English-Speaking Children's Interpretation of Disjunction in the Scope of 'not every'

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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 to disjunction (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 judgment task.

Keywords: acquisition of semantics; disjunction in natural language; scope ambiguity

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 to such sentences may be revealing about their innate 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

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appreciate the consequences of introducing negation for semantic interpretation.

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

(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 illustrate, there is an asymmetry in the interpretation of disjunction in (1) and (2) depending on the surface structure position of the disjunction word (in the subject phrase versus the predicate phrase). 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 emphasized 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 conversational 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 predominance 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 Ns* and *no Ns* assign the same truth conditions to disjunction when it appears in either argument. Disjunction is assigned a conjunctive interpretation in both arguments of *no Ns*, and disjunction is assigned disjunctive truth conditions in both arguments of *some Ns*. These determiner phrases, therefore, fail to support any substantive generalizations about the asymmetry in 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 predicate phrase of 'every', and there were no cases in which disjunction appeared in the subject phrase of sentences with 'every' (neither did disjunction occur in the subject phrase of sentences with '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 sentences like (1) and (2). In both English and in Mandarin Chinese, 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 aspect of children's knowledge of logical principles 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 (3a), negation takes scope over 'some', as indicated in (3b). 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 (4a), 'some' is assigned wide scope over negation, as indicated in (4b). We understand the sentence to mean that every farmer did not clean at least one animal (although they probably cleaned some other animals). Gualmini (2005) tested 30 3- to 5-year-old English-speaking children on sentences like these, and found that the child subjects correctly 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 (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 taking 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), 7(a), asymmetrically entails the other reading, 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 other circumstances that also 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 them to initially adopt the subset interpretation (7a) in order to guarantee that the superset reading (7b) 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 on semantic interpretation 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 (Notley *et al*. 2011). 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 assign a disjunctive interpretation to disjunction in the first argument, the subject phrase, and children should assign a conjunctive interpretation to disjunction 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 they are presented with certain kinds of semantic scope ambiguities.

The paper is organized 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 learned. 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-Or*

The first logical fact is that the meaning of disjunction in natural language is inclusive-*or*. In considering the input containing the disjunction operator ('or' in English), the underlying meaning of this logical 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 for Eric 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. 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 that is associated with inclusive-*or* (where both disjuncts are true) is suppressed due to a conversational implicature. The implicature arises because the logical operators OR and 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 'basic' 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 reveal 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 in 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 downward entailment (DE) in natural language, because children 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 operators piecemeal, as they amass relevant input for each operator. 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;1–5;2) and Dutch-speaking children (aged 1;5–3;10) have revealed children 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 children 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

[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).

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 flavored 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 became ill 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 flavored. 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, b, 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.* 2011). 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 subject phrase of the universal quantifier, but not in the predicate phrase. 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 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’ 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 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 when it appears 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 an accurate 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, hearers 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, so hearers 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 for both other truth conditions to be true: (i) that all sick passengers who ordered chicken became ill, and (ii) that all sick passengers who ordered beef became ill. If the conjunctive interpretation were not computed, then (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 the 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 just (ii) is true, but accept (14) when both (i) and (ii) are true. We draw attention to this because the experimental 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 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.	*Japanese*
	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, b, 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

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[2] The notion of scope under consideration does not depend on one operator appearing in a 'higher' structural position than the other in the syntactic tree corresponding to the sentence that is uttered (i.e. at spell-out). In both English and Japanese, negation is typically analyzed as residing 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 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 computation of the sentence meaning.

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 by that quantifier, and must be interpreted in 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 the 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 hypothesize. 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*. 2011). 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*. 2011).

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 judgment 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 experi-

[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.

menters — 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, such as 'every princess took some treasure'. This was because it has been shown that negative statements about stories are often pragmatically infelicitous and can lead to irrelevant errors by child subjects. A positive lead-in sentence preceding the negative statement helps to satisfy the pragmatic felicity conditions associated with negation and, as a consequence, is likely to reduce the number of irrelevant errors committed by children (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 fulfill 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 crowns, so, in the end, they each took a star. 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 ruled out the possibility that children's rejections were due to the fact that they only 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 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) recognize 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 favor 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 recognize that 'not every' is downward entailing on its nuclear scope. The relevant prediction is summarized 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 toyshop 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 incorrectly computed 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 boy bought a ball' was false.

To make this potential 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) performed 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

[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.

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 the sentence might be rejected. As with the 'Nuclear Scope OR' condition, in this condition, too, the disjuncts were ordered such that the second disjunct made 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, children were simply not processing the full disjunctive statement. On the other hand, if children accessed the adult meaning of these sentences, they should have accepted them.

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."

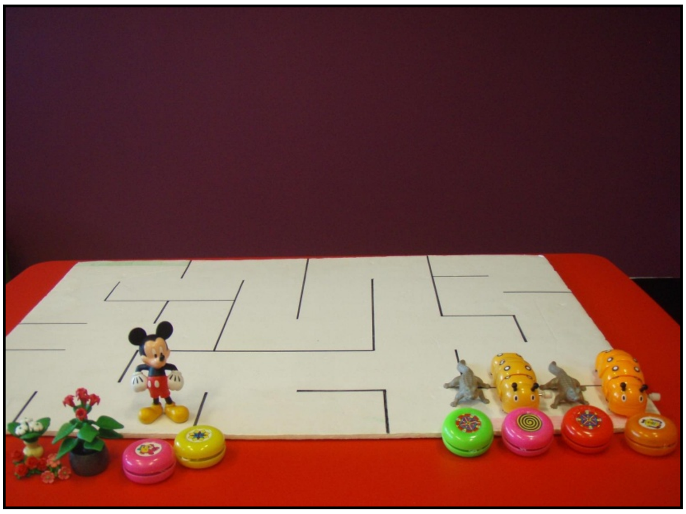

Figure 3: FALSE 'Restrictor OR' Condition

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 disjunction in 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, children fail to recognize 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 summarized 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 analyze ‘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 analyze ‘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 recognize 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 child-care centers 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 undergraduate 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. As with the target sentences, the filler items were preceded by a lead-in sentence that made them felicitous in the context.

(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 familiarize 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 the data analysis either because they answered incorrectly on more than one filler item (2 children), or because they answered incorrectly on 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 judgment 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 judgment 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 judgment. For example, sometimes they gave mismatched responses, in which they provided a justification typical of a false judgment, 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 leftover 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 leftover 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 judgment, 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, because the acceptance rate for the adult-true trials is well above 50% for children, we can be confident that those children who were included in the subsequent data 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

[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' would be the only meaning 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 analyzed 'not every' as a compound quantifier.

that, indeed, only two pirates had caught ONLY dinosaurs. One adult failed to respond on one trial. The child and adult responses to the two types of control sentences are summarized in Table 1. A Mann-Whitney test showed no signify-cant 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 judgment 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 mismatched 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 judgment 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 mismatched 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 summarized 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 'Nuclear 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 mismatched 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 mismatched 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 summarized 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 at 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 in 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 that 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 favor 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 would be revealed. In all, the results of the 'Nuclear Scope OR' condition strongly support Prediction 1, providing evidence that both the SSM and the relevant 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 was 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. One contributing factor might be the complex character of the downward entailing context. 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, as we discussed in the introduction, 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 (30a) 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 (30a), as opposed to (30b), 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 *et al*. 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, but not in the restrictor. On the other hand, an NPI item like ‘any’ is not licensed in the nuclear scope, but is licensed 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 children’s 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 emphasized 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.

Appendix: Test Materials

A.1. 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]

A.2. 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 toyshop 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]

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