Story 3

Test sentence:	*Shi*	*maotouying*	*xiansheng*	*nadao–de*	*yinse*	*yingbi*
	FOC	owl	sir	get– DE	silver	coin
	'It is Mr Owl who got a silver coin'					

Story 4

Test sentence:	*Shi*	*kaola*	*xiansheng*	*nadao–de*	*juzi*
	FOC	koala	sir	get– DE	orange
	'It is Mr Koala who got an orange.'				

Story 5

Test sentence:	*Shi*	*tiaotiaohu*	*tiao–guo–de*	*liba*	
	FOC	Tigger	jump–over– DE		fence
	'It is Tigger who jumped over the fence.'				

Story 6

Test sentence:	*Shi*	*laoshu*	*xiansheng*	*chi–de*	*huluobo*
	FOC	rat	sir	eat– DE	carrot
	'It is Mr Rat who ate a carrot.'				

Moving from Chapter 3 to Chapter 4

In Chapter 3, we showed that English- and Mandarin-speaking children prefer to associate scope of pre-subject ONLY with the verb phrase. We proposed that children initially analyse ONLY as a sentential adverb dominating both the subject noun phrase (NP) and the verb phrase (VP) in the syntax. We also showed that the scope assignment children choose depends, in part, on the question-under discussion in the context, as would be predicted by the Question-Answer Requirement Model. However, there remains a default 'VP Scope' response for some children, even in contexts biased towards associating ONLY with the subject. The QAR Model offers no explanation of these responses. In this case, we suggested that children's underlying preference is driven by an attempt to align focus expressions and focus elements based on the information structure of the local language.

Because the 'VP Scope' error is so robust, it was important to be aware of it when designing our control study using pre-subject ONLY in Chapter 4. This control study examined English- and Mandarin-speaking children's interpretation of conjunction in sentences like *'Only Mickey Mouse ate both a carrot and a capsicum'*. For this control, the responses of any child making possible 'VP Scope' errors with pre-subject ONLY would be uninformative, so we included trials to identify those children. The rest of Chapter 4 returns to our main line of investigation, reporting on children's interpretation of conjunction in sentences like *'The elephant didn't eat both the carrot and the capsicum'*. Because the strong interpretation of these sentences is also the non-isomorphic one, the results of this study will allow us to adjudicate between the SSM and the Isomorphism Account in accounting for child scope preferences.

CHAPTER 4
Children's interpretation of conjunction in the scope of negation in English and Mandarin: new evidence for the Semantic Subset Maxim

This paper will be submitted for publication:

Notley, A., Zhou, P., Goro, T., & Crain, S. Children's interpretation of conjunction in the scope of negation in English and Mandarin: new evidence for the Semantic Subset Maxim.

I would like to acknowledge the roles of my co-authors. Peng Zhou ran the Mandarin-language experiments; Takuya Goro initiated the investigation by conducting a pilot study. His experimental design was adopted for Experiment 1. Stephen Crain reviewed drafts of the paper, and offered advice. I was otherwise responsible for all other aspects of testing and writing.

Abstract

This study tested 3- to 5-year-old English- and Mandarin-speaking children on their interpretation of sentences like *The elephant didn't eat both the carrot and the capsicum*. Adult English speakers favour a weak interpretation of such sentences, in which *not* scopes over *and* (i.e. the elephant probably ate one of the vegetables, but not both). In contrast, adult Mandarin speakers favour a strong interpretation of the Mandarin counterpart sentences, in which *and* scopes over *not* (i.e. it was both the carrot and the capsicum that the elephant did not eat; he ate neither of the vegetables). Despite these differences in adult interpretation, the Semantic Subset Maxim (Notley et al., 2012) predicts that children learning any language should initially prefer the subset strong reading of such sentences. Alternatively, the Isomorphism Account (Musolino et al., 2000) predicts that children should initially prefer to assign scope in line with the surface syntax of their language. Because negation is higher in the phrase structure than conjunction in both English and Mandarin, both groups of children would thus be expected to prefer the weak reading of the same sentences. We used a truth value judgement task to evaluate these predictions, and found that all children initially assigned a non-isomorphic strong interpretation to our test sentences.

1. Introduction

In 1994, Crain, Ni & Conway outlined a learnability problem that children could potentially encounter in the course of language acquisition. The problem could arise for ambiguous sentences, where one reading of the sentence asymmetrically entails the other reading. An example is the sentence *Every horse didn't jump over the fence*. When the universal quantifier 'every' takes scope over the negation operator 'not', the sentence entails that none of the horses jumped over the fence. On the other hand, when the negation operator 'not' takes scope over 'every', the sentence yields a broader range of truth conditions. The circumstances corresponding to the 'not > every' interpretation include the circumstance in which none of the horses jumped over the fence, as well as other circumstances where some of the horses, but not all of them, jumped over the fence. That is, when the sentence is true on the 'every > not' reading, it is also true on the 'not > every' reading. But the reverse does not hold, since there are circumstances that make the sentence true on the 'not > every' reading, but false on the 'every > not' reading. If one interpretation of an ambiguous sentence asymmetrically entails another interpretation, as in the situation we have just sketched, then the interpretation that makes the sentence true in the narrowest set of circumstances is called the 'strong' reading, and the interpretation that makes the sentence true in the broader range of circumstances is called the 'weak' reading. For the sentence *Every horse didn't jump over the fence,* the 'every > not' interpretation is the strong reading, and the 'not > every' interpretation is the weak reading.

With these preliminaries in mind, we can introduce the learnability problem identified by Crain et al. (1994). First, suppose that adult speakers of some language only assign the strong reading to negative statements with a universal quantifier. That is, suppose adults only assign the 'every > not' reading to the translation of the English sentence *Every horse didn't jump over the fence*. Suppose, also, that children initially hypothesise that negative statements with a universal quantifier are true on the weak reading ('not > every'). As we saw, both the strong reading and the weak reading make a negative statement with the universal quantifier true in one circumstance, where none of the horses jumped over the fence. Of course, for children, the same statement will be true in other circumstances, as well, in contrast to adults. The problem is: How will children find out that such negative statements are <u>only</u> true, for adults, in this one circumstance? All of the evidence children encounter will be consistent with their hypothesised weak reading. In order to revert to the strong reading, children would have to record the fact that adults do not use negative statements in certain circumstances, where these sentences are acceptable for children. But observing and mentally recording what does not happen is likely to be beyond the cognitive capacities of most adults, much less children. Moreover, we know that even when negative evidence of this type is made explicit to adults, only a small percentage of them actually manage to make use of such information in learning scenarios (Hovland & Weiss, 1953).

There is another way out of the dilemma. A child could produce a negative statement in one of the circumstances that makes the sentence true on the weak reading, but false on the strong reading. And the adult could come to the rescue, and provide feedback informing the child that they had said something that was false, because in the circumstance at least one horse had jumped over the fence. Although conceivable, it seems farfetched to believe that every child who hypothesised the weak reading could count on input from adults to provide such corrective feedback. Any child who is not fortunate enough to have such parental interactions, in sufficient quantities, would not converge on an equivalent grammar to that of other speakers of the local language. Since all children do in fact converge on grammars that are equivalent to those of adults, children are clearly able to circumvent this learnability problem. But how?

The proposal advanced by Crain et al. (1994) is that children circumvent the learnability problem by initially hypothesising the strong reading of these types of ambiguous sentences. This enables children to converge on the grammar of the local language, regardless of which reading is favoured by adults. Suppose, for example, that adult speakers of a language assign both strong and weak readings to negative statements with the universal quantifier. Then children who initially favour the strong reading will witness such statements being used in circumstances that are inconsistent with the strong reading. This would constitute positive evidence that adults allow the weak reading in addition to the strong reading. In view of these observations, Crain et al. (1994) proposed that children adhere to the Semantic Subset Principle, which was defined as follows:

> "if the interpretative component of Universal Grammar makes two interpretations, A and B, available for a sentence S, and if interpretation A makes S true in a narrower range of circumstances than interpretation B does, then interpretation A is hypothesized before B in the course of language development" (Crain et al., 1994, p. 455)

Some data originally suggested to support this formulation of the Semantic Subset Principle came from children's interpretation of sentences like *Every horse didn't jump over the fence* in English and Mandarin. As just discussed, English sentences of this form can receive both a strong and weak reading. By contrast, when such sentences are translated into other languages (e.g. Mandarin Chinese, or German), it is often claimed that only the strong reading is possible. One reason for this, it has been argued, is that languages like Mandarin Chinese have a structural constraint on scope relations that enforces an isomorphism between surface syntax and semantic interpretation.[1]

In view of the potential learnability problem that could confront children acquiring languages like Mandarin, the Semantic Subset Principle predicts that children acquiring all languages should initially assign the strong 'every > not' interpretation to the sentences under consideration, such that *Every horse didn't jump over the fence* should initially be judged to be true only in the circumstance in which no horse jumped over the fence. This would enable English-speaking children to add the weak reading in languages like English, where the sentence is also true on the weak reading, where not all horses jumped over the fence. Adult input could provide the evidence for the existence of the 'not > every' reading in the local language.

Experimental findings that were in line with the predictions of the Semantic Subset Principle were soon forthcoming. The first relevant findings were from a study with 5- and 6-year-old English-speaking children who were tested using sentences like *Every horse didn't jump over the fence*. The test sentences were presented in a context in which two horses managed to jump a fence, and one failed to make it over. So, the test sentences were true on the weak reading, which can be paraphrased as 'Not every horse jumped over the fence', but they were false on the strong reading, which can be paraphrased as 'None of the horses jumped over the fence'. The 5-year-old child subjects rejected the test sentences like *Every horse didn't jump over the fence*, 100% of the time. An older group of 6-year-old children rejected them 85% of the time. By contrast to both of these groups of children, adults accepted the same sentences 100% of the time (Musolino et al., 2000). Thus, English-speaking children appeared to have a strong preference to initially assign the strong reading to these sentences as predicted by the Semantic Subset Principle.

However, subsequent research called into question the predictions of the Semantic Subset Principle (SSP). It was shown that contextual manipulations could facilitate children's access to the weak reading of sentences like *Every horse didn't jump over the* *fence*. In a ground-breaking study, Gualmini (2005) demonstrated that English-speaking children who ranged in aged from 3;0 to 5;7 accessed the weak interpretation of such sentences 81% of the time when the experimental conditions made it more felicitous to interpret negation as taking scope over the universal quantifier. This was done by setting up the focus of the test stories to be whether or not all of the horses could make it over the fence. In another study, using similar contextual manipulations, it was found that Mandarin-speaking children aged 3;4-4;3 accessed both the weak reading (89% of the time) and the strong reading (100% of the time) of the Mandarin counterparts to sentences like *Every horse didn't jump over the fence* (Zhou & Crain, 2009). These studies show that children acquiring both English and Mandarin are not LIMITED to the strong reading of the target sentences.

These findings can be reconciled with the SSP if, across languages, negative sentences with a universal quantifier are deemed not to be in a superset-subset relationship. Pursuing this possibility, Zhou & Crain (2009) argue that the Mandarin sentences in question contain an additional focus operator that is lacking in the corresponding English sentences, and they contend that this operator is responsible for eliminating the weak interpretation. On this scenario, both children acquiring English and children acquiring Mandarin could initially hypothesise both strong and weak readings for negative statements with a universal quantifier. However, once children acquiring Mandarin master the semantics of the focus operator in Mandarin, the weak reading of the critical sentences is jettisoned from their grammars. On the other hand, because English lacks this focus operator, both readings remain intact.

Although this explanation rescues the Semantic Subset Principle (SSP) in this one case, it became reasonable to ask whether the learnability problem that the SSP is designed to solve ever arises. This question was posed by Musolino (2006), who concluded that it is unlikely that semantic subset problems exist. He proposed that children's independent knowledge of the syntax of their language allows them to determine whether or not various sentences are ambiguous, as was suggested to be the case in the study of Mandarin versus English reported in Zhou & Crain (2009). In response, Gualmini & Schwarz (2009) point out, however, that until an exhaustive search of ambiguities across all the world's languages has been conducted, it is premature to conclude that semantic subset problems do not exist.

Gualmini & Schwarz (2009) nonetheless argue that the SSP is not a necessary solution to the kind of learnability problem that was introduced by Crain et al. (1994).

These researchers explore other kinds of evidence children might exploit to eventually arrive at a strong reading of a sentence in cases where they have initially hypothesised only a weak reading. In fact, the solutions advanced by Gualmini & Schwarz are compatible with a reformulation of the Semantic Subset Principle. According to the reformulation we have in mind, the principle can be recast as a maxim for assigning preferences to alternative interpretative options, rather than as a categorical constraint on children's initial hypotheses in the course of language acquisition. We dub this reformulation of the SSP the Semantic Subset Maxim.

In the sections that follow we begin by stating the Semantic Subset Maxim. Then we review the current literature on children's scope preferences, showing that the findings are consistent with the predictions of this maxim. After that, we discuss an alternative proposal that has been advanced to account for children's scope preferences, called the Isomorphism Effect. It turns out that almost all of the current findings are also consistent with this explanation of children's scope preferences. To adjudicate between these alternative accounts, we have designed an experimental study involving sentences in which one scope reading asymmetrically entails the other. In the present study, we examine two logical connectives, negation and conjunction, using test sentence such as *The pig didn't eat both the carrot and the capsicum*. The experiment compares English- and Mandarin-speaking children's interpretation of these sentences. To anticipate the conclusion we reach, the findings support the Semantic Subset Maxim, and resist explanation based on the Isomorphism Effect.

1.1 The Semantic Subset Maxim (SSM)

The Semantic Subset Maxim (SSM) was first introduced by Notley, Zhou, Jensen & Crain (2012) . The SSM is expected to apply whenever two (or more) scope-bearing elements appear together in a sentence, and the scope relations between the operators result in a strong and a weak reading (where the strong reading asymmetrically entails the weak one). It is assumed that even if a language displays a strong preference for a particular scope assignment between two operators, the reverse scope assignment must remain theoretically available to speakers because it can normally be elicited with enough contextual or prosodic manipulation. Therefore, in contrast to the SSP, the SSM assumes that children will also have two (or more) interpretations initially available to them. The child's task then becomes to determine which of the available interpretations is preferred in the local language. Faced with this ambiguity, and if the two interpretations available form a subset-superset relationship, then the Semantic Subset Maxim enjoins children to initially favour the subset reading, i.e., the strong reading. Following the same logic as the SSP, children who subsequently witness circumstances in which the sentence is true on the superset reading, i.e., the weak reading, can add these circumstances to the truth conditions they associate with the ambiguous sentences in their grammars.

Proceeding in this way ensures that children follow the most EFFICIENT path in aligning their grammatical system with that of other members of the linguistic community, including preferences for resolving scope ambiguities. Based on positive evidence, children can rapidly align their preferences with those of adult speakers. On the other hand, if children were to initially favour the superset reading, then the majority of the input will be consistent with that interpretation, and the path towards alignment will be more circuitous.

1.2 Existing Evidence in Line with the SSM

This reformulation of the SSP is in line with the past findings on children's interpretation of sentences like *Every horse didn't jump over the fence*. That is, in the absence of contextual manipulations, we take the original research to show that English-speaking children have a preference for assigning the strong reading to sentences like this. Other research with children acquiring Mandarin lends further support to this conclusion. For example, some work has been done on 4-year-old Mandarin-speaking children's responses to the Mandarin counterparts of sentences like *Every rabbit is not eating carrots* (Fan, 2010). When these sentences were presented to children with no special contextual manipulations, children aged 4;2-4;11 accepted the test sentences 100% of the time in a context in which none of the rabbits in question was eating a carrot. By contrast, they accepted the same sentences only 27% of the time in contexts in which two were eating carrots and one was not. In other words, Mandarin-speaking children also initially show a preference for the strong reading of these sentences.

It has also been found that, even with contextual manipulations designed to boost the availability of the weak reading, English-speaking children aged 5;3-5;7 prefer to assign a strong reading to sentences like *Every cat didn't hide behind the sofa*. This finding contrasts with the finding that younger children (between 4;5-5;2) access both the strong and weak readings of such sentences (Conroy et al., 2009). This finding may initially appear puzzling, but it fits nicely with the predictions of the SSM. Children may have both scope readings available to them at an early stage in language development, but in attempting to systematically sort out the scope PREFERENCES of their local language, children pass through a stage in which they prefer the strong reading. This allows children to methodically determine whether their language also allows a weak reading.

The results of studies looking at children's interpretation of sentences containing negation and an existential quantifier like 'some' or 'a' also support the predictions of the SSM (e.g. *The detective didn't find some guys*). Actually, for English-speaking adults, sentences like *The detective didn't find some guys* only have one reading; 'some' must take scope over 'not'. The resulting meaning is that there were some guys that the detective didn't find (but, by implication, he probably also did find some guys). This is because 'some' is a PPI in English, a positive polarity item. Positive polarity items typically must not occur in the scope of negation. However, if children are not initially sensitive to this constraint on PPIs, then they could access two possible meanings of a sentence like *The detective didn't find some guys*. The first reading is the adult-like one (that there were some guys that the detective didn't find). This is the 'weak' reading because it is true if the detective did find some guys and not others, and also if the detective found no guys. The second reading is one in which 'not' takes scope over 'some'. In this case the sentence means that the detective didn't find any guys. This is the strong reading. Musolino et al. (2000) tested children on sentences like these. The sentences were delivered in contexts in which the strong reading was false, but the weak reading was true. For example, a detective looking for his four friends successfully found two of them, and failed to find two of them. The 30 children aged 3;10-6;6 could be divided into two groups based on the data. The younger group (aged 3;10-5;2) rejected the test sentences 65% of the time, while the older group (aged 5;2-6;6) rejected the test sentences 35% of the time. In contrast, the adult controls accepted the same sentences 100% of the time. These results again show that children initially display a preference for interpreting 'some' within the scope of negation, thereby assigning a strong interpretation to the test sentences (something adults never do). This is as predicted by the SSM.

This effect has also been found in Dutch for sentences like *De jongen heft een vis niet gevangen* 'The boy didn't catch a fish'. Dutch children were found to judge such sentences to be false 84% of the time in a context in which a boy caught two of three available fish. Dutch adults, on the other hand, always judged the same sentences to be true (Kramer, 2000). Similary, Lidz & Musolino (2005/2006) tested 24 Kannada-speaking children (aged 4;0-4;11) on their interpretation of sentences like (1) and (2) below.

(1) Avanu biskit tinn-al-illa
He cookie eat-INF-NEG
'He didn't eat a cookie'

(2) Avanu biskit-annu tinn-al-illa
He cookie-ACC eat-INF-NEG
'He didn't eat a cookie'

Sentence (1) has two possible interpretations for adults, a strong and a weak one. The strong reading is the one in which negation takes scope over the indefinite noun phrase, and the resulting meaning is that the character in question ate no cookies. The weak reading is the one in which the indefinite noun phrase takes scope over negation, and the resulting meaning is that there is a particular cookie that the character in question did not eat. Sentence (2), on the other hand, in which the indefinite noun phrase is additionally marked for accusative case, only has one reading, the weak one. So, for adults, sentence (2) can only mean that there is a particular cookie that the character in question did not eat. Nonetheless, the Kannada-speaking children interviewed by Lidz & Musolino consistently rejected sentences like (1) AND (2) in contexts that made the weak reading true, but falsified the strong reading (e.g. where Cookie Monster ate one of two cookies). The children only accepted sentences like (1) 23% of the time, and sentences like (2) 35% of the time, while adults accepted them between 88%-94% of the time.

We wish to note that, just like for negative statements with the universal quantifier, it has been shown that manipulating the context helps children access the weak reading of negative statements with the existential quantifier. Essentially, the contextual manipulations that need to be implemented are designed to satisfy the felicity conditions on the use of negation. To satisfy the felicity conditions for negation, there needs to be a mismatch between the final outcome of the story and the expected outcome. By manipulating the context in this way, Gualmini (2005) found that 15 English-speaking children (aged 4;01-5;06) were able to access the weak reading of sentences like *The troll didn't deliver some pizzas* 90% of the time. In this case, the expected outcome introduced earlier in the story was that the troll would deliver all the pizzas. However, the final outcome was that the troll delivered some, but not all of the pizzas. This final outcome made the sentence true on a weak reading. A recent proposal based on this finding is the Question-Answer Requirement model (Gualmini, 2007a, 2007b, 2008; Hulsey et al., 2004). This model predicts that children base their preferred interpretation of a scopally ambiguous sentence on whether it is a good answer to the 'question-under-discussion'. Further, only if both interpretations address the question, will children then choose the interpretation that makes the sentence true in the given context. In previous studies, children might have supposed that the question-under-discussion was whether or not the troll would deliver any of the pizzas. In this case the strong reading on which negation takes scope over the existential quantifier constitutes the best answer to this question: no pizzas were delivered by the troll. This reading was false in the context given and so children rejected the test sentences. In the 2005 Gualmini study, the question-under-discussion was explicitly set up to be whether or not the troll would deliver all of the pizzas. Now either scope interpretation would constitute a good answer to this question. On a strong reading the test sentence would be false in the context given since the troll did deliver some pizzas. On a weak reading, the test sentence would be true in the context given since the troll delivered some, but not all of the pizzas. Hulsey et al. (2004) argue that when both interpretations address the question-under-discussion then children will choose the scope interpretation which makes the test sentence true in the given context, in this case the weak reading. The fact remains, however, that without such contextual manipulations, children have been found to exhibit a preference for the strong reading.

Finally, the SSM is supported by studies investigating children's interpretation of sentences like *The pig didn't eat the carrot or the pepper* and *The dog reached the finish line before the turtle or the bunny* across languages. These sentences can be grouped together because they contain a downward entailing operator and disjunction ('or'). The class of downward entailing operators in natural language includes the negation operator and a wide range of other parts of speech, like the temporal conjunction 'before'. These expressions form a natural class in human languages because they allow inferences from general terms to more specific terms. For example, consider the statement *John did not learn a Romance language*. This statement contains negation ('not') and the general term 'Romance language'. If this statement is true, then it logically follows that the statement *John did not learn French* is also true, where the general term 'Romance language' has been replaced by the specific term 'French'.

When a downward entailing operator takes scope over disjunction, disjunction is assigned a conjunctive interpretation. For example, when negation is assigned scope over disjunction in the sentence *The pig didn't eat a carrot or a pepper*, the interpretation is that the pig did not eat either vegetable. On the other hand, if disjunction is assigned scope over negation, the interpretation is that the pig either didn't eat a carrot or didn't eat a pepper, and it's not clear which. These readings are in a subset-superset relationship. The strong reading is the one on which the pig ate neither vegetable since if this is true, then it is certainly true that the pig didn't eat one vegetable. English has a strong preference to assign the strong reading to sentences like this. Japanese, on the other hand, has a strong preference to assign the weak reading.

Turning to child language, it has been shown that both 3- to 5-year-old English-speaking and Japanese-speaking children pass through a stage at which they prefer the strong reading (Crain et al., 2002; Goro & Akiba, 2004a, 2004b; Gualmini, 2005; Gualmini & Crain, 2002, 2005). For example, 30 English-speaking children (aged 3;11-5;9) judged sentences like *The girl who stayed up late will not a get a dime or a jewel* to be false 92% of the time in contexts in which the girl who stayed up late received a jewel (Crain et al., 2002). Similarly, 30 Japanese-speaking children (aged 3;7-6;3) judged the Japanese translation of sentences like *The pig did not eat the carrot or the pepper* to be false 75% of the time in contexts in which the pig ate a carrot, even though Japanese-speaking adults always judged the same sentences to be true. In fact, four of the Japanese-speaking children were effectively adults and consistently accepted the sentences. When the data from these four children were removed, the rejection rate for the remaining 26 children was 87% (Goro & Akiba, 2004a, 2004b).

Similar results have been reported for English- and Mandarin-speaking children's interpretation of sentences like *The dog reached the finish line before the turtle or the bunny*. English has a strong preference to assign a strong reading to these sentences, on which the dog reached the finish line before both other participants. Mandarin allows for the same sentences to be assigned a weak reading, on which the dog arrived before one of the other participants, about 25-40% of the time. However, again, children acquiring either English or Mandarin have been shown to pass through a stage at which they prefer to assign the strong reading. Notley, Zhou, Jensen & Crain (2012) showed that 15 English-speaking children (aged 3;4-5;1) rejected test sentences like *The dog reached the finish line before the turtle or the bunny* 93% of the time in contexts in which the dog reached the finish line before the bunny, but after the turtle. The 14 younger Mandarin-speaking children tested (aged 4;6-4;7) also rejected the sentences, 100% of the time. This was in contrast to Mandarin-speaking adults who accepted the same sentences 25% of the time, and a group of 6 older Mandarin-speaking children (aged 5;0-5;4) who performed more like adults, accepting the test sentences 100% of the time (Notley et al., 2012).

1.3 The Semantic Subset Maxim vs. the Isomorphism Account

The evidence we have cited so far is all in line with the predictions of the SSM. It is, however, for the large part, also all in line with an alternative hypothesis predicting children's scope assignment preferences. This hypothesis, which we will call the Isomorphism Account, was introduced by Musolino et al. (2000) and predicts that children prefer to assign scope in line with the surface syntactic position of two logical operators. Note that it is the heirarchical precedence of one operator over the other in the phrase structure tree, rather than the linear precedence, that is thought to determine children's scope preferences (Lidz & Musolino, 2002). In turns out that in almost all of the sentence types we have discussed so far, the reading corresponding to the strong scope interpretation, the subset reading, is also the one that children would be expected to assign according to the Isomorphism Account. To quickly review, we list the sentence types below. In each case the scope reading in which the hierarchically higher operator takes wide scope over the lower operator is given in parentheses after the sentence. Note that, each time, this scope reading also corresponds to the strong interpretation of the sentence.

Examples (3)-(6) are from English and examples (7) and (8) are from Mandarin. Because English and Mandarin are analysed as right-branching languages, linear precedence mirrors hierarchical precedence. It is clear to see in all these examples that assigning wide scope to the first appearing operator in the sentence, the higher operator in the phrase structure, results in a strong reading of the sentence. Note that in (8), the Mandarin temporal conjunction corresponding to 'before' in English is made up of two particles: *zai…zhiqian* and that the Mandarin disjunction operator *huozhe* appears lower in the phrase structure than the first part of this temporal conjunction. Examples (9) and (10) are from Kannada and Japanese respectively. Because these are analysed as left-branching languages, negation again occupies a higher position relative to the verb phrase in the syntactic structure, even though it occurs later in the sentence.

(3) **Every horse** did **not** jump over the fence (every > not)

(4) The detective did **not** find **some guys** (not > some)

(5) The pig did **not** eat a **carrot or a pepper** (not > or)

(6) The **dog** reached the finish line before the **turtle or the bunny** (before > or)

(7)

Mei	zhi	xiaotuzi	dou	**bu**	zai	chi	huluobo
Every	CL	rabbit	all	NEG	-ing	eat	carrot

‘Every rabbit is not eating carrots’ (mei>bu)

(8)

Xiaogou	**zai**	**wugui**	**huozhe**		**tuzi**	**zhiqian**
dog	at	turtle	or	rabbit	before	
paodao-le	zhongdian					
reach-ASP	finish line					

‘The dog reached the finish line before the turtle or the bunny’
(zai…zhiqian > huozhe)

(9)

Avanu	**biskit**	tinn-al-**illa**
He	cookie	eat-INF-NEG

‘He didn’t eat a cookie’ (-illa > biskit)

(10)

Butasan-wa	**ninjin ka piiman-wo**	tabe-**nakat**-ta
pig-TOP	carrot or pepper-ACC	eat-NEG-Past

‘The pig did not eat the carrot or the pepper’ (-nakat > ka)

To recap, almost all of the evidence we have cited is compatible with both explanations of children’s scope assignment preferences. To demonstrate that children prefer the strong reading of sentences containing two scope-bearing elements when these elements are in an asymmetrical entailment relation, we need to look at their interpretation of sentences in which the strong reading and the isomorphic reading are not confounded. Currently, however, the available evidence is still quite limited. This study aims to add to the current literature, by looking at ways in which strong readings can be distinguished from isomorphic readings.

One piece of existing evidence that children prefer a strong reading rather than an isomorphic one comes from the Dutch data we discussed above. Although there are several differing structural analyses of Dutch sentences like (11), it is generally agreed that such sentences are examples of scrambling across negation. That is, the object NP (in this case *een vis* 'a fish') occupies a higher position than negation in the phrase structure (for a discussion of the different structural analyses see Unsworth, 2005). This means the Isomorphic Account would predict that children should prefer the weak reading of these sentences, the one on which there is a particular fish that the boy did not catch. Indeed, this is the reading assigned to these sentences by Dutch adults. However, children, as we have seen, prefer the strong reading, the one on which the boy caught no fish.

(11)	De	jongen	heft	**een**	**vis**	**niet**	gevangen
	The	boy	has	a	fish	not	caught
	'The boy didn't catch a fish' (een vis>niet)						

A few other studies have looked at children's interpretation of sentences in which negation appears higher in the clause structure than the universal quantifier in English (e.g. *The smurf didn't buy every orange*). According to the SSM, in the absence of contextual manipulations, children are still expected to prefer the strong reading of these sentences, the 'every > not' reading. In the case of the sentence *The smurf didn't buy every orange*, this would be a reading on which the smurf bought none of the oranges. However, on the Isomorphism Account, children would be expected to prefer the 'not > every' reading, according to which the smurf bought some oranges, but not all of them. Musolino (1999) tested 20 English-speaking children ranging in age from 3;11 to 6;0 (mean 4;11) on sentences like *The smurf didn't buy every orange.* This sentence was presented in context in which the smurf bought some oranges, but not all of them. The finding was that the children accepted the test sentences 85% of the time, showing they were certainly capable of accessing a weak 'not > every' interpretation. However, Musolino did not test children on contexts in which the smurf bought no oranges, which is needed to generate a comparison between acceptance rates in the two contexts.

In a separate study, Musolino & Lidz (2006) found that English-speaking children aged 5;0-5;10 (mean 5;4) accepted sentences like *The strong guy didn't put every* *elephant on the table* in contexts in which the strong guy put no elephants on the table 75% of the time, in contrast to adults who only accepted such sentences 20% of the time. However, in this study, no comparison was made with contexts in which the strong guy put some, but not all, of the elephants on the table. Until a study is conducted that compares the two possible readings, it is difficult to draw any conclusions. The SSM predicts that children should accept sentences like *The smurf didn't buy every orange* in 'every > not' contexts to a higher degree than they do in 'not > every' contexts.

Precisely this comparison has been recently documented in Mandarin. In Mandarin, as in English, negation occupies a higher position than the universal quantifier in the syntactic structure in sentences like (12).

(12)	Bu-shi mei-ge	xiaonühai	dou	chuan	qunzi
	not-be every-CL	girl	all	wear	skirt

'It is not every girl who is wearing a skirt'

Nonetheless, 15 Mandarin-speaking children aged 4;2-4;11 accepted sentences like (12) in contexts in which none of the girls were wearing skirts (they were all wearing pants) 87% of the time. The same sentences were accepted only 67% of the time in contexts in which two girls were wearing skirts, and one was wearing pants. This contrasted sharply with Mandarin-speaking adults, who accepted the sentences in an 'every > not' context only 38% of the time, but accepted the same sentences in a 'not > every' context 100% of the time (Fan, 2010).

Some other available evidence in support of the SSM over the Isomorphism Account comes from studies aimed at providing support for the Question-Answer Requirement model. The relevant sentences are passive constructions such as (13) and (14).

(13) Some pizzas were not delivered

(14) Some pizzas were not lost

These sentences were presented in a context in which a dwarf delivered two of four available pizzas, and in which the question-under-discussion was clearly set up to be whether the dwarf could deliver all the pizzas. According to the Question-Answer

Requirement model a sentence like (13) constitutes a good answer to the question-under-discussion on either of its scope interpretations, and so children are expected to access the scope interpretation that makes the sentence true. This is indeed what was observed, with 12 children aged 2;10-5;3 (mean 4;7) accepting sentences like (13) 94% of the time. This showed they were able to access the weak ‘some > not’ reading when context supported this reading. On the other hand, sentence (14) is infelicitous as an answer to the question-under-discussion. In this case (that is, without contextual manipulations supporting the true weak reading), the SSM would predict that children should prefer the strong reading, in which negation takes scope over the existential quantifier. This reading was false in the context given. The Isomorphism Account, on the other hand, would predict exactly the opposite pattern: children should prefer the weak reading, in which the existential quantifier takes scope over negation. This reading was true in the context given. It was found that 15 children aged 2;10-6;01 (mean 4;9) only accepted test sentences like (14) 43% of the time, compared to adults who accepted them 93% of the time (Hulsey et al., 2004). These data have been put forward in support of the Question-Answer Requirement model, but they are also good evidence for the SSM as opposed to the Isomorphism Account.

The present study is designed to provide further evidence that can assist in identifying the source of children’s scope assignment preferences, by adjudicating between the SSM and the Isomorphism Account. As we have seen, there is a growing body of evidence that children across languages initially assign downward entailing operators wide scope over disjunction in sentences like *The pig did not eat the carrot or the pepper* and *The dog reached the finish line before the turtle or the bunny*. We have argued that this scope assignment results in a conjunctive interpretation of disjunction, and therefore a strong reading of these sentences. The critical observation is that the opposite scope relations are anticipated when a downward entailing operator appears with conjunction, instead of disjunction. To see why, consider example (15) (previous example (5)), and the truth conditions stated in (16), as compared to (17).

(15) The pig did not eat the carrot or the pepper

(16) a. the pig ate neither vegetable
(not > or, the strong reading)
b. it is the carrot or the pepper (or possibly both) that the pig did not eat
(or > not, the weak reading)

As the truth conditions in (16) indicate, the strong reading of example (15) is the interpretation in which negation takes scope over disjunction. Now consider example (17), and the truth conditions stated in (18). The truth conditions stated in 18(a) reveal that, when negation takes scope over conjunction, the result is the weak reading of (17).

(17) The elephant did not eat both the carrot and the pepper

(18) a. The elephant did not eat both of the vegetables, just one (or possibly neither)
(not > and, the weak reading)
b. It is both the carrot and the pepper that the elephant did not eat (neither)
(and > not, the strong reading)

As we shall see in the results presented here, it turns out that adult English-speakers prefer the weak reading of (17), but adult Mandarin-speakers prefer the strong reading of the Mandarin counterpart to (17), which is given in (19).

(19)	Xiaoxiang	huluobo	he	qingjiao	dou	mei	chi
	elephant	carrot	and	capsicum	both	not	eat

'The elephant didn't eat both the carrot and the capsicum'

According to the SSM, both children acquiring Mandarin and children acquiring English should initially favour the strong reading, according to which the pig ate neither vegetable. Assigning this interpretation would bring Mandarin-speaking children's behaviour in line with that of adults. However, adhering to the SSM would lead English-speaking children to initially prefer the scope interpretation that is less preferred by English-speaking adults. This difference between child and adult English would stand in direct contrast to children's observed behaviour in interpreting sentences like (15). We have offered evidence that, in responding to sentences like (15), children across languages tend to prefer the English-like strong reading 16(a). Just the opposite prediction can be made for sentences like (17). Both English-speaking children and Mandarin-speaking children are expected to prefer the Mandarin-like strong reading, as in 18(b).

According to the Isomorphism Account, however, the opposite pattern of cross-linguistic behaviour would be anticipated. This is because the strong reading is diametrically opposed to the surface syntax in both English and in Mandarin. In sentences like (17) and (19) negation structurally dominates conjunction in the surface syntax. This means that on the Isomorphism Account, we would expect both groups of children to tend to prefer the English-like weak reading 18(a) of sentences like (17) and (19). If children adhere to the SSM, on the other hand, then the most efficient way for Mandarin- and English-speaking children to deal with the potential learnability problem instantiated in (17) is to initially favour the non-isomorphic interpretation according to which conjunction takes scope over negation. In the next section we outline two experiments that were designed to test the empirical adequacy of the predictions of the two accounts.

2. Experiment 1

2.1 Methodology: Experiment 1

2.1.1 Materials: Experiment 1

To test children's interpretation of conjunction in the semantic scope of negation, we adapted the truth value judgement task (TVJT) used by Goro & Akiba (2004a, 2004b) to test children's interpretation of disjunction in the semantic scope of negation. The TVJT is designed to investigate which meanings children can and cannot assign to sentences (Crain & Thornton, 1998). The task involves two experimenters – one acting out stories with toy characters and props, and the other playing the role of a puppet who watches the stories alongside the child. At the end of each story, the puppet explains to the child subject what he thinks happened in the story. The child's task is to decide whether the puppet said the right thing or not. If the child informs the puppet that he was wrong, then the child is asked to explain to the puppet what really happened.

Our task consisted of 8 short scenarios in which an animal was asked whether they were happy to eat a carrot and a green capsicum. If the animal in question decided to eat both vegetables, the child was asked to give the animal a gold medal. If the animal only ate one vegetable, the child was asked to give the animal a silver medal. If the animal ate neither vegetable, the child was asked to give the animal a black cross. Animals that didn't want to eat their vegetables had the option of placing these unwanted vegetables in a fridge or rubbish bin. This meant there were never any vegetables left in front of the animals. Once the last animal had finished eating, our puppet was then asked if he could remember what each animal had eaten, based on the medal it had received. There were 4 critical trials on which the animal had only eaten one vegetable and had therefore received a silver medal. An example of a critical trial is illustrated in Figures 1-3.

Figure 1: Elephant presented with choice of vegetables

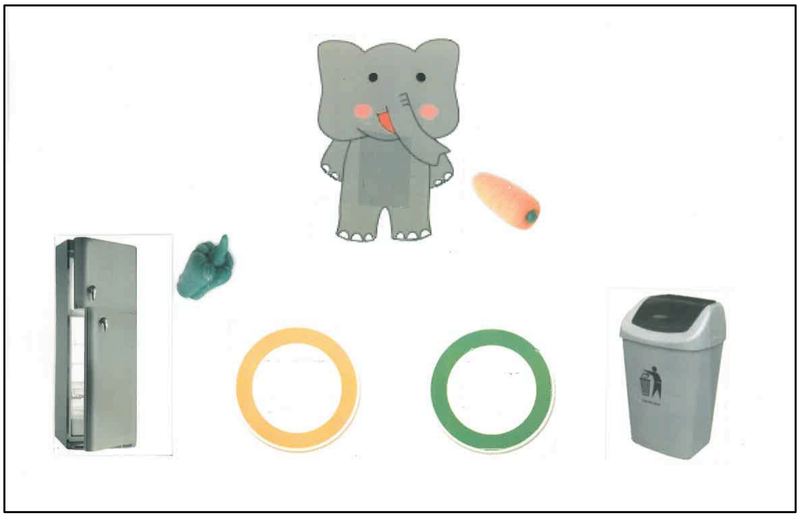

Figure 2: Elephant eats the carrot and puts the capsicum in fridge

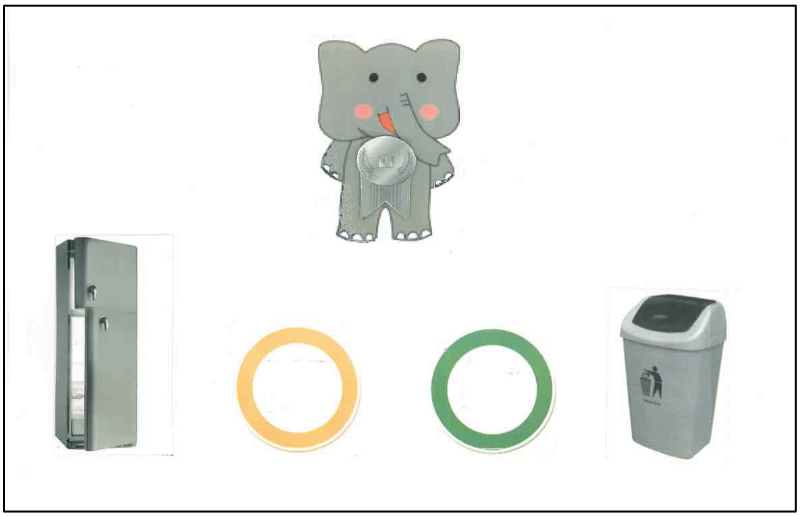

Figure 3: Elephant receives a silver medal

On the 4 critical trials the puppet uttered a test sentence like (20) in English or (21) or (22) in Mandarin

(20) The elephant didn't eat both the carrot and the capsicum

(21) Xiaoxiang meiyou chi huluobo he qingjiao
elephant not eat carrot and capsicum
'The elephant didn't eat the carrot and the capsicum'

(22) Xiaoxiang huluobo he qingjiao dou mei chi
elephant carrot and capsicum both not eat
'The elephant didn't eat both the carrot and the capsicum'

Two different structures were tested in Mandarin. The structures differed in the presence or absence of the quantificational adverb *dou* ('all' or 'both'). In (21), without *dou*, negation both precedes and is higher in the clause structure than conjunction. In (22), with *dou* contributing the meaning of the English particle *both*, conjunction precedes negation. Nonetheless, the conjoined noun phrase is still analysed as having been initially generated lower in the phrase structure tree than negation. If negation is assigned wide scope over conjunction, then sentences (20)–(22) mean that the elephant did not eat both vegetables, but could have eaten one of them, or possibly neither. Since the elephant ate a carrot, but not both a carrot and a capsicum, sentences (20)–(22) are true on this interpretation. On the other hand, if conjunction takes wide scope over negation, then sentences (20) – (22) mean that both of the vegetables are such that the elephant did not eat them. This is the ‘neither’ reading. Since the elephant ate the carrot, (20)–(22) are false on this interpretation.

As we noted in the introduction, to be felicitous, the use of a negative statement usually requires an explicit discrepancy between what is expected to happen in a story and what actually happens. In our stories, the animals were all expected to try to eat both vegetables and thereby receive the best reward, a gold medal. This made the use of negation felicitous for the test sentences, describing animals with silver medals who had not succeeded in eating both vegetables.[2]

The 4 critical trials were interspersed with 4 filler trials. On two filler trials the animal in question had eaten both vegetables. These were ‘Gold Medal Fillers’. On the other two filler trials the animal in question had eaten neither vegetable. These were ‘Black Cross Fillers’. The puppet uttered sentences like (23) and (24) in response to one ‘Gold Medal Filler’ and one ‘Black Cross Filler’ trial each.

(23) The panda didn’t eat anything

(24) The mouse ate everything

Sentences like (23) were false for ‘Gold Medal Filler’ trials, but true for ‘Black Cross Filler’ trials while sentences like (24) were true for ‘Gold Medal Filler’ trials and false for ‘Black Cross Filler’ trials. This meant there were a balanced number of true and false filler trials across the testing session. The fillers were included to check that the children were concentrating and could answer both ‘yes’ and ‘no’ correctly, and to obscure the purpose of the experiment. Children who failed more than one filler would be excluded from the data set.

Before commencing the testing session, each subject was introduced to our puppet and given two practice items. On one practice item our puppet made an obviously true statement about a story, and on the other he made an obviously false statement about the same story. This was so that the subjects would know that the puppet could say something wrong and to familiarise them with the task. The full list and ordering of practice, test, and filler sentences is given for English in Appendix A. The Mandarin materials were translated directly from the English ones.

2.1.2 Subjects: Experiment 1

We tested 21 English–speaking children (11 male, 10 female) between the ages of 3;10 and 5;6 (mean age 4;9) and 15 English–speaking adult controls (3 male, 12 female) between the ages of 19 and 38 (mean age 22). The English-speaking child subjects were recruited from two day-care centres at Macquarie University, Sydney, Australia, while the adult subjects were students at Macquarie University.

In addition, we tested 40 Mandarin-speaking children: 20 children (9 male, 11 female) between the ages of 4;1 and 4;8 (mean age 4;5) heard test sentences without *dou*, while the other 20 children (7 male, 13 female) between the ages of 4;1 and 4;7 (mean age 4;5) heard test sentences with *dou*. Forty Mandarin-speaking adult controls were also tested: 20 adults (12 male, 8 female) between the ages of 21 and 26 (mean age 24) heard test sentences without *dou*, while the other 20 adults (10 male, 10 female) between the ages of 23 and 27 (mean age 25) heard test sentences with *dou*. The Mandarin-speaking child subjects were recruited from the kindergarten at Beijing Language and Culture University, while the adult subjects were undergraduates at Beijing Language and Culture University. All subjects were tested individually.

2.2 Results: Experiment 1

All of the English-speaking and Mandarin-speaking children responded correctly to at least 3 out of 4 filler trials (2 English-speaking children failed to respond correctly in one filler trial each). Therefore, the responses to the test sentences by all of the children were included in the final data set. We coded each child subject's initial response to the test sentences. Self-corrections were accepted only if the test sentence had not been repeated. The children's justifications were also recorded. The data will be discussed by language.

2.2.1 English Results: Experiment 1

The 21 English-speaking children were presented with a total of 84 critical trials across subjects. The children rejected the test sentences on these trials 95% of the time (80/84 trials). A typical justification for these rejections from a child aged 4;4 is given in (25).

(25) Puppet: The lion didn't eat both the carrot and the capsicum

Child: No, he ate one thing

On 2 of the remaining 4 trials two different children rejected the test sentences, but justified their rejections by stating that the animal in question had eaten both vegetables. As this was not the case (the animal had only eaten one vegetable), these rejections were omitted from the final analysis. On the remaining 2 trials, one child aged 3;10 accepted the test sentences. These trials were included in the analysis.

The 15 English-speaking adults were presented with a total of 60 trials. The adults rejected these trials 28% of the time (17/60). The adults accepted the puppet's statements on the remaining 72% of the trials (43/60).[3] A Mann-Whitney test revealed a highly significant difference between the acceptance rates of English-speaking children versus adults ($Z = 4.63$, $p < .001$).

2.2.2 Mandarin Results: Experiment 1

The first group of 20 Mandarin-speaking children were presented with 80 critical trials without *dou*. The children rejected these trials 98% of the time (78/80). A typical justification for these rejections from one child aged 4;4 is given in (26). As the example indicates, Mandarin-speaking children rejected the test sentences on the same grounds as English-speaking children.

(26) Puppet: *Xiaoxiang meiyou chi huluobo he qingjiao*
'The elephant didn't eat the carrot and the capsicum'

Child: *Budui, ta chi-le huluobo*
'You're wrong, he ate a carrot'

The first group of 20 Mandarin-speaking adults were presented with a total of 80 sentences without *dou*. Similarly to the children, adults rejected the test sentences on these trials 95% of the time (76/80). One adult consistently accepted the target sentences. A Mann-Whitney test showed no significant difference between Mandarin-speaking children's and adult's acceptance rates to critical trials without *dou* ($Z = 0.036$, $p = 0.989$).

The second group of 20 Mandarin-speaking children were presented with 80 critical trials with *dou*. The children rejected the test sentences on these trials 99% of the time (79/80). A typical justification for these rejections from a child aged 4;5 is given in (27).

(27) Puppet: *Xiaoxiang huluobo he qingjiao dou mei chi*
'The elephant didn't eat both the carrot and the capsicum.'
Child: *Budui, ta zhi chi-le huluobo*
'You're wrong, he only ate a carrot'

The second group of 20 Mandarin-speaking adults who heard sentences with *dou* were presented with a total of 80 trials across subjects. The adults rejected these trials 100% of the time (80/80 trials). A Mann-Whitney test showed no significant difference between the acceptance rates of Mandarin-speaking children and adults to critical trials without *dou* ($Z = 1.00$, $p = 0.799$). Moreover, the presence or absence of *dou* (and the resulting different word orders) had no effect on children's or adult's responses. The two groups performed similarly in response to sentences of both types. Mann-Whitney tests confirmed there were no significant differences between the two groups of children's responses ($Z = 0.036$, $p = 0.989$) or the two groups of adult's responses ($Z = 1.00$, $p = 0.799$) in the two conditions. The English and Mandarin results are summarised in Table 1.

Test Item	English Children N=21	English Adults N=15	Mandarin Children N=20	Mandarin Adults N=20
English	2% (2/84 trials)	72% (43/60 trials)		
Mandarin without *Dou*			2% (2/80 trials)	5% (4/80 trials)
Mandarin with *Dou*			1% (1/80 trials)	0% (0/80 trials)

Table 1: English and Mandarin Acceptance Rates in Experiment 1

2.3 Discussion: Experiment 1

The results of Experiment 1 clearly support the predictions of the Semantic Subset Maxim, and not the Isomorphism Account. Recall that the SSM predicts that if children are presented with a scopally ambiguous sentence in which one interpretation asymmetrically entails the other, then they are expected to prefer the strong reading, the one which makes the sentence true in the narrowest set of circumstances, even if this reading is not an isomorphic one. We have shown that children acquiring both English and Mandarin Chinese do strongly prefer to assign conjunction wide scope over negation, thereby interpreting sentences like *The elephant didn't eat both the carrot and the capsicum* to mean that the elephant ate neither vegetable.

On the isomorphic account children would actually be expected to prefer to assign negation wide scope in English and in Mandarin sentences. Negation is the higher operator structurally in the English sentences, and in both types of Mandarin sentence, even though the absence or presence of the quantifier *dou* (English 'both') changes the linear relation between conjunction and negation in Mandarin. Briefly, when *dou* is present, the conjoined noun phrase is analysed as being base-generated in canonical object position (below negation) and is then moved to a pre-negation position, leaving a trace. Negation continues to occupy a higher position in the phrase structure relative to this trace. If negation were assigned wide scope in our test sentences, a weak reading would be accessed on which the elephant may have eaten a carrot or a capsicum or neither vegetable. Our test sentences were true on this weak reading because the elephant had eaten one vegetable, but not both. However all the children tested overwhelmingly rejected the sentences. This behaviour was similar to Mandarin-speaking adults, but was in clear contrast to English-speaking adults who showed a preference to accept the same sentences. Eventually, English-speaking children are expected to change their preferences in line with adults. Evidence for English-speaking adult's preference for the weak reading will be easy to accumulate as children only need to hear the target sentences used in contexts like the one tested here, which are false on the strong reading, but true on the weak reading.

This analysis of our results depends on children and adults having a Boolean interpretation of conjunction in relation to negation. That is, in Boolean logic, a statement like 'P and Q' is only true in one circumstance: if P is true and Q is true. The statement is false in the remaining three possible circumstances: if (i) P is true, but Q is not, (ii) Q is true, but P is not, or (iii) neither P nor Q is true. When Boolean conjunction is negated, these truth conditions are reversed. So 'not (P and Q)' is true in all three circumstances in which 'P and Q' is false, namely when either only P or Q is true, or when neither is true. It is the Boolean nature of conjunction that allows adult English-speakers to access a 'not both' reading in sentences like *The elephant didn't eat both the carrot and the capsicum*. Because 'not' is assigned scope over 'and', and because 'and' is interpreted as interacting in a Boolean way with negation, there are three conditions that make the sentence true: if (i) the elephant ate the carrot, but not the capsicum, (ii) the elephant ate the capsicum, but not the carrot, or (iii) the elephant ate neither vegetable. The only condition that falsifies the sentence on the 'not > and' scope assignment is the circumstance where the elephant ate both vegetables. In our critical trials, the elephant did eat one vegetable, making the sentences true if negation is assigned scope over conjunction. We have thus interpreted children's REJECTIONS of sentences like this as evidence that they interpret Boolean conjunction to take scope over negation.

However, it should be shown that children do indeed have a Boolean interpretation of conjunction in relation to negation. Without independently establishing the meaning children assign to conjunction, it might be possible to argue that their interpretation of a statement like 'not (P and Q)' is one which is true in only one circumstance, namely when neither P nor Q is true. It has been suggested that this kind of interpretation of conjunction can arise across languages when the conjuncts involved are definite noun phrases (rather than sentences, predicates, or quantified phrases), because the conjoined noun phrase can be interpreted as denoting a set or plurality (Hoeksema, 1988; Szabolcsi & Haddican, 2004). If children were interpreting the conjoined noun phrase *both the carrot and the capsicum* in our test sentences as denoting a plural, then regardless of what scope relations they assigned to negation and conjunction, they would interpret a test sentence like *The elephant didn't eat both the carrot and the capsicum* to mean that the elephant ate neither of the vegetables. On this view our data could still be in line with the predictions of the Isomorphism Account.

To rule out the possibility that children assign a non-Boolean interpretation to conjunction in relation to negation, we need to demonstrate that children have a Boolean 'not both' interpretation of conjunction under negation in some other linguistic context, when it combines definite noun phrases of the type used in Experiment 1. This can be accomplished by testing children's interpretation of sentences in which the wide scope reading of conjunction with respect to negation is cancelled. One environment that cancels scope effects is in what is called the assertion of a sentence with a focus expression such as *only*.

Before we examine sentences with focus expressions, consider the negative statement with the existential quantifier *some* in (28). The pertinent observation is that *some* takes scope over negation in (28). The meaning assigned to (29) can be paraphrased as: there were some oranges that the dwarf did not buy (but he probably did buy some oranges). If we want to state that there were no oranges that the dwarf bought, we could introduce the negative polarity item *any*, as in (29). A negative polarity item such as *any* must be interpreted within the scope of negation. Before we move on, notice the difference in meaning between (28) and (29).

(28) The dwarf didn't buy some oranges

(29) The dwarf didn't buy any oranges

Now compare the sentences in (30) and (31), where the focus expression *only* either precedes the existential quantifier *some* (30), or the negative polarity item *any* (31). These sentences mean the same thing. This shows that, in sentences with a focus expression, the existential quantifier *some* no longer takes scope over negation; it has the same distribution as a negative polarity item.

(30) Only the dwarf bought some oranges

(31) Only the dwarf bought any oranges

In sentences with *only*, as in (30) and (31), the meaning can be divided into two propositions. One proposition is about the dwarf – the dwarf bought some oranges. This proposition is called the presupposition. The presupposition is a proposition about the individual in focus, the dwarf. The second proposition is about a set of individuals in the conversational context that are being contrasted with the individual in focus. This second proposition is called the assertion. The assertion states that everyone in the contrast set lacks the property being attributed to the focus element, the dwarf. So the assertion is that everyone else did not buy any oranges. The two propositions associated with (30) are given in (32).

(32) Only the dwarf bought some oranges

a. The dwarf bought some oranges

b. For all individuals x such that x is not the dwarf, x did not buy some (= any) oranges

For the sentence under consideration to be true, both 32(a) and 32(b) must be true. So, in order to judge the truth of a statement with a focus expression, hearers must mentally construct a contrast set and check that the property being attributed to the individual that is in focus does NOT also hold for any member of the contrast set. The property being attributed to the dwarf is *bought some oranges*. This property uses the existential quantifier *some*. In the assertion, therefore, the negation of this property, *didn't buy some oranges*, must be true of everyone being contrasted with the dwarf. Notice, however, that despite the fact that English-speaking adults assign *some* scope over negation in negative statements such as (28), *The dwarf didn't buy some oranges,* when *some* appears in the assertion of a sentence with a focus expression, such as *Only the dwarf bought some oranges*, the meaning of *some* reduces to that of the negative polarity item, *any*. That is, it must be true that nobody else (being contrasted with the dwarf) bought any oranges. Crucially, the sentence *Only the dwarf bought some oranges* is false if anyone other than the smurf bought some of the oranges, even if they also failed to buy some.

This example illustrates that the assertion of a focus expression requires the elements within it to be interpreted within the scope of negation. We can thus use this linguistic environment to find out the exact meaning that children assign to conjunction, by placing conjunction in the scope of a focus expression, and then examining the assertion that is derived. The truth-value judgement task we designed to accomplish this is described in the next section.

3. Experiment 2

3.1 Methodology: Experiment 2

For this second study, the task consisted of 6 short test stories acted out in front of the subjects and a puppet using small toys. The stories centred around 3 characters, Mickey Mouse, Rabbit, and Tigger, who were participating in various activities together. There were 2 conditions depending on whether the statement the puppet made at the end of each story was true or false for adults. These will be called the Adult-True and Adult-False conditions respectively. An example of each is given below.

3.1.1 Materials: Experiment 2

<u>Adult-True Condition</u>

"Mickey Mouse, Rabbit and Tigger are going to do some magic tricks. They choose some magician's accessories from a set of magic trick boxes and white rabbits in front of them. Rabbit decides to choose a rabbit, Tigger chooses a box, and Mickey Mouse chooses a box and a rabbit."

The situation at the end of the story is illustrated in Figure 4.

Figure 4: Experiment 2 Adult-True Condition

At the end of the story, the puppet was asked if he knew who chose a box and a rabbit to do their magic trick. The puppet then produced a sentence like (33) in English containing the focus operator *only*. In Mandarin there were two versions of the test sentences, one with the quantificational adverb *dou* ('all'), and one without *dou*. Both contained the focus operator *zhiyou.* Examples are (34) and (35).

(33) Only Mickey Mouse chose both a box and a rabbit

(34)	Zhiyou	Milaoshu	xuan-le	hezi	he	tuzi
	Only	Mickey Mouse	choose-ASP	box	and	rabbit

‘Only Mickey Mouse chose a box and a rabbit’

(35)	Zhiyou	Milaoshu	hezi	he	tuzi	dou	xuan-le
	Only	Mickey Mouse	box	and	rabbit	both	choose-ASP

‘Only Mickey Mouse chose both a box and a rabbit’

The two meaning components of the English test sentence (33) are given in (36).

(36) a. Mickey Mouse chose both a box and a rabbit
b. For all individuals x such that x is not Mickey Mouse, x did not chose both a box and a rabbit

For (33) to be true, both 36(a) and 36(b) must be true. Hearers must mentally construct a contrast set (Tigger and Rabbit) to the focused individual and check that the background information contained in 36(a) does NOT hold for any members of this contrast set. Because the background information in 36(a) contains conjunction, this means the hearer must negate conjunction in checking whether 36(b) holds. As expected, although Mandarin- and English-speaking adults differ in their scope assignment preferences when negation appears overtly with conjunction (as in our test sentences in Experiment 1), in sentences like (33)-(35), adults speaking either language access the same interpretation, one in which covert negation is assigned scope over conjunction. This means the Boolean nature of conjunction for adults is revealed in both languages.

For example, adult speakers of either English or Mandarin judge sentences like (33)-(35) to be true in the context under consideration, since Mickey Mouse chose both a box and a rabbit, and neither Rabbit nor Tigger chose both items for their magic trick; they each chose just one of the items. They can only arrive at this reading if their interpretation of conjunction is Boolean. That is, if English ‘and’ (Mandarin *he*) is interpreted in a Boolean way, then sentences (34)-(35) are true if Mickey Mouse chooses both a box and a rabbit for his magic trick, and neither Rabbit nor Tigger choose both items for their magic tricks (Rabbit could choose one of these items, or neither; and the same must be true of Tigger). Children, like adults, are thus expected to judge these sentences to be true if their interpretation of conjunction in relation to negation is Boolean.

Suppose, on the other hand, that for children, the conjoined noun phrase *both a box and a rabbit* denotes a plural set in sentences (33)–(35). If so, then these sentences will only be true if Mickey Mouse chooses both a box and a rabbit, and Rabbit and Tigger chose neither item. On this interpretation, sentences (33)–(35) are actually false in the context under discussion, since both Rabbit and Tigger did choose one item each for their magic tricks. In short, if children reject test sentences (33)–(35), then they may not have a Boolean interpretation of conjunction. If they accept them, on the other hand, then we can conclude that they do have a Boolean interpretation of conjunction.

There are other possibilities to consider, however. One possibility is that children's acceptances show a failure to compute the contrast set altogether. On this supposition, sentences (33)–(35) would be true if Mickey Mouse chose both a box and a rabbit, regardless of what Rabbit and Tigger chose. In short, children who do not compute a contrast set could accept (33)–(35) on the strength of the presupposition alone.

Alternatively, children's acceptances could reveal a failure to correctly identify the subject NP as the focus element. In fact, there is mounting cross-linguistic evidence showing that, in contrast to adult speakers, young children compute contrast sets, but that they often associate a pre-subject focus operator with the verb phrase, or with the object NP, rather than with the subject NP (Crain et al., 1994; Jing, Crain, & Hsu, 2005; Notley, Zhou, Thornton, & Crain, 2009; Zhou & Crain, 2010). In the present case, this would mean that a child might interpret sentences like (33)–(35) to mean the only things that Mickey Mouse chose were a box and a rabbit. On this interpretation, sentences (33)–(35) would also be true in the context given. To check that children's acceptances of the Adult-True condition sentences were not due to a failure to compute contrast sets or to assign focus to the subject, we included 2 Adult-False condition sentences, which are illustrated below.

Adult-False Condition

"Mickey Mouse, Rabbit and Tigger are getting ready to have a music concert. They can choose what instrument they'd like to play from some bells and whistles in front of them. Mickey Mouse chooses a bell and a whistle, and so does Rabbit. Tigger chooses a bell."

The situation at the end of the story is illustrated in Figure 5.

Figure 5: Experiment 2 Adult-False Condition

At the end of the story, our puppet was asked if he knew who played a whistle and a bell at the music concert. The puppet then uttered a sentence like (37) in English or (38) or (39) in Mandarin.

(37) Only Rabbit played both a whistle and a bell

(38) Zhiyou tuzi wan-le shaozi he lingdang
only rabbit play-ASP whistle and bell
'Only the rabbit played a whistle and a bell'

(39) Zhiyou tuzi shaozi he lingdang dou wan-le
only rabbit whistle and bell both play-ASP
'Only the rabbit played both a whistle and a bell'

In these Adult-False scenarios, if Boolean conjunction is interpreted within the scope of covert negation, then (37) – (39) will be true if Rabbit did play both instruments, and so long as neither Tigger nor Mickey Mouse played both instruments (Tigger could have played one of the instruments, or neither; and the same must be true of Mickey Mouse). This is the interpretation assigned to (37) by English-speaking adults and to (38) and (39) by Mandarin-speaking adults. On this interpretation, (37) – (39) are false in the context given because Mickey Mouse played both a whistle and a bell, in addition to Rabbit.

If, on the other hand, children initially interpret the conjoined noun phrase *both a whistle and a bell* as denoting a plural set, then (37) – (39) will only be true if Rabbit did play both instruments, and Tigger and Mickey Mouse played neither instrument. On this interpretation (37) – (39) are also false in the context given because both Mickey Mouse and Tigger did play instruments.

The Adult-False scenarios thus do not allow us to determine whether children have a Boolean interpretation of conjunction in relation to negation. In either case, children are expected to reject the test sentences. However, the Adult-False scenarios do allow us to determine if children are computing contrast sets, and are using the assertion in deciding on the truth-value of the test sentences. Because the presupposition was true in the scenarios we presented to children, if they only access the presupposition of the Adult-False test sentences, then they should accept these sentences. For example, in the context corresponding to (37)–(39), it was true that Rabbit played both a whistle and a bell. In addition, the Adult-False scenarios allow us to determine whether or not children are associating the pre-subject focus operator (English 'only'; Mandarin *zhiyou*) to the subject NP. A child who erroneously assigns focus to the VP should also accept these test sentences. For example, it was true that the only things that Rabbit played were a whistle and a bell. There was never a third kind of object in our scenarios.

So, a pattern of true responses across both conditions will show that children are either failing to compute a contrast set or failing to correctly assign focus to the subject. These children's responses will be non-revealing for our purposes. On the other hand, a pattern of true responses to Adult-True scenarios accompanied by false responses to Adult-False scenarios will show that children are correctly interpreting the focus operator, and that they must have the Boolean interpretation of conjunction. A pattern of false responses in both conditions will be taken as evidence that children are assigning the correct meaning to the focus operator, but that they lack the Boolean interpretation of conjunction in relation to negation in these contexts.

The 4 Adult-True trials and 2 Adult-False trials were administered in a pseudo-random order, interspersed with 6 filler sentences. The fillers were sentences like (40) which did not include 'only' or conjunction.

(40) Tigger chose a box

The fillers were included to balance the number of true and false responses across the testing session, to check that the children were concentrating and could answer both 'yes' and 'no' correctly, and to obscure the purpose of the experiment. Children who failed more than one filler would be excluded from the data set.

Before commencing the testing session, each subject was introduced to our puppet and given two practice items. On one practice item our puppet made an obviously true statement about a story, and on the other he made an obviously false statement about the same story. This was so that the subjects would know that the puppet could say something wrong and to familiarise them with the task. The full list and ordering of practice, test, and filler sentences for Experiment 2 is given for English in Appendix A. The Mandarin materials were translated directly from the English ones.

3.1.2 Subjects: Experiment 2

We tested 18 English–speaking children (9 male, 9 female) between the ages of 3;2 and 5;1 (mean age 4;3) and 13 English–speaking adult controls (2 male, 11 female) between the ages of 19 and 38 (mean age 22). The English-speaking child subjects were recruited from a day-care centre at Macquarie University, Sydney, Australia. The adult subjects were students at Macquarie University.

In addition, we tested 38 Mandarin-speaking children. One group of 20 children (8 male, 12 female) between the ages of 4;2 and 5;1 (mean age 4;6) were presented test sentences without *dou*. A second group of 18 children (10 male, 8 female) between the ages of 4;3 and 5;2 (mean age 4;7) were presented test sentences with *dou*. Thirty-eight Mandarin-speaking adult controls were also tested. One group of 20 adults (13 male, 7 female) between the ages of 21 and 26 (mean age 24) heard sentences without *dou*, and another group of 18 adults (6 male, 12 female) between the ages of 22 and 26 (mean age 23) heard test sentences with *dou*. The Mandarin-speaking child subjects were recruited from the kindergarten at Beijing Language and Culture University, while the adult subjects were undergraduate students at Beijing Language and Culture University. All subjects were tested individually.

3.2 Results: Experiment 2

One English-speaking child failed more than one filler and has been excluded from the data set. The remaining 17 children (9 male, 8 female) ranged in age from 3;6 to 5;1 (mean age 4;4). All of the Mandarin-speaking children correctly responded to all fillers. We coded each subject's initial response to the test sentences. Self-corrections were accepted only if the test sentence had not been repeated. The children's justifications were also taken into consideration when coding the data. Rejections for which irrelevant justifications were offered were not included in the final counts. The data will be discussed by language.

3.2.1 English Results: Experiment 2

The 17 English-speaking children responded to 68 Adult-True condition sentences, and 34 Adult-False sentences across children. As a single group, the children accepted their Adult-True sentences 90% of the time (60/68 trials), but rejected their Adult-False sentences only 53% of the time (18/34 trials). We can, however, divide the English-speaking children into 2 clear groups based on their response patterns. The first group consisted of children who largely accepted their Adult-True sentences and rejected their Adult-False sentences. This group was made up of 10 children (5 male, 5 female) aged 3;6-5;1 (mean age 4;4). These children accepted their true trials 88% of the time (35/40 trials) and rejected their false trials 90% of the time (18/20 trials). They gave reasons for these rejections referring to the fact that another character in the context had also done both things in question. An example of this from a child aged 4;10 is given in (41).

(41) Puppet: Only Tigger found both a sea plant and a shell
Child: But it was Tigger and Rabbit
Experimenter: So was Cookie Monster right or wrong?
Child: Wrong

The results of these children show that when *only* is correctly interpreted, then conjunction is definitely assigned a Boolean interpretation. The second group consisted of children who largely accepted both their Adult-True and Adult-False sentences. This group was made up of 7 children (4 male, 3 female) aged 4;0-4;10 (mean age 4;5). These children accepted their Adult-True sentences 90% of the time (25/28 trials) and also accepted their Adult-False sentences 100% of the time (14/14 trials). The results of these children cannot be used to determine how they interpret *and*, because they are having difficulty correctly interpreting *only* at this stage. Importantly, however, no child tested rejected both Adult-True and Adult-False condition sentences, which could have shown that they do not initially assign Boolean truth conditions to conjunction.

The 13 English-speaking adults responded to 52 Adult-True condition sentences, and 26 Adult-False sentences across adults. They accepted their Adult-True sentences 100% of the time (52/52 trials), and rejected their Adult-False sentences 96% of the time (25/26 trials), pointing out that another character in the context had also done both things in question. On the 1 remaining Adult-False trial, one subject did reject the trial, but gave reasons for this rejection that were not related to one of the other characters in the context also having done both things in question. This was probably due to a lapse in concentration. This trial has thus not been included in the final count of adult rejections. A Mann-Whitney test showed no significant difference between the first group of children's and adult's acceptance rates to the crucial Adult-True trials ($Z = 2.067$, $p = .232$). These results are summarised in Table 2.

	Children Gp.1 N=10	Children Gp. 2 N=7	Children Total N=17	Adults N=13
Adult-True	88% (35/40 trials)	90% (25/28 trials)	90% (60/68 trials)	100% (52/52 trials)
Adult-False	10% (2/20 trials)	85% (12/14 trials)	41% (14/34 trials)	0% (0/26 trials)

Table 2: English Acceptance Rates in Experiment 2

3.2.2 Mandarin Results: Experiment 2

The first 20 Mandarin-speaking children responded to a total of 80 Adult-True trials and 40 Adult-False trials without *dou* across subjects. As a single group, the children accepted their Adult-True trials 90% of the time (72/80 trials), and rejected their Adult-False trials 70% of the time (28/40 trials). Again, the children could be divided into two clear groups. The first group consisted of 14 children (3 male, 11 female) aged 4;3 to 5;1 (mean age 4;7). This group accepted their Adult-True trials 86% of the time (48/56 trials) and rejected their Adult-False trials 100% of the time (28/28 trials). They gave reasons for these rejections related to the fact that another character in the context had also done both things in question. An example of this from a child aged 4;7 is given in (42).

(42) Puppet: *Zhiyou Tiaotiaohu zhaodao-le haicao he beike*
‘Only Tigger found a sea plant and a shell’
Child: *Budui, Xiaozhu ye zhaodao-le haicao he beike*
‘Wrong, Piglet also found a sea plant and a shell’

The results of these children again show that when *zhiyou* is correctly interpreted, then conjunction is typically assigned a Boolean interpretation. Two children in this group did, however, consistently reject their Adult-True trials, giving reasons for their rejections like (43). This was the kind of justification we expected if children did not initially assign Boolean truth conditions to *he* (English ‘and’).

(43) *Budui. Tiaotiaohu xuan-le yi-ge hezi, xiaozhu xuan-le yi-le tuzi.*
'Wrong. Tigger chose a box, and Piglet chose a rabbit.'

The second group was made up of 6 children (5 male, 1 female) aged 4;2 to 4;9 (mean age 4;7). These children accepted their Adult-True sentences 100% of the time (24/24 trials) and also accepted their Adult-False sentences 100% of the time (12/12 trials). The results of these children cannot be used to determine how they interpret *he* (English ‘and’), because they are having difficulty correctly interpreting *zhiyou* (English ‘only’) at this stage.

The 20 Mandarin-speaking adults who heard sentences without *dou* were presented with a total of 80 Adult-True trials and 40 Adult-False trials across subjects. The adults accepted their Adult-True trials 90% of the time (72/80 trials), and rejected their Adult-False trials 100% of the time (40/40 trials), pointing out that another character in the context had also done both things in question. It is interesting to note that 2 adults did reject all their Adult-True trials, as well as their Adult-False trials. Their reasons for rejecting the Adult-True trials showed they were interpreting the Mandarin equivalent of a sentence like *Only Mickey Mouse chose a box and a rabbit* to mean nobody else in the context chose either of the things that Mickey Mouse chose. For example, they pointed out that Tigger had chosen a box and Rabbit had chosen a rabbit. Similarly to the 2 children who gave answers like (43) to their Adult-True trials, this was the response we predicted if hearers did not assign *he* (English 'and') Boolean truth conditions. We will return to this in the discussion of Experiment 2. In any case, A Mann-Whitney test showed no significant difference between the first group of children's and adult's acceptance rates to the crucial Adult-True trials in Mandarin, in response to sentences without *dou* ($Z = 0.376$, $p = 0.8491$). These results are summarised in Table 3.

	Children Gp.1 N=14	Children Gp. 2 N=6	Children Total N=20	Adults N=20
Adult-True	86% (48/56 trials)	100% (24/24 trials)	90% (72/80 trials)	90% (72/80 trials)
Adult-False	0% (0/28 trials)	100% (12/12 trials)	30% (12/40 trials)	0% (0/40 trials)

Table 3: Mandarin Acceptance Rates to Sentences Without *Dou* in Experiment 2

The second group of 18 Mandarin-speaking children were presented with a total of 72 Adult-True trials and 36 Adult-False trials with *dou* across subjects. As a single group, the children accepted their Adult-True trials 100% of the time (72/72 trials), and rejected their Adult-False trials 72% of the time (26/36 trials). Once again, the children could be divided into two clear groups. The first group consisted of 13 children (6 male, 7 female) aged 4;3 to 5;2 (mean age 4;7). These children accepted their Adult-True trials 100% of the time (52/52 trials) and rejected their Adult-False trials 100% of the time (26/26 trials). As in the first condition without *dou*, children's justifications for their rejections referred to the fact that another character in the context had also done both things in question. The second group consisted of 5 children (4 male, 1 female) aged 4;4 to 5;1 (mean age 4;7). These children accepted their Adult-True trials 100% of the time (20/20 trials), and also accepted their Adult-False trials 100% of the time (0/10 trials). The results of these children cannot be used to determine how they interpret *he* (English 'and'), because they are having difficulty correctly interpreting *zhiyou* (English 'only') at this stage. Importantly, when sentences like the ones tested here included *dou* then no child tested rejected both Adult-True and Adult-False condition sentences.

The 18 Mandarin-speaking adults who heard sentences with *dou* were presented with a total of 72 Adult-True trials and 36 Adult-False trials with *dou* across subjects. The adults accepted their Adult-True trials 100% of the time (72/72 trials) and rejected their Adult-False trials 100% of the time (36/36 trials). Again, when sentences like the ones tested here included *dou*, adults clearly showed a Boolean interpretation of *he*

(English 'and'). As the first group of children and adults performed identically in this version of the task, a Mann Whitney test revealed no significant differences between the two groups' acceptance rates to the critical Adult-True trials ($Z = 0.850$, $p = 0.798$). These results are summarised in Table 4.

	Children Gp.1 N=13	Children Gp. 2 N=5	Children Total N=18	Adults N=18
Adult-True	100% (52/52 trials)	100% (20/20 trials)	100% (72/72 trials)	100% (72/72 trials)
Adult-False	0% (0/26 trials)	100% (10/10 trials)	28% (10/36 trials)	0% (0/36 trials)

Table 4: Mandarin Acceptance Rates to Sentences With *Dou* in Experiment 2

Contrary to Experiment 1, we did find that the presence or absence of *dou* had a small effect on both children's and adult's responses. However, it is important to note this effect was not a statistically significant one. That is, a Mann-Whitney test showed no significant difference between the first group of Mandarin-speaking children's acceptance rates of Adult-True trials without *dou* compared to the first group of children's acceptance rates of Adult-True trials with *dou* ($Z = 1.390$, $p = 0.550$). Similarly, a Mann-Whitney test showed no significant difference between the adult's acceptance rates of Adult-True trials in the two conditions (with and without *dou*) ($Z = 1.688$, $p = 0.443$).

3.3 Discussion: Experiment 2

Experiment 2 was designed to check that children assign Boolean truth conditions to the relation between conjunction and negation. When Boolean conjunction is negated there are three circumstances that make a statement like 'not (P and Q)' true: (i) if P is true, but Q is not, (ii) if Q is true, but P is not, and (iii) if neither P nor Q is true. However, if children do not initially assign Boolean truth conditions to conjunction, they might interpret 'not (P and Q)' to be true in only one circumstance, namely when neither P nor Q is true (regardless of the scope relations they assign to negation and conjunction). In this case, a test sentence like *The elephant didn't eat both the carrot and the capsicum* in Experiment 1 would mean that the elephant ate neither vegetable. Since in our critical trials the elephant always did eat one vegetable, it was hypothetically possible that children might reject our test sentences not because they assigned conjunction scope over negation, but because they initially interpreted the conjoined noun phrases we tested as denoting plural sets. To reveal children's interpretation of conjunction, we used focus sentences in which the covert negation operator in the assertion meaning component of the sentence is required to take scope over conjunction. The results of Experiment 2 demonstrate clearly that children do have a Boolean interpretation of conjunction.

Children manifested two main response patterns. A small group of both English- and Mandarin-speaking children accepted all the test trials in Experiment 2, showing that they were failing to correctly interpret the focus operator (English *only*, Mandarin *zhiyou*). The remainder of the children in both language groups rejected the Adult-False trials, demonstrating that they could interpret the focus operator. However, these children overwhelmingly accepted the Adult-True trials, revealing their knowledge that conjunction in English and Mandarin is Boolean conjunction. More specifically, the character in focus performed two actions on all of the critical trials, and each member of the contrast set performed one of the two actions. For example, the test sentence *Only Mickey Mouse chose both a box and a rabbit* was presented in a context in which Mickey Mouse chose both objects and Tigger and Rabbit chose one object each. When conjunction is assigned a Boolean interpretation, then the assertion component of this sentence entails that Tigger and Rabbit played just one instrument, or (possibly) played neither one. Because children by-and-large accepted the Adult-True sentences in these contexts, children demonstrated their understanding of Boolean conjunction.

However, we did find 2 Mandarin-speaking children and 2 Mandarin-speaking adults who were potentially not assigning Boolean truth conditions to *he* ('and') in sentences without *dou*. Interestingly, this response by subjects was entirely absent in the sentences with *dou*. The groups who encountered sentences with *dou* demonstrated knowledge that the underlying meaning of *he* is Boolean conjunction. Our results might be explained in one of two ways. On one explanation, it is possible that Mandarin conjunction can sometimes be interpreted in a non-Boolean way in contexts without *dou*. This explanation would be in line with the view that a non-Boolean use of conjunction can be derived across languages when the conjuncts involved are definite noun phrases, rather than quantified phrases. Because *dou* renders the conjunction expression overtly quantificational the non-Boolean interpretation disappears in these contexts. On another explanation, it is possible that Mandarin speakers sometimes access a reading in which Boolean conjunction is assigned scope over negation, even in the covert assertion meaning component of a sentence containing *zhiyou* ('only'). In any case, when the expression *he…dou* ('both…and') is used, it is clear that Mandarin speakers have a

Boolean interpretation of conjunction, and that they are assigning the covert negation operator scope over this Boolean conjunction. We should note that 3 different English-speaking children also showed evidence of a possible non-Boolean interpretation of *and* on one of their four trials in English. Nonetheless, given that this kind of interpretation only surfaced infrequently in English and Mandarin, it is unlikely that this is the reason for the overwhelming rejection of our critical trials in Experiment 1. The preferred interpretation of English *and* and Mandarin *he* either in the absence or presence of *dou* is clearly Boolean for children and adults.[4] We are thus confident, given the results of Experiment 2, that the children we tested in Experiment 1 were not rejecting our test sentences because they were interpreting conjunction as denoting a plural set. Instead, in order to arrive at a 'strong' interpretation of sentences like *The elephant didn't eat both the carrot and the pepper*, they must have been assigning Boolean conjunction scope over negation.

4. General Discussion

This study was designed to adjudicate between two hypotheses about children's initial preferences for resolving ambiguities involving scope. One hypothesis is the Semantic Subset Maxim (SSM). The SSM makes a specific prediction about children's decisions when they are confronted with ambiguous sentences, where one of the scope readings asymmetrically entails the other. According to the SSM, children will initially prefer the strong reading of these ambiguities, also called the subset reading. This preference will assist children in efficiently aligning their semantic interpretations with those of adults. If adult speakers of the language favour the weak (superset) reading, children will encounter adult input falsifying their initial hypothesis, since they will encounter adults using the relevant sentences in contexts that are only true on the weak reading. Assuming that adults speak truthfully, it will be straightforward for children to extend their grammars, by adding the weak reading. If children initially favour the weak reading, by contrast, then the majority of evidence children encounter will be consistent with this interpretation, and there will be no impetus for children to switch from their original hypothesis. This remains true, moreover, even if adult speakers of the local language strongly favour the strong reading, since the circumstances associated with the weak reading include the one circumstance that makes the sentence true on the strong reading.

The second hypothesis is the Isomorphism Account. This hypothesis predicts that when faced with scopally ambiguous sentences, children assign an isomorphic mapping between surface syntax and semantic interpretation. On this account, the structurally dominant (c-commanding) logical operator takes scope over the operator it dominates. It has been suggested that children find it easier to process isomorphic mappings between these levels of representations, and that children have more difficulty than adults do in recovering from this analysis, when information subsequently encountered indicates that the initial analysis is not intended (Lidz & Musolino, 2005/2006).

Until now, almost all of the findings from studies of children's resolution of scope ambiguities have been compatible with either hypothesis, at least for ambiguous sentences where one reading asymmetrically entails the other. Investigations of children's preferred interpretations of scopally ambiguous sentences in which the isomorphic reading is not also the strong reading are scarce. This study aimed to add to this small body of data by directly testing competing predictions made by the two hypotheses. We investigated children's interpretation of sentences like *The elephant didn't eat both the carrot and the capsicum* in English and in Mandarin. In both languages, negation occupies a higher position in the phrase structure tree relative to conjunction (or to the trace of conjunction in the case of Mandarin sentences with *dou*) in the relevant sentences. This means that negation should take scope over conjunction on the Isomorphic Account, yielding the 'not both' interpretation. On this interpretation, the example test sentence should be judged to be true if the elephant ate just one of the vegetables, or (possibly) neither of them. The Isomorphism Account would predict that both Mandarin- and English-speaking children should prefer this 'not both' reading, the weak reading. According to the SSM, on the other hand, children acquiring Mandarin or English should initially favour the strong reading, with conjunction taking scope over negation. This makes the sentence true only in 'both not' circumstances, so the example sentence would be true only if the elephant ate neither vegetable.

The findings of the present study showed that children acquiring either language overwhelmingly assigned the strong 'both not' reading to the test sentences, rather than the isomorphic 'not both' reading. English-speaking children rejected crucial trials on which the elephant had eaten a carrot, but not both a carrot and a capsicum 98% of the time, while Mandarin-speaking children rejected the same trials 98-99% of the time. Moreover, from the results of our second experiment, we can be confident that these results were not possibly due to children not assigning Boolean truth conditions to conjunction. Rather, we believe the data show that both groups of children were assigning Boolean conjunction wide scope over negation in Experiment 1, so as to access a strong reading of the test sentences. These results are in line with the Semantic Subset Maxim, but not the Isomorphism Account.[5]

Having presented evidence in favour of the SSM, we now address the motivation behind this maxim. Recently, the rationale behind the Semantic Subset Principle, on which the SSM is based, has been questioned. Gualmini & Schwarz (2009) have outlined several forms of alternative evidence in the input that children might use to eventually arrive at a strong reading of a sentence if they have initially hypothesised a weak reading. These researchers suggest two main sorts of evidence that children might use in relation to the kinds of sentences we have been discussing. We will discuss these in turn.

The first suggestion applies to constructions that are subject to scalar implicatures. These include constructions containing the universal quantifier, as well as ones containing disjunction or conjunction. We will use the case of conjunction to illustrate. The logical connectives 'and' and 'or' form a scale, based on information strength. When statements with both logical connectives are true, statements with 'and' asymmetrically entail the corresponding statements with 'or', because statements with 'or' are also true in other circumstances. Therefore statements with 'and' are said to be stronger than the corresponding statements with 'or'. According to the Gricean conversational maxim of quantity (which entreats speakers to make their contributions as informative as possible), hearers generally assume that if a speaker uses a weak term, he or she is not in a position to use a stronger term to describe the situation under consideration (Grice, 1975). Hearers therefore remove the truth conditions associated with a stronger reading of a sentence from the meaning of the weaker reading. In the case of sentences like *The elephant didn't eat both the carrot and the capsicum*, the strong reading of this sentence is that the elephant ate neither vegetable. The weak reading is that the elephant did not eat both vegetables, but could have eaten the carrot, or the capsicum, or neither.

Now, when a scalar implicature applies to the weak reading of the sentence, the truth condition on which the elephant ate neither vegetable is cancelled. In other words, hearers generally assume the elephant ate exactly one of the vegetables. This means that the two possible meanings of the sentence *The elephant didn't eat both the carrot and the capsicum* are no longer in a subset-superset relationship, and the potential semantic subset problem disappears. A child who had initially hypothesised the weak reading of a sentence like this could then acquire the strong reading by hearing the sentence used in a context in which the elephant ate neither vegetable. Since this condition no longer forms part of the truth conditions of the weak reading, the child must admit the strong reading to their grammars. This would allow a child acquiring Mandarin, for example, who might have hypothesised the weak reading of such a sentence, to correct his or her scope preference so as to be in line with adult Mandarin speakers who prefer the strong reading of such sentences.

As Gualmini & Schwarz themselves point out, children probably do not adopt a solution based on scalar implicatures until relatively late. This is because it has been consistently found that children do not compute scalar implicatures to the same extent as adults (e.g. Chierchia, Crain, Guasti, Gualmini, & Meroni, 2001; Gualmini et al., 2001; Guasti et al., 2005; Noveck, 2001). For example, Chierchia et al. (2001) tested 15 children aged 3;5-6;2 on sentences like *Every boy chose a skateboard or a bike* in contexts in which every boy chose both a skateboard and a bike. On 30 out of a total of 60 trials (or 50% of the time), the children judged the sentences to be true. This was in clear contrast to adult controls, who never judged the sentences to be true. On examining the individual child data, these researchers identified a group of 7 children who rejected the test sentences 93% of the time, while a second group of 7 children only rejected the same sentences 7% of the time. These groups were not reported as being age-dependent, so presumably both younger and older children made up each group. In other words, children as old as 6;2 can still fail to compute scalar implicatures. It is thought this is not because they lack the notion of information strength, but because they lack the computational resources needed to mentally construct an alternative representation of the sentence under consideration and then compare the relative information strength of this alternative sentence to the test sentence (Gualmini et al., 2001). In other words, if children have initially hypothesized the weak reading of a scopally ambiguous sentence, and their language actually prefers the strong reading, they may not be able to re-align their preferences using evidence from scalar implicatures until relatively late, around age 6.

The second type of evidence that Gualmini & Schwarz (2009) suggest children may be able to use is intended to represent a more general solution to the entailment problem faced by children. The relevant evidence should be available for any sentence subject to an asymmetrical entailment problem, not just those that are also subject to a scalar implicature. The explanation hinges on the entailment-reversing properties of downward entailing operators. Gualmini & Schwarz (2009) point out that when an ambiguous sentence of the kind we have been discussing is embedded under a downward entailing operator, then the entailment relations between the two possible meanings of the sentence are reversed. They use the case of sentences like (44) *Every horse didn't jump over the fence* to illustrate. The two possible meanings of this sentence are given in 45(a) and 45(b).

(44) Every horse didn't jump over the fence

(45) a. No horse jumped over the fence (every>not, strong reading)
b. Not all the horses jumped over the fence (not>every, weak reading)

Meaning 45(a) is the strong reading, and entails meaning 45(b), because if none of the horses jumped over the fence then it is certainly true that not all of them did. Now, when (44) is embedded under a downward entailing expression like 'it's impossible', then the entailment relations between the two possible meanings are reversed, as illustrated in (47).

(46) It's impossible that every horse didn't jump over the fence

(47) a. It's impossible that no horse jumped over the fence
i.e. at least one horse must have jumped over the fence
(impossible > every > not, weak reading)
b. It's impossible that not all the horses jumped over the fence
i.e. every horse must have jumped over the fence
(impossible > not > every, strong reading)

Meaning 47(b) becomes the strong reading, and entails meaning 47(a), because if every horse jumped over the fence, then it is certainly true that at least one did. Gualmini & Schwarz (2009) argue that a child who initially hypothesises only meaning 45(b), the weak reading, for the sentence *Every horse didn't jump over the fence* could receive evidence for meaning 45(a) by hearing sentence (46) in a context in which at least one horse (but not every horse) has jumped over the fence. This context makes meaning 47(b) false, but meaning 47(a) true. Having concluded that meaning 47(a), the weak reading, exists for a sentence like *It's impossible that every horse didn't jump over the fence*, the child could then infer that meaning 45(a), the strong reading, also exists for a sentence like *Every horse didn't jump over the fence*.

This proposal is subject to the same caveat as before. If evidence of the relevant kind exists, it must be relatively rare in children's experience, because the structures are complex, and are difficult to compute even for adults. Presumably, children would not be exposed to sufficient evidence of this type until relatively late in the course of acquisition. In addition, it is not clear that this solution actually can be generalised to all instances of ambiguity arising when one possible meaning of a sentence asymmetrically entails the other. A case in point would be trying to apply this solution to the types of sentences we tested in this study. Consider a sentence like (48) *The elephant didn't eat both the carrot and the capsicum*. The two possible meanings of this sentence are given in 49(a) and 49(b).

(48) The elephant didn't eat both the carrot and the capsicum

(49) a. It is both the carrot and the capsicum that the elephant did not eat
(and > not, strong reading)
b. The elephant didn't eat both vegetables, but may have eaten one or none
(not > and, weak reading)

Embedding (48) under the downward entailing expression 'it's impossible' yields the two possible meanings in 51(a) and 51(b).

(50) It's impossible that the elephant didn't eat both the carrot and the capsicum

(51) a. It's impossible that it is both the carrot and the capsicum that the elephant didn't eat
i.e. The elephant did eat one of those vegetables, or possibly both
(impossible > and > not, weak reading)
b. It's impossible that the elephant didn't eat both vegetables
i.e. The elephant did eat both vegetables
(impossible > not > and, strong reading)

While meaning 49(a) asymmetrically entails meaning 49(b), in (50) this relationship is reversed, so 51(b) is the stronger reading, and asymmetrically entails 51(a). Following Gualmini & Schwarz's argument, a child who initially hypothesises only meaning 49(b), the weak reading, for the sentence *The elephant didn't eat both the carrot and the capsicum* could receive evidence for meaning 49(a) by hearing a sentence like *It's impossible that the elephant didn't eat both the carrot and the capsicum* in a context in which the elephant has eaten one vegetable, but not both. This context makes meaning 51(b) false, but meaning 51(a) true. Having concluded that meaning 51(a), the weak reading, exists for a sentence like *It's impossible that the elephant didn't eat both the carrot and the capsicum*, the child could then infer that meaning 49(a), the strong reading, also exists for a sentence like *The elephant didn't eat both the carrot and the capsicum*. This would be particularly important for a Mandarin-speaking child who had initially hypothesised the weak reading of (48) and would need to re-align this preference to be in line with adult speakers of Mandarin who prefer the strong reading. The problem is that Mandarin speakers would not use sentence (50) in the crucial weak context. We surveyed 6 Mandarin speakers who all reported that the counterpart of sentence (50) in Mandarin could only have meaning 51(b). Our intuition is that 51(b), the strong reading, would also be the only meaning available for English speakers. So, it seems that this kind of evidence would never be available for children.

In fact, it appears that whenever the strong reading of a sentence involves an inverse (or non-isomorphic) scope relationship, then the generalised solution proposed by Gulamini & Schwarz fails. Another example is the case of sentences that contain both an existential quantifier and a universal quantifier like (52).

(52) Every farmer washed a cow

(53) a. A particular cow was washed by every farmer (a > every, strong reading)
b. Every farmer washed a (possibly different) cow (every > a, weak reading)

In (52), if the existential quantifier 'a' is assigned inverse scope over the universal quantifier 'every', then the interpretation is that all the farmers washed the same cow. This is the strong reading given in 53(a). On the other hand, if 'every' is assigned scope over 'a', then the interpretation is that each farmer washed a possibly different cow (or they could have washed the same cow). This is the weak reading given in 53(b). It has been a matter of debate whether a reading in which the existential quantifier takes wide scope over the universal quantifier actually exists in the grammar separately to the reading in which the universal quantifier takes wide scope over the existential quantifier. In early work on scope relations, it was suggested that there was no need to posit a separate grammatical account for the strong reading of sentences like (52). This reading arose because it was assumed to be a special case on which the weak reading was true. However, it was later observed that the entailment pattern that applied to sentences like (52) only held in the case of existential wide scope. For example, when an existential quantifier appears with a numeral quantifier, a reading in which the existential quantifier takes wide scope over the numeral quantifier can be independently motivated. The details of the arguments do not concern us here. Suffice it to say, that it is now accepted that existential wide scope readings exist separately from universal wide scope readings in sentences like (52), and that these existential wide scope readings should be accounted for in the grammar (Reinhart, 1997; Szabolcsi, 2001).

Given that two interpretations of sentence (52) exist, and that one of these interpretations asymmetrically entails the other, children face a potential learnability problem. If children initially posit the weak reading 53(b), then evidence for the strong reading will be difficult to accumulate. However, according to Gualmini & Schwarz, input in the form of sentences like (54), which contain the downward entailing expression 'it's impossible', should be sufficient to allow children to acquire the strong reading of sentence (52).

(54) It's impossible that every farmer washed a cow

(55) a. It's impossible that a particular cow was washed by every farmer
i.e. there is no cow who was washed by every farmer (each farmer washed some cows although no particular cow was washed by all of the farmers, or possibly some farmer did not wash a cow at all)
(impossible > a > every, weak reading)
b. It's impossible that every farmer washed a cow
i.e. there is some farmer who did not wash a cow at all
(impossible > every > a, strong reading)

Theoretically, a child who hears sentence (54) in a context in which interpretation 55(a) is true, but 55(b) is false would have evidence that interpretation 53(a) can also be true for sentence (52). This would mean a child would need to hear sentence (54) used in a case in which no particular cow was washed by every farmer, but every farmer in the set of farmers did wash at least one cow. However, it is highly unlikely that sentence (54) is ever used to convey this meaning in English. So, again, this line of evidence will never be open to English-speaking children. This is not to say that children couldn't use other forms of evidence (perhaps from sentences containing an existential quantifier and a numeral quantifier) to eventually ascertain that sentences like (52) can have meaning 53(a). All we wish to point out here is that Gualmini & Schwarz's (2009) proposed general solution, although theoretically sound, may not be applicable across the board because some sentences may never be used in the crucial contexts.

We think, in fact, that there may not be a generalised solution to the entailment problem, which is precisely why children would benefit from adhering to a learning maxim like the Semantic Subset Maxim. Children learning a language which favours a strong reading of a sentence subject to an entailment problem, and who initially posit the weak reading, can eventually recover. However, they will probably need to use evidence from a variety of sources, depending on the structure in question, and this evidence may not be available until relatively late in the acquisition process. The SSM is designed to prevent this DELAY in children's attainment of their target grammar in the majority of cases.

Furthermore, the need for an explanatory mechanism to account for children's development of semantic scope preferences is highlighted by the fact that children do not necessarily initially mirror the scope preference patterns of the adults around them. In the case of the sentences tested here, we found that English-speaking children behaved much like Mandarin-speaking adults who preferred a strong reading of our test sentences, and unlike English-speaking adults who largely preferred a weak reading. This has also been shown in other cross-linguistic work, where Japanese- and Mandarin-speaking children prefer a strong reading of sentences like *The pig didn't eat the carrot or the pepper* and *The dog reached the finish line before the turtle or the bunny*, even though adult speakers of these languages prefer, or at least also often allow, a weak reading of the same sentences (Goro & Akiba, 2004a, 2004b; Notley et al., 2012). Results like these suggest that children are following a developmental trajectory in this domain that is not initially driven by the input. Rather, we propose that our data constitutes new and compelling evidence that children's initial scope assignment preferences (when one scope reading of an ambiguous sentence asymmetrically entails the other) are driven by the Semantic Subset Maxim.

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Endnotes

[1] It is hard to see how there could be languages that lack the strong reading, and only accept negative statements with the universal quantifier on the weak reading, since the weak reading makes sentences true in circumstances associated with the strong reading. This observation has led some researchers to the conclusion that the kinds of sentences under consideration are not ambiguous at all. However, the fact that some languages appear to accept only the strong reading of such sentences is prima facie evidence that the phenomena involves an ambiguity of scope relations.

[2] Under the QAR model, one might posit that the question-under-discussion was whether the animals would eat both (or all) of their vegetables. We believe both scope readings of our test sentences would then have constituted good answers to this question. However, we did not set this up explicitly, as we were not aiming to directly test the QAR.

[3] The adult rejection rate here (28%) may appear high. However, other work testing English-speaking adults' interpretation of sentences without 'both' like 'The smurf didn't jump over the tree and the pond', found adults rejected the sentences in contexts in which the smurf jumped over the tree, but not the pond, over two-thirds (66%) of the time (Goro, Minai & Crain, 2006). Evidently, a scope reading in which conjunction takes wide scope over negation is very much available to English adults. By adding the operator 'both' to our test sentences, we have actually significantly improved the rate of adults' acceptance of these kinds of sentences.

[4] A previous study has also tested 4-year-old English-speaking children's interpretation of sentences like the ones tested here, but without the presence of the operator 'both' (e.g. *Only Aladdin opened the blue box and the black box*). Much like for the Mandarin-speaking children's interpretation of test sentences without *dou*, the English-speaking children accepted their true trials 95% of the time, and rejected their false ones 90% of the time (Goro, Minai, & Crain, 2006). So, even when conjunction is not overtly quantificational, it is still overwhelmingly interpreted as interacting with negation in a Boolean manner, in both English and Mandarin.

[5] We should point out here that our experiment was not designed to test the predictions of the Semantic Subset Maxim against the Question-Answer Requirement Model (Gualmini, 2007a, 2007b, 2008; Hulsey et al., 2004). As such, we did not control our question-under-discussion (QUD) directly. If we suppose, however, that our QUD in Experiment 1 was something like 'What did the elephant (or any other relevant animal) eat?', then the answer 'The elephant didn't eat both the carrot and the capsicum' only constitutes a good answer to this QUD if conjunction is assigned wide scope over negation (yielding the interpretation 'The elephant didn't eat either vegetable'). In other words, the results of this experiment do not allow us to adjudicate yet between the QAR Model and the SSM: both would predict that children should assign wide scope to conjunction in the contexts we used to present our test sentences. Nonetheless, the results of this experiment contribute to the literature by providing evidence against the predictions of the

Isomorphism Account. In the conclusion of this thesis, I will outline some suggestions for future work testing the predictions of the QAR Model against the SSM.

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Appendix A: Experiment Materials

Experiment 1

Practice Materials in English:

Animal	Food Eaten		Truth	Sentence
Piglet	Capsicum		True	Piglet ate the capsicum
Winnie-the-Pooh	Corn	Ice-cream	False	Winnie-the-Pooh ate the ice-cream and the banana

Test and Filler Materials in English:

Animal	Vegetable Eaten		Reward	Sentence
Panda	Carrot	Capsicum	Gold	The panda didn't eat anything
Elephant	Carrot		Silver	The elephant didn't eat both the carrot and the capsicum
Sheep	Neither		Black Cross	The sheep didn't eat anything
Rabbit	Carrot		Silver	The rabbit didn't eat both the carrot and the capsicum
Mouse	Carrot	Capsicum	Gold	The mouse ate everything
Lion	Capsicum		Silver	The Lion didn't eat both the carrot and the capsicum
Pig	Neither		Black Cross	The pig ate everything
Dog	Capsicum		Silver	The dog didn't eat both the carrot and the capsicum

Experiment 2

Practice Materials in English:

Item	**Truth**	**Sentence**
Warm-Up 1	False	Mickey Mouse and Tigger fell in the mud
Warm-Up 2	True	Rabbit managed to jump over the fence

Test and Filler Materials in English:

Item	**Truth**	**Sentence**
Test	True	Only Mickey Mouse ate both strawberries and bananas
Filler	False	Tigger ate some apples
Test	False	Only Rabbit played both a whistle and a bell
Filler	True	Tigger played a bell
Test	True	Only Mickey Mouse chose both a box and a rabbit
Filler	False	Tigger chose a rabbit
Test	False	Only Tigger found both a sea plant and a shell
Filler	True	Mickey Mouse found a plant
Test	True	Only Tigger tried both the cones and the ramp
Filler	False	Rabbit tried the ramp
Test	True	Only Rabbit chose both a wheelbarrow and flowers
Filler	False	Mickey Mouse chose some flowers

Moving from Chapter 4 to Chapter 5

In Chapter 4, we presented further evidence showing that both English- and Mandarin-speaking children have an initial preference to assign a strong scope interpretation to scopally ambiguous sentences in which one reading asymmetrically entails the other. In this case, the sentences contained the downward entailing operator NOT and conjunction. The interesting thing about these data is that, in the sentences we tested in both English and Mandarin, negation dominates conjunction structurally, but the strong scope interpretation is arrived at by assigning conjunction scope over negation. These data thus support the predictions of the Semantic Subset Maxim, and not those of the Isomorphism Account.

To further test the SSM, we turn now to a study investigating children's scope preferences in complex sentences containing three logical operators: negation, the universal quantifier, and disjunction. The results of this study are presented in Chapter 6. Before moving on to the Chapter 6 study, however, we need to lay some groundwork in Chapter 5. We thus diverge, once again here, from our major line of investigation, to examine children's first hypotheses about the meaning of the universal quantifier EVERY. The findings of this investigation inform the design of our Chapter 6 enquiry.

CHAPTER 5

The early stages of universal quantification

This paper has been published in the Proceedings of the 9th Tokyo Conference on Psycholinguistics:

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I would like to acknowledge the roles of my co-authors. Britta Jensen helped transcribe and code the longitudinal database. Francesco-Alessio Ursini provided reliability coding on approximately 20% of each data set. I was otherwise responsible for all analysis of the data and writing.

A version of this paper including an additional set of longitudinal data has also been published in the Proceedings of the 2008 Conference of the Australian Linguistic Society:

Jensen, B., Notley, A., & Crain, S. (2010). Universal quantification in children's English. In de Beuzeville, L., & Peters, P. (Eds.), *Proceedings of the 2008 Conference of the Australian Linguistic Society,* University of Sydney, Australia: Australian Linguistic Society.

1. Introduction

The way in which young children interpret the universal quantifier (e.g. *every* in English) has been the subject of much debate over the last 40 years. In 1964, Inhelder and Piaget reported when they presented French-speaking children around age 5 with a display of blue circles, blue squares and red squares, and asked *'Are all the circles blue?'*, their subjects sometimes gave erroneous answers like *'No, there were circles and squares* [blue]*'* (Inhelder & Piaget, 1964, p.61). Since then, using picture-verification tasks like that in Figure 1, many researchers have replicated these results in several different languages (e.g. Crain et al., 1996; Donaldson & Lloyd, 1974; Drozd & van Loosbroek, 1999; Drozd & van Loosbroek, 2006; Philip, 1995, 1996; Philip & Lynch, 2000). Child responses like that in Figure 1 have been called symmetrical responses or over-exhaustive search errors because children seem to require a one-to-one relation between elements of the subject set (*boys*) and elements of the object set (*elephants*). The question we will address here is whether or not this response by children reflects a non adult-like representation of the set relation defined by the universal quantifier.

Test question:

Here are some boys and some elephants. Is every boy riding an elephant?

Child response:

No, not that one

[pointing to the extra elephant]

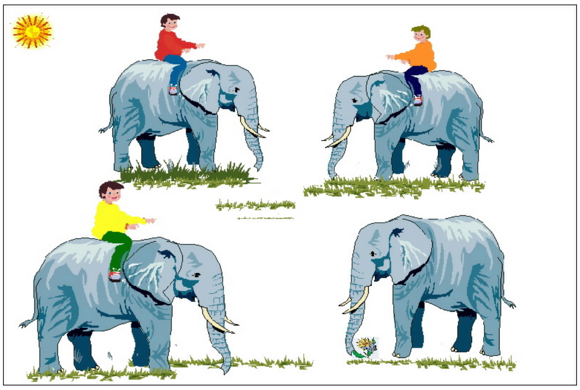

Figure 1: Picture Verification Task & Non Adult-Like Child Response

In adult grammar, *every* is a determiner defining a two-place relation between its restrictor (the noun phrase it combines with syntactically) and its nuclear scope (the predicate phrase). The quantificational phrase is said to 'live on' the set denoted by the restrictor (Barwise & Cooper, 1981), meaning that if *Every boy is riding an elephant*, then *Every boy is a boy who is riding an elephant*. The truth or falsity of such a sentence in a given context can be established by checking the set of boys and checking the set of boys riding elephants to see whether the two sets coincide. Importantly, the entire set of elephants need not be checked. Some proposals that aim to explain over-exhaustive search errors propose that children pass through a stage when, in addition to an adult-like reading, they have a reading in which they check the entire set of elephants and use this set in assessing the test sentence (Philip, 1995; Geurts, 2003). We call these non adult-like accounts. Other proposals maintain that children have adult-like knowledge of the set relation defined by the universal quantifier, but have difficulty in interpreting *every* when it is used in infelicitous discourse contexts (Crain et al., 1996; Drozd & van Loosbroek, 1999; Drozd & van Loosbroek, 2006). We call these adult-like accounts.

To contribute to this debate, we present findings from children younger than have ever been tested before. Our aim is to uncover children's earliest hypothesis about universal quantification. If they entertain a non adult-like reading at some point during their development, it is most likely to appear at an early age. However, our data show that even 2-year-old children respond in an adult-like manner to test items presented in felicitous contexts. These data support adult-like accounts of children's acquisition of the lexical item *every*.

2. Possible Child Hypotheses about Universal Quantification

2.1 Non Adult-Like Accounts

One non adult-like account of children's representation of universal quantification is Philip's (1995) Event Quantification Account (EQA). The EQA suggests that, similar in certain ways to quantificational adverbs, children can interpret universal quantifiers as quantifying over events rather than individuals. In Philip's view, one logical form a child might assign to a sentence like *Every boy is riding an elephant* includes a disjunction of events in the restrictor of *every*, along the lines of (1).

(1) Every(e) [Boy(e) or Elephant(e)] [is a Boy-riding-an-Elephant(e)]
'For every event *e* in which a boy participates or in which an elephant participates (or both), a boy is riding an elephant in *e*.'

Even overlooking the difficulties in motivating children's choice to quantify over events rather than over objects, the EQA has at least two serious shortcomings. First, it attributes a reading of the universal quantifier to children which violates the conservativity of determiner meanings, i.e., the ‘lives on’ relation of Barwise & Cooper (1981). No quantificational determiner in human language works in the way the EQA proposes. Second, the account faces a learnability problem. To account for the fact that children who make over-exhaustive search errors are also capable of giving adult-like answers in tasks like that in Figure 1, Philip assumes that children have both an adult-like reading and an event quantificational reading available to them. Given that adults accept a symmetrical reading in situations where the subject and object set are equal in number, the problem is how children ever expunge the event quantificational reading from their grammar. Without negative evidence in the input, children would need to keep a mental record of the consistent absence of certain adult responses in situations like Figure 1. At the same time, they would encounter positive evidence that is consistent with one of their interpretations. It is thus unclear how they could ever ‘unlearn’ their non adult reading.

Another account with some non adult-like features is Geurts’ (2003) Weak Mapping account. Geurts draws on the distinction between strong and weak quantifiers to suggest that children’s non adult behaviour in response to universally quantified sentences is due to a misapplication of weak processing strategies to the strong quantifier *every*. He suggests that children have an adult-like underlying semantic representation for *every* in line with strong quantifiers, but that the domain of quantification (the restrictor) is still syntactically underdetermined. This leaves room for contextual factors to push the child towards a weak quantifier processing strategy when mapping syntax to semantics, with the domain of quantification being defined by whatever set is made most salient to the child. In cases like Figure 1 above, the extra elephant makes the object set more salient. The child thus decides to use the set of elephants as the restrictor of the universal quantifier. Geurts’ account avoids the problem of violating determiner conservativity by only allowing one set of elements, the most salient set, to be interpreted in the restrictor of *every* on any one occasion. However, without a clearer operational definition of set saliency, Geurts’ account remains difficult to test and, indeed, runs the risk of circularity (by determining set saliency based on the occurrence of child errors).

In addition to the question of when a set is to be considered salient, Geurts’ account faces several other questions. Geurts motivates his explanation by arguing that the semantic representation of weak quantifiers is less complex than strong quantifiers and that using a weak quantifier syntax-semantics mapping rule makes fewer processing demands on children’s working memory and attention. For example, because weak quantifiers like *some* are intersective, checking that *Some boys are riding an elephant* only requires one to check that the set of boys and the set of elephants intersect. Strong quantifiers, on the other hand, are relational. They require one to check both the set of boys and the set of boys riding elephants and verify that they overlap perfectly. However, it is not clear whether this difference in processing steps would be enough to push children to use weak processing strategies when interpreting *every*, when it has been shown independently that 3-5-year-old children know that *every* is a strong determiner, sharing properties of semantic interpretation similar to the strong determiner *the* (Meroni, Gualmini, & Crain, 2007).

The Weak Mapping account must also explain how children eventually converge on a completely adult-like grammar. Geurts' answer to this is that, as children's working memory capacity and attention increase (with maturation), they will automatically begin to use the adult-like strong quantifier processing strategy. Because they are assumed to have the correct underlying relational semantic representation for *every*, there is nothing to 'learn' or 'unlearn'. This explanation, however, depends on the assumption that children have less working memory capacity than adults. Though this has been shown for some tests of working memory (e.g. McDonald, 2008), the way working memory is defined and measured varies considerably, making an explanation based on limitations in working memory open to debate and difficult to assess. Even if one accepts that children have such limitations, it needs to be shown that these limitations suffice to impair a strong (but not a weak) determiner mapping process. Again, the experimental finding that children interpret *every* as a strong determiner casts doubt on an account of children's non adult responses based on limitations in working memory capacity (Meroni et al., 2007).

2.2 Adult-Like Accounts

In contrast to non adult-like accounts, other researchers have concluded that children's interpretation of *every* is essentially adult-like. Over-exhaustive search errors are seen as an experimental artifact, resulting from infelicitous test conditions. For Crain and colleagues, who support the Full Competence account, the infelicity stems from the fact that when asking someone to judge the truth or falsity of a sentence, a different possible outcome from the actual outcome should have been under consideration at some point. A felicitous context for the question *Is every boy riding an elephant*? would require the possibility that, at some point, not every boy is riding an elephant. This is called the ‘condition of plausible dissent’. In the case of Figure 1, where the answer to the question has never been in doubt and is not in doubt when the question is asked, children might infer that a different question is intended, one about the ‘extra’ elephant. These researchers suggest that while adults and older children can accommodate infelicity of this type in a test trial, younger children cannot.

Interestingly, it has been shown that although adults do not make errors on trials like Figure 1, they are sensitive to the infelicity of the task. Eye-tracking results show that adults fixate significantly longer on the extra elephant in trials like Figure 1, as compared to pictures which depict both an extra elephant and some other animal that the boys might have ridden (Meroni, Crain, & Gualmini, 2001). Moreover, if the pragmatic felicity of the task is deliberately sabotaged, so that the wrong set is established as the topic of discourse, adults too show breakdowns in accessing the correct meaning of *every*, committing errors similar to children, though to a lesser extent (Philip & Lynch, 2000). Adults also commit errors if the ‘extra’ object is part of a natural pairing of objects, such as saucers and tea cups (Freeman, Sinha, & Stedmon, 1982).

In further support of their view, Crain and colleagues tested 34 3-5-year-old children using trials like that in Figure 1. They found over-exhaustive search errors 35% of the time, and this was concentrated in a group of 14 children who made these errors 82% of the time. These 14 over-exhaustive children were then tested using test trials similar to Figure 1, but in contexts satisfying the condition of plausible dissent. Twelve of the 14 children no longer made a single over-exhaustive search error. Two children still rejected the target sentences, but their justifications showed their rejections were not due to the extra objects in the story. Rather, they prohibited the use of *every* to refer to sets of 3 members. These 2 children were retested with stories in which 5 characters made up the quantified NP set, and they accepted the test sentences (Crain et al., 1996).

Other adult-like accounts include Drozd & van Loosbroek’s Presuppositionality Account (1999, 2006) and Philip’s Relevance Account (2004). Both propose that children correctly represent the set of boys as the restrictor of the universal quantifier. Errors are thought to arise in contexts like Figure 1 because the presuppositionality demands of the universal quantifier have not been sufficiently met. Strong quantifiers like *every* carry a presupposition of existence about the speaker’s intended domain of quantification. In tasks like Figure 1 the visible set of boys is intended as the domain of quantification, but given the minimal discourse context of such tasks it is suggested that children may not always use this set as the presupposed set of boys. Rather, they use other aspects of the context (in this case the extra elephant) to determine the set of boys they are being asked about. Philip further suggests that they do this because they may lack knowledge of a pragmatic rule restricting verification of sets to visible objects in the context (Philip, 2004).

Importantly, all of these adult-like accounts agree that children correctly interpret the set of boys as the restrictor of *every* in cases like Figure 1 under normal discourse circumstances (when the object set has not been deliberately established as the discourse topic). All these accounts also agree that errors can be minimised by presenting a richer context to children. They differ in what aspects of the context have to be manipulated to prevent over-exhaustive search errors. Drozd & van Loosbroek (2006) maintain that satisfying the presuppositionality demands of the universal quantifier, by making the set corresponding to the restrictor clear in the context, is a sufficient condition to reduce children's error rates. They point to data showing no significant difference in 4-5-year-old Dutch-speaking children's performance on test trials like Figure 1 in which only the presuppositionality demands of the context were met, as compared to trials in which both the presuppositionality demands and the condition of plausible dissent were met. Nonetheless, although not statistically significant, their results clearly show that children's performance on trials in which the condition of plausible dissent was also met was better than in trials in which it was not (see Crain (2000) for a critique of Drozd & van Loosbroek's analysis of their 1999 results). Drozd & van Loosbroek (2006) admit this aspect of their results remains to be explained.

In this study we do not address the issue of which contextual conditions are sufficient to obtain adult-like responses from children. Instead, we present new data (from younger children than have ever been reported in the experimental literature on this topic) supporting the emerging consensus that children's interpretation of the set relation of *every* is essentially adult-like from the start.

3. Longitudinal Study

3.1 Subjects

Three English-speaking children, Ruby, Ian and Pam, attended our lab for fortnightly 1-hour experimental play sessions over a period of 6-12 months. Ruby participated in 13 sessions from age 1;11-2;5. Ian participated in 15 sessions from age 2;4-3;1. Pam participated in 21 sessions from age 2;1-2;11.

3.2 Methodology

We employed two experimental tasks: an act-out and a judgement task. The children were first introduced to different sets of toys making up subjects and objects in transitive sentences (e.g. subject sets: a set of turtles, mermaids or friends; object sets: a set of strawberries or felt blankets). Both subject and object sets could vary in number from trial to trial, but each set contained at least 3 members (and usually more) so that all contexts favoured a distributive universal wide-scope reading. On an act-out trial, children were instructed to distribute one set in relation to another. A representative example is given in (2). Act-out trials were often followed by a judgement trial as in (3). At other times, judgement trials were given independently, in reference to arrays set up by the experimenter.

(2) Give every friend a strawberry.

(3) Does every friend have a strawberry?

Both types of task were classified into three conditions dependent on the number of subjects and objects in the experimental play space: *Equal* (where number of friends = number of strawberries), *Less* (fewer strawberries than friends) and *More* (more strawberries than friends). The *More* condition was intended to resemble trials like Figure 1 where the presence of extra objects might result in a non adult response from the children. Because the tasks were naturalistic, presented in the course of a continuous play discourse with the child, they naturally fulfilled both the presuppositionality demands of *every* and the condition of plausible dissent. By being introduced to real sets of toys, the presuppositional domain of quantification was made clear to children. By being asked to manipulate the toys themselves or by seeing them manipulated in front of them as a task unfolded, many possible outcomes besides the final one were available. We made no special effort to manipulate the saliency of the subject or objects sets or otherwise define the context, although it could perhaps be argued that the object sets were always more salient for children, being the items they were asked to distribute themselves. The play sessions were video recorded and transcribed in full. The relevant trials were then isolated for scoring.

3.3 Scoring

Ruby was given 57 trials. Of these, 48 trials (22 act-out trials, and 26 judgement trials) were scored, while 9 were experimentally flawed and therefore discarded (for example, if the experimenter interfered with the toy array during a trial, or if the array could not be seen clearly on the video record of the trial). Ian was given 53 trials. Of these, 41 trials (17 act-out trials, and 24 judgement trials) were scored, and 12 were discarded. Pam was given 92 trials. Of these, 72 trials (30 act-out trials, and 42 judgement trials) were scored, and 20 were discarded.

For each trial, the child's first response was recorded, as well as any subsequent response or justification for their response that they may have given. Trials in which the child's first response was adult-like (and any subsequent response matched their first response) were classified as 'right'. Trials in which the child's first response was non adult-like (and any subsequent response was also non adult-like) were classified as 'wrong'. Trials in which the child's first and subsequent responses differed were classified as 'mismatch'. In the 6 'mismatch' responses across all data sets, the first response was non adult-like, but the subsequent response showed adult-like comprehension. These 6 trials were not counted as correct, but added to the final category 'other', containing trials in which the child was distracted by another toy or not paying attention, and therefore gave no response or a response not related to the test trial.

Between 20-26% of each child's data set was selected at random to be scored by a second coder (11 trials for Ian, 13 trials for Ruby, 24 trials for Pam). Overall inter-rater reliability was high (0.81). Cases in which there was disagreement were discussed with a third coder and a consensus reached.

4. Predictions

Non adult-like accounts and adult-like accounts make different predictions for children's responses in the *More* condition. This condition relates to trials of the form *Give every A a B*, in which there are more elements in the object set B than in the subject set A. On Philip's EQA, children require every element of set A and B to be involved in the event in question. On Geurts' Weak Mapping Account, children quantify over elements in set B if this set is salient. As noted, set salience is a vague notion, but in the *More* scenarios presented here, set B would arguably be the more salient set as this set was controlled by the child and contained extra members in relation to set A (in addition, this set was sometimes verbally queried after completion of a trial). So, on these non adult-like accounts in a *More* act-out task, we could expect to see children distribute all the objects in set B, either by sharing them out to the subjects present, or (perhaps preferably for a one-to-one mapping) by searching for extra subjects in set A to give them to. In a judgement task we could expect children to reject arrays in which every element of set A (e.g. friends) has an element of set B (e.g. strawberries), but in which extra elements of set B are present.

Adult-like accounts do not predict any difficulty for children in the *More* condition if task felicity demands are met. To minimally complete the act-out task children must distribute as many Bs as there are As. Extra Bs should be irrelevant. However, it is not incorrect on adult-like accounts for the child to distribute all the elements of set B to the subjects present. What is not predicted is that children will search for extra members of set A in order to distribute the extra objects. The *Less* condition was included as a control for the crucial *More* condition (children who appear to be adult-like by answering 'yes' to *More* judgement trials should answer 'no' to *Less* judgement trials). The *Equal* condition was included in case any child only allowed a symmetrical reading of *every*. The different predictions are summarised in Figure 2.

	Non Adult-Like	**Adult-Like**
***More* Act-Out**	(1) Distribute all Bs	(3) Discard Extra Bs
***More* Judgement**	(2) Answer 'no' if extra elements in set B have not been exhausted	(4) Answer 'yes' if extra elements in set B have not been exhausted

Figure 2: Predictions of Non Adult-Like vs. Adult-Like accounts

5. Results

Before presenting the results, a few notes about the trial types and tasks are in order. Act-out tasks were used because they are easier for very young children than judgement tasks. This is because, in general, the act-out task doesn't place any verbal demands on the child, while all judgement tasks minimally require a yes/no answer. However, trials in the *Less* condition were the most difficult in both task types. To succeed on an act-out *Less* trial, a child had to indicate to the experimenter that the task (e.g. *Give every A a B*) could not be completed because there weren't enough Bs. Similarly, in a judgement *Less* trial (e.g. *Does every A have a B?*), the correct answer was always 'no'. This is a difficult answer to give for very young children, who tend to say 'yes' when they are uncertain (even if in some cases they can demonstrate in other ways the correct answer to the question). Nonetheless, the *Less* condition was included because of its important function as a control for the other experimental tasks.

Presentation of results will be divided by subject, and all three conditions (*Equal*, *Less* and *More*) include both act-out and judgment task types.

5.1 Ruby (1;11-2;5)

Ruby's 'right', 'wrong', and 'other' responses are presented in Figure 3. Her first correct response for the *Equal* and *More* conditions is at 1;11, and her first correct response in a *Less* condition is at 2;3. In the *Equal* and *More* conditions, she shows a clear majority of correct responses. In the *Less* condition, the hardest condition, her results are less clear (2 right and 2 wrong). In fact, Ruby's 2 right responses are to act-out trials. Her incorrect responses are judgment trials at the young ages of 2;0 and 2;1. Recall that it is particularly difficult for very young children to perform a judgement which requires them to answer 'no', as is the case here.[1]

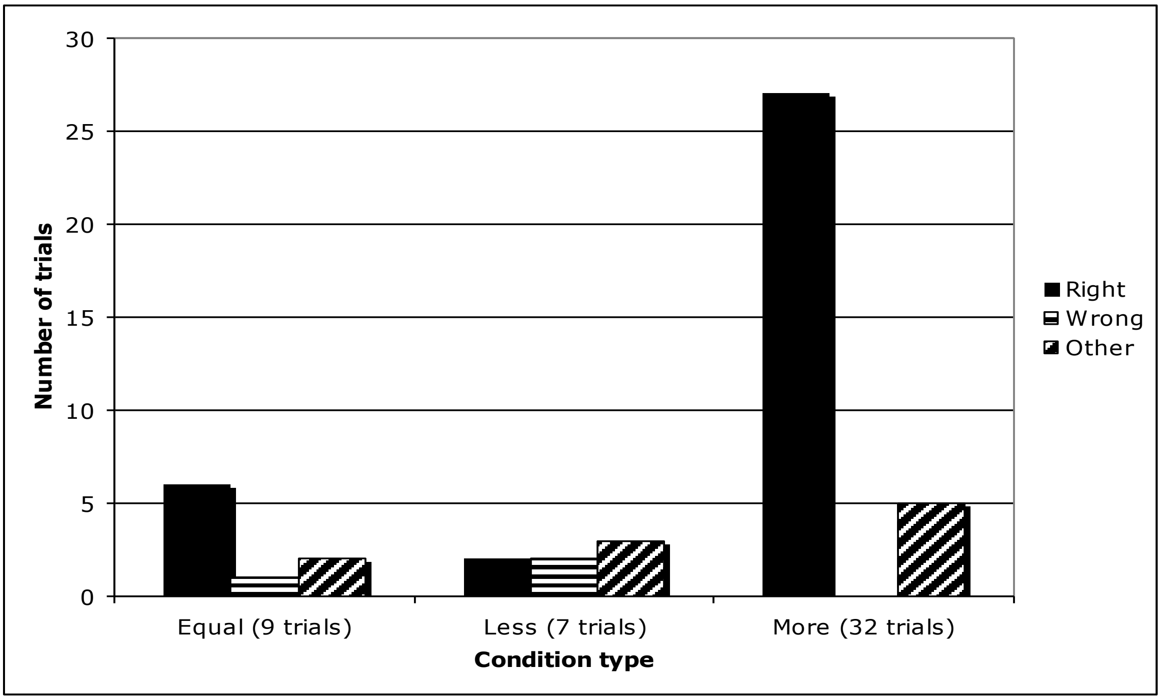

Figure 3: Ruby (1;11-2;5) Results Across All Conditions

The majority of Ruby's data consists of *More* trials. It is striking that there are no incorrect responses to trials of this type, even from as young as 1;11. In every trial of this type, the extra objects are present, visible and controlled by the child. Thus, the extra objects are contextually salient. In two cases, the extra objects are made particularly salient when the experimenter asks about them.

In a *More* trial, after providing every member of set A with a member of set B, there are three possible behavioural responses a child could have to the extra Bs: (i) expand the A set (look for more As to give the extra Bs to), (ii) distribute all Bs to the As that are present, or (iii) ignore/discard the extra Bs. Only children who pass through a non adult stage in their mastery of *every*, in which they quantify over the set in the nuclear scope of the universal quantifier might opt for (i). Option (ii) is possible on all accounts. Option (iii) is predicted by adult-like accounts, and is intuitively the most natural adult response.

Out of her 27 correct *More* trials, Ruby was presented 20 times with a different unique set of extra objects (Bs). In the remaining 7 trials, a judgment trial had immediately followed an act-out trial about the same sets of objects. Naturally, for the purpose of examining how extra objects were treated, these trials were not double-counted. Her extra object responses are presented in Figure 4. In the vast majority of her correct *More* cases, Ruby responds in an adult-like manner. Most often, she chooses to ignore the extra objects in set B, in two cases following an experimenter prompt. An example of this response from age 2;4 is given in (4).

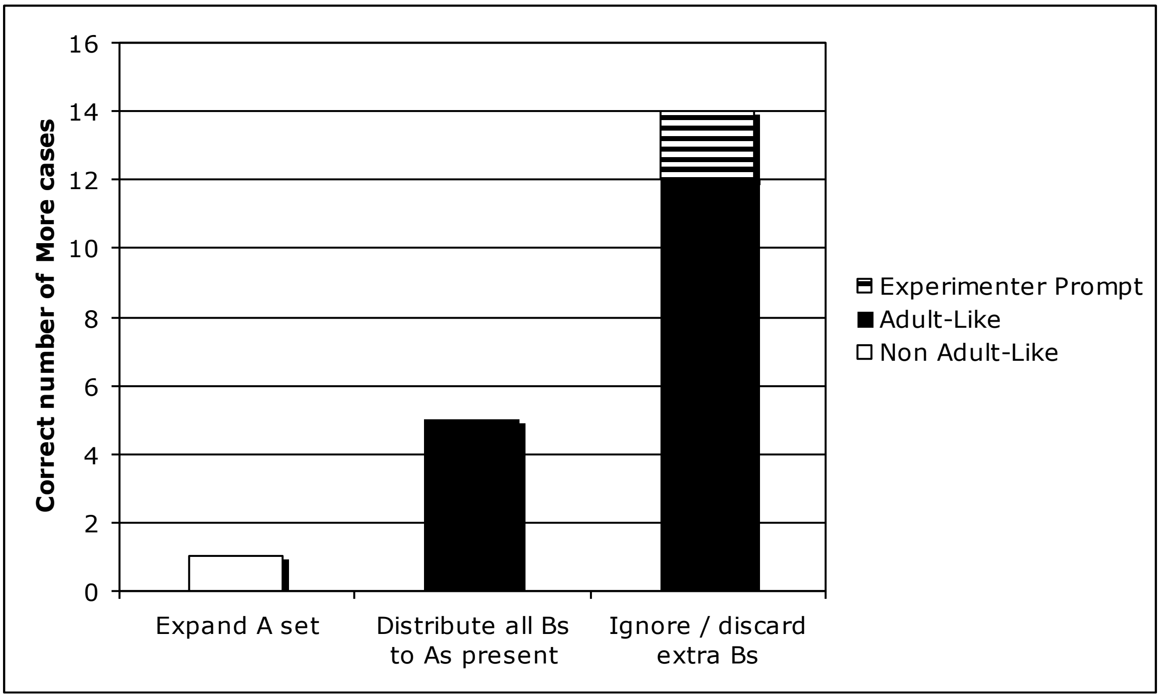

Figure 4: Ruby (1;11-2;5) Extra Object Responses in More Condition

(4) [Context: 5 babies, 6 blankets; Ruby has given 1 blanket to each baby]
Experimenter: *Now does every baby have a blanket? Let's look.*
Ruby: *Yeah*
Experimenter: *What will we do with this blanket?* (indicating extra blanket)
Ruby: *um… it's another blanket*

Only once (in 20 cases) does Ruby respond in a potentially non adult-like way by expanding the intended A set in order to distribute all the extra objects. The case was one in which Ruby had 6 strawberries to distribute and after giving strawberries to the 4 toy characters in question, she gives one strawberry to a Kermit puppet sitting behind her and keeps one for herself, thus exhausting the B set. It should be noted, however, that she hesitates momentarily in between satisfying the task and deciding to continue distributing strawberries. It is thus not clear that the further distribution is actually part of the task for her. Nonetheless, to be objective we coded this as an instance of 'expand the A set'. We stress that it was the only case (across all three data sets) that could possibly be interpreted in this way. Even accepting the coding, Ruby's response can still be accounted for on an adult-like model because the test question was actually asked about *everybody* and Ruby could potentially have defined the A set *everybody* to include Kermit and herself in addition to the four friends. Roughly half of each child's trials were phrased using the word *everybody* or *everyone*. Because the preceding context was designed to satisfy presuppositionality demands of *every*, the set being referred to was generally clear. Nonetheless, it could still be possible for a hearer to entertain a different interpretation from a speaker in this case. In light of Ruby's otherwise consistent adult-like responses (and given the other children's data), it seems likely that her single 'expand the A set' response should also be accounted for in an adult-like way.

5.2 Ian (2;4-3;1)

Ian's responses are presented in Figure 5 for all conditions. His first correct response to *Less* and *More* trials is at 2;4, and his first correct response to an *Equal* trial is at 2;5. Note that he has no wrong responses in the *Equal* or *More* conditions and that in each condition he shows a majority of correct responses. It is unsurprising that the *Less* condition is where he makes errors, as this is the most demanding condition. Note, however, that his two incorrect responses occur in his earliest files, at age 2;4 and 2;5, and that even in the *Less* condition he shows a majority of correct responses. It is also unsurprising that he fares better than Ruby on this condition given that he starts testing 5 months later than she does. Being older, he has had more experience in answering negative judgment questions. An example of a 'right' response from Ian in the *Less* condition at age 2;8 is given in (5).

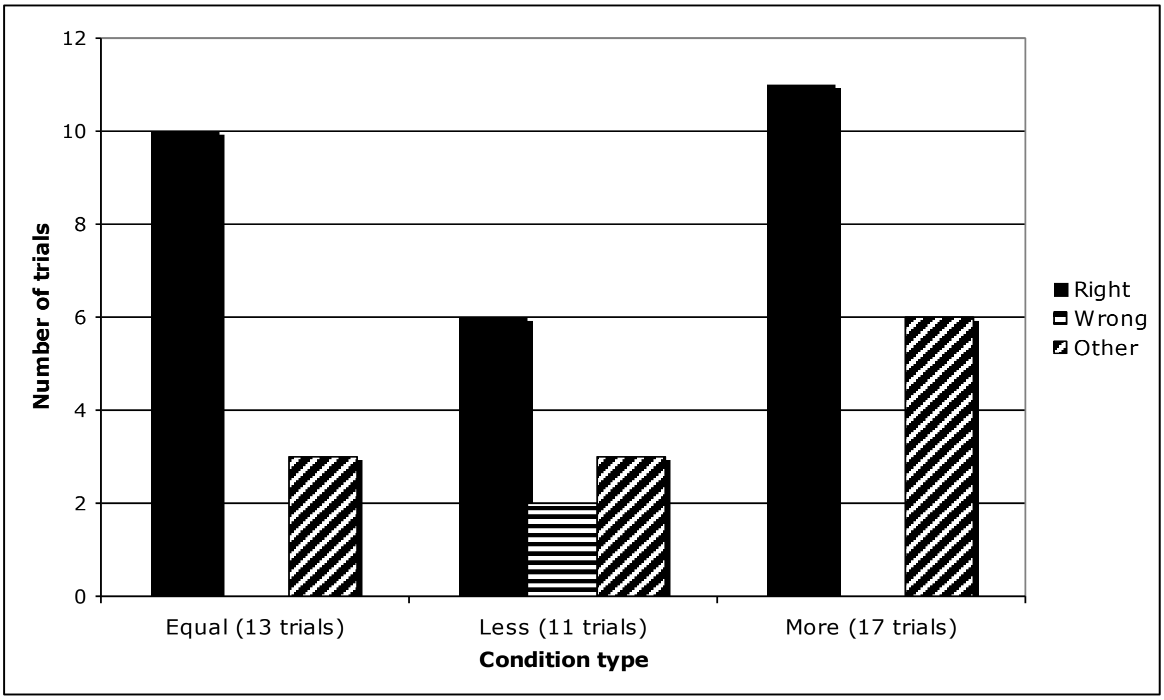

Figure 5: Ian (2;4-3;1) Responses Across All Conditions

(5) [Context: 5 babies, 4 have lettuce]

Experimenter: *Does every baby have some lettuce?*

Ian: *That one haven't got lettuce* [pointing to baby with no lettuce]

Of Ian's 11 correct *More* trials there are 7 cases in which he was presented with a set of extra objects (Bs). His extra object responses are presented in Figure 6. Ian gives an adult-like behavioural response to the extra Bs 100% of the time. Like Ruby, in the majority of cases he chooses to ignore the extra objects in set B. An example of Ian's response to extra objects with an experimenter prompt at age 2;8 is given in (6).

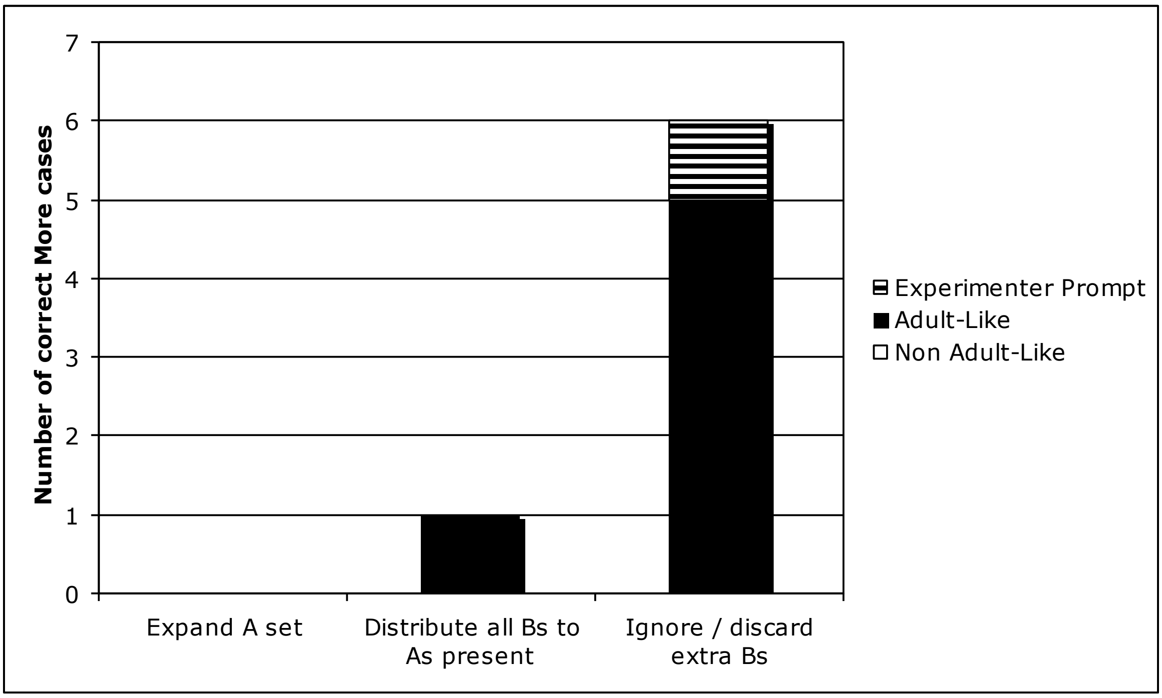

Figure 6: Ian (2;4-3;1) Extra Object Responses in More Condition

(6) [Context: 5 babies, 6 blankets; Ian has handed out blankets as follows: 3 babies each have their own blanket and 2 babies are under 1 blanket]
Experimenter: *Does every baby have a blanket?*
Ian: *yes, that one have a blanket*, *and that one has a blanket, that one and that one and that one* [touching each baby in turn]
Experimenter: *what happens to these blankets?* [indicates 2 extra blankets]
Ian: *maybe put them away*

5.3 Pam (2;1-2;11)

Pam's responses are presented in Figure 7 for all conditions. Her first correct response to a *More* trial is at 2;1, and her first correct responses to *Less* and *Equal* trials are at 2;2. Like the other children, Pam shows a majority of correct responses across conditions. She makes no incorrect responses in the *Equal* condition and only one in the *More* condition. She gives two 'wrong' responses in the *Less* condition, the most demanding condition. An example of a 'right' response from Pam in the *Less* condition at age 2;11 is given in (7).

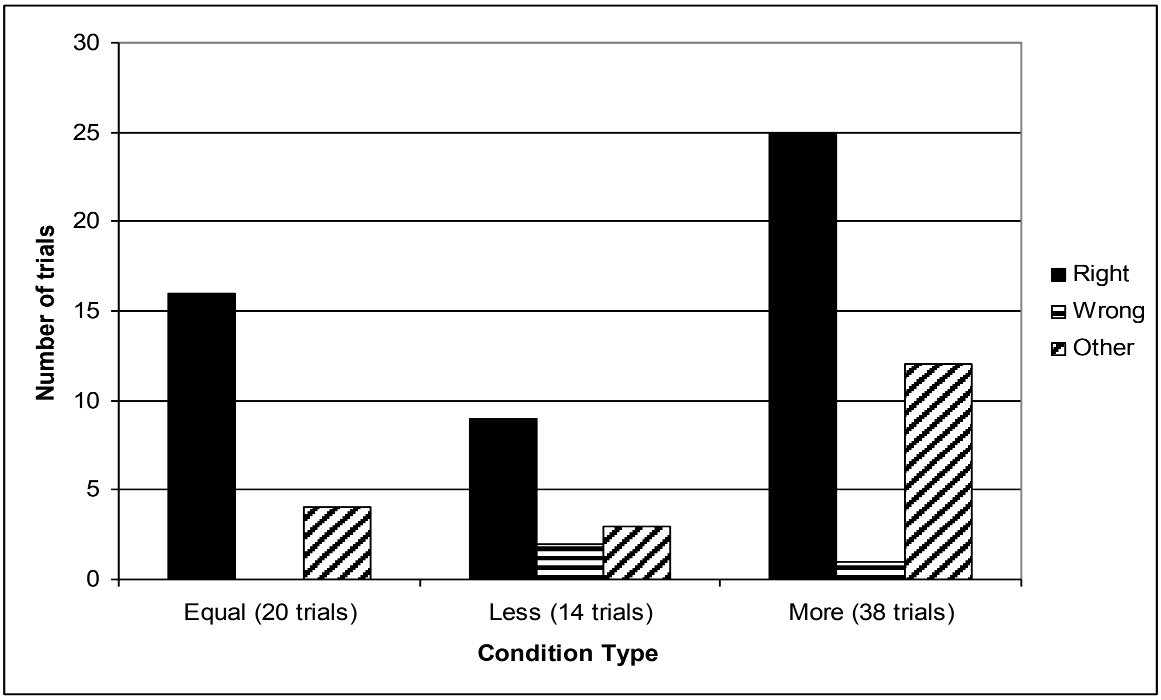

Figure 7: Pam (2;1-2;11) Responses Across All Conditions

(7) [Context: 5 friends, 4 have shells]
Experimenter: *Does every friend have a shell?*
Pam: *…oh Winnie-a-Pooh hasn't got one*

Of Pam's 25 correct *More* trials, there are 22 cases in which she was presented with a set of extra objects (Bs). Her extra object responses are presented in Figure 8. Like Ian, Pam gives an adult-like behavioural response to the extra Bs 100% of the time, and like both other children, in the majority of cases she chooses to ignore the extra objects in set B. An example of Pam's response to extra objects with an experimenter prompt at age 2;7 is given in (8).

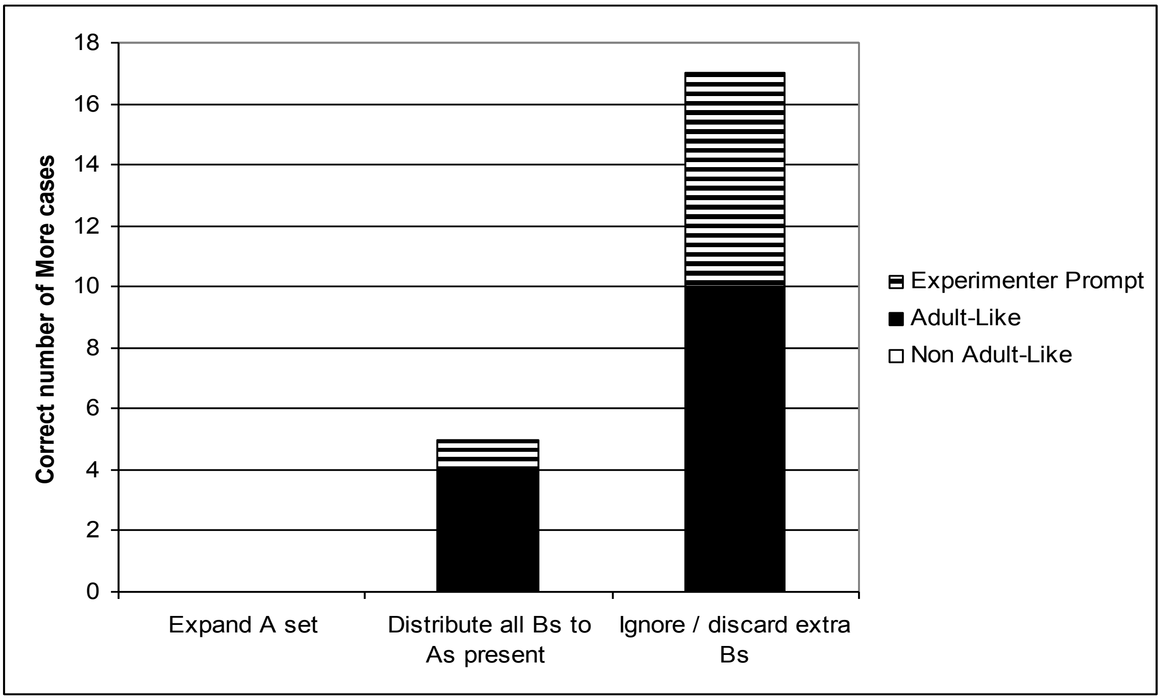

Figure 8: Pam (2;1-2;11) Extra Object Responses in More Condition

(8) [Context: 4 babies each under a blanket, 2 extra blankets]

Experimenter: *Now is every baby under a blanket?*

Pam: *yes* [nodding]

Experimenter: *what about these blankets?* [indicating extra blankets]

Pam: *no you don't need that blankets*

5.4 Discussion of Results

We have shown that, overwhelmingly, children as young as 1;11 give adult-like answers to trials similar to that in Figure 1, in the *More* condition, when these trials are presented in natural contexts. Moreover, the data clearly demonstrate that even when extra objects are contextually salient (being present, visible, controlled by the child and, in some cases, verbally queried), children are generally satisfied that a *More* trial is complete when the minimal condition for *every* has been fulfilled (every 'A' has a single 'B'). That is, two-year-olds are content to ignore or discard extra Bs in keeping with the most intuitive adult-like analysis of such a situation. These results are consistent with predictions (3) and (4), in line with theories which attribute an adult-like reading of the universal quantifier to children from the outset.

It should be noted that non adult-like accounts would also permit an adult-like response in the *More* condition, if it were granted that in these cases the children were using their adult-like semantic model of the universal quantifier or adult-like mapping processes from syntax to semantics (because, even though the objects in set B were salient, the overall discourse context ensured the objects in set A were also salient). This would represent a viable alternative, however, only if children displayed non adult-like behaviour in at least some cases or at least preferred a less typical adult response (to distribute all Bs to As present), consistent with predictions (1) and (2). In fact, across all the *More* cases, children chose to distribute all Bs to As present relatively rarely, and only one child chose once to expand the A set in order to exhaust the extra objects. Moreover, as noted before, this particular case could also be accounted for under the adult-like view, given that the A set was referred to as *everybody*. Therefore, we feel that the data provide no strong evidence to support non adult-like accounts of children's acquisition of the universal quantifier.

6. Broader Implications and Directions for Future Research

We have seen that the data support an adult-like account but, at present, we are not in a position to adjudicate between the three relevant theories. These accounts all hold that children correctly quantify over the set of *boys* in a sentence like *Every boy is riding an elephant*. However, they differ in their explanations of why errors arise. Recall that the Full Competence account maintains that child errors with universal quantification are due to infelicitous test conditions linked to asking a yes/no question, when the condition of plausible dissent is not met. The Presuppositionality Account and the Relevance Account, on the other hand, hold that child errors are due to infelicitous test conditions linked to a specific requirement of *every* as a strong quantifier: its domain of quantification must be presupposed in context. The difficulty in distinguishing between these two explanations is that the condition of plausible dissent encompasses the felicity condition of clearly defining the domain of quantification in context. We do not disagree that this is a necessary condition for successful performance by children on these tasks. However, we feel that having identified two conditions (presupposition and plausible dissent) which help to reduce non adult-like errors in these tasks, it would be most prudent to use both in future experiments. It is only by making experiments as pragmatically felicitous as possible for young children that we can uncover their real abilities.

A separate issue that Drozd & van Loosbroek raise within the framework of their 2006 account is whether children know that *every* is obligatorily distributive. On their account, they suggest that children could be expected to make more non adult-like errors when they have to rely on the existential narrow-scope reading to build a distributive interpretation for *every* in a context that could be interpreted collectively (e.g. 3 boys riding 1 elephant, and 2 extra elephants). On the Full Competence account children should have no problem entertaining the two different scope readings for *every* (the universal wide-scope reading and the existential wide-scope reading) in felicitous contexts. Drozd & van Loosbroek (1999; 2006) present findings from 4-5-year-old Dutch children showing that when presented with 'collective' pictures like the one described above, and asked *Is every boy riding an elephant?* children do make more errors than when presented with 'distributive' pictures like Figure 1. Moreover, their error rate does not improve when the discourse context is modified to better satisfy the presuppositionality demands of *every*. Unfortunately, Drozd & van Loosbroek do not statistically compare children's performance on this condition in infelicitous contexts with their performance in contexts that satisfied both the presuppositionality demands of *every* and the condition of plausible dissent (however, the mean correct responses they report do show an improvement; for example, 4-year-old responses improve by 28%, from 35% to 63% correct when presented with 'collective' pictures in contexts aimed at satisfying plausible dissent in addition to the presuppositionality demands of *every*).

We did not design our study to address this separate issue, as all contexts we used were consistent with the distributive universal wide-scope reading. However, in other act-out trials the 3 child subjects were provided with a single set B object (these trials are not included in the data reported above). In order to satisfy the task, children had no trouble accessing the existential wide-scope reading. An example comes from Ruby at age 2;5. In the context of 1 piece of bread and 5 dogs she is asked to *give every dog some bread*; she offers the single piece of bread to each dog in turn. Nonetheless, although children can clearly access a distributive existential wide-scope reading, we recognize there are aspects of Drozd & van Loosbroek's findings in this area that are puzzling and certainly deserve more in-depth study. Why, for instance, do children's correct response rates on 'collective' picture tasks not improve as much as they do on 'distributive' picture tasks in felicitous contexts?

Further research into the issue of children's knowledge of *every*'s distributive nature should take care not to confuse the existential wide-scope reading of *every* with a truly collective reading of the universal quantifier. Brooks and Sekerina (2006) point out that the pictures used in previous research may have confounded children's preference for a universal wide-scope reading with their ability to interpret *every* as distributive in an existential wide-scope context. A study using 'truly collective' pictures (e.g. 3 girls carry a cake together, 2 extra cakes) has shown that 5-6-year-old children prefer to associate the related quantifier *each* with 'distributive' pictures rather than 'collective' ones (Brooks & Braine, 1996; Brooks, Braine, Jia, & da Graca Dias, 2001). Current findings could be clarified by testing younger children on their acceptance of *every* in contexts which can only be interpreted collectively. On a Full Competence account children would be expected to show rates of acceptance similar to adults.

7. Conclusion

The crucial point of conflict we have addressed in this study is what set children choose to quantify over when interpreting the universal quantifier. Adult-like accounts hold that children correctly quantify over the subject noun in sentences like *Every boy is riding an elephant*. We have presented data from some of the earliest stages of child language development in support of these accounts, showing that in felicitous naturalistic contexts, children do not make non adult-like responses in trials like Figure 1, our *More* condition. They quantify over the subject noun and extra members of the object noun set (set B) are deemed irrelevant. We feel the simplest explanation for these results is that children have an adult-like model of universal quantification. Indeed, this seems to be the emerging consensus in the field, as even Philip (2004) has recently presented evidence from 3-5-year-old children against his non adult-like EQA (which violates determiner conservativity and faces learnability problems), and revised his view in favour of an adult-like account.

Our data are consistent with any of the adult-like accounts discussed and it could even be argued that they are consistent with Geurts' Weak Mapping account since he agrees that children have an underlying adult-like semantic representation of the universal quantifier set relation. We thus choose to adopt the theory that offers the highest degree of parsimony: Full Competence. We need to gain a better understanding of the notion of working memory as it relates to strong and weak quantifier processing and of how children interpret the use of *every* in truly collective contexts before we decide to introduce more theoretical machinery than is absolutely necessary to account for children's interpretation of the universal quantifier. Until then, we are left with the observation that very young children appear to assign the same meaning to *every* as adults do.

Acknowledgements

We would like to thank Stephen Crain for working with the children in this study, for generously sharing his data with us, and for many useful comments about the issues discussed.

Endnotes

[1] It is also worth pointing out that 2 of Ruby's 3 'other' responses here are 'mismatch' answers in which her first answer is non adult-like, but her subsequent answer demonstrates adult-like knowledge. An example at age 2;4 is: [Context: 5 friends, 4 have balls] Experimenter: *Does everybody have a ball?* Ruby: *Yeah.* Experimenter: *Are you sure?* Ruby: *Dis one has no ball* (pointing to friend without ball). Note, too, that although Ruby's change in answer is prompted by a follow-up question, follow-ups of this type were not only used when a child gave an incorrect answer. Ruby had 4 trials in which a follow-up like *'are you sure?'* or *'really?'* was used rather than a repetition of the test question, twice when she had given an incorrect answer and twice when she had given a correct answer. After the follow-up questions, she changed her incorrect answers, but did not change her correct answers.

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Moving from Chapter 5 to Chapter 6

In Chapter 5, we showed that even very young children initially assign adult-like semantics to the universal quantifier, but that certain felicity conditions on the use of this quantifier need to be satisfied to reveal this knowledge. These are that the condition of plausible dissent be met, and that the presuppositional demands on the use of EVERY be satisfied. We included these two conditions in the design of our Chapter 6 study, which tested older children's understanding of complex sentences containing the universal quantifier, as well as two other logical operators.

Our Chapter 6 study was originally designed to explore the extent to which children make use of combinatory principles of logic in interpreting complex sentences containing multiple logical operators. In conducting the study, however, we came upon an unexpected finding. The sentences we were testing (e.g. Not every princess took a star or a shell) turned out to be ambiguous for adult English speakers. Because the ambiguity involved an asymmetrical entailment between readings, we were able, once again, to test the predictions of the Semantic Subset Maxim.

CHAPTER 6

English-speaking children's interpretation of disjunction in the scope of 'not every'

This paper is presented in its original published format:

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I would like to acknowledge the roles of my co-authors. Rosalind Thornton acted as the second experimenter in the truth value judgement task reported on, playing the role of the puppet; Stephen Crain provided experimental design advice and feedback on drafts of the paper. I was otherwise responsible for all other aspects of testing and writing.

Abstract

This study examined 4- to 5-year-old English-speaking children's interpretations of sentences containing negation, the universal quantifier, and disjunction. Disjunction is assigned two different meanings in such sentences depending on its position in surface syntax: in the subject phrase of 'not every' (e.g. *Not every passenger who ordered chicken or beef became ill*), a disjunctive meaning is assigned (e.g. at least one passenger who ordered chicken OR at least one passenger who ordered beef became ill); in the predicate phrase of 'not every' (e.g. *Not every passenger who became ill ordered chicken or beef*), a conjunctive meaning is assigned (e.g. at least one passenger who became ill did not order chicken AND did not order beef). If children bring knowledge of combinatory logical principles to the task of language acquisition, then they should be sensitive to this asymmetry. We tested this prediction using a truth-value judgement task.

1. Introduction

This paper explores how 4- to 5-year-old English-speaking children interpret sentences that contain three logical expressions: negation, the universal quantifier, and disjunction. It is instructive to look at how children interpret complex sentences like these, because it is unlikely that they have encountered many (or any) such sentences in the primary linguistic data. Therefore, the interpretations children assign may be revealing about their knowledge of combinatory principles of logic. In the previous literature, children's understanding of sentences with the universal quantifier and disjunction has been studied, but without negation. Let us begin by reviewing that literature, focusing on sentences without negation, such as (1) and (2). Then we can appreciate the consequences of introducing negation for semantic interpretation.

When disjunction appears in the subject phrase of a universally quantified sentence, as in 1(a), it generates a conjunctive interpretation, as indicated in 1(b). However, when disjunction appears in the predicate phrase, as in 2(a), it licenses disjunctive truth conditions, as indicated in 2(b).

(1) Every passenger who ordered chicken or beef became ill

a. Every $_{\text{SUBJ}}$[passenger who ordered chicken OR beef] $_{\text{PRED}}$[became ill]

b. Meaning: every passenger who ordered chicken became ill AND every passenger who ordered beef became ill (AND every passenger who ordered both became ill)

(2) Every passenger who became ill ordered chicken or beef

a. Every $_{\text{SUBJ}}$[passenger who became ill] $_{\text{PRED}}$[ordered chicken OR beef]

b. Meaning: every passenger who became ill ordered chicken OR beef (OR possibly both)

As these examples indicate, there is an asymmetry in the interpretation of disjunction in (1) and (2) depending on which surface structure position (subject phrase versus predicate phrase) disjunction appears in. The asymmetry arises, first, because disjunction is assigned the truth conditions associated with inclusive-or, as in classical logic and, second, because the entailment relations of the subject phrase and the predicate phrase of the universal quantifier are reversed. Briefly, the subject phrase is downward entailing (licensing inferences from sets to their subsets), so disjunction is assigned a conjunctive interpretation when it appears in the subject phrase. By contrast, the predicate phrase of the universal quantifier is not downward entailing, so disjunction is assigned ‘disjunctive’ truth conditions, rather than a conjunctive interpretation, when it appears in the predicate phrase. A more detailed explanation of this asymmetry is given in section 1.1.

The previous literature on children’s acquisition of logical principles has emphasised the difficulty children would experience if they had to learn the meanings of logical expressions based on the input from adults (Crain et al., 2006; Crain et al., 2005; Crain & Khlentzos, 2008, 2010; Crain & Thornton, 2006). First consider, for example, how English-speaking children learn that ‘or’ is inclusive- or, and not exclusive-or. This is problematic because ‘or’ is far more likely to appear in linguistic contexts that invite an exclusive-or interpretation, rather than an inclusive-or interpretation, in the spontaneous speech of both children and adults (Morris 2008). In a review of 240 transcriptions of audio-taped exchanges between 2- to 5-year-old children and their parents taken from the CHILDES database, Morris (2008) reports 465 uses of ‘or’ out of a total of 100,626 conver- sational turns. For children, utterances in which disjunction meant inclusive-or were produced less than 10% of the time, and uses of ‘or’ with an inclusive-or interpretation were produced by adults only slightly more often than 10% of the time. A representative sample of input to Adam and Eve from the Brown corpus (Brown 1973) is provided in Crain et al. (2005), further illustrating the predomi- nance of the exclusive-or interpretation of disjunction in the input to children.

Further arguments against a learning account are based on the asymmetry in the truth conditions associated with disjunction when it appears in the subject phrase versus the predicate phrase of the universal quantifier. The universal quantifier is special in this regard. Other determiner phrases such as *some of the Ns* and *none of the Ns* assign the same truth conditions to disjunction when it appears in either argument. Disjunction is assigned a conjunctive interpretation in both arguments of *none of the Ns*, and disjunction is assigned disjunctive truth conditions in both arguments of *some of the Ns*. These determiner phrases, therefore, fail to support any substantive generalizations about the interpretation of disjunction in sentences with the universal quantifier.

Worse still for a learning account is the fact that the input contains little, if any, information about how the universal quantifier and disjunction are interpreted when they appear together. We surveyed every adult utterance in the MacWhinney and Brown corpora in the CHILDES database; a total of 130,337 utterances (Brown 1973, MacWhinney 2000). There were just two instances of disjunction in the nuclear scope of 'every', and there were no cases in which disjunction appeared in the restrictor of 'every' (neither did disjunction occur in the restrictor of 'all'). Despite the paucity of evidence, previous research on child language has found that pre-school children know the asymmetry in the interpretation of disjunction in (1) and (2). In both English and Mandarin, children have been shown to generate the conjunctive interpretation of disjunction in sentences like (1), but not in ones like (2) (Boster & Crain, 1993; Chierchia et al., 2001; Chierchia et al., 2004; Gualmini et al., 2003; Su & Crain, 2009).

To recap, children have been found to know the asymmetry in the interpretation of disjunction in the subject phrase versus the predicate phrase of the universal quantifier. This difference in interpretation hinges on two facts; first, that disjunction is inclusive-or and, second, that the universal quantifier (unlike some other quantifiers) interacts differently with (inclusive) disjunction when it appears in the subject phrase versus the predicate phrase. Yet, children have little direct experience bearing on either of these facts. The majority of their input is consistent with disjunction being exclusive-or, and children rarely encounter sentences that contain both disjunction and the universal quantifier.

Taken together, these observations about the input children receive, and about what children know about the meanings of complex sentences, seem inconsistent with a learning account of children's knowledge of logical principles. The alternative is to suppose that children are innately endowed with knowledge of the relevant combinatory principles of logic. Further support for this innateness hypothesis is the finding that children even know the asymmetry between the two arguments of 'every' in sentences with the existential quantifier 'some' and negation. This is particularly striking as this phenomenon involves three logical operators, as the sentences in (3) and (4) illustrate.

(3) Every farmer who didn't clean some animal has a broom

a. Every $_{\text{SUBJ}}$[farmer who did NOT clean SOME animal] $_{\text{PRED}}$[has a broom]

b. Every farmer who didn't clean any animal has a broom (not > some)

(4) Every farmer didn't clean some animal

a. Every $_{\text{SUBJ}}$[farmer] $_{\text{PRED}}$[did NOT clean SOME animal]

b. For every farmer, there is some animal that he did not clean (some > not)

When negation and 'some' occur together in the subject phrase of a universally quantified sentence, as in 3(a), negation is assigned wide scope over 'some', as indicated in 3(b). We understand the sentence to mean that farmers who didn't clean any animals at all have brooms. On the other hand, when negation and 'some' occur together in the predicate phrase, as in 4(a), 'some' is assigned wide scope over negation, as indicated in 4(b). We understand the sentence to mean that every farmer did not clean at least one animal (although he probably did also clean some other animals). Gualmini (2005) tested 30 3- to 5-year-old English-speaking children on sentences like these, and found that the children successfully assigned opposing scope relations to negation and 'some' in these two linguistic environments.

Previous results have shown, therefore, that children are aware of the consequences of the asymmetry between the two arguments of the universal quantifier, and are able to demonstrate this knowledge even in sentences with three logical operators; sentences that they are unlikely to have ever come across. The present study was designed to take this important finding a step further. The study asks whether children are aware of the reversal of this asymmetry under negation.

Negation reverses entailment relations. Consider the interpretive consequences of adding negation to sentences (1) and (2). The results are sentences (5) and (6). While disjunction appears in the subject phrase of (5), it no longer generates a conjunctive interpretation, due to negation. However, disjunction now generates a conjunctive interpretation when it appears in the predicate phrase, as in (6).

(5) Not every passenger who ordered chicken or beef became ill

a. Not every $_{\text{SUBJ}}$[passenger who ordered chicken OR beef] $_{\text{PRED}}$[became ill]

b. Meaning: at least one passenger who ordered chicken OR beef was unaffected

(6) Not every passenger who became ill ordered chicken or beef

a. Not every $_{\text{SUBJ}}$[passenger who became ill] $_{\text{PRED}}$[ordered chicken OR beef]

b. Meaning: at least one passenger who became ill did not order chicken AND did not order beef

In short, there is an asymmetry in the interpretation of disjunction in (5) and (6), depending on the surface structure position of disjunction (whether it appears in the subject phrase versus the predicate phrase). However, the asymmetry is the reverse of that observed in examples like (1) and (2). If it turns out that children know the asymmetry in the interpretation of disjunction in sentences like (5) and (6), as well as the reverse asymmetry in sentences like (1) and (2), then this will constitute additional evidence that knowledge about combinatory principles of logic is available to children from the earliest stages of language acquisition. A learning account of these particular phenomena is highly problematic. We surveyed the MacWhinney and Brown corpora on the CHILDES database and found no instances of the compound quantifier 'not every'. There were 40 adult utterances in which 'not' preceded the quantifier 'all', but none of them also included the disjunction operator.

The present study has another research aim. While we were conducting this study, we came across an unanticipated finding. It turned out that the adult English-speakers we interviewed judged sentences like (6) to be ambiguous. We repeat example (6), as (7), below to illustrate the two adult interpretations.

(7) Not every passenger who became ill ordered chicken or beef

a. Meaning 1: at least one passenger who became ill did not order chicken AND did not order beef

b. Meaning 2: it was chicken or beef that not every passenger who became ill ordered (at least one passenger who became ill did not order chicken, OR did not order beef, OR did not order either meat)

On the reading indicated in 7(a), disjunction is interpreted within the scope of 'not every', so the meaning can be paraphrased as follows: 'There is at least one sick passenger who did not eat chicken AND who did not eat beef'. This is the conjunctive interpretation of disjunction. On the reading indicated in 7(b), by contrast, disjunction is interpreted as having wider scope than 'not every', so the meaning can be paraphrased as follows: 'It was chicken OR beef that not every passenger who became ill ordered'. In other words, the sentence is true if either (a) some sick passenger did not eat chicken (but did eat beef), or (b) some sick passenger did not eat beef (but did eat chicken), or if some sick passenger did not either dish. This is the disjunctive interpretation. Although the disjunctive interpretation is not the preferred reading for adult speakers of English, we discovered in the course of our study that it is available to many adult speakers. Given that two readings are possible for sentences like (7), children, too, must be faced with this ambiguity. This means that we also need to address the question of which of these two readings constitutes children's initial hypothesis.

In answering this question, we began with the observation that one of the readings of (7), namely 7(a), asymmetrically entails the other, 7(b). That is, (7) is true on the meaning represented in 7(a) in just one circumstance. The same circumstance makes sentence (7) true when it is assigned the meaning in 7(b), but there are also other circumstances that make (7) true on the meaning represented in 7(b). Simply put, 7(a) is the subset reading, and 7(b) is the superset reading. This phenomenon is a semantic version of the familiar subset problem described by Berwick (1985) and by Pinker (1984). Both of these researchers observed that a learnability problem could arise for children when one language generates a subset of the sentences generated by another language. In the absence of negative evidence, children are compelled to initially adopt the 'subset' language.

Since the early 1990's, it has been claimed, albeit controversially, that when children are presented with a semantic ambiguity of the kind in (7), that they are also guided by a learnability constraint that compels children to initially adopt the subset interpretation 7(a) in order to guarantee that the superset reading 7(b) can be learned from positive evidence, if the superset interpretation is assigned by adult speakers of the local language (Crain et al., 1994). This constraint was initially called the Semantic Subset Principle, to distinguish it from the (syntactic) Subset Principle proposed originally by Berwick and by Pinker, but it has recently been reformulated as the Semantic Subset Maxim in order to handle cases of scope ambiguity (Crain et al., 1994; Notley et al., 2012). According to the Semantic Subset Maxim, children should initially prefer the scope assignment that generates the conjunctive interpretation 7(a). The present study is designed to test this prediction.

To sum up, the present study has two goals. The first goal is to determine whether children are aware of the asymmetry in the interpretation of disjunction in the two arguments of the complex quantifier 'not every'. If so, children should show a disjunctive interpretation of disjunction in the first argument, the subject phrase, and a conjunctive interpretation in the second argument, the predicate phrase. To arrive at these two different interpretations of disjunction, children must apply intricate combinatory principles of logic, based on the meanings of logical expressions. Our first goal, then, is to determine the extent to which (first-order) logic determines both the underlying semantics of various logical operators and whether logic dictates how the meanings of these logical operators are combined for children. We have documented that these principles are not amply demonstrated in the input. Therefore, if children successfully process the interpretations of complex sentences with multiple logical operators, this can be taken as evidence that they have innate knowledge of the combinatory principles of (first order) logic. Moreover, this evidence will extend current findings to a complex quantifier that is subject to a logical equivalence rule not yet investigated in the literature. The second goal of the study is to test the predictions of the Semantic Subset Maxim concerning children's initial hypotheses when presented with certain kinds of semantic scope ambiguity.

The paper is organised as follows. First, we will present the logical principles that are responsible for the conjunctive interpretation of disjunction in certain contexts, as opposed to the disjunctive interpretation. For each principle we will also review some relevant child acquisition data supporting the view that the principle is innately specified, rather than learnt. This background will then allow us to understand what logical knowledge children need in order to compute the conjunctive interpretation of disjunction in the predicate phrase, but not in the subject phrase of the compound quantifier 'not every'. We will then introduce the rationale behind the Semantic Subset Maxim and review some current support for this maxim. Finally, we will outline how our study further tests both the Semantic Subset Maxim, and the logical principles that are at play when children comprehend sentences that contain 'not every' and disjunction.

1.1 The Source of the Conjunctive Interpretation of Disjunction

A conjunctive interpretation of disjunction arises when disjunction is interpreted in the scope of a downward entailing (DE) operator. To access this interpretation children must know the underlying meaning of disjunction, and they must know which expressions in natural language are downward entailing. These two logical facts are outlined below, along with what research studies have determined to date about children's sensitivity to each of these facts.

1.1.1 Logical Fact 1: OR in natural language is inclusive

The first logical fact is that the meaning of disjunction in natural language is inclusive-OR. In considering sentences the input containing the disjunction operator ('or' in English), the underlying meaning of this operator is not immediately clear, even in cases where the inclusive-OR interpretation of disjunction is permitted. Compare sentences (8) and (9) in a context in which there are blue, green and red balloons to choose from.

(8) Eric wants a red balloon or a green balloon

(9) I bet Eric will choose a red balloon or a green balloon

In response to (8), hearers generally infer that Eric wants just one balloon, either a red one or a green one, not both. This is the exclusive-OR reading of disjunction, according to which exactly one of the disjuncts is true. In response to (9), hearers generally infer that the speaker has made a correct prediction so long as Eric chooses a red balloon or a green balloon, or both (but not a blue balloon). This is the inclusive-OR reading of disjunction, which includes the possibility that both disjuncts are true.

Note, however, that the inclusive-OR meaning of disjunction generates the truth conditions that are associated with the exclusive-OR meaning. Based on this observation, among others, it has been argued that disjunction is always inclusive-OR and that the exclusive-OR meaning is derived when the additional truth condition associated with inclusive-OR (where both disjuncts are true) is suppressed due to a conversational implicature. The implicature arises because the operator OR and the operator AND form a scale based on information strength. On the scale containing AND and OR, statements with AND are stronger than the corresponding statements with OR, where a term α is 'stronger' than another term β if α asymmetrically entails β. Since the truth conditions assigned to 'P and Q' are a subset of the truth conditions of 'P or Q', statements with AND asymmetrically entail the corresponding statements with OR, which are true in a wider range of circumstances. Following the Gricean conversational maxim of quantity (which entreats speakers to make their contributions as informative as possible), hearers generally assume that if a speaker uses OR, he or she is not in a position to use the stronger term AND to describe the situation under consideration (Grice, 1975). Hearers therefore remove the truth conditions associated with AND from the meaning of OR, yielding the exclusive-OR reading of disjunctive statements (Horn, 1996).

It turns out that children are sensitive to the fact that the underlying meaning of OR is inclusive-OR. As noted earlier, reviews of the input to English-speaking children on the

CHILDES database reveals that, overwhelmingly, children hear sentences in which an exclusive-OR meaning of disjunction is intended. In spite of the paucity of relevant input, several experimental studies have shown that 3- to 6-year-old children access an inclusive-OR reading when disjunction words are presented in a context that is felicitous for this reading, such as the antecedent of a conditional statement (Chierchia et al., 2004; Crain et al., 2000; Gualmini et al., 2000).

1.1.2 Logical Fact 2: Downward entailing expressions license inferences from sets to subsets

The second logical fact is that there exists a class of expressions in human languages that are called DOWNWARD ENTAILING (DE), and these expressions license logically valid inferences from sets to subsets. This class encompasses both negative expressions like NOT, NONE, and WITHOUT, as well as non-negative expressions like the universal quantifier EVERY and the temporal conjunction BEFORE. Despite syntactic and semantic differences among these expressions, they form a natural class in human languages because they license downward entailing inferences from general terms (e.g. 'Romance language') to more specific terms (e.g. 'French').

Consider the statement 'John did not learn a Romance language'. This statement contains negation ('not') and the general term 'Romance language'. If this statement is true, then it logically follows that the statement 'John did not learn French' is also true, where the general term 'Romance language' has been replaced by the specific term 'French'. The universal quantifier 'every' also validates inferences from general terms to specific terms, so if the statement 'Every Romance language is offered for study at this university' is true, then it must also be true that 'French is offered for study at this university'. Note, however, that, as we discussed above, the universal quantifier presents an asymmetry across its arguments. It is only downward entailing on its first argument, and not on its second argument. So, 'Every student is taking a Romance language' does not necessarily entail that every student is taking French.

Child language acquisition data again provide evidence that children are sensitive to which expressions are downward entailing in natural language, because have been found to use this property to master a set of apparently unrelated linguistic facts. DE expressions have two main diagnostic properties. The first is that they license negative polarity items like 'any'. The second is that they license the conjunctive interpretation of disjunction. On a learning approach, one would expect children to master these two logical properties piecemeal, as they amass the relevant input for each. On a nativist approach, by contrast, one would expect both properties to emerge together as early as they can be tested.

Let's look at the evidence that children know about the first diagnostic property of DE expressions. As the examples in (10) illustrate, the use of 'any' is licensed in DE contexts. By contrast, non-downward entailing contexts do not tolerate negative polarity items such as 'any'. Without a DE operator, sentences with 'any' are ungrammatical, as illustrated in (11).

(10) a. Eric did not apply for any scholarship
b. Every student of any Romance language should apply for a scholarship
c. Benjamin applied for a scholarship before any other student

(11) a. *Eric applied for any scholarship
b. *Every student who applied for a scholarship studies any Romance language
c. *Benjamin applied for a scholarship after any other student

It has been shown that children adhere to this restriction on the use of negative polarity items, from the earliest stages of language acquisition. Large-scale reviews of the spontaneous production data of both English-speaking children (aged 0;11-5;2) and Dutch-speaking children (aged 1;5,-3;10) have revealed they almost never produce negative polarity items without a downward entailing licensor of some sort (Tieu, 2010; van der Wal, 1996).[1] In elicited production tasks, it has also been found that children do not produce negative polarity items in non-downward entailing environments, while they do produce them in downward entailing environments (Crain & Thornton, 2006; O'Leary, 1994; van der Wal, 1996). The fact that children avoid and produce negative polarity items in just the right contexts shows that they are sensitive to the difference between downward entailing environments and non-downward entailing environments.

It is conceivable that children master the distribution of negative polarity items by keeping track of the statistical likelihood of each negative polarity item appearing in a range of linguistic environments. They could then use this information to classify which expressions in natural language are downward entailing. Even if this were the case, however, we would not necessarily expect them to be sensitive to the second diagnostic property of downward entailing expressions, the conjunctive interpretation of disjunction, at the same early stage of language development. If, on the other hand, children are innately sensitive to which expressions in language are and are not downward entailing, then we would expect them to compute a conjunctive interpretation of disjunction in DE environments as soon as they can be tested. In the next section, we will explain why this interpretation arises, before reviewing the available evidence showing that children do, indeed, access this interpretation. We will then look specifically at how the compound quantifier 'not every' also demonstrates this property.

1.1.3 The Conjunctive Interpretation of Disjunction in the Scope of a DE Expression

Downward entailing operators license a conjunctive interpretation of disjunction in one of two ways, depending on the type of DE operator in question. In both cases, however, the conjunctive interpretation depends on the disjunction operator being assigned the truth conditions associated with inclusive disjunction (inclusive-OR).

The first way the conjunctive interpretation of disjunction can arise pertains to all negatively flavoured DE operators. We will illustrate using negation, as in (12).

(12) John will not eat broccoli or cauliflower
$\Rightarrow$ John will not eat broccoli and John will not eat cauliflower

When disjunction is interpreted in the scope of negation, sentence (12) is understood to entail that John will not eat broccoli AND that John will not eat cauliflower. The logic is as follows. Ordinary statements with inclusive-OR are true in three circumstances, just as in classical logic. In classical logic, a statement of the form 'P or Q' is true if:

(i) P is true (but Q is not), or
(ii) Q is true (but P is not), or
(iii) both P and Q are true

This means that 'P or Q' is false in just one circumstance: when neither P nor Q is true. When 'or' is negated, the truth conditions for inclusive-OR are reversed. So 'not (P or Q)' is true in the one circumstance in which 'P or Q' is false, namely when neither P nor Q is true. This relationship is captured in one of de Morgan's laws of propositional logic (de

Morgan, 1966), where the symbol '$\neg$' stands for 'not', the symbol '$\vee$' stands for 'or', and the symbol '$\wedge$' stands for 'and':

(13) $\neg(P \vee Q) \Rightarrow \neg P \wedge \neg Q$

The second way the conjunctive interpretation of disjunction can arise pertains to all DE operators containing the universal quantifier in their semantics. We will illustrate using 'every', as in (1), repeated here as (14).

(14) Every passenger who ordered chicken or beef became ill
$\Rightarrow$ every passenger who ordered chicken became ill AND every passenger who ordered beef became ill (AND every passenger who ordered both became ill)

Sentence (14) is understood to entail that passengers who ordered chicken AND passengers who ordered beef became ill. The logic, in this case, depends on the set relations that 'every' creates when it is in construction with a noun phrase that contains disjunction, such as 'every passenger who ordered chicken or beef'. A sentence containing a quantificational determiner is divided into three parts for the purpose of meaning computation: the quantifier, the restrictor and the nuclear scope (Heim, 1988). The restrictor is the noun phrase with which the quantificational determiner combines syntactically. The nuclear scope is the predicate phrase. In the restrictor in (14), 'or' is used to partition the universally quantified superset 'every passenger' into two subsets 'passengers who ordered chicken' and 'passengers who ordered beef'. The quantificational expression 'every passenger who ordered chicken or beef' refers to the entirety of the partitioned superset of passengers. This superset then necessarily includes:

(i) passengers who ordered chicken
(ii) passengers who ordered beef, and
(iii) passengers who ordered both chicken and beef

Here, the conjunctive interpretation of disjunction arises because all THREE circumstances associated with inclusive-OR must be true in order to guarantee the truth of the universally quantified statement. This contrasts with the conjunctive interpretation of disjunction in cases like (12), in which only ONE truth condition is satisfied: the one in which both disjuncts are false.

Once again, the evidence from the child language acquisition literature demonstrates that children are sensitive to this diagnostic property of downward entailing expressions, whether the DE expression is negatively or non-negatively flavoured. Negative DE expressions which have been investigated include negation and the quantifier 'none'. It has been shown that both English- and Japanese-speaking 3- to 5-year-old children consistently assign a conjunctive interpretation to disjunction when it appears with negation in sentences like 'The pig did not eat a carrot or a pepper'. They reject the sentence as a description of a context in which the pig did not eat a carrot, but did eat a pepper (Crain et al., 2002; Goro & Akiba, 2004a, 2004b; Gualmini, 2005; Gualmini & Crain, 2005). This result has also been shown to hold in child English for the operator 'none' (Gualmini & Crain, 2002).

Non-negative DE expressions which have been investigated include the temporal conjunction 'before' and the universal quantifier 'every'. It has been shown that both English- and Mandarin-speaking children consistently assign a conjunctive interpretation to disjunction when it appears with BEFORE in sentences like 'The dog reached the finish line before the turtle or the bunny'. On the conjunctive interpretation the sentence means that the dog reached the finish line before the turtle AND before the bunny. Children reject such sentences as a description of a context in which a dog, a turtle and a bunny run a race, and the dog comes second (Notley et al., 2012). Furthermore, as we discussed in the introduction, both English- and Mandarin-speaking children have been shown to generate the conjunctive interpretation of disjunction in the restrictor of 'every', but not in the nuclear scope. They reject sentences like 'Every princess who picked a red flower or a white flower received a jewel' in contexts in which, for example, only princesses who picked red flowers received a jewel, and they accept sentences like 'Every princess with a jewel picked a red flower or a white flower' in contexts in which every princess with a jewel picked a red flower (Boster & Crain, 1993; Chierchia et al., 2001; Chierchia et al., 2004; Gualmini et al., 2003; Su & Crain, 2009).

1.2 The Conjunctive Interpretation of Disjunction in the Nuclear Scope of 'Not Every'

Now let's consider how the conjunctive interpretation of disjunction arises in sentences containing the compound quantifier 'not every'. As we have pointed out, negation reverses the entailment relations typical of ‘every’: ‘not every’ is downward entailing on its nuclear scope (predicate phrase), and not on its restrictor (subject phrase). Recall examples (5) and (6), repeated here as (15) and (16).

(15) Not every passenger who ordered chicken or beef became ill

a. Not every $_{\text{REST}}$[passenger who ordered chicken OR beef] $_{\text{SCOPE}}$[became ill]

b. Meaning: at least one passenger who ordered chicken OR beef was unaffected

(16) Not every passenger who became ill ordered chicken or beef

a. Not every $_{\text{REST}}$[passenger who became ill] $_{\text{SCOPE}}$[ordered chicken OR beef]

b. Meaning: at least one passenger who became ill did not order chicken AND did not order beef

If disjunction is interpreted in the nuclear scope (predicate phrase) of ‘not every’ in (16), then a conjunctive interpretation is assigned to disjunction, such that that there must be at least one sick passenger in the context who did not order chicken AND who did not order beef. To arrive at this meaning, two combinatory logical principles are required. The first dictates that ‘not every’ is logically equivalent in meaning to ‘some not’. This logical equivalence can be represented by the logical rule given in (17) where the symbol ‘∀’ stands for the universal quantifier ‘every’, the symbol ‘∃’ stands for the existential quantifier ‘some’, A represents the restrictor, and B represents the nuclear scope. The meaning rule in (17) says that ‘Not every A has the property B’ is logically equivalent in meaning to ‘Some A does not have the property B’. We will call this the ‘not every = some not’ logical equivalence.

(17) $\neg \forall (A) (B) \Rightarrow \exists (A) \neg (B)$

When (17) is applied to sentence (16), a covert negation operator ‘not’ is made to act on the nuclear scope of the sentence: ‘ordered chicken or beef’. This, in turn, means that the disjunction operator contained within the nuclear scope gets interpreted as if it were appearing in an overt negative downward entailing environment. Then, through the application of a second logical principle, namely de Morgan’s law illustrated in (13), the conjunctive interpretation is computed. On the other hand, when (17) is applied to sentence (15), disjunction gets interpreted as if it were appearing in the restrictor of the existential quantifier. This is an upward entailing environment, not a downward entailing one. Subsequently, the meaning of (15) is that there must be at least one passenger who did not order chicken, or at least one passenger who did not order beef, who did not become ill, not one of each.

The reversal of entailment relations between ‘every’ and ‘not every’ provides us with a way of further testing whether the logical principles we have discussed are available to children from the outset of the acquisition of language. In the present study, the goal is to see whether or not children are sensitive to the entailment expressed in (17). If so, then children are expected to assign a conjunctive interpretation to disjunction when it appears in the nuclear scope of ‘not every’, but not when it appears in the restrictor.

We should point out here that our study was not designed to test whether children also cancel the scalar implicature associated with disjunction in the nuclear scope of ‘not every’, as opposed to the restrictor. Another notable feature of DE environments is the cancellation (or reversal) of scalar implicatures (Atlas & Levinson, 1981). As discussed earlier, disjunction is subject to a scalar implicature in ordinary (positive) contexts, including the predicate phrase of the universal quantifier. That is why adult speakers generally reject a sentence like ‘Every passenger who became ill ordered chicken or beef’ as a description of a context in which every sick passenger ordered both chicken and beef. Due to the application of a scalar implicature, hearers remove the truth condition on which every passenger ordered both meats. However, speakers judge a sentence like (14), *‘Every passenger who ordered chicken or beef became ill’* to be true in exactly the same context. Because disjunction appears in the restrictor in (14), a downward entailing environment, the scalar implicature is cancelled and speakers do not remove the truth condition on which every passenger ordered both meats from their interpretation. Indeed, this truth condition cannot be removed, because, due to the conjunctive interpretation of disjunction, all three truth conditions associated with disjunction hold in a universally quantified DE environment.

Notice, however, that it is not necessary to consider whether scalar implicatures are cancelled in order to see the conjunctive interpretation of disjunction at work in universally quantified contexts. For example, if a conjunctive interpretation of disjunction is computed in (14), then, even if there are no passengers who ordered both kinds of meat, it is still necessary that both truth condition (i), that all sick passengers who ordered chicken became ill, and (ii), that all sick passengers who ordered beef became ill, be true. If the conjunctive interpretation were not computed, (14) could be true if only one of the truth conditions (i) or (ii) were true, but not both. In other words, if our goal is to determine whether or not a conjunctive interpretation of disjunction is computed in the restrictor of the universal quantifier, we do not need to worry about representing truth condition (iii) in th experimental workspace, according to which passengers who ordered both chicken and beef became ill. We can determine this by seeing if speakers reject (14) when just (i) or (ii) is true, but accept (14) when both (i) and (ii) are true. We draw attention to this because the contexts we use in the present study focus only on the first two possible truth conditions of our test sentences. We use these contexts to test whether children possibly (erroneously) access a conjunctive interpretation of disjunction in the restrictor of 'not every', not whether they cancel the relevant scalar implicature.

Having introduced the logic behind the interpretations assigned to disjunction in the restrictor and nuclear scope of 'not every', we will now discuss the possible semantic scope ambiguity associated with sentences like (16), *'Not every passenger who became ill ordered chicken or beef'*. To do so, we introduce some background about cases of semantic scope ambiguity involving disjunction and downward entailing operators in general, before moving on to the case of 'not every'. We will then discuss the Semantic Subset Maxim, which makes a specific prediction about how children will resolve ambiguities of this kind.

1.3 Cross-Linguistic Differences in Semantic Scope Assignment

The logical principles we have presented (that the meaning of disjunction is inclusive-OR; that DE expressions form a natural logical class; and that disjunction is assigned a conjunctive interpretation in DE environments) are proposed to be universal principles of all natural languages. There are, however, some interesting cross-linguistic differences in how various languages interpret sentences containing disjunction and a downward entailing operator, demonstrating that these sentences are subject to semantic scope ambiguity.

For example, sentences containing the DE operator negation and disjunction like (12), *'John will not eat broccoli or cauliflower'*, actually have two possible interpretations. If disjunction is interpreted in the scope of negation, a conjunctive interpretation arises. Languages which prefer this scope assignment include English, German, French, Greek, Romanian, Bulgarian, and Korean (Szabolcsi, 2002). If, on the other hand, disjunction is interpreted outside the scope of negation, no conjunctive interpretation arises. For example, in Japanese, sentence (18) is typically interpreted to mean ‘It is broccoli or a cauliflower that Taro will not eat (I’m not sure which one)’.[2]

(18)	Taro-wa	burokkori	ka	karifurawa-o	tabe-nai
	Taro-TOP	broccoli	or	cauliflower-ACC	eat-NEG

‘Taro will not eat broccoli or cauliflower

⇒ ‘It is broccoli or cauliflower that Taro will not eat (I’m not sure which one)’

Other languages that prefer for disjunction to be interpreted as taking scope over negation in simple negative sentences include Hungarian, Mandarin, Russian, Serbo-Croatian, Slovak, and Polish (Goro & Akiba, 2004a, 2004b; Szabolcsi, 2002). Due to the relation allowed between disjunction and negation in languages like these, disjunction typically implies exclusivity (e.g. ‘It is either broccoli or cauliflower (but not both) that Taro doesn’t like’). This is because disjunction is subject to exactly the same scalar implicature as it is when it appears in a sentence without negation.

This account of the interpretive differences between languages maintains that the basic meaning of disjunction in all human languages is inclusive-OR, and that when inclusive-OR appears in the semantic scope of a DE operator a conjunctive interpretation will necessarily be generated. In languages like Japanese in which an exclusive-OR reading of disjunction is assigned to sentences like (18), it is supposed that disjunction takes semantic scope over negation. The disjunction operator is therefore not in a DE environment, and no conjunctive interpretation is generated.

Just as sentences containing negation and disjunction can be ambiguous, we discovered that sentences containing ‘not every’ and disjunction can also be ambiguous. Note that this ambiguity does not arise in sentences containing ‘every’. This is because when disjunction occurs in the restrictor of a quantifier, it is bound to that quantifier, and must be interpreted its scope. When disjunction occurs in the nuclear scope of a quantifier, by contrast, two alternative scope relations become available. However, when disjunction occurs in the non-downward entailing nuclear scope of ‘every’ it receives its normal disjunctive interpretation regardless of the semantic scope of this quantifier (compare ‘Every princess picked a red flower or a white flower’ to ‘It was a red flower or a white flower that every princess picked’). On the other hand, when disjunction occurs in the downward entailing nuclear scope of ‘not every’, two different readings are available. For example, sentence (7), repeated here as (19), receives two interpretations. If ‘not every' takes scope over disjunction, disjunction receives the conjunctive interpretation indicated in 19(a). If disjunction takes scope over 'not every', disjunction receives the disjunctive interpretation indicated in 19(b). This is not the preferred interpretation for English-speaking adults, but it is a possible interpretation, as we will see in our results section.

(19) Not every passenger who became ill ordered chicken or beef

a. Meaning 1: at least one passenger who became ill did not order chicken AND did not order beef

b. Meaning 2: it was chicken or beef that not every passenger who became ill ordered

It turns out that the two readings available for sentence (19) form a subset-superset relationship. That is, on the conjunctive interpretation of disjunction in 19(a), the only circumstance that will make the sentence true is if there is some sick passenger who ordered neither of the meats in question. On the alternative interpretation, in which disjunction takes scope over negation, there are three logical circumstances which will make the sentence true: (i) if some sick passenger didn't order chicken, but did order beef, or (ii) if some sick passenger didn't order beef, but did order chicken, or (iii) if some sick passenger ordered neither meat. The circumstances that would make the sentence true on a conjunctive interpretation are thus contained within the circumstances that would make the sentence true on a disjunctive interpretation. It has been proposed that in a situation like this, children should be constrained by learnability considerations as to which reading they will initially hypothesise. We outline this hypothesis and its prediction for our study in the next section.

1.4 The Semantic Subset Maxim (SSM)

The Semantic Subset Maxim (SSM) becomes operative when a sentence has two possible scope interpretations, and these two interpretations form a subset-superset relationship. Once engaged, the SSM compels children to initially favor the reading that makes the sentence true in the narrowest range of circumstances, the subset reading (see Notley et al., 2012). The rationale behind the SSM is that it prevents unnecessary delays for children in acquiring the scope assignment preferences manifested by adult speakers of the local language. If children are acquiring a language in which the superset reading of a sentence is favored by adult speakers, then the SSM guarantees that children who have an initial preference for the subset reading will encounter positive evidence in the input demonstrating that the sentence is true on a wider set of interpretations. Based on the evidence, children will then be able to quickly align their preferences with those of adult speakers. If, on the other hand, children initially favor the superset reading, then the majority of the input they receive will always be consistent with that interpretation, including input from speakers who strongly prefer a subset reading. It would therefore take children considerably longer to align their preferences with those of the adults around them on this scenario.

The findings we discussed previously showing that children, across languages, assign a conjunctive interpretation to disjunction in various downward entailing contexts provide support for the SSM. In particular, the results showing that Japanese- and Mandarin-speaking children prefer to assign a subset conjunctive interpretation to sentences like 'The pig did not eat the carrot or the pepper' or 'The dog reached the finish line before the turtle or the bunny' are particularly telling. This is because, in these languages, adult controls actually preferred or, at least, allowed a superset reading in which disjunction was assigned wide scope over the DE operator in question (Goro & Akiba, 2004b; Notley et al., 2012).

We can use the scope ambiguity introduced in sentences containing 'not every' and disjunction to further test the SSM. The SSM would predict that children should strongly prefer to assign the conjunctive interpretation, 19(a), to sentences like (19). The conjunctive interpretation makes the sentence true in the narrowest set of circumstances. Children can then easily expand their scope preferences to include alternative interpretations based on positive evidence provided by adult language users.[3] We turn now to our methodology, explaining how our study was designed to both test the logical principles outlined, and the predictions of the SSM.

2. Methodology

To test children's interpretation of disjunction in the nuclear scope and restrictor of 'not every' we designed a truth value judgement task (TVJT). This research technique is designed to investigate which meanings children can and cannot assign to sentences (Crain & Thornton, 1998). The task involves two experimenters – one acting out stories with toy characters and props, and the other playing the role of a puppet who watches the stories alongside the child. At the end of each story, the puppet explains to the child subject what he thinks happened in the story. The child's task is to decide whether the puppet said the right thing or not. If the child informs the puppet that he was wrong, then the child is asked to explain to the puppet what really happened. There were two test conditions: one in which 'or' appeared in the nuclear scope of 'not every'; and one in which 'or' appeared in the restrictor of 'not every'. We will refer to these conditions as the 'Nuclear Scope OR' condition and the 'Restrictor OR' condition. Each condition had 4 trials, yielding 8 different test items. Each condition is illustrated below, followed by the relevant predictions.

2.1 'Nuclear Scope OR' Condition

In the 'Nuclear Scope OR' condition there were four test stories like this one:

"Here is an enchanted castle where there is some hidden treasure: silver stars, crystal shells, and golden crowns. And here are four princesses who have been having a picnic in the woods nearby, and are now walking home. One of the princesses spies the palace. "Oh what a beautiful palace," she says. "Let's go and see what's inside." They go in and see some crystal shells. Two of the princesses take a shell each. The other two want to look for something better. Then the princesses go upstairs. The two princesses with shells see a pile of silver stars – they each take one. The other two still want to look for something better. They continue looking and find a secret room with golden crowns in it. But they already have crowns on their heads. So they decide not to take the crowns. Instead, they go back to the pile of stars and each take one. The princesses are happy with the treasure they have chosen to take home."

Figure 1: FALSE 'Nuclear Scope OR' Condition

Figure 1, which corresponds to the scene at the end of the story, illustrates this condition. After the story, the puppet watching alongside the child uttered test sentence (20) to describe what he thought happened in the story. Note that each test sentence was preceded by a positive lead-in like 'Every princess took some treasure'. This was because it has been shown that negative statements about stories are not pragmatically felicitous and can thus lead to irrelevant child errors. However, a positive lead-in preceding the negative statement can help to maintain pragmatic felicity and child errors for this reason drop (Gualmini, 2005; Musolino & Lidz, 2006).

(20) That was a story about four princesses looking for treasure. Every princess took some treasure and I know: Not every princess took a shell or a star.

On the conjunctive interpretation of disjunction (20) is true if there is at least one princess who did not take a shell and who did not take a star. However, in all 4 trials in this condition, the context was, in fact, designed to make this reading false. For example, in our princess story, even though some princesses didn't take shells, they all did take stars. There was therefore no princess who did not take a shell and who did not take a star.

Part of the TVJT methodology recommends that when making a test sentence false, the context should fulfil the condition of plausible dissent. That is, the context should make clear to the child another possible outcome on which the test sentence would have been true. So, in all our Nuclear Scope-OR stories, a possible outcome was outlined in which two of the four characters might not have done either of the actions mentioned. For example, in the case of the princesses, two princesses did not take shells, and they also initially rejected stars, in search of something better. They almost took some crowns. This would have made test sentence (20) true on a conjunctive interpretation of disjunction. Finally, however, the princesses decided that they didn't need crowns because they already had some crowns, so, in the end, they did take a star each. By including a positive lead-in and satisfying the condition of plausible dissent, it is unlikely that children's responses in this task are due to pragmatic confusion. In addition, we always ordered the disjuncts so that the disjunct that made each test sentence false on the conjunctive interpretation was second. In this way we could rule out any child rejections being due to the fact that the child may only have listened to the first part of a test sentence (e.g. Not every princess took a shell). If this were the case, the child would actually have to accept, not reject the test sentences.

While the context of all the stories in the 'Nuclear Scope OR' condition made the test sentences false on the conjunctive interpretation of disjunction, the stories were also designed to make the test sentences true if children, in fact, do not compute the conjunctive interpretation of disjunction in the nuclear scope of 'not every'. They might do this either because they prefer a reading on which disjunction scopes over 'not every', or because, even though they assign 'not every' scope over disjunction, they do not apply the necessary logical principles in these contexts. In either case, sentence (20) could possibly mean 'Not every princess took a shell OR not every princess took a star (OR not every princess took a star or a shell)'. In our princess story, it was true that not every princess took a shell, making the overall disjunctive statement 'Not every princess took a shell OR not every princess took a star' true.

Let's now consider what our prediction in this condition is. To reject the test sentences in this condition, children must (a) recognise that 'not every' is downward entailing on its nuclear scope, and (b) assign 'not every' semantic scope over 'or'. Only the combination of these two conditions will ensure that children are then able to calculate a conjunctive interpretation of disjunction, and reject the test sentences. Therefore, a majority of child rejections in the 'Nuclear Scope OR' condition will show, first, that children are guided by the logical principles presented. Moreover, this will be new evidence that children make complex logical computations involving the 'not every = some not' equivalence. Second, rejections in this condition will constitute support for the Semantic Subset Maxim (which encourages children to favour the scope assignment which leads to a narrower, stronger reading of the sentence in question).

On the other hand, child acceptances in this condition could be indicative of two states of affairs. It could be that children are aware of the logical principles, but that they assign ‘or’ semantic scope over ‘not every’. This would be evidence against the Semantic Subset Maxim, as by assigning ‘or’ semantic scope over ‘not every’, children access a wider possible meaning of test sentences like (20). Alternatively, it could be that children do not recognise that ‘not every’ is downward entailing on its nuclear scope. The relevant prediction is summarised below.

Prediction 1: If children are guided by innate logical principles, and by the SSM, then they should reject the ‘Nuclear Scope-OR’ test sentences (at a rate at least higher than 50% across children). If children are not guided by logical principles and the SSM, they could accept the sentences.

2.2 ‘Restrictor OR’ Condition

In the ‘Restrictor OR’ condition there were two test stories like this one:

“This is a story about Mrs. Mouse’s toyshop. She has balls and books for sale in her shop. Here come two little boys and two little girls. The first little boy comes into the shop. “Hi Mrs. Mouse, I’m allowed to buy something in your shop today, what do you have for sale?” Hmmm, balls and books. The little boy decides on a ball. The next little girl also buys a ball. Then the last little girl and boy come into the shop. “Hi Mrs. Mouse. We saw our friends bought balls, but do you have anything else for sale?” Mrs. Mouse shows them the books. They are both considering books, but finally the little boy decides to take a ball. The last little girl really likes the books and she decides to buy one of those instead.”

Figure 2: TRUE 'Restrictor OR' Condition

Figure 2, which corresponds to the scene at the end of the story, illustrates this condition. After the story, the puppet watching alongside the child uttered test sentence (21) to describe what he thought happened in the story.

(21) That was a story about Mrs. Mouse's toy shop and the children who came to the shop. Every child bought something, and I know: Not every girl or boy bought a ball.

In the 'Restrictor OR' test trials, a conjunctive interpretation does not arise, so sentence (21) does not mean that there must be both a girl and a boy who did not buy a ball; if only one girl or one boy did not buy a ball, this is sufficient to make the sentence true. In 2 of the 4 trials in this condition, the context was designed to make the test sentence true in this way - because only one character failed to complete an action. At the same time these contexts made the test sentence false if children did incorrectly compute a conjunctive interpretation of disjunction in the restrictor of 'not every'. In this case, sentence (21) would mean 'There is some girl who did not buy a ball AND there is some boy who did not buy a ball'.[4] In our toyshop story it was not true that 'some boy did not buy a ball', so the overall conjunctive statement 'Not every girl bought a ball AND not every buy bought a ball' was false.

To make this possible reading as clear as possible, each story was designed so that one member of each group of participants (e.g. one girl and one boy) fulfilled an action (e.g. buying a ball). Then towards the end of the story, the other member in each group hesitated to carry out the same action (e.g. both the second girl and boy consider buying books). At the early point in the story, then, a possible outcome was that 'not every girl bought a ball AND not every boy bought a ball'. Introducing a possible outcome in this way satisfies the condition of plausible dissent, making it felicitous for the child to reject the test sentence based on the actual outcome. The actual outcome made the test sentence false on a non-adult reading, because as the story unfolded, the second boy decided to buy a ball. The contrast between the possible outcome and the actual outcome makes it clear to the child why they sentence might be rejected. As with the 'Nuclear Scope OR' condition, in this condition, too, the disjuncts were ordered such that the second disjunct was the one that would make the sentence false on a non-adult reading. In this way, we ensured that children's rejections could be attributed to the fact that they had erroneously computed a conjunctive interpretation of disjunction in the restrictor of 'not every', rather than because, say, they were simply not processing the full disjunctive statement. On the other hand, if children were to access the adult meaning of these sentences, they should accept the test sentences.

To control for the fact that children can also give a 'yes' response in situations where they are simply confused or fail to comprehend a sentence (Crain & Thornton, 1998), the other two trials in this condition were designed to make the test sentence false. An example is given below.

"Here are two caterpillars and two crocodiles who are going to try to make their way through a maze. Mickey Mouse is the judge. He is waiting at the end of the maze with some prizes. If an animal can make it to the end, they can choose a yo-yo or some flowers as their prize. Ok, here goes the first caterpillar. He manages to make it to the end and he chooses a yo-yo. Now the first crocodile is having a turn. He gets a bit stuck, but eventually makes it to the end. He decides to take a yo-yo too. Now the second caterpillar is having his turn. He makes it to the end too. He considers the flowers, which have nice juicy leaves he could eat, but in the end decides to take a yo-yo too. Finally, the last crocodile goes through the maze. He goes round and round but finally makes it to the end. He chooses a yo-yo for his prize too. "

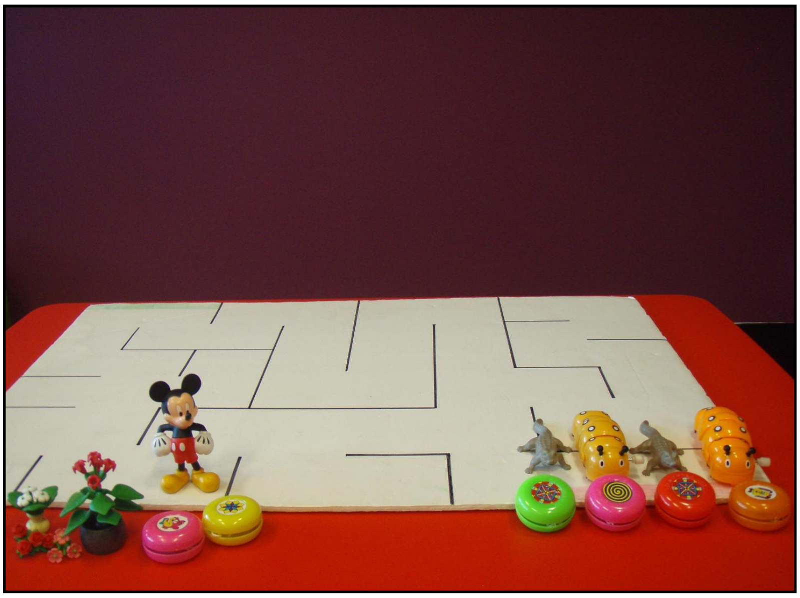

Figure 3: FALSE 'Restrictor OR' Condition

Figure 3, which corresponds to the scene at the end of the story, illustrates this condition. After the story, the puppet watching alongside the child uttered test sentence (22) to describe what he thought happened in the story.

(22) That was a story about some caterpillars and some crocodiles in a maze. Every animal reached the end of the maze and got a prize and I know: Not every caterpillar or crocodile choose a yo-yo

In the two trials of this type, the context made the test sentence false; that is, there was no character who failed to fulfill the action described (such as choosing a yo-yo as a prize). Note that this context is necessarily false on both the adult reading of the sentence, and the possible non-adult reading (in which both a caterpillar and a crocodile must fail to choose a yo-yo). Therefore, these rejections alone do not allow us to draw any conclusions about children's interpretation of these sentences. However, taken in combination with their responses to the true 'Restrictor OR' trials, the overall pattern of responses in this condition will reveal whether children are accessing the adult reading. A majority of 'no' responses across all 4 trials will mean children are accessing a non-adult meaning; a majority of 'yes' responses across all 4 trials will mean children are confused by the test sentence; while a consistent pattern of 'yes' and 'no' responses will reveal adult-like knowledge of the meaning of the test sentences.

Let's now consider what we predict for this condition. If children are guided by the logical principles we outlined, then they should demonstrate a different interpretation of disjunction in this context, as opposed to the 'Nuclear Scope OR' contexts. That is, children should be aware that, despite the fact that 'not every' is downward entailing on its nuclear scope, it is not downward entailing on its restrictor. Therefore, children should accept our true 'Restrictor OR' trials and reject our false 'Restrictor OR' trials. If, on the other hand, they do not recognise that negation reverses the entailment relations of the quantifier 'every', they could erroneously compute a conjunctive interpretation of disjunction in the restrictor, and reject both types of 'Restrictor OR' trial. These predicted outcomes are summarised below.

Prediction 2: If children are guided by logical principles, they should accept the adult-true 'Restrictor-OR' test sentences and reject the adult-false 'Restrictor-OR' test sentences. Otherwise, they could reject both the adult-true and adult-false 'Restrictor-OR' test sentences.

2.3 Control Condition

In addition to the two test conditions, we included a control condition to check that children could respond to sentences containing the compound quantifier 'not every', without the complicating factor of disjunction. These controls were administered following two stories identical in form to the 'Nuclear Scope OR' condition stories, but using different characters. After each control story, the puppet uttered two control sentences like (23). There were thus a total of 4 control sentences.

(23) Not every pirate caught a horse

Note that, because 'not every' is a compound quantifier, it is not possible for the two composite parts of this determiner to enter into a scope relation with each other. This means that sentences like (23) are always assigned a reading in which some pirates did not catch horses (but typically some did). We will call this the 'not all' reading. Although sentences like (23) are also theoretically true on the 'not all' interpretation if no pirate catches a horse (i.e. it is certainly true that if none of the pirates caught a horse that not all of them did), this truth condition is generally ruled out for adults by the application of a scalar implicature. Accordingly, two of our control sentences described contexts in which, for example, two of four pirates had caught horses, but the other two had not. These controls were thus clearly true for adults and we will call them the adult-true controls. The other two controls described contexts in which, for example, all four pirates had caught horses. These controls were thus false for adults and we will call them the adult-false controls.

We included the controls to allow for the possibility that children do not interpret 'not every' as a compound quantifier, but rather as two separate logical operators that can take scope over each other. In this case, one possible scope assignment would be to assign 'not' wide scope over 'every'. This results in the 'not all' reading, identical to the adult interpretation of the compound quantifier. The other possible scope assignment would be to assign 'every' wide scope over 'not'. This results in a 'none' reading, and sentence (23) would mean that no pirate caught a horse. This 'none' reading is a narrower, stronger meaning of the sentence than the 'not all' reading (which, as we pointed out above, is true if just some pirates do not catch horses, or if none of them do). As such, according to the SSM, if children do interpret the compound quantifier 'not every' as two separate scope-bearing elements, then they should tend to access a 'none' reading of our control sentences. In this case we would expect to see children reject the adult-true controls, as well as the adult-false controls. Alternatively, if they successfully analyse 'not every' as a compound quantifier then we expect to see children accept the adult-true controls, and reject the adult-false controls. A third possible state of affairs is that children do not successfully analyse 'not every' as a compound quantifier, but they also do not preferentially assign 'every' wide scope over 'not', contra the predictions of the SSM. The overall percentage of children's responses to the adult-true control condition should allow us to distinguish between these scenarios. Here is the relevant prediction:

Prediction 3: If children erroneously apply scope to 'every' and 'not' as separate operators, and the SSM holds, then they should prefer a 'none' reading of the adult-true control sentences, and reject the adult-true control sentences more than 50% of the time (or at least around 50% of the time if the SSM does not hold, and they therefore have no preference between the 'not all' and 'none' readings of the sentences).

> If children do not apply scope to 'every' and 'not' as separate operators, then they should access the 'not all' reading of the adult-true control sentences, and accept the adult-true control sentences more than 50% of the time.

It was important to control for the children's analysis of 'not every' without disjunction, because any child who failed the adult-true controls (showing that they perhaps allowed 'every' to take scope over 'not') might also allow 'every' to take scope over 'not' in our test condition sentences. In this case, they might interpret a sentence in the 'Nuclear Scope OR' condition like 'Not every princess took a shell or a star' to mean that no princess took either of the objects in question, or that no princess took one of the objects in question. On either of these possible interpretations, our test sentences in the 'Nuclear Scope OR' condition would be false (because at least some of the princesses took shells, and all of them took stars). We would thus not be able to tell whether a child's rejections in this condition were due to their being guided by logical principles and the SSM (Prediction 1) or due to an erroneous analysis of the compound quantifier 'not every'.

Similarly, a child who failed the adult-true controls might interpret a sentence in the 'Restrictor OR' condition like 'Not every boy or girl bought a ball' to mean that no boy and no girl bought a ball, or that either no boy or no girl bought a ball. On either of these possible interpretations, our test sentences in the 'Restrictor OR' condition would also be false (because three children did buy balls, including both boys and girls). We would thus not be able to tell whether the child's rejections in this condition were due to a failure to recognise that negation reverses the entailment relations of 'every' (Prediction 2) or again, due to an erroneous analysis of the compound quantifier 'not every'. On the other hand, for children who pass the controls, we can be confident that our predictions for both the 'Nuclear Scope OR' and 'Restrictor OR' conditions hold.

2.4 Subjects

We tested 22 English–speaking children (14 male, 8 female) between the ages of 4;2 and 5;2 (mean age 4;8). The child subjects were recruited from two day-care centres at Macquarie University, Sydney, Australia. In addition, 19 English–speaking adults were tested as controls (4 male, 15 female) between the ages of 19 and 27 (mean age 21). All were students at Macquarie University.

2.5 Procedure

The 8 test and 4 control items (12 items in total) were administered in a pseudo-random order, interspersed with filler items (10 items in total). On these filler items, the puppet produced statements like (24) and (25), which were either obviously true or obviously false.

(24) What the first princess did was choose a purple shell and a silver star

(25) Choose a red yo-yo is what the last crocodile did

These filler items were included to balance the overall number of true and false sentences, to check that the child could answer both 'yes' and 'no' correctly, and to obscure the purpose of the experiment.

The children were tested individually in a quiet corner of their day-care centre. Each child was introduced to our puppet, Cookie Monster, and given two practice items before the actual test, one in which Cookie Monster made an obviously true statement about a story, and one in which he made an obviously false statement about a story. This was so that children would know that the puppet could say something wrong. These practice items were also used to familiarise children with the task. The full test was only administered to those children who correctly responded to the puppet's statements in the practice items. Because the stories were quite involved and the test sentences relatively difficult, the test, control and filler items were divided in half and presented over two sessions to reduce fatigue. Each session included 4 test items, 2 control items and 5 fillers. The full list and ordering of test materials for the two sessions is given in Appendix A.

To test the 19 adult subjects, the stories were video recorded. The adults were then tested in small groups of 3-5 participants. They watched the stories and recorded whether they thought each test sentence was a true or false description of the story on an answer sheet. They were always asked to justify their answer, whether they judged the test sentence to be true or false, so the answer sheet introduced no bias in how they should respond to any particular test sentence. Also, in that way they would not be aware if they were responding similarly or differently to other participants in their group, as all participants spent about the same time writing after the presentation of each test sentence.

3. Results

Five children were excluded from analysis because they either failed more than one filler item (2 children), or they failed more than one control item (3 children). In total, the results of 17 children (11 boys, 6 girls), aged 4;2-5;2 (mean age 4;8) are presented below. We coded each subject's initial response to the test sentences. Self-corrections were accepted only if the test sentence had not been repeated. Both the child's true or false judgement of each sentence, as well as their justification for their answers, were taken into consideration in coding the data. Only answers in which the justification matched the judgement given were considered in the final analysis.

On some occasions both children and adults gave responses in which their justification did not appropriately account for their judgement. For example, sometimes they gave mis-matched responses, in which they provided a justification typical of a false judgement, but they accepted the test sentence, or vice versa. On other occasions some children gave justifications referring to extra objects in the context. All the test and control stories always had plenty of extra objects in the context that did not get acted on at all. For example, in the princess story, at the end of the story, there were several left-over shells and stars in the castle. This was done because much work on children's and adult's interpretation of the universal quantifier has shown that a single left-over object in the context can affect pragmatic felicity. Although adults can generally cope with this infelicity, it can mislead children, who then judge stories on the fact that an object was left-over, rather than on the truth content of the test sentences (Crain et al., 1996; Freeman et al., 1982; Meroni et al., 2001). Although we tried to satisfy pragmatic felicity by including plenty of extra objects (rather than just one), occasionally children still gave an answer based on extra objects in the context. In short, any answers like these, in which a justification did not appropriately account for a judgement, were coded as 'Other', and were not included in the final counts of rejections and acceptances.

3.1 Control Results

Each child was given 2 adult-false controls and 2 adult-true controls. The 17 children included in further analysis successfully accepted the adult-true control sentences 91% of the time (31/34 trials). The 3 rejections in this condition came from 3 separate children, rather than from one child consistently. The children also rejected the adult-false controls 88% of the time (30/34 trials). These rejections were accompanied by justifications explaining that in fact, all the characters in question had performed some action. For example, in response to the adult-false control *'Not every pirate caught a dinosaur'*, a child aged 4;5 said 'no, because all of the pirates caught dinosaurs'. There were 2 acceptances of an adult-false control (from 2 separate children). The remaining 2 responses (also from 2 separate children) were coded as 'Other' because the children justified their answers by referring to objects left over in the testing context, rather than to the characters in question. A Wilcoxon Signed Ranks test showed the difference between the children's acceptance rates in the two control conditions to be significant ($Z = 3.79$, $p < 0.001$). According to Prediction 3, as the acceptance rate of the adult-true trials is well over 50% across children, we can be confident that the children included in further analysis treated 'not every' as a compound quantifier, assigning it a 'not all' meaning.[5]

The 19 adults tested successfully accepted all their adult-true control trials 100% of the time (38/38 trials). They rejected their adult-false control trials 92% of the time (35/38 trials). Two adults did accept one of these trials each. These acceptances were both in response to the sentence 'Not every pirate caught a dinosaur' in a context in which two pirates caught dinosaurs, and two pirates caught dinosaurs and horses. The adults accepted the test sentence, explaining that, indeed, only two pirates had caught ONLY dinosaurs. One adult omitted to respond to one trial. The child and adult responses to the two types of control sentences are summarised in Table 1. A Mann-Whitney test showed no significant difference between children's and adult's acceptance rates to the controls either to adult-false trials ($Z = 0.11$, $p = 0.950$) or adult-true trials ($Z = 1.87$, $p = 0.379$).

	Response	Children N=17	Adults N=19
Adult False	Rejection	88% (30/34 trials)	92% (35/38 trials)
	Acceptance	6% (2/34 trials)	5% (2/38 trials)
	Other	6% (2/34 trials)	3% (1/38 trials)
Adult True	Rejection	9% (3/34 trials)	0% (0/38 trials)
	Acceptance	91% (31/34 trials)	100% (38/38 trials)
	Other	0% (0/38 trials)	0% (0/38 trials)

Table 1: Child and Adult Control Results

3.2 'Nuclear Scope OR' Condition Results

Each child was given 4 trials in the 'Nuclear Scope OR' condition giving a total of 68 trials for analysis. The total rejection rate was 82% (56/68 trials). These 56 rejections comprised 2 different kinds of responses. In 46 of the 56 rejections the children provided an adult-like justification for their answer (typically referring to the fact that all four characters in the story had performed some action). These answers were coded as 'False – Correct Justification'. An example of this type of response from a child aged 4;5 is given in (26).

(26)	Puppet:	Not every princess took a shell or a star
	Child:	every princess, not every princess took a shell, that was correct, but every, but every…every of these people have a star

On the other 10 trials (from 6 different children), the children judged the test sentences to be false, but their justifications referred to the fact that two characters in the story had not performed some action (rather than to the fact that all four had performed some action). We included these in the overall count of false judgements, and coded them as 'False – Inverted Justification'. This probably occurred because of the difficulty involved in justifying a negative judgement about a negative sentence. In fact, the correct justification involves explaining that the FAILURE to perform some action (by some characters) is correct, and that the SUCCESS in performing some other action (by all characters) is incorrect. So, although the children who gave 'False – Inverted Justification' responses did judge the sentences to be incorrect descriptions of the story they had just heard, they then had trouble explaining which part of the context had not been correctly described. They offered the failure to perform some action as a more pragmatically felicitous justification of what made the test sentence incorrect than the success in performing some other action. An example of this type of response from a child aged 4;8 is given in (27).

(27)	Puppet:	Not every princess took a shell or a star
	Child:	every princess got a star, but not, not all of them got these [shells]
	Puppet:	so was I right or wrong?
	Child:	um right for the stars and wrong for the shells

Children accepted trials in this condition 10% of the time (7/68 trials), and these acceptances came from 7 different children, rather than from one child consistently. The remaining responses were coded as ‘Other’ because either the child gave no answer (1 trial), an answer related to objects left-over in the testing context, or some other justification not clearly related to the test sentence (2 trials), or a mis-matched answer in which they provided a correct justification for a rejection, but then accepted the test sentence (2 trials). These other responses accounted for 7% of the data (5/68 trials).

The 19 adults tested also responded to 4 trials each, giving a total of 76 trials for analysis. The total rejection rate was 68% (52/76 trials). In 51 of the 52 rejections, adults offered a justification for their answer referring to the fact that all four characters in the story had performed an action. However, on one trial, one adult did give an ‘Inverted Justification’. This shows that even for adults, justifying a negative judgement about a negative sentence can be difficult pragmatically. The adults accepted their ‘Nuclear Scope OR’ trials 25% of the time (19/76 trials). In justification of these acceptances, the adults offered the kind of explanations that we had allowed for in the context if disjunction were allowed to scope over ‘not every’, making a statement like ‘Not every princess took a shell or a star’ possibly true if, for example, not every princess took a shell. An example of this kind of response is given in (28).

(28) Test sentence: Not every frog jumped over the fence or the pond
Response: True, not every frog jumped over the fence

The remaining adult responses were coded as ‘Other’ because either they gave no answer (1 trial), an answer related to objects left-over in the testing context (2 trials), or a mis-matched answer in which they provided a correct justification for a rejection, but judged the test sentence to be true (2 trials). These other responses accounted for 7% of the data (5/76 trials).

The child and adult responses in this condition are summarised in Table 2. A Mann-Whitney test showed no significant difference between children’s and adult’s rejection rates in this condition ($Z = 1.34$, $p = 0.232$).

Response	Children N=17	Adults N=19
False – Correct Justification	67.7% (46/68 trials)	67.1% (51/76 trials)
False – Inverted Justification	14.7% (10/68 trials)	1.3% (1/76 trials)
Total Rejection	**82.4% (56/68 trials)**	**68.4% (52/76 trials)**
True	10.3% (7/68 trials)	25.0% (19/76 trials)
Other	7.3% (5/68 trials)	6.6% (5/76 trials)

Table 2: Child and Adult 'Scope OR' Condition Results

3.3 'Restrictor OR' Condition Results

Each child was given 2 true trials and 2 false trials in the 'Restrictor OR' condition, giving a total of 34 true trials and 34 false trials for analysis. The children accepted their true 'Restrictor OR' trials 65% of the time (22/34 trials). There were 5 rejections of true trials (from 5 separate children). In these cases the children gave justifications for their answers referring to the fact that all the members of one of the sets of actors had, in fact, performed the action in question. To illustrate, an example from a child aged 4;6 is given in (29), although no child consistently responded to these trials in this way.

(29) Puppet: Not every fish or dolphin swam through a square
Child: every fish went to the square and one dolphin went to the square
Puppet: oh it was a hard one for me, not every fish or dolphin swam through a square, right or wrong?
Child: wrong

Rejections like these accounted for 15% of the data (5/34 trials). The remaining 7 trials were coded as 'Other' because either the child gave no answer (1 trial), an answer related to objects left-over in the testing context (2 trials), or a mis-matched answer in which a correct justification was provided for an acceptance (by talking about the one character who had, indeed, not performed the action in question), but the children then rejected the test sentence (4 trials). These other responses accounted for 20% of the data (7/34 trials).

The children rejected their false ‘Restrictor OR’ trials 94% of the time (32/34 trials). One child accepted one false trial, and one trial was coded as ‘Other’ because a child provided a mis-matched answer in which he provided a correct justification for a rejection, but accepted the test sentence. A Wilcoxon Signed Ranks test showed the difference between the children’s acceptance rates to the true and false test sentences in the ‘Restrictor OR’ condition to be significant ($Z = 3.52$, $p < 0.001$). The strong rejection rate in response to the false ‘Restrictor OR’ trials means we can be confident that the children’s acceptances of the true trials are genuine acceptances, rather than the result of confusion.

The 19 adults tested also responded to 2 true and 2 false trials each, giving a total of 38 true and 38 false trials for analysis. The adults accepted their true trials 92% of the time (35/38 trials). The remaining 3 trials were coded as ‘Other’. These trials all related to our story about fish and dolphins swimming through shapes. Because the positive lead-in to this story’s test sentence was ‘Every animal swam through a shape’, 3 adults judged this to be false because a stingray in the story, who was introduced as the teacher at fish school, did not swim through any shape. The adults rejected their false ‘Restrictor OR’ trials 100% of the time (38/38 trials).

The child and adult responses in this condition are summarised in Table 3. A 2 (Age: child, adult) x 2 (Condition: true, false) ANOVA was carried out on the results with acceptance rate as the dependent measure. There was a main effect of condition, $F(3,71) = 575.61$, $p < 0.000$, but no main effect of age. Both children and adults tended to accept the true ‘Restrictor OR’ trials and reject the false ones. However, there was also an interaction effect of condition and age, $F(3,71) = 7.58$, $p < 0.01$. So, children tended to accept their true trials less often than adults, while accepting their false trials more often than adults. This is not surprising, however, given that adults performed more or less at ceiling in this condition. Post-hoc Mann-Whitney pair-wise comparisons revealed that there was actually no significant difference between children’s and adult’s acceptance rates in this condition in response to false trials ($Z = 1.06$, $p = 0.778$). However, there was a significant difference between the two groups’ acceptance rates in response to true trials ($Z = 2.99$, $p < 0.05$).

	Response	Children N=17	Adults N=19
True 'Restrictor OR'	Acceptance	64.7% (22/34 trials)	92.1% (35/38 trials)
	Rejection	14.7% (5/34 trials)	0% (0/38 trials)
	Other	20.6% (7/34 trials)	7.9% (3/38 trials)
False 'Restrictor OR'	Acceptance	2.9% (1/34 trials)	0% (0/38 trials)
	Rejection	94.1% (32/34 trials)	100% (38/38 trials)
	Other	2.9% (1/34 trials)	0% (0/38 trials)

Table 3: Child and Adult 'Restrictor OR' Condition Results

4. Discussion

This study investigated 4- to 5-year-old English-speaking children's interpretation of disjunction in both the nuclear scope and in the restrictor of the compound quantifier 'not every'. The aim of this investigation was two-fold. The first aim was to assess the extent to which children are guided by logical principles in their interpretation of sentences containing multiple logical operators. Given that these sentences are not readily available in the primary linguistic data, children's responses to such sentences could be revealing about their knowledge of logic. We suggested that in order to compute a conjunctive interpretation of disjunction in the nuclear scope, but not the restrictor of 'not every', children must make use of several logical facts: (i) that the meaning of OR in natural language is inclusive-OR, (ii) that 'not every' is logically equivalent to 'some not', and (iii) that disjunction gives rise to a conjunctive interpretation in the scope of a DE operator, through the application of de Morgan's law stating that 'not (P or Q)' is logically equivalent to 'not P and not Q'. As noted in the introduction, children are unlikely to be exposed to sufficient input demonstrating how the logical expressions 'not', 'every', and 'or' are interpreted in combination. Given that the requisite input is rare, we reasoned that if children are able to compute the meanings of these sentences, then it is likely they are engaging innate knowledge of the combinatory principles of logic. So, one aim of the present study was to provide evidence bearing on the 'nature versus nurture' debate on the acquisition of logical principles.

The second aim was to test the predictions of the Semantic Subset Maxim. The Semantic Subset Maxim states the following: presented with a sentence in which two or more scope interpretations are available, if these two interpretations form a subset-superset relationship, children should initially favour the subset reading, namely the reading that makes the sentence true in the narrowest range of circumstances. Adopting this maxim ensures that children will quickly acquire the same scope preferences as adult speakers of the local language. When disjunction occurs in the nuclear scope of 'not every', a scope ambiguity of this type arises. If 'not every' is assigned wide scope over disjunction, then a conjunctive interpretation of disjunction is computed. If, on the other hand, disjunction is assigned wide scope over 'not every', then 'or' is interpreted outside of a downward entailing environment, and no conjunctive interpretation arises. The conjunctive reading is a narrower, stronger reading of the sentence than the disjunctive reading, so the SSM predicts that children should prefer the conjunctive interpretation of disjunction.

In our first test condition, the 'Nuclear Scope OR' condition, children were asked to respond to sentences like 'Not every princess took a shell or a star'. These sentences were designed to be false on a conjunctive interpretation of disjunction, but true on a disjunctive interpretation. We found that children rejected the test sentences in this condition 82% of the time. This shows that they assigned a conjunctive interpretation to disjunction, as predicted. This result supports our experimental hypothesis that children are guided by innate logical principles in their interpretation of complex logical sentences containing logical operators. In fact, we found that children preferred the conjunctive interpretation of the test sentences more than adults did. Adults only rejected our 'Nuclear Scope OR' test sentences 68% of the time, and they accepted them 25% of the time. The acceptances were spread across 11 of the 19 adults. Although the difference between adult and child preferences in this condition was not statistically significant, it was a trend in the direction predicted by the SSM. Perhaps with a larger sample size, a significant difference might even be revealed. In all, the results of the 'Nuclear Scope OR' condition strongly support Prediction 1, providing evidence that both the SSM and the logical principles outlined above do, indeed, appear to be in operation in the language apparatus of children.

Our second test condition was the 'Restrictor OR' condition. In this condition, children responded to sentences like 'Not every girl or boy bought a ball'. Half of these sentences were true if disjunction was given a disjunctive interpretation, but false if a conjunctive interpretation were assigned. Children accepted the test sentences 65% of the time in this condition. Although above chance, children's acceptance rate was significantly different from that of adults (92% acceptance). These results, therefore, do not unequivocally support the second experimental hypothesis, Prediction 2. If children draw upon the 'not every = some not' logical equivalence in interpreting our test sentences, then they should have shown a more robust pattern of acceptances in this condition, as compared to their pattern of rejections in the 'Nuclear Scope OR' condition.

Nonetheless, this result does not necessarily mean that children were unaware that negation reverses the entailment relations of 'every', and that they thereby erroneously assigned a conjunctive interpretation to disjunction in the restrictor of 'not every', as would have been the case if children rejected the remaining trials. Children only rejected the true 'Restrictor OR' trials on 5 out of 34 trials (15% of the time). The rest of children's responses were classified as 'Other,' because children failed to clearly justify the reasons for making their judgements. This finding is indicative of a general difficulty children experienced in accepting these kinds of test sentences in the contexts provided, rather than a problem in distinguishing the arguments of 'not every'.

There are several possible reasons for this. Perhaps the complex character of the downward entailing context contributed. If we take the defining property of a DE environment to be the licensing of an inference from sets to subsets, then the nuclear scope of 'not every' clearly is downward entailing, while the restrictor is not. It is possible to make an inference from a general term to a more specific term in the nuclear scope of 'not every' (e.g. If it is true that 'Not every living thing is an animal' then it is certainly true that 'Not every living thing is a bird'), while it is not in the restrictor (e.g. If is true that 'Not every animal has four legs', then it is not necessarily true that 'Not every fox has four legs'). In this study we concentrated on one of the diagnostic properties of DE contexts, the conjunctive interpretation of disjunction, which arises in the nuclear scope of 'not every' and not in the restrictor. However, another diagnostic property is the licensing of NPI items like 'any'. In fact, it turns out that 'any' is NOT licensed in the nuclear scope of 'not every', while it is licensed in the restrictor. Compare 30(a) and (b).

(30) a. *Not every girl or boy bought any ball

b. Not every girl or boy who had any money bought a ball

The ungrammaticality of 30(a), as opposed to 30(b), shows that being in the scope of a DE operator is not necessarily a sufficient condition to license an NPI like ‘any’. When certain logical operators intervene between a DE operator and an NPI, the patterns of licensing can be disrupted. In (30), it seems that the intervention of the universal quantifier ‘every’ between ‘not’ and ‘any’ blocks the negation operator from licensing ‘any’ in the predicate phrase. On the other hand, ‘any’ is grammatical in the subject phrase, because it is in the scope of the DE operator ‘every’ in that structural position.

Intervention effects in NPI licensing have been the subject of much investigation (see for example: Chierchia, 2004; Chierchia, Fox & Spector, 2011, Guerzoni, 2006; Linebarger, 1987), however a discussion of these effects would take us beyond the concerns of the present paper. All we wish to point out is that, due to these effects, the DE properties of the complex quantifier ‘not every’ present a mixed picture to children. On the one hand, the conjunctive interpretation arises in the nuclear scope, and not in the restrictor. On the other hand, an NPI item like ‘any’ is not licensed in the nuclear scope, but is in the restrictor. Perhaps this conflicting combination of diagnostic properties contributed to children’s difficulty with our ‘Restrictor OR’ trials. Nonetheless, if this were the reason for children’s difficulty, it is strange that it did not appear to affect their ability to respond to the ‘Nuclear Scope OR’ trials. Our guess is, rather, that children’s difficulty stemmed from a pragmatic infelicity in the construction of our trials. This would mean that in a more felicitous context, it should be possible to show that children accept true ‘Restrictor OR’ trials to a higher degree. This in turn would show that the logical principles under investigation are, indeed, applied by children in all the required semantic environments.

One source of possible infelicity in our ‘Restrictor OR’ trials is the fact that we used a negative statement, rather than a positive one, to describe the situation at the end of each story. It has been shown that two approaches can help in mitigating this infelicity. One approach recommends the use of a positive lead-in statement (Musolino & Lidz, 2006), which is the tactic we employed. Another approach recommends introducing an explicit discrepancy between the expected and actual outcome of each story (Gualmini, 2005). We wondered whether combining these two approaches might be required to help children accept complex negative statements like those tested in the ‘Restrictor OR’ condition. We adapted our true ‘Restrictor OR’ stories to set up a clear discrepancy between the expected and actual outcome. For example, in our toyshop story, we mentioned that the balls for sale in the shop cost three coins, and the books only cost two coins. Every child who visited the shop wanted to buy a ball, but only two boys and one girl had enough money to do so. The last little girl only had two coins, because she had spent one on the way to the shop, and so she had to buy a book. This set-up emphasised that all the children were expected to buy balls, but in actual fact, one could not. The puppet then uttered the test sentence with a positive lead-in as in the original study (e.g. ‘Every child bought something, and I know: Not every girl or boy bought a ball’). We piloted these new stories with 5 children (aged 3;9-5;1). The children heard two stories each. However, we found almost identical results to the ones reported here. The children accepted the stories 66% of the time, and rejected them 33% of the time. We take from this that our original positive lead-ins were already sufficient to counter any infelicity associated with the use of a negative statement to describe the situations under consideration. Indeed, this makes sense given that the children were perfectly able to accept our true control statements (e.g. Not every pirate caught a horse) with a positive lead-in alone.

Another more promising possibility is that our stories did not satisfy one of the presuppositions that is associated with the use of a universally quantified phrase that contains disjunction in the restrictor. Consider a phrase like ‘every passenger who ordered chicken or beef’. It is only useful to divide the superset of passengers into two subsets if we are then contrasting these two subsets with one or more other subsets. For example, we might want to say ‘every passenger who ordered chicken or beef became ill, but passengers who ordered fish did not’. If there are only passengers who ordered chicken or beef in the context, and they all fell ill, then it is pragmatically odd to state this. One might as well say ‘Every passenger became ill’. Using disjunction in the restrictor of a universally quantified phrase therefore presupposes that there is at least one other subset in the context that doesn’t share the property attributed to the two subsets being quantified over. To satisfy this presupposition, we would need to include a contrast set of characters in our stories, in addition to the two sets of characters being universally quantified over. We leave this modification for a future study.

Despite inconclusive results in our ‘Restrictor OR’ condition, our ‘Nuclear Scope OR’ condition has allowed us to further test both the predictions of the Semantic Subset Maxim, and the hypothesis that children possess a body of logical knowledge that initially guides them in their interpretation of sentences containing logical operators. We have shown that English-speaking children access the conjunctive interpretation of disjunction in the nuclear scope of ‘not every’, a compound quantifier that had not yet been investigated in the literature. In fact, they access this interpretation more often than adults, which is in line with the predictions of the Semantic Subset Maxim. We have further suggested that children are capable of correctly interpreting these complex sentences because they are guided by a set of logical principles which together result in OR being assigned a conjunctive interpretation whenever it occurs in a downward entailing environment in natural language.

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Endnotes

[1] Children's utterances may still be non-adult like at an early stage because they choose to use a downward entailing operator which is not the most appropriate in a certain context, or they use pseudo-licensing strategies (e.g. anaphoric 'no', headshaking, intonation contour) until their negation vocabulary has expanded enough to give them access to the correct variety of licensors (Van der Waal, 1996).

[2] The notion of scope under consideration here does not depend on one operator appearing in a 'higher' structural position in relation to the other in the syntactic tree when the sentence is uttered (at spell-out). In both English and Japanese, negation is typically analysed as appearing in a higher node in the syntactic tree than disjunction, at spell-out. Nonetheless, disjunction is interpreted as taking semantic scope over negation in Japanese in sentences like (18). To account for this reading in languages like Japanese, it is generally posited that disjunction has moved covertly at the level of logical form to a higher node in the syntactic tree for the purpose of the computation of the sentence meaning.

[3] We are not committed to this evidence coming from sentences like (19) being used in a context in which, for example, not every sick passenger ate chicken, but every sick passenger did eat beef. Evidence from other types of sentences containing a DE operator and disjunction, used in a context in which disjunction is interpreted as scoping over the DE operator, would probably suffice.

[4] Or more precisely that there must be both a girl, and a boy, and any individual who is both a girl and a boy, who did not buy a ball. As we have discussed the third possible truth condition cannot apply in these contexts, but the two remaining truth conditions are sufficient to test whether the conjunctive interpretation of disjunction is computed or not.

[5] It is also possible that children accepted the adult-true control sentences because, despite treating 'not' and 'every' as two separate scope-bearing elements, children preferred to interpret 'not' as taking scope over 'every', given that the 'not all' meaning of 'not every' is the only one modeled for them in the input. In the introduction, however, we reported that we found no instances of 'not every' in a large survey of input. Moreover, we also reported that several cross-linguistic studies have shown that children do not necessarily prefer the scope relationships modeled for them in the input. For these reasons, we think this is a less likely explanation of our data than the one we have offered here, that children successfully analysed 'not every' as a compound quantifier.

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Appendix A: Test Materials

Testing Session 1:

Warm-Up:	I know what happened to Piglet. Piglet ate the (thing he ate) [T]
Warm-Up:	Let me see, Eeyore ate the (1st thing he ate) [T], and he didn't eat the (2nd thing he ate) [F].
Control:	That was a story about 4 pirates trying to catch animals and I know – Not every pirate caught a dinosaur [F]
Control:	Let me try something else. Not every pirate caught a horse [T]
Filler:	I know what the first pirate did. Catch a horse and an orange dinosaur is what the first pirate did [F]
Test 1:	That was a story about 4 farmers washing animals. Every farmer washed some animals and I know - Not every farmer washed a cow or a dog [F]
Filler:	I know what the pigs did. What the pigs did is get out of their pond [F]
Test 2:	That was a story about 4 babies and their parents, the mums and dads. Every parent came to check on the babies and I know - Not every mum or dad put a baby to bed [F]
Filler:	I know what the last dad did. Choose a yellow blanket is what the last dad did [T]
Test 3:	That was a story about 4 frogs playing a jumping game. Every frog jumped over something and I know - Not every frog jumped over the fence or the pond [F]
Filler:	I know what Mrs. Kangaroo did. What Mrs. Kangaroo did is jump over all the frogs [F]
Test 4:	That was a story about some fish and some dolphins at school learning about shapes. Every animal swam through a shape, and I know – Not every fish or dolphin swam through a square [T]
Filler:	The first little fish swam through a blue square [T]

Testing Session 2:

Control:	That was a story about 4 aliens trying new things to eat. Every alien had something to eat, and I know - Not every alien tried a strawberry [F]
Control:	Let me try something else. Not every alien tried a feather [T]
Filler:	Some of the aliens tried the red feathers, and none of the aliens tried the purple feather [T]
Test 5:	That was a story about Mrs. Mouse's toy shop and the girls and boys who came to the shop. Every child bought something and I know - Not every girl or boy bought a ball [T]
Filler:	I know what the last little girl did. Buy a blue book is what the last little girl did [T]
Test 6:	That was a story about 4 princesses looking for treasure. Every princess took some treasure and I know - Not every princess took a shell or a star [F]
Filler:	I know what the first princess did. What the first princess did is take a star and a purple shell [T]
Test 7:	That was a story about some caterpillars and some crocodiles in a maze. Every animal reached the end of the maze and got a prize, and I know – Not every caterpillar or crocodile chose a yo-yo [F]
Filler:	I know what the last crocodile did. Choose a red yo-yo is what the last crocodile did [F]
Test 8:	That was a story about 4 trolls who liked to tickle animals. Every troll tickled somebody and I know - Not every troll tickled a turtle or a teddy [F]
Filler:	I know what the bunnies did. What the bunnies did is hop so fast the trolls couldn't catch them [T]

CHAPTER 7

Conclusion

1. Introduction

This thesis investigated how children resolve ambiguities associated with a specific class of sentences, ones that contain two scope-bearing expressions, where one reading of the sentence asymmetrically entails the other reading. I began with two main questions in mind:

(i) which reading of these scopally ambiguous sentences do children initially favour?

(ii) if children initially favour one reading, why?

In Chapter 1, I reviewed three current models of language acquisition, each of which offers a different answer to these questions. These were the Isomorphism Account, the Question-Answer Requirement (QAR) Model, and the Semantic Subset Principle, which was reformulated as the Semantic Subset Maxim (SSM).

The Isomorphism Account predicts that children should initially favour the isomorphic reading of scopally ambiguous sentences: the one in which the structurally dominant scope-bearing expression in the surface syntax takes scope over the other logical operator. It has been suggested that children favour the isomorphic reading because this way of parsing sentences requires less processing load. When the context information favours the inverse scope reading, the Isomorphism Account anticipates that children will experience processing difficulties, and may lack the necessary computational resources to recover from the favoured isomorphic reading (Lidz & Musolino, 2005/2006; Musolino et al., 2000).

The QAR Model predicts that children should favour the scope assignment that provides the best answer to what they take to be the question-under-discussion where the question-under-discussion is determined by the preceding context. If both interpretations address the relevant question, then children are expected to favour the interpretation that makes the sentence true in the context, supposing that children adhere to the conversational principle of charity. It has been suggested that children's preferred interpretations in different contexts reflect the fact that they are less able than adults to accommodate a question-under-discussion that differs from the one made salient in the preceding context (Hulsey et al., 2004).

Finally, the Semantic Subset Principle (SSP) predicts that children should initially favour the subset reading of a scopally ambiguous sentence, i.e., whichever reading asymmetrically entails the other reading. Children favour the subset reading to avoid a learnability dilemma. If children were to favour the superset reading (which is also true in the set of circumstances associated with the subset reading), then the SSP suggests they would not be able to converge on the scope preference of adults who speak a language that favours the subset reading. Adopting the superset reading means that the input children receive will be consistent with their non-adult hypothesis. The SSP expects that this learnability constraint only applies when the sentence in question is ambiguous in one particular language, but not in another. Since children cannot know which language they are potentially acquiring, they must comply with the SSP, or they will be at risk of finding themselves in a situation from which they could not recover (Crain et al., 1994).

In this thesis I outlined a fourth model, based on the SSP, but addressing some possible shortcomings of the original proposal. This model was called the Semantic Subset Maxim (SSM). The SSM makes the same predictions as the SSP, but assumes that a sentence containing two (or more) scope-bearing operators will be ambiguous in every language (even if adult speakers have a very strong preference for one of the readings in a particular language). It follows from this recast of the principle, that children will always be faced with a semantic subset problem in interpreting sentences for which one reading asymmetrically entails the other. The SSM also recasts the predictions of the SSP in terms of preferences, rather than the categorical presence or absence of a reading. The SSP was proposed as a principle preventing children from committing an error from which they could not recover, whereas the SSM is proposed as a maxim preventing children from unnecessary delay in their acquisition of scope preferences. Based on arguments advanced by Gualmini and Schwarz (2009), we concede that children may have the resources to eventually recover from a situation in which they initially hypothesise the superset reading of a sentence, when adults favour the subset reading. However, lacking the SSM, children could take considerable time to amass enough input to overturn a preference for the superset reading. The SSM anticipates a fairly rapid transition to the adult preferences for scope interpretations, based on positive evidence, rather than on the kinds of considerations outlined by Gualmini and Schwarz.

In support of this new proposal I presented the results of three main studies (and two supporting studies) demonstrating that children do, indeed, appear to pass through a stage in which they favour the subset reading (and not necessarily the isomorphic reading) of scopally ambiguous sentences. Moreover, I showed this cross-linguistically in both English and Mandarin, languages that differ in their adult scope preferences. In the next sections I review the conclusions of the five studies, before making some suggestions for future research.

2. Children's Interpretation of the Scope Relation between BEFORE and OR

The first major study, reported on in Chapter 2, looked at children's preferences in interpreting sentences like (1). The narrow subset reading of this sentence is that the dog reached the finish line before the turtle and before the bunny. This is the reading strongly preferred in English. The wide superset reading of this sentence is that the dog reached the finish line before the turtle, or before the bunny, or possibly before both of them. This is a reading often allowed in Mandarin.

(1) The dog reached the finish line before the turtle or the bunny

We tested 3- to 5-year-old English- and Mandarin-speaking children on sentences like these. The sentences were presented in two contexts: a first-place context and a second-place context. In the first-place context stories, children heard a sentence like (1) after seeing a race between a dog, a turtle, and a bunny, in which the dog had won the race. The sentence was thus true on a subset reading of the sentence, and possibly true on a superset reading as well. In the critical second-place context stories, children heard a sentence like (1) after seeing the same race, but in this case the dog had come second. The sentence was thus false on a subset reading, but true on a superset one.

The English-speaking children rejected sentences like (1) in the second-place condition 93% of the time, and the younger Mandarin-speaking children (age 4;6-4;7) also rejected the sentences 100% of the time. In other words, the data show that children speaking either language initially prefer the subset reading of these ambiguous sentences in which one reading asymmetrically entails the other. This was in spite of the fact that Mandarin-speaking adults showed a superset reading across the two conditions 25%-40% of the time (they accepted second-place conditions sentences 25% of the time, and they rejected first-place condition sentences, having computed a scalar implicature ruling out the truth condition on which the dog had come before both other participants, 40% of the time). The cross-linguistic approach taken in this study thus highlighted how children, across languages, behave similarly to each other, and not necessarily like the adults speaking the target language around them. This, in turn, is good evidence for the existence of a universal mechanism, such as the Semantic Subset Maxim, governing scope preferences in children at an initial stage.

The SSM accounts nicely for the data presented in Chapter 2. However, the subset reading of sentences like (1) also happens to the isomorphic one in both English and Mandarin (the temporal conjunction dominates disjunction in the surface syntax in both languages). This means that the Isomorphism Account could also account for these data. To adjudicate between these two accounts, we need to know which reading of an ambiguous sentence children prefer when the subset reading is the non-isomorphic reading, rather than the isomorphic one. This was the purpose of the study reported in Chapter 4.

We prefaced Chapter 4 with a supporting study investigating children's interpretation of simple sentences containing the focus expression ONLY. The findings of this supporting study allowed us to appropriately design a necessary control in our Chapter 4 study. So, before we discuss the results of our next major study, we will briefly summarise the findings of our supporting study, reported on in Chapter 3.

3. Children's Interpretation of the Scope of ONLY

Chapter 3 was concerned with children's interpretations of sentences like (2), which we investigated in three different experiments.

(2) Only Eeyore has a yo-yo

In the first experiment, we conducted a longitudinal study of two very young English-speaking children (aged 2;2 – 3;1) over 6-12 months. The children were presented with sentences like (2) in a context in which, for example, Eeyore had a yo-yo, and three other characters had both yo-yos and balls. The two children judged such sentences to be correct descriptions of these contexts, because Eeyore only had a yo-yo. We called these errors 'VP Scope' errors, because the children appeared to be erroneously assigning scope of the focus operator 'only' to the verb phrase (VP), rather than to the subject noun phrase (NP).

In the second experiment, we explored this error type in a more controlled fashion by testing 4-year-old Mandarin-speaking children's understanding of the Mandarin counterpart to sentences like (2). The sentences were presented in two contexts: one in which the sentences were true for adults (e.g. Eeyore had a yo-yo and a ball, and Tigger had a ball), and one in which they were false for adults (e.g. Eeyore had a yo-yo and a ball, and Tigger had a yo-yo). Children rejected the test sentences in both contexts 87-90% of the time, justifying their answers by referring to the fact that Eeyore also had a ball. The results of this second experiment confirmed that children prefer to assign scope of a pre-subject focus operator to the verb phrase, even though this is not possible in the adult grammar.

To account for this scope preference, we proposed that children initially analyse ONLY as a sentential adverb dominating both the subject NP and the VP in the syntax. This structural analysis creates a scope ambiguity for children; one that is not present for adults. Because ONLY dominates both the subject NP and the VP, it can potentially be associated with either one of them. Note that in this case, the Isomorphism Account makes no prediction about child preferences, because both potential readings are isomorphic readings. Similarly, the SSM makes no prediction, as this maxim applies only when one scope reading asymmetrically entails the other.

The QAR Model, however, may take us some distance towards explaining children's preferences. Let's imagine that the question-under-discussion (QUD) in our experiments was understood to be 'What does Eeyore have?'. If (2) is a speaker's attempt to answer this question, then an interpretation in which 'only' is associated with the VP constitutes a better answer to this question (e.g. Eeyore has a yo-yo, and nothing else) than if 'only' is associated with the subject NP (e.g. Eeyore, and nobody else, has a yo-yo). If, on the other hand, the QUD is defined as 'Who has a yo-yo?', we would expect a shift in children's scope assignment preferences to the subject NP. In the third experiment, we tested this using another group of 4-year-old Mandarin-speaking children. The children again heard sentences like (2) in contexts that were either true or false for adults. However, this time the stories were biased towards the question 'Who did something?'. We found that the children now accepted the true sentences 76% of the time (whereas in Experiment 2 they had only accepted them 10% of the time). Nonetheless, even in this experiment, the children still showed evidence of a VP Scope preference 24-38% of the time (rejecting adult-true sentences 24% of the time, and rejecting adult-false sentences 38% of the time due to the fact that the focus operator was associated with the

VP). From these results, we concluded that pragmatic factors alone are not the sole driving force behind children's scope preferences. In other words, although the QAR Model explains how children's scope preferences may SHIFT from one particular context to another, it does not fully explain the existence of default preferences. In the present case, we suggested that children's underlying preference is driven by an attempt to align focus expressions and focus elements based on the prosodic or information structure of the local language.

4. Children's Interpretation of the Scope Relation between NOT and AND

Armed with the knowledge about children's possible 'VP Scope' response to sentences containing pre-subject ONLY, we can now move on to a discussion of our second major study, which investigated children's interpretation of sentences containing negation and conjunction, like (3). The narrow subset reading of this sentence is that the elephant ate neither vegetable. This is the reading preferred in Mandarin. The wide superset reading of this sentence is that the elephant didn't eat both vegetables, but may have eaten only the carrot, or only the capsicum, or neither. This is the reading preferred in English.

(3) The elephant didn't eat both the carrot and the capsicum

We tested 3- to 5-year-old English- and Mandarin-speaking children on sentences like these. The sentences were presented in a context in which the elephant had eaten a carrot, but not a capsicum. The sentences were thus false on a subset reading of the sentence, but true on a superset one. Note, that in this case, the subset reading was also the non-isomorphic reading. In both English and Mandarin, negation dominates conjunction structurally in the surface syntax. However, on the subset reading, conjunction takes wide scope over negation (e.g. 'It was both the carrot and the capsicum that the elephant did not eat').

The Mandarin-speaking children rejected sentences like (3) in the context provided 98-99% of the time (depending on the absence or presence of the Mandarin quantifier *dou,* equivalent to English 'both'). The English-speaking children also rejected the sentences 98% of the time. In other words, the data again show that children acquiring either language prefer the subset reading of these ambiguous sentences in which one reading asymmetrically entails the other. This was in spite of the fact that English-speaking adults showed a superset reading, accepting the same sentences 72% of the time. Again, the cross-linguistic approach taken in this study has highlighted how children, across languages, behave similarly to each other, and not necessarily like the adults speaking the target language around them. Moreover, in this study, we showed that children do not prefer the isomorphic reading of ambiguous sentences, supporting our claim that the Semantic Subset Maxim, and not the Isomorphism Account, best explains children's scope preferences (for sentences in which one scope reading asymmetrically entails the other) at an initial stage.

In further support of our claim, we wanted to rule out the possibility that children might simply assign a non-Boolean interpretation to conjunction under negation, on which a statement like 'not (P and Q)' is true in only one circumstance, when neither P nor Q is true. If this were the case then our test sentences would not have been ambiguous for children; only the subset reading would have been available. To rule out this possible explanation of our data, we conducted a control test in which we asked children to respond to sentences containing conjunction in sentences with the focus expression ONLY, like (4).

(4) Only Mickey Mouse ate both a strawberry and a banana

The meaning of (4) can be paraphrased as: Mickey Mouse ate both a strawberry and a banana (presupposition), and all other relevant participants in the context did NOT eat both a strawberry and a banana (assertion). The covert assertion component of (4) is a scope-cancelling environment, meaning that the negation operator contained in this component must take wide scope over conjunction. This environment can thus be used to reveal whether negated conjunction is assigned Boolean truth conditions. If so, then the sentence will be true in a context in which participants other than Mickey Mouse did not eat both kinds of fruit, but did eat just a strawberry or just a banana. If not, then the sentence will be false in the same context (because participants other than Mickey Mouse should not have eaten either kind of fruit).

We tested a separate group of 3- to 5-year-old English- and Mandarin-speaking children on sentences like (4) in the context just described. Knowing that children of this age often assign scope of pre-subject ONLY to the VP, we also included control trials to identify any children for whom this was the case. The responses of these children would be non-informative. Once these children's responses were removed, we found that the English-speaking children accepted the critical sentences 88% of the time and the Mandarin-speaking children accepted them 86-100% of the time (depending on the absence or presence of the operator *dou*). These results show that children were not assigning a non-Boolean interpretation to conjunction under negation in our original experiment. To access the subset reading of test sentences like (2), they must have assigned conjunction wide scope over negation contra the predictions of the Isomorphism Account, but in line with the predictions of the Semantic Subset Maxim.

In our third and final major study, we examined whether the predictions of the SSM hold even in complex cases for sentences containing three logical operators. The results of this study were reported on in Chapter 6. We prefaced Chapter 6 with a supporting study investigating children's interpretation of simple sentences containing the universal quantifier EVERY. The findings of this supporting study allowed us to appropriately design our Chapter 6 study. So, before we discuss the results of our final major study, we will briefly summarise the findings of our supporting study, reported on in Chapter 5.

5. Children's Interpretation of the Scope of EVERY

In Chapter 5 we were concerned with very young children's responses to questions like (5). We followed three English-speaking children (aged 1;11 – 3;1) longitudinally over 6-12 months. The children were asked questions like (5) in a context in which, for example, every bear had a strawberry, but there were also several left-over strawberries.

(5) Does every bear have a strawberry?

The universal quantifier only quantifies over the noun phrase it combines with syntactically, the restrictor (in this case 'bear'), and not over the predicate phrase, the nuclear scope (in this case 'have a strawberry'). Therefore, the answer to (5) in the given context should be 'yes'. Left-over strawberries do not matter. However, it has been suggested in the literature that children, unlike adults, can require or at least allow the universal quantifier to quantify over its nuclear scope (Geurts, 2003; Philip, 1995). If this is the case, then children could answer 'no' to (5), because every strawberry had not been allocated to a bear. Our aim in testing such young children was to uncover children's earliest hypothesis about the meaning of the universal quantifier. If they entertain a non adult-like reading at some point in their development, it is most likely to appear at an early age.

However, we found that the 2-year-old children we tested overwhelmingly answered 'yes' to questions like (5). Moreover, when queried about the extra strawberries in the context, they explicitly commented that these did not matter. These results are in line with theories that attribute an adult-like reading of the universal quantifier to children from the outset (Crain et al., 1996; Drozd & van Loosbroek, 2006). These accounts maintain that previously reported child errors with the universal quantifier have been due to infelicitous test conditions. Two causes of infelicity have been identified: when the condition of plausible dissent is not met, and when the domain of quantification is not properly presupposed.

The condition of plausible dissent requires that to be able to judge a sentence to be true or false, a different possible outcome from the actual outcome should have been under consideration at some point. The presupposition demands of 'every' require that the set being quantified over be clearly defined in the preceding context. When these two sources of infelicity are ruled out, child errors for these reasons can also be ruled out. It was therefore important in designing our Chapter 6 study, investigating sentences containing the complex quantifier 'not every', that we satisfied these conditions.

6. Children's Interpretation of the Scope Relation between NOT EVERY and OR

In our last major study we investigated children's interpretation of sentences like (6) containing three logical operators: negation, the universal quantifier, and disjunction. The subset reading of this sentence is that there is at least one princess who did not take a star and did not take a shell. This is the preferred reading in English. The superset reading of this sentence is that there is at least one princess who did not take a star, or who did not take a shell, or who did not take either object. This reading is also allowed by some English speakers.

(6) Not every princess took a star or a shell

We tested 4- to 5-year-old English-speaking children on sentences like these. The sentences were presented in a context in which there was at least one princess who did not take a shell (but no princess who did not take either object). The sentences were thus false on a subset reading of the sentence, but true on a superset one. The children rejected the sentences 82% of the time. This was in spite of the fact that English-speaking adults showed a superset reading 25% of the time, and only rejected the same sentences 68% of the time. In other words, once again, children are seen to differ from adults, in that they prefer a subset reading of these ambiguous sentences at an initial stage.

In this study we were further concerned with the underlying logical principles that children must make use of if the Semantic Subset Maxim is to apply. The sentences we tested children on throughout this thesis are only ambiguous if children have an appropriate knowledge of these principles. For instance, in both our Chapter 2 study and our Chapter 6 study, the scope ambiguity we tested depends on a conjunctive interpretation of disjunction arising on one scope interpretation and not on another. Children need both knowledge about the underlying semantics of disjunction and knowledge about how disjunction interacts with downward entailing operators like negation and the universal quantifier, to arrive at a conjunctive interpretation of disjunction in certain contexts. We demonstrated in Chapter 6 that this knowledge is unlikely to come from the primary linguistic data. Indeed, it is generally accepted that most possible word and phrase meanings are underdetermined by the evidence available in the input (Larson & Segal, 1995), and that therefore the child must be working within a constrained hypothesis space in order to successfully converge on the semantic rules governing the language he or she is learning. Therefore, evidence that children compute a conjunctive interpretation of disjunction in appropriate contexts, and only in appropriate contexts, is good evidence that they possess a body of innate logical knowledge that they bring to bear on the task of language acquisition.

Sentences containing the quantifier 'every' have already been used to begin to reveal the extent of children's logical knowledge, because the universal quantifier is only downward entailing on its restrictor, and not on its nuclear scope (Boster & Crain, 1993; Chierchia et al., 2001; Chierchia et al., 2004; Gualmini, 2005; Gualmini et al., 2003; Su & Crain, 2009). In this study, we took these results a step further, by asking if children also know that negation reverses the entailment relations typical of 'every'. That is, the compound quantifier 'not every' is downward entailing on its nuclear scope, and not on its restrictor. Therefore, in addition to testing children on sentences like (6), we also tested them on sentences like (7), in which disjunction appears in the restrictor of 'not every', and subsequently is assigned a disjunctive meaning, not a conjunctive one.

(7) Not every girl or boy bought a ball

The sentences were presented in a context in which there was one girl who did not buy a ball (but not both a girl and a boy who did not buy a ball). The sentences were thus true if disjunction was assigned a disjunctive interpretation, but false if disjunctive was assigned a conjunctive interpretation. The children accepted these sentences 65% of the time. This acceptance level was above chance, but still significantly different from that of adults (92%). Nonetheless, 20% of the children's remaining responses were removed from analysis because they could not clearly justify their judgements. This may have been because, despite our best efforts to satisfy the felicity requirements of the universal quantifier, we may have overlooked a further presuppositional demand of this quantifier when used in combination with disjunction: the requirement for there to be a contrast set to the two subsets defined by disjunction in the context.

Testing sentences of this complexity on children is difficult, and the results of this study are, nonetheless, quite promising, suggesting that children are aware of the asymmetry in the interpretation of disjunction in sentences with 'not every'. Modifying the experimental contexts used for sentences like (7) could help to demonstrate this fact with a more robust pattern of data. This would further reveal the extent to which children are guided by combinatory logical principles in their interpretation of sentences containing logical operators.

7. Final Remarks and Suggestions for Future Research

This thesis provided a comparison of three current models of language acquisition designed, in part, to explain children's early preferences for assigning interpretations to ambiguous sentences. The Semantic Subset Principle (SSP) was reformulated as the Semantic Subset Maxim in order to explain children's scope assignment preferences. I presented evidence from three main experiments in support of this reformulation of the SSP. I explicitly presented evidence against the competing Isomorphism Account in one experiment. Another experiment revealed the utility of the QAR Model in accounting for shifting scope assignment preferences in different pragmatic contexts. However, I also pointed out a limitation in the QAR Model. It does not explain children's underlying default preferences. Under this model we must assume that children who manifest a scope interpretation not expected in the given context are entertaining a different question-under-discussion than the one intended. However, if we use the scope interpretation individual subjects assign to a test sentence to determine what the question under discussion might have been for them, then the entire model runs the risk of circularity.

In future work, it would be helpful to design further studies that pit the predictions of the QAR Model against the SSM, to ascertain the role of each in accounting for child scope preferences. One way this could be done would be to use sentences like (8), in a context in which an elephant eats a carrot, but not a pepper.

(8) The elephant didn't eat both the carrot and the pepper

a. The elephant didn't eat either vegetable (and > not)
b. The elephant didn't eat both of the vegetables, but may have eaten one, or neither (not > and)

(9) QUD: Did the elephant eat any vegetables?

(10) QUD: Did the elephant eat both (or all) the vegetables?

If the question-under-discussion is understood to be (9), then interpretation 8(a), the subset reading of (8), on which conjunction takes wide scope over negation, constitutes the best answer to this question. In the given context, this interpretation is false. According to both the QAR and the SSM, children would be expected to reject these sentences. If the question-under-discussion is instead defined as (10), then both interpretation 8(a) and 8(b) constitute good answers to the question. However, in the given context, only interpretation 8(b), the superset reading, on which negation takes wide scope over conjunction, is true. Therefore, while the SSM would predict that children should still reject these sentences, the QAR model would predict that children should accept them. If, as we have suggested, the QAR can only account for shifting preferences, while the SSM accounts for the default preference, then, although, we might expect to see a higher percentage of child acceptances in this condition, we would still see interpretation 8(a) persist in a non-negligible percentage of children.

Given our current findings, the answers I put forward to the two main questions of this thesis are (i) that children will tend to favour the subset reading of a scopally ambiguous sentence in which one reading asymmetrically entails the other reading, and (ii) that they do this for learnability reasons. Indeed, the Semantic Subset Maxim prevents most children from finding themselves in the kind of situation that L2 adult learners sometimes have to contend with. For example, it has been found that Japanese learners of English tend to hypothesise that English sentences like *'The elephant didn't eat the carrot or the pepper'* mean that is was the carrot or the pepper that the elephant didn't eat (transferring their preferred superset scope assignment from their L1). Subsequently, they find it very difficult to acquire the subset conjunctive interpretation that is preferred in English. On the other hand, English learners of Japanese tend to transfer their preferred subset scope assignment to the same sentences in Japanese, and then rapidly acquire the superset reading that is preferred in Japanese (Gruter, Lieberman, & Gualmini, 2010). Although I am not suggesting that children, and adults, cannot eventually recover from a situation in which they have hypothesised a superset reading, the Semantic Subset Maxim prevents unnecessary delay for children.

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APPENDIX

Ethics Clearance

4 April 2007

Dr Rosalind Thornton
Department of Linguistics
Division of Linguistics and Psychology
Room 420

Reference: HE23MAR2007-R05076

Dear Dr Thornton

Final Approval

Title of project: "The meaning of OR in logic and human languages"

The above application was reviewed by the Ethics Review Committee (Human Research). The Committee considered your application to be of excellent quality and stood out as a model of comprehensiveness and clarity.

Approval of the above application is granted, effective 4 April 2007. You may now proceed with your research. Please note that final approval is subject to your compliance with the following condition:

1. Please forward evidence that a Working With Children Check has been completed for Dr Jensen when this is available. Please also be advised that Dr Jensen should keep a copy of the Prohibited Employment Declaration (Form E) and the Consent for Employment Screening (Form F) on her during the course of the research.

Please note the following standard requirements of approval:

1. Approval will be for a period of twelve (12) months. At the end of this period, if the project has been completed, abandoned, discontinued or not commenced for any reason, you are required to submit a Final Report on the project. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. The Final Report is available at: http://www.ro.mq.edu.au/ethics/human/forms.
2. However, at the end of the 12 month period if the project is still current you should instead submit an application for renewal of the approval if the project has run for less than five (5) years. This form is available at http://www.ro.mq.edu.au/ethics/human/forms. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report (see Point 1 above) and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).
3. Please remember the Committee must be notified of any alteration to the project.
4. You must notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that might affect continued ethical acceptability of the project.
5. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University (http://www.ro.mq.edu.au/ethics/human).

If you will be applying for or have applied for internal or external funding for the above project **it is your responsibility** to provide Macquarie University's Research Grants Officer with a copy of this letter as soon as possible. The Research Grants Officer will not inform external funding agencies that you have final approval for your project and funds will not be released until the Research Grants Officer has received a copy of this final approval letter.

Yours sincerely

pp. [signature]

Dr Margaret Stuart
Director of Research Ethics
Chair, Ethics Review Committee (Human Research)

ETHICS REVIEW COMMITTEE (HUMAN RESEARCH)
MACQUARIE UNIVERSITY (E11A))
SYDNEY, NSW, 2109 AUSTRALIA
Ethics Secretariat: Ph: (02) 9850 6848 Fax: (02) 9850 4465 E-mail: ethics.secretariat@vc.mq.edu.au
http://www.research.mq.edu.au/researchers/ethics/human_ethics

MACQUARIE
UNIVERSITY ~ SYDNEY

5 May 2008

Ms Anna Notley
Macquarie Centre for Cognitive Science
Division of Linguistics and Psychology

Reference: HE02MAY2008-D05799

Dear Ms Notley

FINAL APPROVAL

Title of project: ***Children's Understanding of Logical words :'Before' and 'Or'***

Thank you for your recent correspondence. Your responses have satisfactorily addressed the outstanding issues raised by the Committee. You may now proceed with your research.

Please note the following standard requirements of approval:

1. Approval will be for a period of twelve months. At the end of this period, if the project has been completed, abandoned, discontinued or not commenced for any reason, you are required to submit a Final Report on the project. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. The Final Report is available at http://www.ro.mq.edu.au/ethics/human/forms
2. However, at the end of the 12 month period if the project is still current you should instead submit an application for renewal of the approval if the project has run for less than five (5) years. This form is available at http://www.ro.mq.edu.au/ethics/human/forms. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report (see Point 1 above) and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).
3. Please remember the Committee must be notified of any alteration to the project.
4. You must notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that might affect continued ethical acceptability of the project.
5. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University (http://www.ro.mq.edu.au/ethics/human).

If you will be applying for or have applied for internal or external funding for the above project **it is your responsibility** to provide Macquarie University's Research Grants Officer with a copy of this letter as soon as possible. The Research Grants Officer will not inform external funding agencies that you have final approval for your project and funds will not be released until the Research Grants Officer has received a copy of this final approval letter.

Yours sincerely

P.P. Dr Margaret Stuart
Director of Research Ethics
Chair, Ethics Review Committee [Human Research]

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Email ethics.secretariat@vc.mq.edu.au

18 March 2009

Ms Anna Notley
Room 483, building C5C
Macquarie University
NSW 2109

Reference: HE27MAR2009-D06391HS

Dear Ms Notley,

Title of project: Children's Understanding of Logical Words: 'Not', 'Every', and 'Or'

Thank you for your recent correspondence. Your responses have addressed the issues raised by The Faculty of Human Sciences Sub-Committee of the Ethics Review Committee (Human Research). Approval of the above application is granted, effective 18th March 2009, and you may now proceed with your research. Please be advised that this final approval also applies to the following amendments:

1. Item 5.4 – Flyer to be used in recruitment.
2. Appendix C – Working with children check for Research Assistant Kriszta Szendroi.

STANDARD REQUIREMENTS ATTACHED TO APPROVAL:

1. Approval will be for a period of twelve (12) months. At the end of this period, if the project has been completed, abandoned, discontinued or not commenced for any reason, you are required to submit a Final Report on the project. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. The Final Report is available at: http://www.research.mq.edu.au/researchers/ethics/human_ethics/forms

2. However, at the end of the 12 month period if the project is still current you should instead submit an application for renewal of the approval if the project has run for less than five (5) years. This form is available at http://www.research.mq.edu.au/researchers/ethics/human_ethics/forms. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report (see Point 1 above) and submit a new application for the project. (The five year limit on renewal of approvals allows the Sub-Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

3. Please remember the Sub-Committee must be notified of any alteration to the project.

4. You must notify the Sub-Committee immediately in the event of any adverse effects on participants or of any unforeseen events that might affect continued ethical acceptability of the project.

5. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University http://www.research.mq.edu.au/researchers/ethics/human_ethics/policy.

If you will be applying for or have applied for internal or external funding for the above project **it is your responsibility** to provide Macquarie University's Research Grants Officer with a copy of this letter as soon as possible. The Research Grants Officer will not inform external funding agencies that you have final approval for your project and funds will not be released until the Research Grants Officer has received a copy of this final approval letter.

Yours sincerely

p.p.

Dr Shirley Wyver
Chair, FoHS Ethics Review Sub-Committee, Ethics Review Committee (Human Research)

Cc: Professor Stephen Crain, Macquarie Centre for Cognitive Science
Dr Rosalind Thornton, Department of Linguistics

24 October 2008

Mr. Nobu Akagi
483, C5C
Macquarie University
NSW 2109

Reference: HE24OCT2008-D06146L&P

Dear Mr. Akagi,

FINAL APPROVAL

Title of project: "Interpretation of Disjunction in Human Language"

Thank you for your recent correspondence. Your responses have addressed the issues raised by the Division of Linguistics and Psychology Sub-Committee of the Ethics Review Committee (Human Research) and you may now proceed with your research.

Please note the following standard requirements of approval:

1. Approval will be for a period of twelve (12) months. At the end of this period, if the project has been completed, abandoned, discontinued or not commenced for any reason, you are required to submit a Final Report on the project. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. The Final Report is available at: http://www.research.mq.edu.au/researchers/ethics/human_ethics/forms
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5. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University http://www.research.mq.edu.au/researchers/ethics/human_ethics/policy

ETHICS REVIEW COMMITTEE (HUMAN RESEARCH)
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If you will be applying for or have applied for internal or external funding for the above project **it is your responsibility** to provide Macquarie University's Research Grants Officer with a copy of this letter as soon as possible. The Research Grants Officer will not inform external funding agencies that you have final approval for your project and funds will not be released until the Research Grants Officer has received a copy of this final approval letter.

Yours sincerely

Mr Colm Halbert
Chair, Division of Linguistics and Psychology Sub-Committee to the Ethics Review Committee (Human Research)
Acting Associate Dean of Research

Cc: Professor Stephen Crain, The Macquarie Centre for Cognitive Science