

## ABSTRACT

Title of Document: EVERYONE KNOWS, THEREFORE EVERY CHILD KNOWS: AN INVESTIGATION OF LOGICO-SEMANTIC COMPETENCE IN CHILD LANGUAGE

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This dissertation discusses children's understanding of semantic contribution of the universal quantifier *every* and its interactions with negation from a logico-semantic perspective. The universal quantifier *every* evokes an asymmetric entailment pattern in its first and second arguments (e.g., Ladusaw, 1979), which influences both sentential meanings and inferential relations among them. Whereas several studies have revealed children's sophisticated ability to compose the meanings of sentences containing *every* (e.g., Gualmini 2005), far less is known about whether children's knowledge about *every* can be extended to the level of meaning comparison, i.e., to the computation of the inferential relations among *every*-sentences. We thus investigate whether children are able to apply their knowledge about *every* to the calculation of the inference relations between *every*-sentences. In particular, this

dissertation aims to experimentally examine children's ability to evaluate the inferences between *every*-sentences.

We first report an experiment featuring the Truth Value Judgment Task (e.g., Crain and Thornton 1998), reconfirming children's adult-like ability to compose individual sentence meanings involving *every*. We then introduce two novel experimental methodologies, the *Prediction-Rephrase Task* and the *Demand-Fulfillment Task*, designed to assess children's ability to evaluate inferences between the entailing and entailed sentences. Three experiments utilizing these new tasks demonstrate that children's highly sophisticated knowledge about *every* is appropriately applied in comparing meaning relations involving *every* across-propositionally. Additionally, we present experiments that reveal children's adult-like knowledge regarding the semantic interaction between *every* and negation (e.g., Ludlow 2002) in both composing and comparing sentential meanings; these findings provide the evidence showing children's adult-like linguistic representations of the sentences, in which the structural relation between *every* and negation determines the patterns of inferences.

Taken together, these studies demonstrate children's adult-like knowledge regarding the semantics of *every* that is applied both in the composition and comparison of sentential meanings, as well as their adult-like knowledge about the interaction between *every* and negation. In addition, our development of the two new experimental methodologies has made possible further steps toward the full understanding of semantic competence in child language, not only at the level of meaning composition but also at the level of meaning comparison.

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INVESTIGATION OF LOGICO-SEMANTIC COMPETENCE IN CHILD  
LANGUAGE

by

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## Table of Contents

Acknowledgements .....	i
Table of Contents .....	iii
Chapter 1. Introduction.....	1
1.1. Meaning in Language and Semantic Competence.....	4
1.2. Entailments, Inferences and the Universal Quantifier “Every”.....	8
1.3. Semantic Competence and “Every” in Child Language.....	18
1.4. Linguistic Studies on Logical Inference in Child Language.....	26
1.5. Organization of the Dissertation.....	32
Chapter 2. Experiment I: Truth Conditional Evaluation of Entailing and Entailed Propositions.....	34
2.1. Logic.....	35
2.1.1. First Argument of “Every”.....	38
2.1.2. Second Argument of “Every”.....	39
2.2. Experimental Design.....	42
2.3. Predictions.....	48
2.4. Results.....	50
2.5. Discussion.....	53
Appendix 2A: Full Sentences and Stories provided in Experiment I.....	56
Appendix 2B: Individual Reponses of the Subjects.....	58
Chapter 3. Experiment II: Evaluation of Inferences between Propositions–Phase 1..	59
3.1. Logic.....	60
3.1.1. Philip and De Villiers (1992).....	61
3.1.2. De Villiers et al. (1998).....	66
3.1.3. Methodological Lessons.....	68
3.2. Experimental Design–“Prediction-Rephrase” Task.....	71
3.2.1. Basic Plot.....	71
3.2.2. Experimental Conditions and Stimuli.....	73
3.2.3. Sample Trials.....	76
3.2.4. Evaluation of Kermit’s Rephrase.....	76
3.3. Predictions.....	77
3.4. Results.....	79
3.5. Discussion.....	81
Appendix 3A: Full Script of “Prediction-Rephrase” Task.....	85
Appendix 3B: Individual Reponses of the Subjects.....	88
Chapter 4. Experiment III: Evaluation of Inference between Propositions–Phase 2..	89
4.1. Logic.....	90
4.2. Experimental Design–“Demand-Fulfillment” Task.....	98
4.2.1. Basic Plot.....	98
4.2.2. Experimental Conditions and Stimuli.....	100
4.2.3. Evaluation of the Stimuli.....	102
4.2.4. Interpretation of Responses in Each Experimental Condition.....	103
4.2.5. Notes on the Non-“Yes” Responses.....	104

4.2.6. Sample Trials.....	106
4.2.7. Additional Information for the Felicity.....	108
4.3. Predictions.....	110
4.4. Results.....	111
4.5. Discussion.....	115
4.5.1. Children’s Sensitivities to the Entailment Patterns.....	115
4.5.2. Evaluations at the Two Phases: Before- and After-Open-the-Box.....	119
4.5.3. Notes on the After-Open-the-Box-Evaluation.....	123
4.6. Discussion of Experiments I, II and III.....	125
Appendix 4A: Full Script of “Demand-Fulfillment” Task.....	127
Appendix 4B: Individual Reponses of the Subjects.....	134
Chapter 5. Reversed Entailments: Semantic Interaction with Negation.....	135
5.1. Semantic Interaction with Negation–The Phenomenon.....	135
5.2. Entailment and Scope.....	138
5.3. Issues in Child Language.....	142
Chapter 6. Experiments IV and V: Truth Conditional Evaluation of Each Proposition– Reversed Entailment.....	146
6.1. EXPERIMENT IV.....	146
6.1.1. Logic.....	148
6.1.2. Experimental Design.....	150
6.1.3. Predictions.....	156
6.1.4. Results.....	158
6.1.5. Discussion.....	160
6.2. EXPERIMENT V: CONTROL.....	161
6.2.1. Logic.....	163
6.2.2. Experimental Design.....	166
6.2.3. Predictions.....	170
6.2.4. Results.....	171
6.2.5. Discussion.....	173
6.3. Discussion of Experiments IV and V.....	174
Appendix 6A: Full Sentences and Stories provided in Experiment IV.....	176
Appendix 6B: Individual Responses of the Subjects: Experiment IV.....	179
Appendix 6C: Full Sentences and Stories provided in Experiment V.....	180
Appendix 6D: Individual Responses of the Subjects: Experiment V.....	183
Chapter 7. Experiment VI: Evaluation of Inference between Propositions–Reversed Entailment.....	184
7.1. Logic.....	185
7.2. Experimental Design–“Demand-Fulfillment” Task, Negative Version.....	187
7.2.1. Basic Plot.....	187
7.2.2. Experimental Conditions and Stimuli.....	189
7.2.3. Notes on Felicity in Presenting Negative Demands.....	191
7.2.4. Evaluation of the Stimuli.....	194
7.2.5. Sample Trials.....	195
7.3. Predictions.....	199
7.4. Results.....	200
7.5. Discussion.....	203

7.5.1. Evaluations at the Two Phases: Before- and After-Open-the-Box.....	203
7.5.2. Additional Discovery .....	207
Appendix 7A: Full Script of “Demand Fulfillment” Task, Negative Version.....	209
Appendix 7B: Individual Responses of the Subjects: Experiment VI .....	219
Chapter 8. General Discussions .....	220
8.1. Summary of Experimental Findings.....	220
8.2. Learning of the Universal Quantifier(s).....	223
8.3. Remaining Issues .....	235
References.....	248

## Chapter 1. Introduction

As speakers of a human language, we know all about meanings, i.e., *word meanings* and *sentence meanings*. For example, we know what the meaning of *dog* is, and what the meaning of *run* is; we know how to compose the meaning of *a dog is running* out of these word meanings. In addition, we know *inferential relations* among meanings, i.e., which meaning *entails* which other meaning: we know that *a dog is running* is necessarily true in any circumstances that *a brown dog is running* is true, but not vice versa; we further know that *every brown dog is running* is true in any circumstances that *every dog is running*, but not vice versa. Crucially, *entailment* is a consequence of sentence meanings composed out of word meanings, which is computed through the comparison among meanings. Thus, the semantic competence of speakers of a human language, which is the representation of our knowledge about meanings of these various levels in our *grammar*, is considered to be the component that composes the sentence meanings out of the word meanings, and that computes the relations of sentential meanings, i.e., evaluate which sentence logically implies which other sentence appropriately. Therefore, to understand how logical reasoning across sentences is implemented in children and adult is to understand the nature of their semantic competence, i.e., the knowledge that allows them to represent meaning in language.

Given this, children, as learners of a human language, have to learn all about meanings. They have to learn what the meaning of *dog* is; they have to learn the composition of meanings, i.e., what the meaning of *a dog is running* is. They have to

also learn the comparison of meanings; *a dog is running* is necessarily true in any circumstances that *a brown dog is running* is true, but not vice versa; they have to further learn that *every brown dog is running* is necessarily true in any circumstances that *every dog is running*, but not vice versa. Study of what young children know about meanings at these various levels thus would offer a window to show the process of how one becomes a speaker of a language.

However, the complexity of deriving meaning from linguistic utterances quickly becomes apparent. In fact, notice that replacing a single element in the sentences above, from *a* to *every*, consequently has a huge influence on the mapping among the parts of one sentence in the representation of the entire meaning not only at the within-propositional level but also across-propositional level. Considering whether children indeed show this competence will in turn be illuminating whether children know about the contribution of the meaning of *every* that determines the relation between sentences that contain it, which has not yet been discussed actively in the field of linguistic research and language acquisition. This dissertation thus aims to experimentally examine children's ability to compute the semantic relations between sentences that contain the universal quantifier *every*. In particular, this dissertation considers meaning in child language from the viewpoint of the relations across sentential meanings, primarily investigating whether children are able to compute the logico-semantic relations among sentences like the following.

- (1) Every dog is running  
→ Every brown dog is running

(2) A dog is running

\*  $\rightarrow$  A brown dog is running

As can be seen in the contrast between (1) and (2), *every dog is running* logically implies *every brown dog is running* is true, but not vice versa, contrarily to the fact that *a brown dog is running* logically implies *a dog is running*, but not vice versa.

To begin with, we will first spell out the aspects of *meaning computation* from the following two points of view: (i) the *within-propositional* computation of meaning, which is the *composition* of the meanings of a propositional variable (sentence) on the basis of the word meanings and the semantic compositional rules; (ii) the *across-propositional* computation of meaning, which determines the relation between propositional variables through the *comparison* of meanings, designating the direction of *entailments* and *logical inferences*. Then we will consider the semantic contribution of the universal quantifier *every*, which will be focused on throughout this dissertation as a case study. In this discussion, we will lay out the various linguistic consequences of *every*'s semantic properties at the both levels of within- and across-propositional meaning computations. Finally, we will consider what has been reported about children's knowledge about the universal quantifier *every* and what has not yet been discussed, claiming that there is almost nothing that has been revealed about children's ability to evaluate the meanings concerning *every* at the across-propositional level, despite the fruitful contributions that have been made in the past regarding the meanings concerning *every* at the within-propositional level.

### 1.1. Meaning in Language and Semantic Competence

Semantic competence in a language consists of the following two aspects: (i) computation of meanings at the within-proposition level (i.e., *composition* of meanings); (ii) computation of meanings at the across-proposition level (i.e., *comparison* of meanings). The first is the computation the *truth conditional meaning* of individual propositions (i.e., sentences), which is composed on the basis of the lexical meanings and the ways that these lexical meanings are combined. Taking the simplest example, let us consider the following.

(3) A dog is running.

The semantics at the level of the within-proposition meanings is concerned with the meaning relationship among words and phrases, providing the systematic rules to determine the conditions under which any sentence is true, i.e., truth conditions. Thus, the meaning of the sentence (3) is represented as in (4) - (5).<sup>1</sup>

(4) For any situation (or circumstance)  $v$ ,

{ $x$ :  $x$  is running in  $v$ }

(5) The sentence (3) is true in the circumstance in which a variable  $x$  is a member of the set of dogs and  $x$  is running; otherwise it is false.

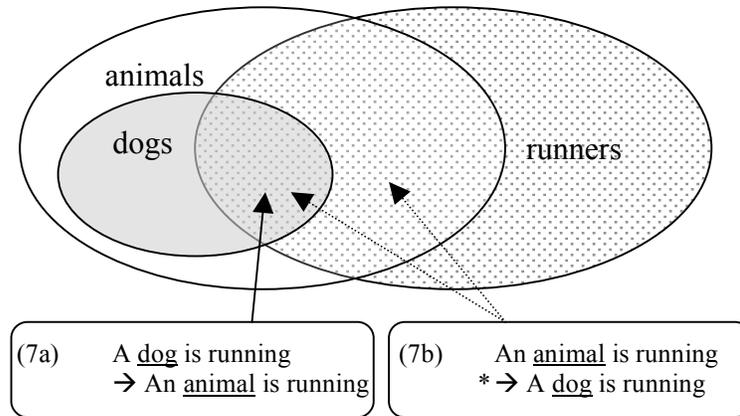
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<sup>1</sup> We will put aside the detail technicalities about how to formalize the sentence meanings in the formal semantics. See Heim and Kratzer (1988), for example, for the technical details.



The meaning relations that have observed above can be schematically illustrated in the Venn diagram as follows.

Figure 1 Schematized Pattern of Across-propositional Meaning Relation for Sentences (6)



Now, let us consider the following two sentences, in which the actions denoted in the verbs constitute a set-subset relation.

- (8) a. A dog is running.  
b. A dog is moving.

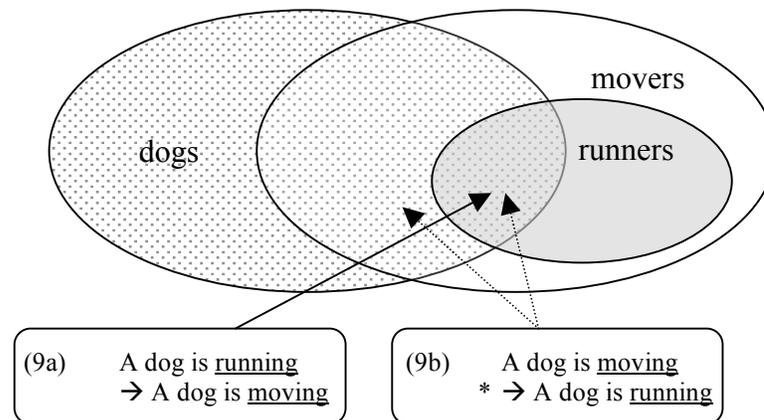
Note that the action of running referred to in (8a) is a subset of the action of moving denoted in (8b). Keeping this in mind, consider the meaning relation between them. (8b) is necessarily true in any circumstances that (8a) is true, since running is a subtype of the action of moving, but not vice versa; (8b)'s being true does not necessarily guarantee that (8a) is necessarily true, since the dog in discussion might

be walking instead of running.<sup>3</sup> Thus we say that (8a) entails (8b), and which can be illustrated as in (9), on a par with the case of (6).

- (9) a. A dog is running (=8a)  
           → A dog is moving (=8b)
- b. A dog is moving (=8b)  
       \* → A dog is running (=8a)

The across-propositional meaning relations that have observed above can be schematically illustrated in the Venn diagram as follows.

Figure 2 Schematized Pattern of Across-propositional Meaning Relation for Sentences (8)



Thus, the across-propositional relations in meanings are related to the direction of the logical inference; the crucial observation is that the inference licensed from the

<sup>3</sup> See the illustration in Figure 2, which demonstrates each situation that represents the relations in truths between two sentences.

entailing to the entailed propositions. As we have discussed, the default pattern of the across-sentential relation in meanings, i.e., the default direction of logical inferences, is from the subset-denoting expression to its relating superset-denoting expression.

To sum up, the semantic competence in human language requires the ability to compute the meanings at the following two levels: (i) the ability to compute the truth conditional meanings of individual propositions (i.e., the computation of lexical meanings on the basis of the semantic composition rules); (ii) the ability to license the logical inferences between propositional variables appropriately (i.e., which proposition entails which other proposition). Hence, “a grammar does not stop at rules for relating words (e.g., De Villiers and De Villiers, 1979)”; “it also has means of expressing the relationship between whole propositions or events (ibid.)”.

However, thus far we have only observed the simplest example of how the relationship among sentential meanings is represented, in which an inference is licensed from the subset-denoting expression to the superset-denoting expression as a default. In the following section, we will look at a case demonstrating that the default pattern is not always licensed, focusing on the role that the universal quantifier *every* plays in determining the inference pattern.

### 1.2. Entailments, Inferences and the Universal Quantifier “Every”

Before considering inferences, let us start with a survey of various linguistic phenomena with respect to the semantic contribution of the universal quantifier *every*. In fact, the universal quantifier *every* provides an interesting domain for considering

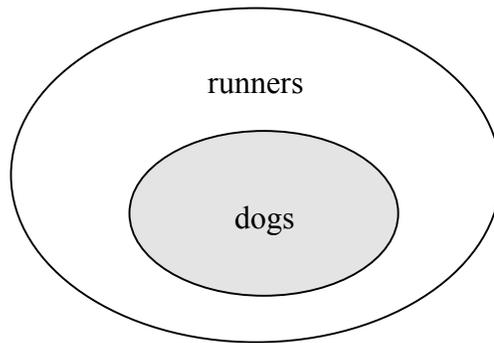
both of the two aspects of semantic competence that we have described in the previous section. The universal quantifier *every* not only influences the meanings of individual sentences containing it at the within-propositional (truth conditional) level but also determines the across-propositional meaning relations among individual sentences containing it in a non-canonical way.

Being a quantificational determiner, *every* gives speakers “the power to move beyond talk about properties of particular individuals to saying what *quantity* of the individuals in a given domain have a given property (Chierchia and McConnell-Ginet, 1990)”. At the semantic level, *every* is mapped onto a two-place relation holding between sets of individuals: the first argument (i.e., the NP) is a property that holds of objects or of individuals; the second argument (i.e., the VP) is also a property that holds of objects or individuals. Consider a simple sentence that contains *every* as the one in (10) as an example.

(10) Every dog is running.

In the sentence (10), a two-place relation holds between the first argument *dog*, which denotes the set of dogs, and the second argument *is running*, which denotes the set of runners. The sentence (10) is true if the set of dogs is a subset of the set of runners, as the schema illustrates below.

Figure 3 Set-theoretical Representation of the Relation denoted by *Every*



Crucially, it is well known that the universal quantifier *every* shows an asymmetry in its first argument (i.e., the NP) and its second argument (i.e., the VP) in a sentence that contains it, with respect to some aspects in determining its truth-conditional meaning. In particular, the first argument of *every* patterns on a par with negation with respect to licensing some specific linguistic element or interpretation at the within-propositional level of meaning, whereas the second argument of *every* does not.

First, *every* licenses a negative polarity item (NPI) such as *ever* or *any* in its first argument, as (11a) and (12a) show, but not in its second argument, as (11b) and (12b) show.

- (11) a. [Every student who has ever read Chomsky] should know it.  
b. \* Every student has ever read Chomsky.
- (12) a. [Every child who ate any vegetable at lunch] may go out and play.  
b. \* Every child ate any vegetable.

Note that the contrast between (a) sentences and (b) sentences in (11) and (12) is parallel to the contrast between affirmative and negative sentences, i.e., (a) sentences and (b) sentences in (13) and (14).

- (13) a. The students have not ever read books by Chomsky.  
b. \* The students have ever read book by Chomsky. (cf. (11))
- (14) a. The children did not eat any vegetables at lunch.  
b. \* The children ate any vegetables at lunch. (cf. (12))

Thus the first argument of *every*, but not the second argument, licenses an NPI, on a par with that the negative sentences, but not the affirmative sentences, licenses an NPI.

Second, *every* licenses disjunction to be interpreted in a way as if it were equal to conjunction<sup>4</sup> in its first argument, as (15a) shows, but not in its second argument, as (15b) shows.

- (15) a. [Every child who ate a carrot or a green pepper] may go out and play.  
≈ Every child who ate a carrot and every child who ate a green pepper may go out and play.
- b. Every child ate a carrot or a green pepper.  
\* ≈ Every child ate a carrot and every child ate a green pepper.

---

<sup>4</sup> Higginbotham (1991) called this phenomenon the conjunctive interpretation of disjunction.

Note again that the contrast between (15a) and (15b) is parallel to the contrast between (16a) and (16b) below.

- (16) a. The children did not eat a carrot or a green pepper.  
      ≈ The children did not eat a carrot and the children did not eat a green pepper.
- b. The children ate a carrot or a green pepper.  
      \* ≈ The children ate a carrot and the children ate a green pepper.
- (cf. (15))

The “conjunctive” interpretation of disjunction in the relevant linguistic contexts calls to mind one of the De Morgan’s laws of propositional logic:  $\neg(A \vee B) \rightarrow \neg A \wedge \neg B$ .<sup>5</sup> The truth tables in Table 1 below illustrate the logical equivalence between disjunction under the scope of negation and the conjunction of the two negated premises.

---

<sup>5</sup> Unlike English, Japanese apparently does not follow De Morgan’s laws with respect to the disjunction under negation. In the Japanese simple negative sentence that corresponds to (16a), the disjunction *ka* does not receive the conjunctive interpretation.

- (i) Kodomo-tachi-wa ninjin-*ka* piiman-o tabe-naka-tta.  
child-pl.-NOM carrot-*or* green pepper-ACC eat-neg-past

For a theoretical analysis about disjunction and negation in Japanese, see Goro (2003, 2004), which claims that the Japanese disjunction *ka* is a positive polarity item (PPI). (See also Szabolcsi (2002, 2004) for the analyses of the Hungarian disjunction in the same vein.) For a detailed discussion about disjunction and negation in child Japanese, see Goro and Akiba (2004). For a related discussion about disjunction in the covert DE in English and Japanese, see Crain, Goro and Minai (2005), Goro, Minai and Crain (2004a, 2004b) and Minai, Goro and Crain (2004).

Table 1 The Truth Tables of Disjunction and Conjunction wrt. Negation

A	B	$A \vee B$	$\neg(A \vee B)$	$\neg A$	$\neg B$	$\neg A \wedge \neg B$
0	0	0	<b>1</b>	1	1	<b>1</b>
0	1	1	<b>0</b>	1	0	<b>0</b>
1	0	1	<b>0</b>	0	1	<b>0</b>
1	1	1	<b>0</b>	0	0	<b>0</b>

Thus, the first argument, but not the second argument, licenses the “conjunctive” interpretation of disjunction, on a par with that the negative sentences, but not the affirmative sentences, licenses the “conjunctive” interpretation of disjunction.

The distinction between the negative and affirmative sentences with regard to the above aspects is said to be a consequence of the semantic property *entailment*. The negative sentence creates a *downward entailment* (henceforth, DE) linguistic environment, in which an NPI and the conjunctive interpretation of disjunction are licensed, whereas the affirmative sentences do not. Hence, on a par with the distinction between affirmative and negative sentences, we say that the first argument of *every* is a DE environment, whereas the second argument of *every* is a non-DE environment.<sup>6</sup>

The discussion so far has focused on the contrast between the first and second argument of *every* with respect to how they determine the individual sentential meanings (at the within-propositional level). Keeping that discussion in mind, let us move on to the relation between the entailment structure that the universal quantifier *every* asymmetrically creates in both arguments, and the across-propositional meaning relations regarding the sentences containing *every*.

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<sup>6</sup> See Ladusaw (1979, 1980) for a detailed discussion of the entailment structure of the arguments of *every* and their consequences.

First, consider the following sentences, in which logical inferences are created with respect to the NP-denotation in the first argument of *every*.

- (17) a. Every dog is running.  
          → Every white dog is running.
- b. Every white dog is running.  
      \* → Every dog is running.

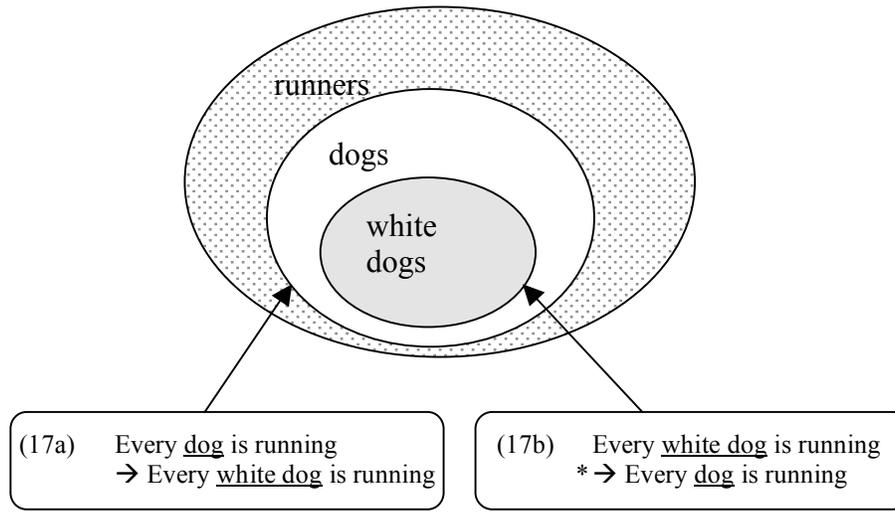
As (17a) shows, if *every dog is running* is true, *every white dog is running* is necessarily true, but not vice versa; even if *every white dog is running* is true, it does not follow that *every dog is running* is true, as (17b) demonstrates, because there may be dogs of other colors that are not running in the domain.<sup>7</sup> Thus, the contrasts in (17) illustrate that the first argument of *every*, being DE, licenses an inference from a set-denoting expression, i.e., *dog*, to its subset-denoting expression, i.e., *white dog*.

The meaning relation between these sentences can be schematized as follows.

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<sup>7</sup> See the illustration in Figure 4, which demonstrates each situation that represents the relation in truths between the two sentences.

Figure 4 Schematized Pattern of Across-propositional Meaning Relations for Sentences (17a)



Note that the inferential pattern observed between *every*-sentences in (17) above is the opposite of the default pattern that we have observed in (6) and (8), which are repeated below.

- (18) a. A dog is running (= (6a))  
→ An animal is running (= (6b))
- b. An animal is running (= (6b))  
\* → A dog is running (= (6a))
- (19) a. A dog is running (= (8a))  
→ A dog is moving (= (8b))
- A dog is moving (= (8b))  
\* → A dog is running (= (8a))

As can be seen, the examples above show that the inferences are licensed from the subset-denoting expression to the set-denoting expression; this is the opposite of the patterns that were demonstrated in (17).

Note now that the same pattern observed in (17) could be seen in the case of the negative versions of (6) and (8), which is another DE environment. Consider (20) and (21). If an animal is not running, then it is necessarily true that a dog is not running, but not vice versa; likewise, if a dog is not moving, then it is necessarily true that a dog is not running, but not vice versa.

- (20) a. A dog is not running (cf. (6a))  
       \* → An animal is not running (cf. (6b))
- b. An animal is not running (cf. (6b))  
           → A dog is not running (cf. (6a))
- (21) a. A dog is not running (cf. (8a))  
       \* → A dog is not moving (cf. (8b))
- b. A dog is not moving (cf. (8b))  
           → A dog is not running (cf. (8a))

Let us now consider the inferences that are created with respect to the noun denotation in the second argument of *every*.

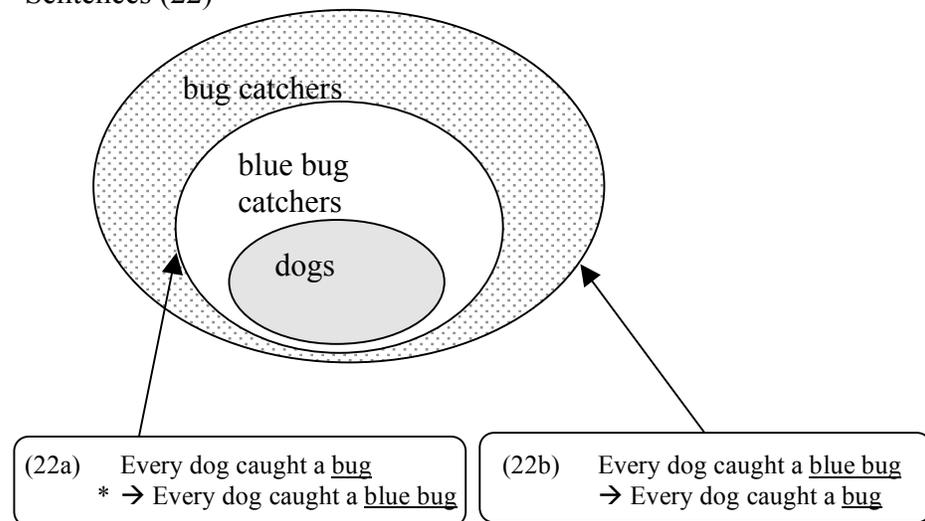
- (22) a. Every dog caught a bug.  
       \* → Every dog caught a blue bug.

- b. Every dog caught a blue bug.  
 → Every dog caught a bug.

Contrary to the pattern observed in (17) (with respect to the first argument of *every*), in any circumstance *every dog caught a blue bug* is true, it is necessarily true that *every dog caught a bug*, as (22b) illustrates; however, even if *every dog caught a bug* is true, it does not necessarily follow that *every dog caught a blue bug*, as (22a) shows, since there is no necessity for the bugs referred to in the first half of (22a) to be blue.<sup>8</sup> Therefore, (22) demonstrates that the second argument of *every*, being non-DE, patterns in the same way as the default pattern, licensing an inference from a subset-denoting expression, i.e., *blue bug*, to its set-denoting expression, i.e., *bug*.

The meaning relation between above sentences can be illustrated as follows.

Figure 5 Schematized Pattern of Across-propositional Meaning Relation for Sentences (22)



<sup>8</sup> See the illustration in Figure 5, which demonstrates each situation that represents the relations in truths between two sentences.

To sum up, we have observed various consequences of the semantic properties of the universal quantifier *every*, which asymmetrically creates a DE environment in its first argument but not in its second argument. We thus conclude that the semantic property of *every* is consequently reflected at the level of across-propositional meaning relations, as well as the within-proposition meanings, and that, as speakers of a human language, we all share the intuition about the behavior of *every* observed above that determines both within-propositional and across-propositional levels of meanings.

### 1.3. Semantic Competence and “Every” in Child Language

Let us now consider semantic competence in child language, focusing on the case of the universal quantifier *every* that we have discussed in the previous section. Recall that children, as language learners, need to learn the following two abilities that constitute the semantic competence:

- (23) a. The ability to compute the within-proposition meanings, i.e., the truth conditional meanings of individual propositional variable (the computation of lexical meanings on the basis of the semantic composition rules)
- b. The ability to compute the across-proposition meanings, i.e., to license the logical inferences between propositional variables (which proposition entails which other proposition)

What children need to learn about the universal quantifier *every* thus includes not only the ability to be able to compute the truth conditional meanings of individual sentences containing it, but also the ability to able to compute inferences created between sentences that contain it. In particular, in order for a child to be a matured speaker of a language, he/she must know what kind of inferences are licensed by the meanings that contain *every* at the within-propositional level.

In the past, a number of studies have discussed children's knowledge about *every* with respect to their ability to compute the meanings of individual sentences containing *every* at the within-propositional level. The initial studies seemed to show that children's semantic computations related to *every* were not adult-like. Inhelder and Piaget (1958, 1964) have observed how preschool children interpreted the following sentence containing *every* in (24), when it is presented in the context such that there are four elephants, three of which are being ridden by a boy each and the other is being ridden by no boy.

(24) Every boy is riding an elephant.

For adults, this sentence should be true in the above context regardless of how many elephants are left unriden, as long as each of the boys is riding an elephant. This demonstrates that in one aspect, *every* quantifies over the denotation of the subject NP, but not over the denotation of the VP, in the adult's grammar. Contrary to this interpretation, children evaluated this sentence as false on the basis of the above context, pointing the unriden elephant as the falsifier. Crucially, children seem to

have symmetrically applied the quantification of *every* over the VP as well as the subject noun.

Inhelder and Piaget's observation has triggered a number of studies that seek to provide explanations for what the locus of children's errors would be; Gualmini (2005) called the studies in this line the *Partial Competence View*, which attribute children's errors to a fundamental difference among children's and adults' semantic knowledge.

Let us now briefly survey some studies in this vein. Drozd and Loosbroek (in press), for example, claimed that children wrongly treat the universal quantifier *every* as if it were equal to the weak quantifiers *many* (the *Weak Quantifier Hypothesis*). Crucially, the meaning of the weak quantifier *many* is context-related and thus computed on the basis of relative quantity, which evokes an ambiguity with respect to what parts in a sentence it quantifies over. Consider the following examples.

(25) Many Scandinavians have won the Nobel Prize in literature.

(Westerstål, 1985)

One interpretation of *many* in (25) allows the sentence to yield a reading such that the number of the Scandinavians who have won the Nobel Prize in literature is large, compared with the number of the Scandinavians. When this interpretation is computed, the quantification of *many* spreads over the denotation of the subject noun, *Scandinavians*. On the other hand, under a second interpretation of *many*, the sentence would yield a reading such that the number of the Scandinavians who have

won the Nobel Prize in literature is large, compared with the number of Nobel Prize winners in literature. With this interpretation, the quantification of *many* ranges over the denotation of the VP. Given this, Drozd and Loosbroek, on the basis of the speculation that children treat *every* in the same way as they treat *many*, argued that children's non-adult symmetric errors in applying the quantification of *every* to the VP are due to a similar mechanism that yields the latter reading of *many* for adults. Meroni, Gualmini and Crain (2000) formalized adults' and children's semantic representations of (25) provided in the Drozd and Loosbroek's framework, as follows.

(26) Adults' interpretation

EVERY [boy][ $\lambda x$  (x is riding an elephant)](boy  $\cap$   $\lambda x$  [x is riding an elephant])  $\in$  EVERY (boy)

(27) Children's *additional* interpretation

EVERY [elephant][ $\lambda x$  (boy is riding x)](elephant  $\cap$   $\lambda x$  [x is ridden by a boy])  $\in$  EVERY (elephant) (Meroni et al. 2000)

Whereas the interpretation as in (26) is the adult-like interpretation, children allow the interpretation in (27), in a non-adult-like way.

In the similar vein, Geurts (2003a) argued that children interpret the strong determiner as if it were weak, and thus the problem lies in the mapping between syntactic form and semantic representation. Crucially, Geurts (2003a) assumes that the strong quantifiers including *every* require a more complex semantic representation

than the weak quantifiers, and the source of children's non-adult interpretations is their wrong association between *every* and a semantic representation for a weak quantifier.

Also, Philip (1995) attributed children's errors observed in Inhelder and Piaget (1964) to their analysis of the universal quantifier as an unselective binder, like the temporal adverbs such as *usually* and *always* (the *Event Quantification Hypothesis*). According to Philip, the determiner *every*, analyzed on a par with the temporal adverbs, can quantify over events in child grammar, whereas it only quantifies over individuals in adult grammar. Under the Event Quantification Hypothesis, children's non-adult interpretation of the sentence (24) requires a one-to-one symmetric association between individuals and events. Hence, children's interpretation of (24) would be stated as follows.

(28) *Symmetrical reading*

All events that involve a boy or an elephant (or both) are events of a boy riding an elephant.

Hence, in order for (24) to be true in children's (non-adult) interpretation, for every elephant there must be a boy riding on that elephant. The 'extra-object' context in discussion contains an elephant that is not being ridden by any boy, and thus it falsifies (24) in child grammar. Gualmini (2005) described children's non-adult interpretation of (24) under this hypothesis as follows:

- (29) For every event  $e$  in which either an elephant or a boy participates, or which is a possible sub-event of a boy-riding-an-elephant, a boy is riding an elephant in  $e$ .<sup>9</sup>

On the other hand, an alternative view has been proposed by Crain, Thornton, Boster, Conway, Lillo-Martin and Woodams (1996). According to Crain et al., the studies that supported the Partial Competence View have missed certain pragmatic felicity conditions in designing and conducting the experiments, which induced children's non-adult responses that apparently demonstrated their limited linguistic competence (the *Full Competence View*<sup>10,11</sup>). Crucially, Crain et al. claimed that in the Truth Value Judgment Task (Crain and McKee, 1985; Gordon, 1996; Crain and Thornton, 1998), the stories presented to the children should be controlled in a way that both answers ("Right" and "Wrong") to the truth value evaluations should be made available as genuine options. As applied to sentence (24) presented in the "extra object" condition, making the target sentence felicitous would require a scenario in which the possibility that some boys don't ride an elephant is considered as well. If this possibility would be left out of consideration, children would be confused as to why the experimenter wants to know if the statement is true. Crain et al. then reported experiments with this felicity condition satisfied, in which children performed as well as adults. On the basis of these results, they concluded that young children have full

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<sup>9</sup> For a detailed explanation, see Philip (1995).

<sup>10</sup> The Full Competence View is based on the idea of the Nativists View (e.g., Pinker, 1984; Crain, 1991; Crain and Pietroski, 2001).

<sup>11</sup> See also Freeman, Sinha and Stedmon (1982) and Freeman and Stedmon (1986) for another example of non-linguistic account of children's non-adult responses to sentences with the universal quantifier.

grammatical competence with universal quantification, and their apparent non-adult performance was due to the lack of satisfaction of the felicity condition in the earlier experiments.

Since Crain et al., the Full Competence View has developed; for example, a number of experimental studies by Crain and his colleagues have revealed children's adult-like ability to compute the truth conditional meanings of *every*-sentences in various respects. Meroni et al. (2000) replicated the "Extra Object" Condition that has drawn researchers' attention since Inhelder and Piaget (1958, 1964), controlling the felicity condition in the experiment, with the further modification that salience is added to the extra elephant that is not being ridden by any boy. Despite the fact that the extra elephant is highlighted, children were not influenced by the salience placed on that elephant; they did not reject the sentence like (24) on the basis of the presence of the salient and extra elephant. Meroni et al.'s findings thus have provided strong empirical evidence in favor of the Full Competence View, demonstrating the improvement of the "Extra Object" Condition directly by means of controlling the experimental environment.

The most recent achievement along this line has been by Gualmini (2005). In his dissertation, Gualmini has reported a series of experimental studies that demonstrate children's adult-like ability to compute the truth-conditional meanings of *every*-sentences, in the way that adults do with respect to the following consequences that the entailment property of *every* determines, including NPI-licensing and (30a) and licensing the conjunctive interpretation of disjunction (30b).

- (30) a. Being DE, the first argument of *every* licenses an NPI such as *any*, but its second argument does not, since it is not DE.
- b. Being DE, the first argument of *every* licenses a conjunctive interpretation of disjunction, but its second argument does not, since it is not DE.

These studies together suggest that children possess the adult-like semantic knowledge about the universal quantifier *every*, with respect to both of these within-sentence properties.

Thus, beginning with Inhelder and Piaget (1958, 1964), children's interpretation of the universal quantifier *every* has drawn a lot of attention from many researchers that are concerned in child language studies. The most up-to-date experimental research has revealed that children's systematic errors, originally pointed out Inhelder and Piaget, in which children interpret *every*-sentences as if *every* quantified over the events denoted in the verb as well as the objects denoted in the subject nouns, are due to the lack of appropriate control of the felicity conditions in the experimental workspace. Thus, the primary contribution of the previous studies that have been discussed above is the experimental demonstration of children's possession of the adult-like ability to compute within-sentence meanings with respect to the universal quantifier *every*.<sup>12</sup>

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<sup>12</sup> For more discussion on the contrast between the Partial Competence View and the Full Competence View, see Gordon (1996), Geurts (2000), Philip and Lynch (2000), Sugisaki and Isobe (2001) and Gouro, Norita, Nakajima and Arijji (2002) among others.

#### 1.4. Linguistic Studies on Logical Inference in Child Language

Having now established that children have all of the components of *every* to compute the within-propositional meaning, we can ask about their across-propositional computation of meanings; what is known about children's ability to compute the across-sentence meaning relations involving the universal quantifier *every*?

To the best of my knowledge, far less has been discovered about children's ability to compute the across-propositional semantics in general from a linguistic point of view. Furthermore, no linguist has ever examined children's knowledge about the universal quantifier *every*, with respect to its creation of the asymmetric entailment structure in both arguments from the perspective of whether this knowledge can be applied to the computation of the across-propositional meaning relations, despite a number of studies have discussed children's ability to compute the within-propositional meanings with respect to the universal quantifier *every*, as has been discussed in the previous section.<sup>13, 14</sup>

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<sup>13</sup> In the field of developmental psychology, children's ability to evaluate the deductive logics has been discussed, and there have been several studies about children's understanding of logical reasoning linguistically encoded. According to them, children were found to be sensitive to the validity of *Modes Ponens* (If p is true, then q is true; p is true; therefore q is true) and *Modes Tollens* (If p is true, then q is true; q is not true; therefore p is not true) and the invalidity of *Asserting-the-Consequence* fallacy (If p is true, then q is true; q is true; therefore p is true) and *Denying-the-Antecedent* fallacy (If p is true, then q is true; p is not true; therefore q is not true) (e.g., Kuhn, 1977; Bucci, 1978; Smith, 1979). Among them, Smith (1979) reported children's ability to solve inference problems involving the construction and evaluation of hierarchies relating to the quantifiers such as *all*. In Smith (1979), children were asked to evaluate the relation between the two premises containing *all* by answering the question as in (ii) (i.e., the consequence) that immediately followed the presentation of the sentence as in (iii) (i.e., the antecedent).

- (ii) All milk has lactose.
- (iii) Does all chocolate milk has to have lactose?

Investigating children's computation of the across-propositional meaning relations involving the universal quantifier *every* would thus not only be the next valuable step to consider their knowledge about the semantics of *every*, but also would make a significant contribution toward a new aspect of children's semantic competence, i.e., the ability to compute inferences in general, which has not yet been energetically discussed in the field.

In making the initial step toward the exploration of the new aspect of children's semantic competence, it is worthwhile to start with the review of a series of studies (Philip and de Villiers, 1992; De Villiers, Curran, DeMunn and Philip, 1998) that have challenged children's ability to evaluate the logical inferences across sentences from the linguistic standpoint. Though their primary focus was not on the asymmetric entailment patterns related to the universal quantifier *every*, they have provided some important issues in considering how we can assess children's ability to calculate inferences between propositions. In what follows, we will briefly review these studies.

The relevant linguistic phenomena that these studies feature (which did not involve the universal quantifier *every*) are as follows. Philip and de Villiers (1992) examined whether children are aware of the fact that the default pattern of inferences, i.e., the one created in a non-DE environment which is licensed from a subset-

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According to the results, the older children such as kindergartners and first graders got virtually all the questions correctly, whereas the 4-year-olds answered the questions correctly at above chance level. The younger children's errors were reported to come mostly from the lack of the knowledge about *have to*. This study strongly suggested children's adult-like ability to compute the inferential relation relating to the universal quantifier *all*. However, no study considered children's sensitivity to the asymmetric entailment structure that the quantifier *every* creates in each argument, which we focus on throughout this dissertation.

<sup>14</sup> As for the review of researches on children's logical reasoning in broader aspects, see Brain and Romain (1983).

denoting expression to its set-denoting expression, is blocked by the presence of some adverbs such as *often*, as the following examples show.

- (31) a. Jimmy eats grapes with a fork.  
→ Jimmy eats grapes.  
b. Jimmy *often* eats grapes with a fork.  
\* → Jimmy *often* eats grapes.

Since the VPs underlined above in the sentences in (31a) are in a non-DE environment, the inference between the first and second sentences in (31a) is validly licensed from the subset-denoting expression (*eats grapes with a fork*) to its set-denoting expression (*eats grapes*). On the other hand, when the adverb *often* is added in the sentences in (31a), the inference from *eats grapes with a fork* to *eats grapes* is blocked, as (31b) shows. Their experimental results failed to demonstrate any conclusive findings toward either perspective as to whether children are sensitive to the validity of inferences.

De Villiers et al. (1998) focused on the verb *forget*, assuming that the verbs like *forget* semantically contain the implicit negation that would yield the DE effect in the inference, as the contrast between (32) and (33) shows.

- (32) a. The boy bought apples.  
\* → The boy bought green apples.

- b. The boy bought green apples.  
     → The boy bought apples.
- (33) a. The boy *forgot* to buy apples.  
     → The boy *forgot* to buy green apples.
- b. The boy *forgot* to buy green apples.  
     \* → The boy *forgot* to buy apples.

Example (32) demonstrates the “default” non-DE pattern, in which the inference is validated from a subset-referring expression (*green apples*) to its related set-denoting expression (*apples*) as in (32b), but not vice versa as in (32a). Example (33) contrastively exhibits the opposite, DE pattern, in which the inference is licensed from a set-referring expression (*apples*) to its related subset-denoting expression (*green apples*) as in (33a), but not vice versa as in (33b). Once again, their results revealed no conclusive findings.

These studies utilized the Questions after Stories Task (e.g., De Villiers and Roeper, 1996). In this task, the antecedent among two propositions (between which an inference is licensed validly or invalidly depending on the denotations of the relevant linguistic expressions) was presented in a short story depicted in the picture materials, and the consequence was presented in a question sentence the child was asked to evaluate with respect to the antecedent. For example, in examining children’s evaluation of the invalid inference as in (31b) in Philip and De Villiers (1992), the child was first shown a picture in which a boy named Jimmy is eating a grape with a fork. Then, the child was asked to answer the comprehensive Yes-No

question about the contents of a picture, such as “Does Jimmy often eat grapes?”. In such a case, the child was expected to answer “No”, since the rejection of such question (i.e., the consequence, “Jimmy often eat grapes?”) on the basis of the comprehension of the contents of the picture (i.e., the antecedent, “Jimmy often eats grapes with a fork”) demonstrate the child’s awareness that the inference from *Jimmy often eats grapes with a fork* to *Jimmy often eats grapes* is blocked.

In a similar way, in De Villiers et al (1998) in which tokens like the one in (33b) was tested, the consequence was embedded in a question such as “Does that mean that *the boy forgot to buy apples?*”, which followed the presentation of the antecedent proposition as in (33a) in a story with pictures. In such a case, the child was expected to answer “No” to show their sensitivity to the invalidity of the inference from *the boy forgot to buy green apples* to *the boy forgot to buy apples*.

Their experiments, however, did not demonstrate any clear patterns of responses from the children; thus it would be difficult to draw any conclusions about children’s evaluation of the validity of logical inferences from these studies. Detailed discussion aside at the moment,<sup>15</sup> we can conclude that a new experimental approach is required to successfully access children’s semantic competence with respect to the across-proposition meaning relations and determine whether children possess the adult-like ability to distinguish the valid and invalid logical inferences between sentences.

On the other hand, recall the recent findings in the framework of the Full Competence View (e.g., Crain, et al., 1996) regarding children’s knowledge about the

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<sup>15</sup> We will discuss in detail the methodological issues that were raised in Philip and De Villiers (1992) and De Villiers et al. (1998) in Chapter 3.

universal quantifier *every*. As has been pointed out, it has been revealed that children are aware of the various consequences of the asymmetric entailments that *every* evokes at the within-propositional level (Meroni, et al., 2000; Gualmini, 2005). On the basis of the findings from these studies, it would be predicted that children are aware of the validity in the logical inferences involving the universal quantifier *every*, demonstrating the adult-like ability to evaluate the meaning relations across-propositionally with respect to the consequences that the asymmetric entailment structure that *every* yields. Thus, the evidence for children's adult-like composition of meanings involving *every* and the apparent lack of evidence for children's adult-like comparison of meanings involving *every* would constitute a puzzle, which we will aim to solve in the present paper.

Therefore, the research questions will be addressed as follows.

(34) Research Questions

- a. Can children compute inferences from subsets to supersets and vice versa appropriately?
- b. Does their knowledge about the universal quantifier *every* extend to the computation of the valid and invalid inferences created between propositions involving *every*?

In particular, we aim to provide the answer to the question in (34a), by considering the question in (34b), i.e., considering children's knowledge about across-propositional meaning relations (their ability to evaluate logical inferences) by taking

the universal quantifier *every* as a case study. Ultimately, this investigation contributes (i) a novel approach to investigate children’s computation of inferences from linguistic structures, (ii) demonstration that children have adult-like knowledge of the unique properties of the universal quantifier in building across-sentence meaning relations (i.e. what makes (34b) an extremely challenging and interesting special case of (34a) from a linguistic and a language development point of view), and (iii) engaging the questions of what it means for children to have acquired and employed this knowledge – including what it suggests about the acquisition of ‘hard words’ like quantifiers and their impact on meaning in and across linguistic structures.

### 1.5. Organization of the Dissertation

In what follows, we will report six experiments in which children’s knowledge about the universal quantifier *every* is investigated from a logico-semantic point of view. The goal of the first three experiments is to directly examine children’s ability to evaluate the inferences created between the sentences containing *every* with respect to the asymmetrical properties of the first and second arguments of *every*. The last three experiments seek to extend the question in (34), testing the linguistic phenomenon in which the relevant entailment regarding *every* is reversed due to the semantic interaction between *every* and negation, as a further ground for investigating children’s logico-semantic competence.

The organization of the dissertation is as follows. Chapter 2 is devoted to discussing the experiment (Experiment I) conducted as a pre-test to ensure that children know the truth-conditional meanings of entailing and entailed sentences that contain *every*. Given the results drawn from Experiment I, Chapter 3 and 4 report two experiments (Experiments II and III) designed to directly assess children's ability to evaluate the logical inferences involving *every*, featuring newly designed experimental methodologies. Chapter 5 will revisit the research questions in (34), considering the phenomenon of reversed entailment. Reversed entailment also addresses a related issue that directly bears on the relation of linguistic structure and logical inference in child language: the relationship among entailment, inference and scope representation. The rest of the chapters will be devoted to discussing the experiments we conducted to examine children's knowledge about the reversed entailment. Chapter 6 then reports two experiments (Experiments IV and V) to investigate children's ability to compute the truth-conditional meanings of the entailing and entailed sentences that contain both *every* and negation, which affects the direction of entailments under specific circumstances. Chapter 7 then reports an experiment featuring the new methodology introduced in Chapter 4 (Experiment VI) which examines children's ability to evaluate the logical inferences determined by the reversed entailment due to the semantic interaction between *every* and negation. Chapter 8 will be devoted to the general discussion of the findings from all the experiments reported thus far and the research questions stated in (34), including consideration of related further issues.

## Chapter 2. Experiment I: Truth Conditional Evaluation of Entailing and Entailed Propositions

Experiment I was conducted as the pre-test to explore children's semantic competence with respect to the meaning computed at the across-proposition level. The objective of this experiment is thus to ensure that children are able to compute the truth conditional meanings that are individually assigned to the entailing and entailed sentences containing *every* (i.e., the antecedent and the consequence of the relevant inferences involving *every*).

Given the recent achievement in the studies within the framework of the *Full Competence View* (e.g., Crain, et al., 1996; Meroni, et al., 2000; Gualmini, 2005), it would be hypothesized that children possess the highly sophisticated knowledge about *every*. Thus Experiment I aims to consider the following hypothesis.

(35) Hypothesis: Experiment I

Children were found to be aware of the consequences of the entailments that are created in the first and second argument of the universal quantifier *every*. Therefore, children would be able to compute the opposing truth values that are assigned to each of the entailing and entailed sentences with respect to both arguments of *every*.

In order to consider this hypothesis, the experiment was designed featuring the Truth Value Judgment Task (e.g., Crain and McKee, 1985; Gordon, 1996; Crain and Thornton, 1998) with the underlying logical paradigm discussed in what follows.

### 2.1. Logic

Let us start with the simplest case to illustrate the basic paradigm. As we have discussed previously, the default pattern of inferences between sentences are created from a subset-denoting expression to a superset-denoting expression, as (36) demonstrates.

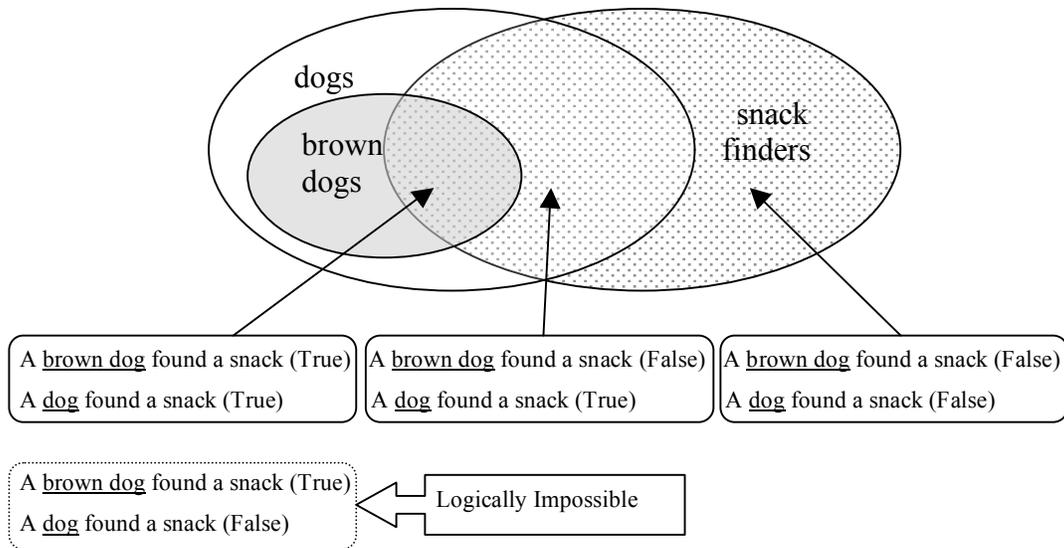
- (36) A brown dog found a snack.  
→ A dog found a snack.

Keeping this in mind, consider the truth conditions these sentences receive at the same time in the same context. First, whenever the entailing sentence is true, the entailed sentence is necessarily true (i.e., whenever it is true that *a brown dog has a snack*, it must be true that *a dog has a snack*). On the other hand, when the entailing sentence is false, an asymmetry emerges; the entailed sentence does not have to be necessarily false — it can logically be either true or false. For example, consider the context in which it is false that *a brown dog has a snack*. In this context, it is also false that *a dog has a snack* if there is no dog that has a snack in the domain; but in

the same context, it can be true that *a dog has a snack*, if, for example, there is a white dog that has a snack in the domain.

The crucial summary here is as follows. When these minimal-paired sentences receive the opposing truth values in the same context at the same time, it is necessary that the entailing sentence is false while the entailed sentence is true, but not vice versa; logically, there cannot be any situations in which the entailing sentence is true while the entailed sentence is false in at the same time. Such relation in truths between these two sentences can be illustrated in the following Venn diagram.

Figure 6 Inferential Relations in Truths among Sentences: Default



To sum up, the following table illustrates how the logical relation between entailing and entailed sentences can be reflected in the truth values assigned to each sentence at the same time.

Table 2 Truth Values and Entailment between Sentences

Entailing sentence	Entailed sentence
T	T
F	T
F	F
T	*F

Recall now that the objective of this experiment is to examine whether children are aware of the truth conditional meanings of the entailing and entailed sentences that are respectively assigned. For the purpose of this objective, we will focus on the situation in which the entailing sentence is false while the entailed sentences is true, i.e., the situations that are represented in the shaded cells in Table 2 above. In particular, if we are to set out the situation to assign the contrastive truth values to each sentence in the experimental workspace, the experiment designed with the Truth Value Judgment Task would be the most effective approach to children's ability to compute the meanings of the entailing and entailed sentences at the within-propositional level.

Keeping this paradigm in mind, let us now illustrate the detailed logic that underlies the experimental design, considering the relevant cases of sentences with *every*.

### 2.1.1. First Argument of “Every”

Let us first focus on the first argument of *every*. Remember first that the first argument of *every* is a DE environment, which patterns the opposite of the default. Consider the sentences in (37) as an example.

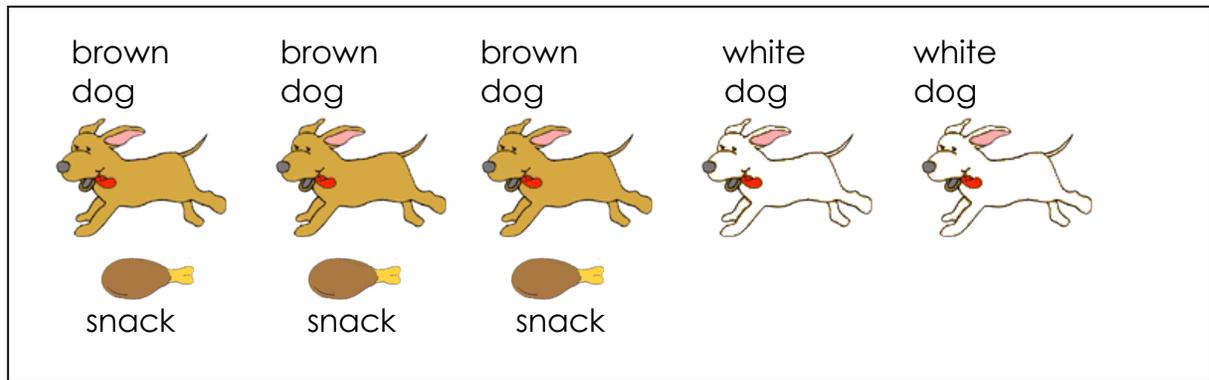
- (37) a. Every dog has a snack  
b. Every brown dog has a snack
- (38) Every dog has a snack (= (37a))  
→ Every brown dog has a snack (= (37b))
- (39) Every brown dog has a snack (= (37b))  
\* → Every dog has a snack (= (37a))

The sentence as in (37a) entails the one like (37b), but not vice versa; consequently, the inference is licensed from superset (*dog*) to its subset (*brown dog*), but not vice versa, as (38) and (39) show, since the first argument of *every*, where superset/subset-denoting expressions (*dog*, *brown dog*) appear, is a DE environment. Note that there is a context in which (37a) is false and (37b) is true at the same time, which we will discuss in what follows.

#### Context: First argument of every

Suppose that the sentences in (37) are presented in the following situation. There are five dogs: three brown dogs and two white dogs. The three brown dogs got a snack each, while the two white dogs did not. See the illustration below.

Figure 7 Dogs and Snacks I



Truth values of the every-sentences (37) in the context

The context in Figure 7 makes the sentence (37a) false, since not all the dogs got a snack, whereas it makes the sentence (37b) true, since all the brown dogs got a snack, even though the white ones did not.

- (40) a. Every dog has a snack. (False) (= (37a))  
 b. Every brown dog has a snack. (True) (= (37b))

2.1.2. Second Argument of “Every”

In the same way, let us now consider the case of the second argument of *every*, taking the sentences (41) as an example.

- (41) a. Every dog has a snack.  
 b. Every dog has a big snack.  
 (42) Every dog has a snack. (= (41a))  
 \* → Every dog has a big snack. (= (41b))

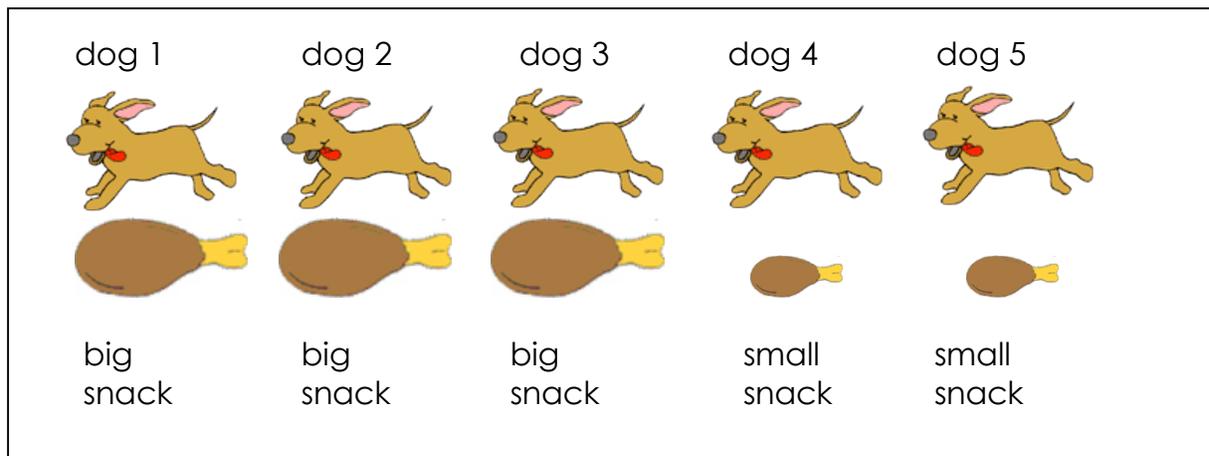
- (43) Every dog has a big snack. (=41b))  
 → Every dog has a snack. (=41a))

Sentence (41b) entails sentence (41a), but not vice versa; as a consequence, the inference is licensed from subset (*big snack*) to its superset (*snack*), but not vice versa, as (42) and (43) show, since the second argument of *every*, where set/subset-denoting expressions (*snack*, *big snack*) appear, is non-DE. Note that there is a context in which the entailing sentence (41b) is false and the entailed sentence (41a) is true at the same time.

Context: Second argument of every

Suppose that the sentences in (41) are presented in the following situation. There are five dogs, three of which got a big snack each, and two of which got a small snack each. See the illustration below.

Figure 8 Dogs and Snacks II



Truth values of the every-sentences in (41) in this context

The context in Figure 8 determines the opposing truth values of the sentences in (41); it makes (41b) false, since not all the dogs got a big snack, but two of them got a small snack, whereas it makes (41a) true, since all the dogs got a snack, even though some of them got a big snack, and others got a small snack.

- (44) a. Every dog has a snack. (True) (= (41a))  
 b. Every dog has a big snack. (False) (= (41b))

Let us now illustrate the relevant paradigm that has been discussed thus far; see the following table.

Table 3 Entailment and Truth Conditions

Relevant argument	Minimal-paired sentences	Entailing/ entailed	TV in a relevant context
1 <sup>st</sup> arg. : DE	(37a) Every <u>dog</u> has a snack	Entailing	False
	(37b) Every <u>brown dog</u> has a snack	Entailed	True
2 <sup>nd</sup> arg.: non-DE	(41a) Every dog has a <u>snack</u>	Entailed	True
	(41b) Every dog has a <u>big snack</u>	Entailing	False

To sum up, for minimal-paired (entailing and entailed) sentences as in (37) and (41), there is a context such that it falsified the entailing sentence and verifies the entailed sentence at the same time, reflecting the entailment relations between them.

In order to examine children's ability to compute the truth conditional meanings of the entailing and entailed sentences (i.e., the antecedent and the consequence of the relevant inference) in the most efficient way, we will exploit such contexts in the Truth Value Judgment Task, discussing in detail in what follows

## 2.2. Experimental Design

On the basis of the paradigm that was described above, we designed the experiment to examine children's interpretation of minimal-paired sentences that contain *every*, featuring the Truth Value Judgment Task (e.g., Crain and McKee, 1985; Gordon, 1996; Crain and Thornton, 1998). In particular, we examined whether children know the fact that the entailing sentence is false while the entailed sentence is true in a certain context, which reflect the entailing relation between the two sentences. This experiment serves as the pre-test to explore children's semantic competence with respect to the meaning computed at the across-proposition level; our purpose here is to ensure that they are aware of the truth-conditional meaning of each of the entailing and entailed sentences in minimal pair that are contrastively assigned individually to each sentence in the same context.

The generic procedure was as follows. There were two experimenters, one of which acted out short stories using toys and props, and the other of which manipulated the puppet such as Kermit the Frog. The puppet watched stories along with the subject. In the end of each story, the puppet described what he thought had happened in the story, which was expressed in the target sentences. The child's task

was to evaluate the puppet's description on the basis of the outcome of the story, and judge him as to whether he was right or wrong.

The two experimental conditions, the "True" Condition and the "False" Condition, were included. Recall that the minimal-paired *every*-sentences receive the opposing truth values respectively, i.e., the entailing sentence is false while the entailed sentence is true, in a certain context. Taking advantage of this fact, the current experiment was designed in a way that the true sentences (i.e., the entailed *every*-sentences) and false sentences (i.e., the entailing *every*-sentences) were presented in virtually identical contexts. Each condition contains the two types of test items: "First-Argument" items manipulated the first argument of *every*; "Second-Argument" items manipulated the second argument of *every*. A full list of target sentences is in (45) - (48) below.

*"First-Argument" items*

- (45) a. Every troll ate a potato chip. (False)  
b. Every yellow troll ate a potato chip. (True)
- (46) a. Every dog rode a horse. (False)  
b. Every white dog rode a horse. (True)

*"Second-Argument" items*

- (47) a. Every smurf caught a bug. (True)  
b. Every smurf caught a blue bug. (False)
- (48) a. Every mermaid found a jewel. (True)  
b. Every mermaid found a red jewel. (False)

The sentences in (45) and (46) involve inference with respect to the first argument of *every*, and the ones in (47) and (48) involve inference with respect to the second argument of *every*. Note that the sentences in (45) and (46) show an inference from (a) to (b), which is licensed from a set-denoting expression (*troll/dog*) to a subset-denoting expression (*yellow troll/white dog*), whereas the ones in (47) and (48) show an inference from (b) to (a), which is oppositely licensed from a subset-denoting expression (*blue bug/red jewel*) to a set-denoting expression (*bug/jewel*). Each pair of sentence was presented in the same context, and the assigned truth values were shown in the brackets in the end of each sentence above. The following table illustrates the conditions and stimuli in a schematic way.

Table 4 Condition and Stimuli

	“True” Condition	“False” Condition
“First-Argument” items	(45b) Every <u>yellow troll</u> ate a potato chip	(45a) Every <u>troll</u> ate a potato chip
	(46b) Every <u>brown dog</u> rode a horse	(46a) Every <u>dog</u> rode a horse
“Second-Argument” items	(47a) Every smurf caught a <u>bug</u>	(47b) Every smurf caught a <u>blue bug</u>
	(48a) Every mermaid found a <u>jewel</u>	(48b) Every mermaid found a <u>red jewel</u>

The study adopted a Latin Square design. Each child heard two sentences from (45) and (46), and two sentences from (47) and (48). There were also four filler trials; two were designed to elicit positive responses, and two were designed to elicit

negative responses. Expected truth values in all the sentences in a session were randomized. The following are the lists of the test sentences in each group; half of the children participated in the first group, and half participated in the second group.

(49) List of the test sentences for Group A

- a. Every troll ate a potato chip. (False) (=45a))
- b. Every white dog rode a horse. (True) (=46b))
- c. Every smurf caught a bug. (True) (=47a))
- d. Every mermaid found a red jewel. (False) (=48b))

(50) List of the test sentences for Group B

- a. Every yellow troll ate a potato chip. (True) (=45b))
- b. Every dog rode a horse. (False) (=46a))
- c. Every smurf caught a blue bug. (False) (=47b))
- d. Every mermaid found a jewel. (True) (=48a))

The following is the sample trial to examine children's evaluation of inference with respect to the first argument of *every*, in which the target sentences in (45) were presented independently in each session.

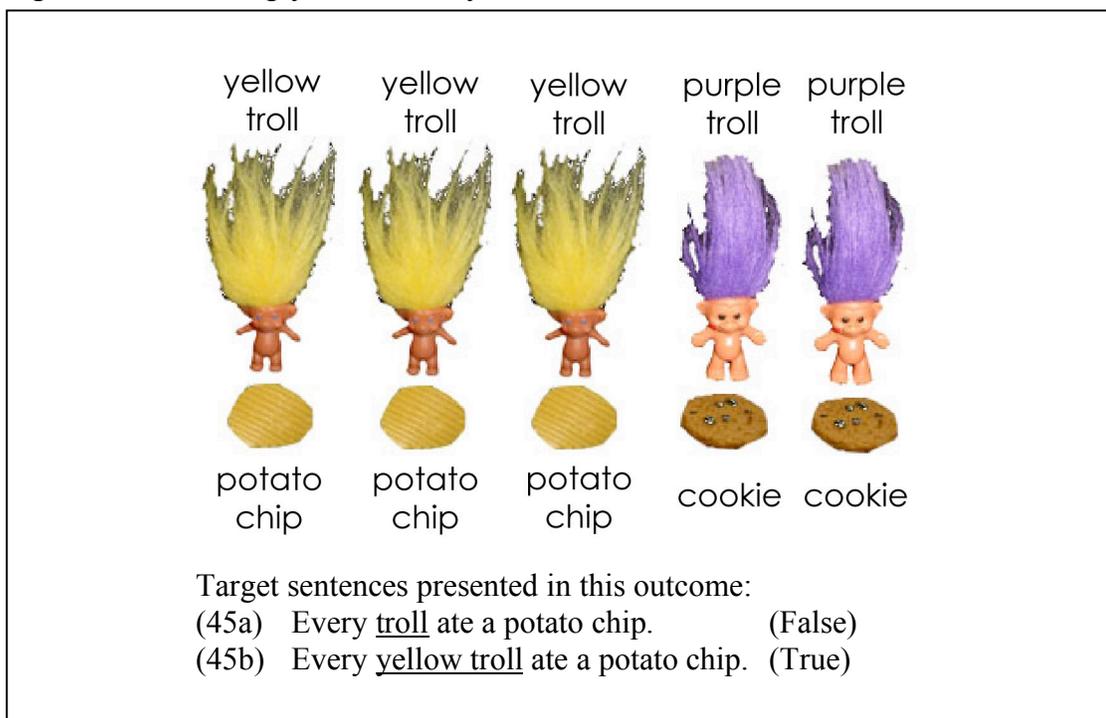
(51) Sample trial 1: "Hungry Trolls" Story

This is a story about Tigger and his friends, five trolls. One day, Tigger got a new kitchen. He was so happy that he invited the trolls to serve them with his homemade snacks. Three trolls have yellow hair and two trolls have purple hair. Tigger says: "Hi friends! I have prepared a lot of food for you. Look, I have baked three regular potato chips and one extra spicy potato chip. I also baked two cookies and one donut. Help yourselves!" The trolls consider their choices. The first yellow troll thought about having something sweet such as

cookies, but he remembered that he had bad teeth and decided to take a potato chip that is not sweet. The second yellow troll loves potato chips, and he thought about having the orange potato chip, but he thought that it might be so spicy that he changed his mind and took a regular potato chip. The third yellow troll also took a regular potato chip. The purple trolls love sweets, and each of them took a cookie and a donut.

The final outcome of this trial is illustrated below.

Figure 9 “Hungry Trolls” Story: The Final Outcome



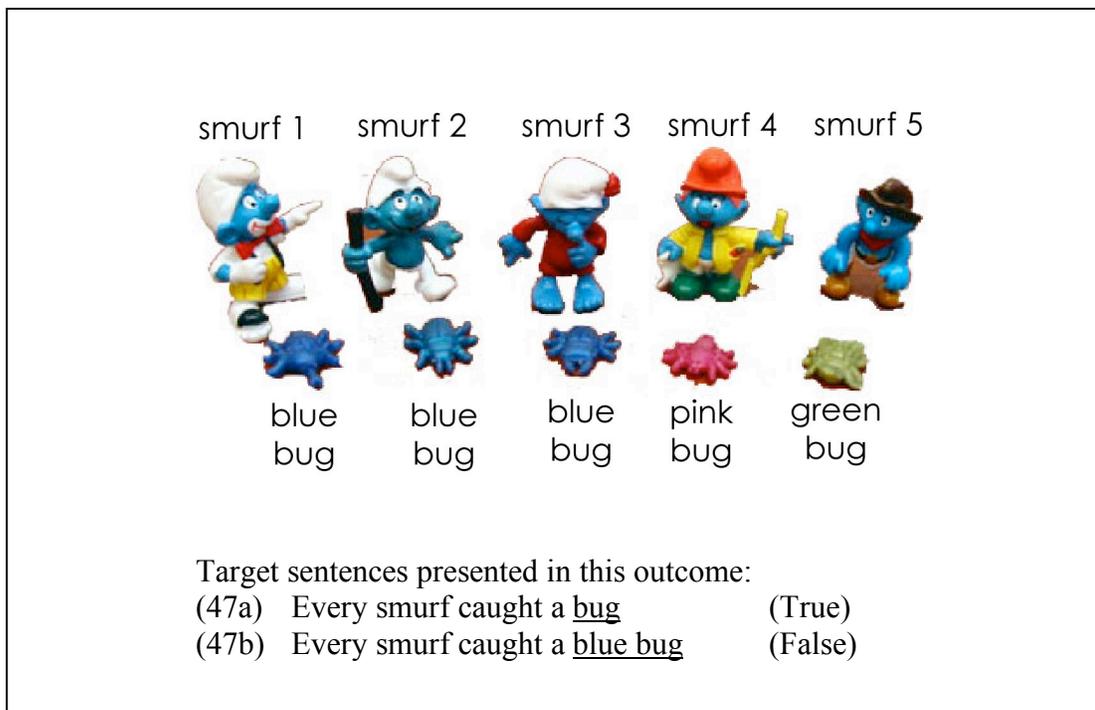
Turning now into the “Second-Argument” items, the following is a sample trial to examine children’s evaluation of inference with respect to the second argument of *every*, in which the sentences in (47) were independently presented.

(52) Sample trial 2: “Smurfs’ Bug-catching Game” Story

This is a story about five smurfs who go to a fair. They want to play a game being operated by Mickey Mouse. In this game, there is a big swimming pool in which some animals are swimming. There are four blue bugs; three small ones and one very big one. In addition there is a red bug, a green bug and a frog. The idea of the game is to catch one of the animals, to win a prize. Mickey Mouse tells the smurfs that if they catch the big blue bug, they will get a bigger prize. At first the smurfs try to catch the frog, but the frog is very quick, and jumps away. Then three smurfs each catch a small blue bug. The remaining smurfs first attempt to catch the big blue bug, but they give up. One of them catches a pink bug and one catches a green bug.

The final outcome of this story is show in the following figure.

Figure 10 “Smurfs’ Bug-catching Game” Story: The Final Outcome



### 2.3. Predictions

Recall that the objective of this experiment is to investigate whether children are able to evaluate the truth values of the individual sentences containing *every* that constitutes a minimal pair. As the logical consequence, the entailing sentence can be false when the entailed sentence is true (but not vice versa) in a certain context. We hypothesized as in (35) that if children were able to correctly compute the truth conditions of each sentence, it would demonstrate their awareness of consequence of entailment pattern which is reflected in the truth conditions. Thus, given that the entailment pattern is evoked asymmetrically in each argument of a sentence containing *every*, children must crucially know that the first argument of *every* is DE and its second argument is non-DE in order to compute the relevant truth conditions assigned to the entailing and entailed sentences.

In particular, if children knew that the first argument of *every* is DE while the second argument is not, then they should know that, among the minimal-paired *every*-sentences with respect to the first argument such as (45) and (46), the sentences in (a) (i.e., the ones with superset-denoting expression) is entailing and thus is false, and the sentences in (b) (i.e., the ones with subset-denoting expression) is entailed and thus is true, in the relevant context. Likewise, children should know that, among the minimal-paired *every*-sentences with respect to the second argument such as (47) and (48), the sentences in (b) (i.e., the ones with subset-denoting expression) is entailing and thus is false, and the sentences in (a) (i.e., the ones with superset-denoting expression) is entailed and thus is true, in the relevant context.

An alternate possibility would be that they assign the truth conditions randomly to the sentences. One potential reason for this alternate would be that they don't know the superset-/subset-relations between nouns in the relevant positions in the target sentences, e.g., *troll* vs. *yellow troll* and *bug* vs. *blue bug*. In particular, if children would not know the function of restrictive adjectives to narrow down the class specifications of the nouns, they would not know the semantic relation between the two words and might treat them as the words that are not semantically related. If this alternate would be borne out, then children would not be able to semantically relate the two sentences in minimal-pair, and thus their truth value judgments might not systematically pattern. Indeed, while this is not the main focus of the experiment, it is worth noting that children's adult-like performance on this task would also demonstrate children's command of these set-subset properties concerning restrictive adjectives.

### Subjects

Twenty English-speaking children aged 3;8 to 5;11 (mean 4;10) participated in this experiment. The participants were children enrolled for the Center for Young Children at University of Maryland, College Park; all participants had their parental permission to participate in the study. Half of them participated in Session A, and the other half participated in Session B, both of which presented virtually the same set of stimulus with different stories. The children were tested one by one in a separate quiet room with the experimenters.

## 2.4. Results

Let us start with children's truth value judgments of the target sentences with respect to the first argument of *every*, which are repeated as follows.

### *"First-Argument" items*

- |      |    |  |         |          |
|------|----|--|---------|----------|
| (53) | a. | Every <u>troll</u> ate a potato chip.        | (False) | (=(45a)) |
|      | b. | Every <u>yellow troll</u> ate a potato chip. | (True)  | (=(45b)) |
| (54) | a. | Every <u>dog</u> rode a horse.               | (False) | (=(46a)) |
|      | b. | Every <u>white dog</u> rode a horse.         | (True)  | (=(46b)) |

As for judging "First-Argument" items as the ones shown in (53) and (54), the children accepted the true sentences like (53b) and (54b) 100% (20/20) of the time, whereas the children accepted the false sentences like (53a) and (54a) only 10% (2/20) of the time. A *t*-test was conducted to analyze the percentages of the acceptance within this condition, showing that these differences are significant,  $t(19) = 13.077, p < 0.0001$ , Standard Error Mean=6.88.

Let us now turn to children's interpretation of the minimal-paired sentences with respect to the second argument of *every*, which are repeated below.

### *"Second-Argument" items*

- |      |    |  |         |          |
|------|----|--|---------|----------|
| (55) | a. | Every smurf caught a <u>bug</u> .      | (True)  | (=(47a)) |
|      | b. | Every smurf caught a <u>blue bug</u> . | (False) | (=(47b)) |

- (56) a. Every mermaid found a jewel. (True) (=48a)  
 b. Every mermaid found a red jewel. (False) (=48b)

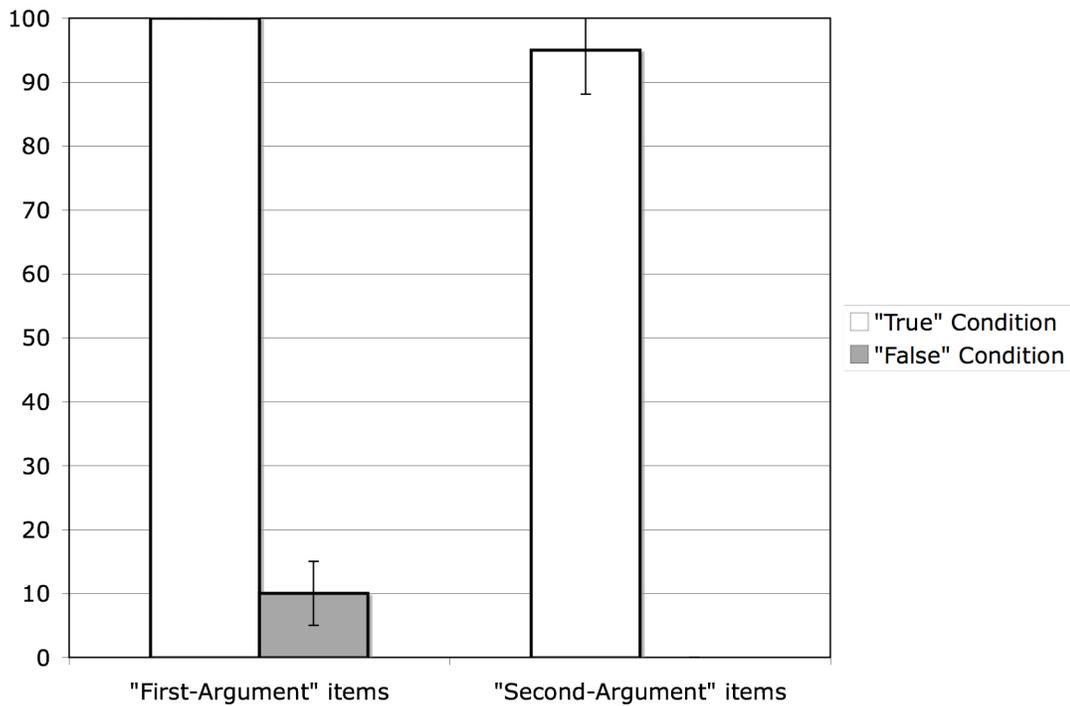
As for judging “Second-Argument” items as in (55) and (56), the children accepted the true sentences like (55a) and (56a) 95% (19/20) of the time, while the children never accepted the false sentences like (55b) and (56b) (0%, 0/20). A *t*-test was conducted to analyze the percentages of the acceptance within this condition, with the results again significant,  $t(19) = 19.00, p < 0.0001$ , Standard Error Mean = 5.00.

Taken together, these results are illustrated in the following table and the figure.

Table 5 Percentages of the Acceptance

	“True” Condition	“False” Condition
“First-Argument” items	100% (20/20)	10% (2/20)
“Second-Argument” items	95% (19/20)	0% (0/20)

Figure 11 Percentages of the Acceptance



A chi-square test was conducted to examine the distribution of the response patterns across conditions (i.e., “True” Condition vs. “False” Condition), according to which there was a significant association between the conditions and the type of responses,  $\chi^2(1) = 68.493$ ,  $p < 0.0001$ . Hence, it was demonstrated that children’s truth value judgments were based on the condition (i.e., the truth values of the sentences).<sup>16</sup>

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<sup>16</sup> Another chi-square test analyzed the distribution of the response patterns across items (i.e., “First-Argument” item vs. “Second-Argument” item), which revealed that there was no significant association between the type of items and the type of responses,  $\chi^2(1) = 0.300$ ,  $p < 0.58$ . This analysis demonstrated that there was no significant difference in how well children performed depending on whether the relevant contrast is in the first or the second argument of *every*.

## 2.5. Discussion

As for the first of argument of *every*, Experiment I revealed children's consistent acceptance of the entailed sentence in which the relevant position holds the subset-denoting expression (e.g., *brown dog*), and the significantly low rate in acceptance of the entailing sentence in which the relevant position holds the relating set-denoting expression (e.g., *dog*). The findings demonstrate that children know that, where  $A' \subseteq A$ , the same context can falsify sentences of the form *Every A is B*, but verify ones of the form *Every A' is B*, as well as that children know that entailing and entailed minimal-paired sentences receive different truth values in the same context in the way that it reflects which sentence entails which other one. These findings provided supporting evidence for children's sensitivity to the fact that the first argument of *every* is DE.

Experiment I also revealed children's high rate of acceptance of the entailed sentences in which the relevant position holds the subset-denoting expression (e.g., *blue bug*), and the consistent rejection of the entailing sentences in which the relevant position carries the relating superset-denoting expression (e.g., *bug*). The results showed children's knowledge that minimal-paired sentences as in (5) and (6) receive different truth values, and that the truth values in these sentences show the opposite pattern to the ones in sentences like (3) and (4), i.e., where  $B' \subseteq B$ , the same context can verify sentences of the form *Every A is B*, but falsify ones of the form *Every A is B'*, which also demonstrating the children's sensitivity to the fact that the second argument of *every* is non-DE.

Taken together, the results in Experiment I provided the novel support for the findings of the previous studies under the Full Competence View (e.g., Crain, et al., 1996; Meroni, et al., 2000; Gualmini, 2005), rather than the Partial Competence View (e.g., Drozd and Philip, 1992; Philip, 1995; Drozd and Van Loosbroek, in press), from the viewpoint of the logico-semantic consequence of the universal quantifier *every*. In particular, this experiment demonstrated that children know the consequence of the asymmetric entailment patterns created in the first and second arguments of *every*, which is reflected in the opposing truth conditions assigned to the entailing and entailed sentences containing *every*.

To sum up, Experiment I, serving as the pre-test to explore children's knowledge about the inferential relation between *every*-sentences in minimal-pair, examined children's knowledge of the truth values of the minimal-paired sentences that contain *every*. It demonstrated children's ability to compute the truth values of the entailing and entailed *every*-sentences with respect to both first and second arguments of *every*, in which the entailing sentence is false and the entailed sentence is true in the same context.

Note once again that Experiment I ensured that children are aware of the opposing truth conditions assigned to the independent minimal-paired sentences containing *every* between which inferences are created depending on the entailment direction regarding each of its arguments. Thus, it does not directly prove anything about children's ability to evaluate the validity of inferences across *every*-sentences. Hence, these findings motivate our subsequent experiments ahead to directly explore children's evaluation of the logical inferences between two propositions, which will

be discussed in the following chapters.



Target sentence: (2A) Every white dog rode a horse. (True)  
(2B) Every dog rode a horse. (False)

### **Trial 3**

Story: This is a story about the ocean. It is the birthday of the king of the ocean. He ordered the five mermaids living in this ocean to look for something beautiful for the birthday present. Mermaids started to search for the beautiful things in the ocean. The first mermaid found a beautiful red jewel behind the rock at the bottom of the ocean. The second mermaid also found a red jewel on the sea shell in the coral. The third mermaid also found a red jewel at the bottom of the ocean. The fourth mermaid found a red jewel, too, but she found it really big and so heavy that she could not pick it up. So she gave it up and instead found a smaller green jewel. The fifth mermaid also found the big red jewel too heavy for her to carry, so instead she found a purple jewel.

Target sentences: (3A) Every mermaid found a jewel. (True)  
(3B) Every mermaid found a red jewel. (False)

### **Trial 4** (=52) on p. 47)

Story: This is a story about five smurfs who go to a fair. They want to play a game being operated by Mickey Mouse. In this game, there is a big swimming pool in which some animals are swimming. There are four blue bugs; three small ones and one very big one. In addition there is a red bug, a green bug and a frog. The idea of the game is to catch one of the animals, to win a prize. Mickey Mouse tells the smurfs that if they catch the big blue bug, they will get a bigger prize. At first the smurfs try to catch the frog, but the frog is very quick, and jumps away. Then three smurfs each catch a small blue bug. The remaining smurfs first attempt to catch the big blue bug, but they give up. One of them catches a red bug and one catches a green bug.

Target sentences: (4A) Every smurf caught a blue bug. (False)  
(4B) Every smurf caught a bug. (True)

*Appendix 2B: Individual Responses of the Subjects*

**Group A**

Subject #	Age	Target (1A) (F)	Target (2A) (T)	Target (3A) (T)	Target (4A) (F)
Subject 1	3;8	W	R	R	W
Subject 2	4;2	*R	R	R	W
Subject 3	4;3	*R	R	R	W
Subject 4	4;5	W	R	R	W
Subject 5	4;8	W	R	R	W
Subject 6	4;10	W	R	*W	W
Subject 7	4;11	W	R	R	W
Subject 8	5;5	W	R	R	W
Subject 9	5;11	W	R	R	W
Subject 10	5;11	W	R	R	W

(T) = “True” Condition

(F) = “False” Condition

R = “Right” responses (Judged as “True”)

W = “Wrong” responses (Judged as “False”)

\* = Incorrect responses

**Group B**

Subject #	Age	Target (1B) (T)	Target (2B) (F)	Target (3B) (F)	Target (4B) (T)
Subject 11	4;2	R	W	W	R
Subject 12	4;3	R	W	W	R
Subject 13	4;5	R	W	W	R
Subject 14	4;5	R	W	W	R
Subject 15	4;5	R	W	W	R
Subject 16	4;7	R	W	W	R
Subject 17	4;10	R	W	W	R
Subject 18	4;11	R	W	W	R
Subject 19	5;1	R	W	W	R
Subject 20	5;10	R	W	W	R

(T) = “True” Condition

(F) = “False” Condition

R = “Right” responses (Judged as “True”)

W = “Wrong” responses (Judged as “False”)

\* = Incorrect responses

### Chapter 3. Experiment II: Evaluation of Inferences between Propositions–Phase 1

Given the results from Experiment I, in which children are found to be able to compute the truth values of the entailing and entailed sentences containing *every*, Experiment II was conducted to directly test children’s ability to distinguish among valid and invalid inferences created entailing and entailed *every*-sentences like those were used in Experiment I. That is, can we find any direct evidence that children can evaluate linguistically-encoded inferences such as “*Every dog has a snack. Therefore, every brown dog has a snack*”? On the basis of the findings from Experiment I, we will address the following hypothesis to be examined in Experiment II.

(57) Hypothesis: Experiment II

The pattern of inferences created between the minimal-paired sentences is determined by the pattern of entailments between the sentences. Children were found to be aware of the various consequences of the asymmetric entailment patterns created in the arguments of *every* (e.g., Gualmini 2005), and were also found to be able to compose the meaning of the antecedent and the consequence of the relevant inference containing *every* (Experiment I). Thus, they would be able compare the meanings of the antecedent and the consequence on the basis of the entailment patterns, i.e., to compute inferences created between the entailing and entailed sentences containing *every* with respect to its both arguments appropriately.

In pursuing the above hypothesis, we now need to establish an experimental methodology that can directly access to the new aspect of child semantics, i.e., the comparison of meanings. In what follows, let us first discuss in detail the logic that underlies the experimental design.

### 3.1. Logic

The focus here was made on how to design the experimental task, in which children will be encouraged to evaluate the semantic relation between the two propositions, without receiving any extraneous burden in the process. The most simple and straightforward evaluation of logical inference between sentences, in an ideal design, would be to present the two propositional variables one after another, and simply ask the evaluator whether the second proposition logically follows from the first proposition.<sup>17</sup> However, with children as the evaluators, this straightforward approach would not be feasible. Therefore, the crucial issue is how to develop an experimental task in which children can feasibly participate as evaluators (while also addressing the experimental pitfalls which have frustrated previous attempts in the literature, as we show in the next paragraph).

Recall now the challenge that has been previously made in the studies by Philip and De Villiers (1992) and De Villiers et al. (1998), which has been briefly reviewed in Chapter 1. We have briefly pointed out the necessity for improvement of the experimental design over the methods used in those two studies, in order to

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<sup>17</sup> See Geurts (2003b), Geurts and van Der Slik (2005) for the experimental studies about deductive reasoning with adults. As for the psychological model of deductive reasoning in adults, see Rips (1994).

successfully assess children's ability to evaluate the logical inferences between propositions. Keeping the potential difficulty in doing this, let us look more closely at the methodological aspects of these studies; this will raise some important issues to be addressed in the new experimental design.

3.1.1. Philip and De Villiers (1992)

In Philip and De Villiers (1992), the contrastive linguistic phenomenon that they have focused on was the one as follows.

- (58) a. Jimmy ate grapes with a fork.  
b. Jimmy ate grapes.

The relevant set-subset relation is constituted with respect to the underlined VPs above; the VP in (58a) (*ate grapes with a fork*) is a subset-denoting expression with a restriction by the PP *with a fork*, while the VP in (58b) (*ate grapes*) is a set-denoting expression. The valid inference is from (58a) to (58b), which is from the subset-denoting expression (*ate grapes with a fork*) to the set-denoting expression (*ate grapes*), showing the default pattern created in a non-DE environment, as illustrated below.

- (59) Jimmy ate grapes with a fork.  
→ Jimmy ate grapes.

The crucial observation is that once an adverb such as *often* is added to the sentences in (58) as seen in (60), the inference from *ate grapes with a fork* to *ate grapes* is blocked, as (61) shows.

(60) a. Jimmy *often* eats grapes with a fork.

b. Jimmy *often* eats grapes.

(61) Jimmy *often* eats grapes with a fork.

\* → Jimmy *often* eats grapes.

Now the inference from the subset-denoting expression to the relating set-denoting expression is not valid any more. In other words, the presence of *often* blocks licensing of the inference observed in (58).

Focusing on this observation, Philip and De Villiers conducted an experiment presenting using the Questions after Stories Task (De Villiers and Roeper, 1996), where the test sentences, which are presented together with a picture depicting the context situation, were followed by the comprehensive questions as in (62b).<sup>18</sup>

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<sup>18</sup> The primary focus in the study was made on the blocking effect of *wh*-movement from the logico-semantic point of view, in conjunction with on the blocking effect of the logical inference. They adopted the claim by Szabolsci and Zwarts (1993) that the non-monotone increasingness (downward entailment) blocks the *wh*-movement, as observed in the following examples. (For an alternative discussion of this examples from the syntactic perspective, see Chomsky (1986) and Rizzi (1990).

(iv) Why<sub>i</sub> did he say he sent flowers t<sub>i</sub>?

(v) \* Why<sub>i</sub> did he *often* say he sent flowers t<sub>i</sub>?

On the basis of Szabolsci and Zwarts who claimed that an inherent semantic property of the expression interferes the long distance *wh*-movement, Philip and de Villiers predicted that children block long distance movement only when they know that an expression that is crossed over by *wh*-phrase is not monotone increasing. The trial we discuss in the present

- (62) a. Jimmy *often* eats grapes with a fork.  
b. Does Jimmy *often* eat grapes?

The expected answer was either “No” or “I don’t know”, because the rejection of the question like (62b) demonstrates their ability to block of the valid inference from the subset-denoting expression to the relating set-denoting expression, as is seen in (61).

However, the children participated in their experiment showed only 50% adult-like valid inferences, where they rejected the question as in (62b) saying “No” or “I don’t know. On the basis of these findings, they concluded that the results showed the absence of children’s ability to block the invalid inferences, and that they failed to differentiate the sentences containing adverbs from the sentences without adverbs, treating them both in a “default” fashion.

There are several issues which make these conclusions difficult to draw. The first problem to be pointed out lies in the linguistic material they have utilized. The crucial observation was that the presence of the adverb *often* blocks the valid subset-to-set inference created in the non-DE (default) pattern. Note that *often* is a ‘habitual’ adverb that provides the information about the frequency of the character’s being involved in the event that is denoted in the verb. Let us go back to their test item again.

- (63) a. Jimmy *often* eats grapes with a fork.  
b. Does Jimmy *often* eat grapes?

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paper is a part of their experimental tasks, which examines if children are sensitive to the non-monotone increasingness that would block the long distance wh-movement.

The premise as in (63a) would yield two kinds of ambiguity: (i) with respect to what *often* modifies, either the event of *eating* (denoted in the entire VP) or the means by which the event of eating is taken place (denoted in the PP *with a fork*); (ii) with respect to the comparison sets, whether Jimmy's eating grapes with a fork is relatively frequent compared to the standard of other people's doing so. The ambiguity in interpreting the premise would have produced the extraneous difficulty that has puzzled children.<sup>19</sup>

In addition, it is not so obvious whether the relation between the premise (63a) and the consequence (63b) are logically related in the way that they can be evaluated, from the logical point of view, as the premise and consequence. In particular, whether Jimmy often eats grapes or not, which is asked in the question (63b) without mentioning his use of a fork, is not relevant in evaluating (63a). Thus, it does not follow whether or not Jimmy often eats grapes in the consequence like (63b) such that Jimmy often eats grapes with a fork. Therefore, it might be that children were confused when answering this question in this context, and as a result, they failed to reject the question. Thus, the low rate of children's adult-like responses that they revealed would be due to the poorly controlled context, rather than their lack of

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<sup>19</sup> The control condition that they conducted in comparison with the one in (63) is illustrated as follows.

- (vi) Story: Yesterday Bob and Kathy made pictures. *Bob used a red crayon and Kathy used a paint brush.*  
Question: *Did Bob use a crayon?*  
Expected answer: "Yes"  
Results: More than 95% of the expected ("Yes") responses

Contrary to the chance-level correct responses in the crucial condition, children showed a high rate of adult-like responses in this condition. These results would be also suggestive to conclude that the source of children's lower rate of the expected responses on the test item would be the presence of *often*.

linguistic knowledge. Therefore, the findings in this study do not suggest anything about children's ability to distinguish two patterns of inferences created between two sentences.

Another locus of their problem is in their experimental task. Note that they presented the sentences with a habitual adverb such as *often* in a story with a picture. Crain and Thornton (1998) have pointed out that it is risky to assume that children are able to interpret pictures in the same way as adults do, on the basis of the poorer results from the task using pictures than the results from the versions with vignettes acted out by the experimenter with toys and props (Crain, Thornton and Murasugi, 1987; Miyamoto and Crain, 1991 among others). Therefore, it is not straightforward to determine what triggers children's errors especially in interpreting sentences in response to pictures; whether it is the lack of linguistic knowledge or it is simply the limitation of their non-linguistic skill to interpret the information depicted on the pictures. In addition, according to Crain and Thornton, the capacity of depicting the context in pictures are limited, because they only represent "snapshots", and thus the types of verbs and predicates that can be used in the test sentences are constrained. Remember that their test sentence refer to the habitual event of Jimmy's grape eating. It would not be straightforward to exhibit the outcome of a character's habit, using the "snapshot" illustration.

### 3.1.2. De Villiers et al. (1998)

Now consider the follow-up study conducted later with the slight modification (De Villiers et al. (1998). De Villiers et al. (1998) employed the mental verbs *forget*<sup>20</sup> to test children's inference. Their motivation was the notion that the verbs like *forget* semantically contain implicit negation that would yield the DE effect in the inference.

(64) The boy *forgot* juice.

→ The boy *forgot* juice from witches.

According to their analysis, the DE feature of *forget* is due to the implicit negation that licenses a negative operator in the lower, but not in the higher, CP. As the following example shows, the covert negation can license the NPI as *any(one)*, which is a hallmark of yielding a DE environment.

(65) The boy {forgot NEG<sub>i</sub>} [OP<sub>i</sub> that he saw any<sub>i</sub>one]

Assuming this, they examined whether children could validate the valid inference regarding the verbs like *forget*. The target sentences were presented basically in the same way as Philip and De Villiers (1992), with a slight improvement in the question

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<sup>20</sup> As Philip and de Villiers (1992), their experimental focus has been three-way folded; one of them is children's awareness of inferences that are contrastively created by the different verbs, on which we have been focused on. We will not discuss their analysis from the rest of the two perspectives, focusing on the analysis from the viewpoint of inferences, which is related to the present paper.

following the target sentence so that children do not have to provide the response “I don’t know” as the correct response.

- (66) a. The boy *forgot* that his mother told him to avoid juice from witches.  
b. Does that mean the boy forgot that his mother told him to avoid juice?

The expected answer was “No”, because rejecting the question like (66b) shows their blocking the invalid inference from the subset-denoting expression (*juice from witches*, with the restrictive PP) to the set-denoting expression (*juice*), such as follows.

- (67) The boy forgot his mother told him to avoid juice from witches.  
\* → The boy forgot his mother told him to avoid juice.

According to their analysis of the results drawn from the experiments, children again failed to demonstrate consistent adult-like judgments regarding inferences.

Again, there are some concerns which make these conclusions difficult to draw. The locus of the primary problem in this task is the use of mental verb such as *forget* in the experiment, which may be considered to be a factor inducing extraneous difficulty for the child to complete the experimental task. It is not straightforward to represent a character’s mental state such as forgetting and its outcome in the experimental workspace. Although De Villiers et al. did not explain how they present the stories in this experiment in detail, it might be possible that the children’s

performance observed in their experiment in was due to the drawbacks of the presentation of the stories, which must depict an event of a character's forgetting, as a result of which would induce children's performance errors. Therefore, on the basis of this series of studies in which children's ability to evaluate the logical inferences between sentences were examined, it remains an unsolved puzzle whether children's poor performance in creating the valid inference reflects their lack of linguistic knowledge or stems from the extraneous non-linguistic demands of the experimental design.

### 3.1.3. Methodological Lessons

Taken together, these studies highlighted the difficulties in designing experiments to investigate children's ability to compute inferences between sentences. These are in turn the difficulty in controlling the felicity in the experimental context as regards how two propositions to be evaluated, in conjunction with the difficulty in choosing the best materials to test. The problem that is raised in the following would imply certain improvements to be considered, in assessing children's logical aspect of semantic competence successfully.

It is particularly notable that the locus of the difficulty lies in the evaluation of the propositions by answering the Yes/No questions, as is done in the experiments using the Questions after Stories Task. Recall, in De Villiers et al (1998), that children were asked to evaluate the inferences between the two propositions by answering a comprehensive question. The crucial part in the trial structure, which was illustrated in (66), will be repeated here.

- (68) a. The boy *forgot* that his mother told him to avoid juice from witches.
- b. Does that mean the boy forgot that his mother told him to avoid juice?

The children were asked to answer the question (68b) after they were presented with the story described in (68a) with the corresponding pictures. From a logical perspective, a child is asked to evaluate the target sentence inductively, rather than deductively, in this context. The question sentence (68b) provides the consequence (*The boy forgot that his mother told him to avoid juice*), and a child is asked to evaluate the premise (*The boy forgot that his mother told him to avoid juice*) addressed in (68a) as to whether it would *induce* the consequence, rather than the former is *deduced* from the latter. Hence, in order to provide the expected response (i.e., saying “No”) to this question, a child has to compute his/her answer in the following steps: (i) imagine premises other than the one that is described in the target sentence (68a): (ii) evaluate whether they can induce the conclusion that is described in the question sentence (68a). Therefore, this task requires complicated computation of the answer to the question, and as a result, it may have added considerable noise to the responses, and made interpretation of the results incredibly difficult.

The same critique applies to the evaluation by question-and-answer session in the first study Philip and De Villiers (1992), in which the comprehensive question was presented in a slightly different fashion. The crucial part of the trial structure in that design is repeated below.

- (69) a. Jimmy *often* eats grapes with a fork.  
b. Does Jimmy *often* eat grapes?

The children were asked to answer the question (69b) in evaluating whether the proposition addressed in (69b), i.e., *Jimmy often eat grapes*, follows from (69a). In the same way that we have just described above, a child may have evaluated the target stimuli addressed in the question (69b) inductively rather than deductively. The question sentence (69b) provides the consequence (*Jimmy often eats grapes*), and a child is asked to evaluate the premise (*Jimmy often eats grapes with a fork*) addressed in (69a); again, from the evaluator's point of view, this could be answered as to whether it would *induce* the consequence, rather than the former is *deduced* from the latter. In order to provide the expected response (i.e., saying "No") to this question, a child has to compute his/her answer in the following steps: (i) imagine premises other than the one that is described in the target sentence (69a): (ii) evaluate whether they can induce the consequence that is described in the question sentence (69b): and (iii) somehow suppress the inductive conclusion. Therefore, this task requires complicated computation of the answer to the question, and as a result, it would have produced considerable noise to the responses, which made interpretation of the results extremely difficult.

On the basis of the discussion above, we conclude that the abandoning the task in the Question-after-Story style is inevitable in thinking about the design for Experiment II; the crucial evaluation phase should be constituted such that children

will make their decisions following the deductive logic in some clear (and entertaining) way.

Keeping this in mind, a novel task was designed to provide a testing ground for children to evaluate the logical inferences based on the deductive reasoning. In particular, instead of the evaluation in the question-and-answer fashion, the children are expected to evaluate the relations between the two propositions as to whether the second proposition could be construed as a rephrase of the first (where the re-phrasal is either a logically-implied consequence of the first proposition, in one condition, or is not a logically-implied consequence of the first proposition, in the other condition) The following section will be devoted to discussing the new methodology in detail.

### 3.2. Experimental Design–“Prediction-Rephrase” Task

In order to investigate the above hypothesis, we designed the experiment featuring the novel task, on the basis of the methodology lessons discussed in 3.1.

#### 3.2.1. Basic Plot

The novel task is called “*Prediction-Rephrase*” Task, in which two propositional variables (premise and consequence) are presented sequentially in the conversation between two puppets. The two experimenters played the role of puppets in this task; one manipulated Merlin the Magician, and the other manipulated Kermit the Frog. Merlin the Magician served as a magic teacher, and Kermit the Frog was supposed to

be his pupil who wanted to learn how to be a magician from him. The conversation started with the following lead-in by Merlin.

(70) The lead-in by Merlin:

I will give you some magic training, Kermit. I will make something happen by saying my magic words. Before performing each magic trick, I will tell you what will happen. You should practice making a prediction; think about what else you can say, based on what I say, without being wrong.

The first propositional variable (i.e., the premise) was presented by Merlin's saying *what will happen*, and the second propositional variable to be evaluated based on the first one (i.e., the consequence) was presented by Kermit's prediction, or *what else he can say based on what Merlin said*.

In what followed, Merlin first showed the set of toy characters on which his magic trick would happen. He then said what he would make happen, which served as the premise, and let Kermit think about what else he can say. Next, Kermit rephrased what Merlin said, which served as the consequence to be evaluated based on the premise.

Note that the introduction of the set of toy characters in the beginning was only the visual stimuli that was presented to the child prior to their judgment of the rephrase, and the outcome of the magic trick, i.e., what ended up happening on these toy characters, was presented after their evaluation, which did not affect our re-phrase task, but was crucial to the experimental purpose, in order simply to keep the children's attention and satisfy their curiosity regarding the magic tricks. The reason why the entire course of the magic trick was not visually presented before the

evaluation was to let the child to reason whether the consequence logically follows from the premise (i.e., whether what Kermit said would happen really followed from what Merlin said would happen), rather than to relate the statement to situation in front of them.<sup>21</sup>

### 3.2.2. Experimental Conditions and Stimuli

In one experimental session, there are four tokens of evaluation tasks and four filler trials. The pairs of entailing and entailed propositions tested in the re-phrase task are listed below.

#### *“First-Argument” items*

- (71) a. Every dog will have a pizza.  
b. Every white dog will have a pizza.
- (72) a. Every dog will get a teddy bear.  
b. Every white dog will get a teddy bear.

#### *“Second-Argument” items*

- (73) a. Every koala bear will get a candy.  
b. Every koala bear will get a green candy.
- (74) a. Every koala bear will get an alien.  
b. Every koala bear will get a blue alien.

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<sup>21</sup> I express my deepest gratitude to Jill de Villiers, who was the first person to point out the necessity of removing of the visual information, in which children could match each statement with the situation presented in front of them, rather than logically reason directly via the two statements and evaluate the relation between them.

The two experimental conditions were created by the alternating the order of presentation among each member of the sentence pairs listed above (generating valid inferences in one condition, and invalid inferences in the other, as discussed below). Within each condition, there are two types of items: “*First-Argument*” items are pairs of sentences (premise and consequences) which are minimal-paired with respect to the first argument of *every* (i.e., (71) and (72)); “*Second-Argument*” items are premises and consequences minimal-paired with respect to the second argument of *every* (i.e., (73) and (74)).<sup>22</sup>

The first condition is the “*Valid*” *Inference Condition*, providing the pairs of premises and consequences between which the valid inferences are created. In particular, among “*First-Argument*” items, i.e., the sentences in (71) and (72) in which the relevant inference is created with respect to the first argument of *every*, the (a) sentences containing the set-denoting nouns in the relevant position were presented as the premise in Merlin’s utterance, and the (b) sentences with the subset-denoting nouns in the relevant position were sequentially presented as the consequence to be evaluated in Kermit’s rephrases. As for the “*Second-Argument*” items, i.e., the sentences in (73) and (74) in which the relevant inference is created with respect to the second argument of *every*, the (b) sentences containing the subset-denoting nouns in the relevant position were presented as the premise, and the (b)

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<sup>22</sup> Additionally, the two practice trials were presented in the beginning, in which the premise and the consequence were represented in sentences without containing the universal quantifier *every*. In this task, these trials were merely provided as the genuine practice for the children to get the idea about how the task works, and the results for these trials were not analyzed as a control in comparison with the test trials. This point was improved in the modified novel task which will be discussed in the next chapter, in which the tokens without *every* were provided as a control in comparison with the test items, as well as serving the purpose of proving a practice phrase for the children.

sentences with the subset-denoting nouns in the relevant position followed as the consequence to be evaluated.

The second condition is the “*Invalid*” *Inference Condition*, providing the pairs of premises and consequences between which the invalid inferences are created. The pairs of sentences were presented in the reversed order. In particular, among the “First-Argument” items, (b) sentences with the subset-denoting nouns were presented as the premise, and the (a) sentences with the set-denoting nouns were presented as the consequence. As for the “Second-Argument” items, the (a) sentences with the subset-denoting nouns were presented first as the premise, and the (b) sentences with the set-denoting nouns were presented as the consequence.

The conditions and stimuli were illustrated in the following table.

Table 6 Conditions and Stimuli

	Type of Item	Premise (Merlin)	Consequence (Kermit)	Pattern of Inference
“Valid Inference” Condition	“First-Argument”	(71a) Every <u>dog</u> will have a pizza	(71b) Every <u>brown dog</u> will have a pizza	Set-to-subset (Valid DE)
	“Second-Argument”	(73b) Every koala bear will get a <u>green candy</u>	(73a) Every koala bear will get a <u>candy</u>	Subset-to-set (Valid non-DE)
“Invalid Inference” Condition	“First-Argument”	(72b) Every <u>white dog</u> will get a teddy bear	(72a) Every <u>dog</u> will get a teddy bear	Subset-to-set (Invalid DE)
	“Second-Argument”	(74a) Every koala bear will get an <u>alien</u>	(74b) Every koala bear will get a <u>blue alien</u>	Set-to-subset (Invalid non-DE)

### 3.2.3. Sample Trials

The followings are the sample trials from each condition.

- (75) a. “Valid” Inference Condition – “First-Argument” item
- Merlin: We have white dogs and brown dogs here. I promise you to make the following happen; every dog will have a pizza (= (71a)).
- Kermit: Ok, Merlin has just said that every dog would have a pizza. So that must mean that I can also say that every white dog will have a pizza (= (71b)).
- b. Pattern of inference:  
Every dog will have a pizza → Every white dog will have a pizza
- (76) a. “Invalid” Inference Condition – “First-Argument” item
- Merlin: We have white dogs and brown dogs here. I promise you to make the following happen; every white dog will get a teddy bear (= (72b)).
- Kermit: Ok, Merlin has just said that every dog would have a pizza. So that must mean that I can also say that every dog will get a teddy bear (= (72a)).
- b. Pattern of inference:  
Every white dog will get a teddy bear \*→ Every dog will get a teddy bear

### 3.2.4. Evaluation of Kermit’s Rephrase

In the end of each trial, the child was asked to consider whether Kermit said something good, or whether he said something he could not say based on what Merlin’s said. The expected response, thus, would be “*Yes*” Responses in the “Valid” Inference Condition, such as their saying “You can say that, Kermit”; on the other hand, *Non-“Yes” Responses* was expected in the “Invalid” Inference Condition, such

as their saying “You cannot say that, Kermit” or “It doesn’t sound good”. The “Yes” Responses in the “Valid” Inference Condition, in which children accepted Kermit’s utterance as the correct “rephrase” of Merlin’s utterance, were mediated as their treatment the sequence of the premise and consequence as the logically valid inference between them. On the other hand, the Non-“Yes” Responses in the “Invalid” Inference Condition, in which children rejected Kermit’s “rephrase” of Merlin’s utterance, were interpreted as their evaluation of the invalid inference between them.

### 3.3. Predictions

On the basis of the findings from Experiment I, in which children were found to be aware of the opposing truth conditions assigned to the antecedent and the consequence of the relevant inferences involving *every*, we have hypothesized that children would demonstrate their adult-like ability to distinguish the valid and invalid inferences. If children were aware of the validity of inferences, as would be predicted on the basis of the contributions of the previous studies which revealed children’s full competence of the semantics of the universal quantifier *every* in computing within-proposition meaning, we would expect their adult-like responses in evaluating the relationship between the two sentences presented sequentially in this experimental context (see (57)). According to this hypothesis, it could be predicted that children would provide the “Yes” responses in the “Valid” Inference Condition, without being influenced by the order of the presentation of the set-/subset-denoting nouns; on the

other hand, children would provide the “No” responses in the “Invalid” Inference Condition, without being influenced by the order the set-/subset-denoting nouns were presented.

Alternately, if children lack the sensitivity to the distinction between the valid and invalid inferences, we would expect the patterns of errors in which children were purely tracking the order of presentation among the set-/subset-denoting nouns. In particular, (i) children would consistently provide the “Yes” Responses whenever the set-denoting noun precedes in the sequential presentation of the two propositions, and consistently provide the Non-“Yes” Responses whenever the opposite, or (ii) children would consistently provide the “Yes” Responses whenever the subset-denoting noun precedes in the sequential presentation of the two proposition, and consistently provide the Non-“Yes” Responses whenever the opposite. Another alternate scenario demonstrating children’s non-adult evaluations of the inferences would be that children would be completely confused, and show the random patterns in responses.

### Subjects

Seven English-speaking children, aged from 5;3 to 6;5 (mean age 5;9), participated in this experiment. The participants were children enrolled for the Center for Young Children at University of Maryland, College Park; all participants had their parental permission to participate in the study. The children were tested one by one in a separate quiet room with the experimenters.

### 3.4. Results

The percentages of the “Yes”-Responses observed in each condition were calculated. In the “Valid” Inference Condition, children provided the “Yes” Responses, i.e., the expected responses, 71% (5/7; Standard Error=18.443) of the time in evaluating the valid inferences with respect to the first argument of *every*, and 100% (7/7) of the time in evaluating the valid inferences with respect to the second argument of *every*. In the “Invalid” Inference Condition, children provided the “Yes” Responses, i.e., the non-expected responses, only 14% (1/7; Standard Error=14.289) of the time in evaluating the invalid inferences with respect to the first argument of *every*, and never did this in evaluating the invalid inferences with respect to the second argument of *every*.<sup>23</sup>

A Wilcoxon Signed-Rank test was conducted in order to examine whether the percentages of “Yes”-Responses observed in the “Valid” Condition were significantly higher than the percentages of “Yes”-Responses recorded in the “Invalid” Condition. In doing so, the sum of the correct answers was calculated in the following way. First, each of the “Yes” Responses observed was scored as 1, and each of the Non-“Yes” Responses was scored as 0. Then, the sum of the total scores in each condition (i.e., the potential maximum score was 7, while the potential minimum score was 0 for

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<sup>23</sup> One of the subjects provided the Non-“Yes” Responses in the “Invalid” Inference Condition (i.e., the correct responses) by saying “Maybe” consistently. Considering an invalid inference on the basis of the “deduction” could be a valid inference on the basis of the “induction”, this would be considered to be “fully adult-like” responses, because this child might have been aware of the two possible validities for the relevant consequence depending on how it would be evaluated (i.e., deductively or inductively). Such responses are consistent with children’s adult-like evaluations of the fallacies of the deductive logics (Asserting-the-Premise fallacy and Denying-the-Consequence fallacy) that were reported in the studies by Kuhn (1979) and Smith (1978) (see the footnote 13).

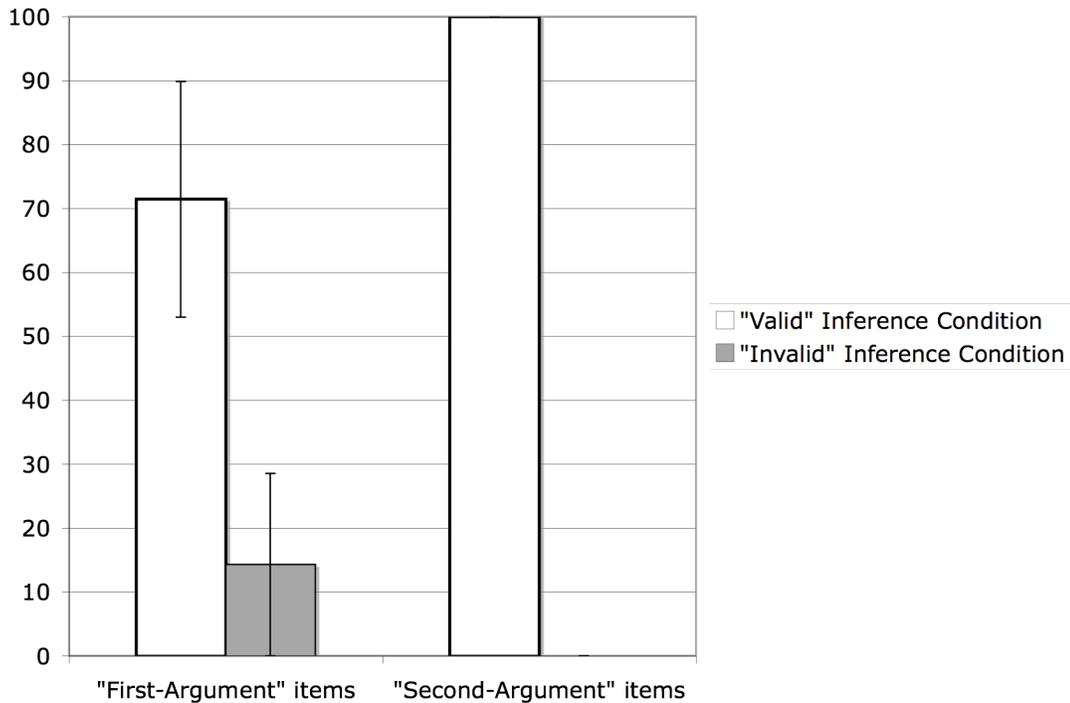
each condition) was compared in terms of whether the total score for the “Valid” Inference Condition was significantly higher than the one for the “Invalid” Inference Condition. According to the results, the total scores for the “Valid” Inference Condition were significantly higher than those for the “Invalid” Inference Condition,  $z = -2.000, p < 0.05$ .

These results are illustrated as follows.

Table 7 Percentages of “Yes” Responses

	Type of Item	Premise (Merlin)	Consequence (Kermit)	Pattern of Inference	% of “Yes” Responses
“Valid Inference” Condition	“First-Argument”	(71a) Every <u>dog</u> will have a pizza	(71b) Every <u>brown dog</u> will have a pizza	Set-to-subset (Valid DE)	71% (5/7)
	“Second-Argument”	(73b) Every koala bear will get a <u>green candy</u>	(73a) Every koala bear will get a <u>candy</u>	Subset-to-set (Valid non-DE)	100% (7/7)
“Invalid Inference” Condition	“First-Argument”	(72b) Every <u>white dog</u> will get a teddy bear	(72a) Every <u>dog</u> will get a teddy bear	Subset-to-set (Invalid DE)	14% (1/7)
	“Second-Argument”	(74a) Every koala bear will get an <u>alien</u>	(74b) Every koala bear will get a <u>blue alien</u>	Set-to-subset (Invalid non-DE)	0% (0/7)

Figure 12 Percentages of “Yes” Responses



### 3.5. Discussion

As the data shows, the overall ratio of children’s adult-like responses was significantly above chance. It thus would suggest children’s adult-like ability to distinguish the valid and invalid inferences concerning *every*.

However, it should be noted that the number of subjects who participated in this experiment is significantly small, and the average age of the children was significantly high. This is because the younger children could not appreciate the task, and thus their data was eliminated from the analysis. This fact leads us to reconsider the experimental design and the possible difficulty that children had to handle in the

task. Let us look more closely at the experimental plot in order to examine where the difficulty may have arisen.

Recall the trials demonstrated in (75) and (76), which are repeated in (77) and (78) respectively as follows.

- (77) a. “Valid” Inference Condition – “First-Argument” item
- Merlin: We have white dogs and brown dogs here. I promise you to make the following happen; every dog will have a pizza (= (71a)).
- Kermit: Ok, Merlin has just said that every dog would have a pizza. So that must mean that I can also say that every white dog will have a pizza (= (71b)).
- b. Pattern of inference:  
Every dog will have a pizza  $\rightarrow$  Every white dog will have a pizza
- (78) a. “Invalid” Inference Condition – “First-Argument” item
- Merlin: We have white dogs and brown dogs here. I promise you to make the following happen; every white dog will get a teddy bear (= (72b)).
- Kermit: Ok, Merlin has just said that every dog would have a pizza. So that must mean that I can also say that every dog will get a teddy bear (= (72a)).
- b. Pattern of inference:  
Every white dog will get a teddy bear  $*\rightarrow$  Every dog will get a teddy bear

A couple of points in these dialogues should be pointed out, which impose the extraneous difficulties for the child to compete the task in the way that the experimenters expected them to do. First factor in the difficulty would be some felicity factor in the context. Note that the consequence was provided by Kermit’s rephrase of Merlin’s prediction, which served as the premise. This part was

introduced as “Kermit’s practice to become a professional magician”, as part of magician’s feature to make a right prediction. Introducing rephrase of a prediction as making a correct prediction would not have sounded felicitous in the conversation. More specifically, Merlin’s request might have sounded strange to the child, and the child might have been confused as to what Kermit should do to satisfy Merlin’s request. With such non-canonical dialogue, what the children was expected to do in the task might have been blurred, and children might have been confused. A second factor in the difficulty for children would have lied in Kermit’s line, led by the fragment “It must mean that I can also say ...”. This fragment, with the multiple embedding structures in sentence, would have simply been too complicated for the children at preschoolers’ age, and it would have confused children.<sup>24</sup>

The discussion above thus considered some possible sources of difficulty which strictly limited the ability to test younger subjects. What was clear from these results, although promising with the older children, is that we then needed to develop an improved methodology that would remove, as much as possible, the difficulties which prevented the younger children from participating successfully. The next

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<sup>24</sup> Given that the dialogues presented in this experiment have yielded the pragmatic difficulties that may have puzzled children, there is a potential risk to induce some sort of *type I errors*, in which children might have provided the “correct” responses for the “wrong” reason (e.g., Crain and Thornton, 1998). That is, assuming that children are strongly “Yes” biased subjects, tending to provide the “Yes” responses even when they are not certain about what they were asked to answer, it would not have been obvious whether their “Yes” Responses were provided on the basis of their adult-like evaluation of the re-phrase, or whether they simply said “Yes” without knowing what they were expected to do in accomplishing the task. On the other hand, children were found to be likely to say “No” when they were confused in the experimental contexts (Fritzley and Lee, 2003). Given this report, the same concerns would have been the case when children provided the Non-“Yes” Responses; it would not have been obvious whether children provided the negative responses based on their linguistic evaluation of the items or based on their puzzlements. This also strongly suggests that the risk to trigger children’s confusion should be minimized as much as possible. This point will be discussed in more detail in Chapter 4.

chapter will be devoted to discuss the experiment featuring the alternate novel methodology in order to solve the problem, involving the younger children as the subjects.

Appendix 3A: Full Script of “Prediction-Rephrase” Task

**General Lead-in**

Merlin: Hi, I’m Marlin! Guess what, I’m the greatest magician in the world! Can you believe it? I will promise you something: I will make many fancy things happen with my magic words and magic cloth.

Kermit: Wow, that sounds really cool! I want to see if Merlin can do good as he promises us. Merlin, how can you be a great magician?

Merlin: Do you want to be like me?

Kermit: Yes! It’s great to be a magician.

Merlin: Ok, Kermit. Then why don’t you practice something about magic? It is important to make a good prediction about what will happen. Here is how our game goes. When I perform my magic, I will first tell you what is going to happen. When I do it, I really mean it. I promise you to make it happen, for sure. You should listen to me really carefully, and something about what will happen.

Kermit: Ok, I will say something about what Merlin promises us to show.

Merlin: Good. But don’t say something weird. I heard that you are sometimes silly. Listen to my promise carefully, and don’t say something so different from what I say. Think carefully about what else you can say without being wrong.

Kermit: Ok, I will.

**Trial 1: Practice Item–“Valid” Inference Condition**

**Premise: The troll will get an orange egg.**

**Consequence: The troll will get an egg.**

Merlin: Ok, here is the first magic. We have a troll here. I will promise Troll to make the following happen: **the troll will get an orange egg.**

Kermit: Wow, cool! Ok, Merlin said that the troll will get an orange egg. So that must mean that I can also say that **the troll will get an egg**.

**Trial 2: Practice Item–“Invalid” Inference Condition**

**Premise: The troll will get a ball.**  
**Consequence: The troll will get an orange ball.**

Merlin: Ok, the next magic. This time I promise Troll to make the following happen: **the troll will get a ball**.

Kermit: Ok, Merlin said that the troll will get a ball. So that must mean that I can also say that **the troll will get an orange ball**.

**Trial 3: “First-Argument: Item–“Valid” Inference Condition** (=75) on page 76)

**Premise: Every dog will have a pizza.**  
**Consequence: Every white dog will have a pizza.**

Merlin: We have white dogs and brown dogs here. I promise you to make the following happen: **every dog will have a pizza**.

Kermit: Ok, Merlin has just said that every dog would bark. So that must mean that I can also say that **every white dog will have a pizza**.

**Trial 4: “First-Argument” Item–“Invalid” Inference Condition** (=76) on page 76)

**Premise: Every white dog will get a teddy bear.**  
**Consequence: Every dog will get a teddy bear.**

Merlin: We have white dogs and brown dogs here. I promise you to make the following happen; **every white dog will get a teddy bear**.

Kermit: Ok, Merlin has just said that every dog would bark. So that must mean that I can also say that **every dog will get a teddy bear**.

**Trial 5: “Second-Argument” Item–“Valid” Inference Condition**

**Premise:** Every koala bear will get a green candy.

**Consequence:** Every koala bear will get a candy.

Merlin: Now we have five koala bears. Next magic goes like this. I will promise the koala bears to make the following happen: **every koala bear will get a green candy**.

Kermit: Ok, Merlin said that every koala bear will get a green candy. So that must mean that I can also say that **every koala bear will get a candy**.

**Trial 6: “Second-Argument” Item–“Invalid” Inference Condition**

**Premise:** Every koala bear will get an alien.

**Consequence:** Every koala bear will get a blue alien.

Merlin: Now, the last magic. I promise the koala bears to make the following happen: **every koala bear will get an alien**.

Kermit: Ok, Merlin said that every koala bear will get an alien. So, that must mean that I can also say that **every koala bear gets a blue alien**.

*Appendix 3B: Individual Responses of the Subjects*

Subject #	Age	P1	P2	First- Valid	First- Invalid	Second-Valid	Second-Invalid
Subject 1	5;3	*N	N	*N	N	Y	N
Subject 2	5;6	Y	N	Y	N	Y	N
Subject 3	5;6	Y	N	*N	N	Y	N
Subject 4	5;9	Y	*Y	Y	N	Y	N
Subject 5	6;1	Y	N	Y	N	Y	N
Subject 6	6;1	Y	N	Y	N	Y	N
Subject 7	6;5	Y	N	Y	*Y	Y	N

P1 = Practice Item 1

P2 = Practice Item 2

First-Valid = “First-Argument” Item in the Valid Condition

First-Invalid = “First-Argument” Item in the Invalid Condition

Second-Valid = “Second-Argument” Item in the Valid Condition

Second-Invalid = “Second-Argument” Item in the Invalid Condition

Y = “Yes” Responses

N = Non-“Yes” Responses

\* = Incorrect responses

## Chapter 4. Experiment III: Evaluation of Inference between Propositions–Phase 2

Intending to examine younger children’s behaviors, Experiment III aims to investigate the same hypothesis as Experiment II, which is repeated as follows.

(79) Hypothesis: Experiment III

The pattern of inferences created between the minimal-paired sentences is determined by the pattern of entailments between the sentences. Children were found to be aware of the various consequences of the asymmetric entailment patterns created in the arguments of *every* (e.g., Gualmini 2005), and were also found to be able to compose the meaning of the antecedent and the consequence of the relevant inference containing *every* (Experiment I). Thus, they would be able compare the meanings of the antecedent and the consequence on the basis of the entailment patterns, i.e., to compute inferences created between the entailing and entailed sentences containing *every* with respect to its both arguments appropriately.

In what follows, we will first discuss the logic that we exploit in revising the experimental methodology to examine younger children’s behaviors as well.

#### 4.1. Logic

Consider the inclusive relation between entailing and entailed expressions. Crucially, the entailing expression is logically stronger than the entailed expression. Thus, the inference is licensed from the logically stronger expression to the logically weaker expression. The relation between the entailing and the entailed expression described here can be explicitly observed in the following linguistic context. Let us have a demonstration, taking the following minimal-pair of entailing and entailed sentences as our example below.

- (80) a. John brings Mary a pen  
b. John brings Mary a red pen

Note that an inference is created from (80b) to (80a), i.e., the ‘default’ pattern from a subset-denoting expression (*red pen*) to a set-denoting expression (*pen*), as (81) demonstrates, since the relevant underlined position in these examples is a non-DE environment.

- (81) a. John brings Mary a red pen (=80b)  
→ John brings Mary a pen (=80a)  
b. John brings Mary a pen (=80a)  
\* → John brings Mary a red pen (=80b)

Now consider these sentences in the following context. Suppose Mary needs a pen, and he demands John to bring one. In response, John brings Mary a red pen. This situation layouts the sentences (80a) and (80b) in the context of fulfilling Mary's demand of John's responding. This situation is depicted in (82) below.

- (82) a. Mary's demand: John brings Mary a pen (=80a)  
b. John's response: John brings Mary a red pen (=80b)

Mary's demand is logically satisfied by John's bringing a red pen, and this outcome should also be pragmatically acceptable as far as Mary did not specify the color of the pen she wants, and thus that any color will do in order to satisfy Mary's demand. Therefore, Mary's demand as represented in (82a) was satisfactorily fulfilled by John's response as the outcome represented in (82b).

Consider now the following context. Suppose Mary needs a red pen, and she demands John to bring one. In response, John somehow ends up bringing a pen, without knowing what color it is. This situation is depicted in (83) below.

- (83) a. Mary's demand: John brings Mary a red pen (=80b)  
b. John's response: John brings Mary a pen (=80a)

Contrary to the first case, Mary has explicitly specified the color of the pen that she needs. Therefore, John's bringing a pen without specifying what color it is would not

logically satisfy Mary’s demand, as long as the color of the pen John is not explicitly determined.

Note now that the order of the two (entailing and entailed) propositions in such contexts determines whether the demand is logically satisfied by the response. Crucially, when the demand logically implies the fulfilling response deductively (e.g., John brings a red pen, therefore John brings a pen), as in (83), the fulfilling response fails as the logical satisfaction of the demand in this context (e.g., bring me a red pen; \*I brought you a pen (of unspecified color)).

Contrarily, when the demand does not logically imply the fulfilling response (e.g., John brings a pen, \*therefore John brings a red pen), as illustrated in (82), the fulfilling response logically satisfies the demand in this context (e.g., bring me a pen; I brought you a red pen). The relationship among inference and demand-fulfillment in this paradigm is schematized in the following chart.

Figure 13 Relation among sentences in inference and demand-satisfaction

Demanded Outcome (D)	Fulfillment Outcome (F)	Inference (D) → (F)	Demand Satisfaction
John brings a <u>pen</u>	John brings a <u>red pen</u>	Invalid	Satisfactory
John brings a <u>red pen</u>	John brings a <u>pen</u>	Valid	Unsatisfactory

Keeping this in mind, let us now consider the relation among sentences containing *every* in inference and demand-satisfaction. First, consider *every*-sentences with respect to its first argument, such as (84). As (85) demonstrates, an inference is

licensed from the set-denoting expression (*pen*) to the relating subset-denoting expression (*red pen*), due to the DE environment of the first argument of *every*.

(84) a. John brings Mary every pen

b. John brings Mary every red pen

(85) John brings Mary every pen (= (84a))

→ John brings Mary every red pen (= (84b))

Suppose that Mary owns a set of pens, a few red pens and blue pens, but she does not carry them with her at the moment; now she demands that John bring them all to her. In response, forgetful John somehow ends up bringing only the red pens. The demand and attempted fulfillment propositions in this context are as follows.

(86) a. Mary's demand: John brings Mary every pen (= (84a))

b. John's response: John brings Mary every red pen (= (84b))

(86) illustrates a case in which the demand is not logically satisfied; the demand in this context is for John to bring every pen in the domain, including both red and blue pens that Mary owns, and thus John's bringing every red pen in response only partially fulfills the demand because of the lack of bringing every blue pen. Recall that the demand logically implies the fulfilling response (i.e., bringing every pen logically implies bringing every red pen), as is illustrated in (87), and thus it does not

logically satisfy the demand (i.e., the request for every pen cannot be satisfied by bringing every red pen), just as in (82).

Now consider the reverse version; Mary demands that John bring every red pen, in the same context. The reversed order of propositions results in an invalid logical inference between them (i.e., bringing every red pen does not entail bringing every pen), as shown in (87) below.

(87) John brings Mary every red pen (=84b))

\* → John brings Mary every pen (=84a))

Suppose further that Mary does not care so much about whether she gets every blue pen, but she crucially needs every red pen.<sup>25</sup> In response, forgetful John ends up bringing every pen, which yields the demand and fulfillment pair in (88).

(88) a. Mary's demand: John brings Mary every red pen (=84b))

b. John's response: John brings Mary every pen (=84a))

Note that John's bringing every pen logically satisfies Mary's demand; Mary originally needs every red pen, which is satisfied as far as all the red pens in the domain are brought to her, regardless of whether every blue pen is also included.

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<sup>25</sup> Some pragmatic factor imposes the implicature in which the demand should be satisfied if only the red pens are brought, excluding the blue pens. This additional information in the context is to eliminate such pragmatic inference in which the *every blue pen* should be excluded from the set of the pens that are to be brought, because they are not referred to in the demand. This factor is to be controlled in the experiment that will be discussed in the following section.

Recall, again, that the demand logically implies the fulfilling outcome (i.e., bringing every red pen does not logically imply bringing every pen), as illustrated in (85a), and thus it does logically satisfy the demand (i.e., the request for every red pen can be satisfied by bringing every pen), just as in (83).

The same logic applies to the inferences with regard to the second argument of *every*. Consider the following pair of entailing and entailed *every*-sentence in (89) below; since the relevant position is non-DE, the inference from *pen* to *red pen* is not valid, as (90) shows.

- (89) a. Every one of the boys brings Mary a pen.  
b. Every one of the boys brings Mary a red pen.
- (90) Every one of the boys brings Mary a pen. (= (89a))  
\* → Every one of the boys brings Mary a red pen. (= (89b))

Suppose now that there are three boys, John, Bill and Tom. Mary demands that each of the boys bring her a pen. In response, each boy somehow brings a red pen to her. This leads us to layout the propositions in (89) in the context as follows.

- (91) a. Mary's demand: Every one of the boys brings Mary a pen.  
b. The boys' response: Every one of the boys brings Mary a red pen.

Mary's demand is logically satisfied by every boy's bringing a red pen, since she does not specify the color of the pen in the demand, and so any color will do. Note

that the demand does not logically the fulfilling response (i.e., every one of the boy's bringing me a pen does not logically imply every one of the boy's bringing me a red pen), as (90) shows, and thus the demand is logically satisfied by the fulfilling response (i.e., the request of every one's bringing me a pen is satisfied by every one's bringing me a red pen), just as in (82) and (88).

Once again, let us now reverse the order of the two propositions, which evokes a valid inference between them, as in (92) below.

- (92) Every one of the boys brings Mary a red pen. (=89b)  
       → Every one of the boys brings Mary a pen. (=89a)

Consider the reversed demand and the fulfillment, as shown in (93).

- (93) a. Mary's demand: Every one of the boys brings Mary a red pen.  
       b. The boys' response: Every one of the boys brings Mary a pen.

Note that while the logical inference from subset-to-set denotation is licensed, the demand is not logically fulfilled (i.e., unless the pens that each boy brought to Mary turn out to be red). This mirrors the pattern of the above cases in (83) and (86).

Thus, the relation among *every*-sentence in inference and demand-satisfaction can be schematized as the following chart, summarizing the basic patterns we have observed in this section regarding the first and second argument of *every*.

Figure 14 Relation among *Every*-sentences in Inference and Demand-satisfaction

	Demand (D)	Fulfillment in response to Demand (F)	Inference (D)→(F)	Demand Satisfaction
1 <sup>st</sup> arg. of <i>every</i> (DE)	(84a) John brings Mary every <u>pen</u>	(84b) John brings Mary every <u>red pen</u>	Valid	Unsatisfactory
	(84b) John brings Mary every <u>red pen</u>	(84a) John brings Mary every <u>pen</u>	Invalid	Satisfactory
2nd arg. of <i>every</i> (non-DE)	(89a) Every one of the boys brings Mary a <u>pen</u>	(89b) Every one of the boys brings Mary a <u>red pen</u>	Invalid	Satisfactory
	(89b) Every one of the boys brings Mary a <u>red pen</u>	(89a) Every one of the boys brings Mary a <u>pen</u>	Valid	Unsatisfactory

To sum up, among minimal-paired propositions containing the relating superset-/ subset-denoting expressions, which proposition entails which proposition is reflected in the context of demand-fulfillment. In particular, when the proposition referred to in the demand logically implies the proposition referred to in the fulfillment, the demand is not logically satisfied by the fulfillment; when the proposition referred to in the demand does not logically imply the other proposition referred to in the fulfillment, the demand is logically satisfied by the fulfillment in this paradigm.

## 4.2. Experimental Design–“Demand-Fulfillment” Task

Exploiting the logic discussed in 4.1., we designed a new experimental task, which is called the “*Demand-Fulfillment*” Task, in order to examine whether children are able to evaluate the logical strength of the entailing and entailed expressions presented in these contexts. Recall that the discussion on the previous studies seeking to investigate this issue has highlighted the importance of controlling children’s task so that it would be easy for children. The new task that we will discuss in the present section was designed in the way that children can evaluate the logical inference between sentences while minimizing the difficulty of the task; the children’s task would be simply to evaluate whether the fulfillment of a demand in a story was satisfactory or not, which demonstrates their evaluation of the inferential relations among the demand and fulfillment propositions as shown in the previous section. Keeping these issues in mind, we will present the detail of the proposed experimental methodology in this section.

### 4.2.1. Basic Plot

Demand-fulfillment contexts similar to the cases discussed in the previous section are presented in a skit featuring toy characters familiar to the children. The basic structure of the skit that served as a context in which the demand-fulfillment was felicitously presented, was as follows. The bad genie appeared and he put a spell on the other characters, to turn them into little monsters. The process of putting a spell on each

character was presented via the animated images in Microsoft PowerPoint format on the monitor of a laptop computer (which was called “Genie’s magic screen” for the purpose of the story presentation). The genie demanded that Grover bring him what he wants in exchange for freeing each character under his spell. Grover leaves for a while to look for what the genie wants. Grover is said to be forgetful, and as a result he brings something that is close to, but not exactly, what the genie requested. The object(s) that the genie demands and the one(s) that Grover brought as the fulfilling outcome are related via superset-subset relations; for example, the genie demands a car and Grover brings a red car, the genie demands a blue train and Grover brings a train, and so on. Crucially, what Grover brings as the fulfilling outcome is carried in a closed box so that no visual cues were provided about what Grover brought until certain point. Grover then tells the child what he brought to the genie in response to the genie’s demand, without showing what he brought in the box, and asks the child whether he did something good enough to satisfy the genie. After the child answers Grover’s question, he/she is asked to open the box and to show what is inside to the genie. If it turns out that Grover could satisfy the genie’s demand, the spell is removed and the character is set free on the screen. If it turns out that Grover failed to satisfy the genie’s demand, the child is asked to help Grover correct his mistake. In the end, the character is freed as well.

The simplified outline of the basic plot is illustrated as follows.

(94) The Basic Plot – Simplified Outline

- a. The genie puts a spell on a character. (The laptop computer “Genie’s magic screen” shows the transformation of the character in the animated pictures.)
- b. The genie presents the demand < *the demand presented* >  
“If you want me to free this character, bring me X.”
- c. Grover leaves for a while and comes back with a box.
- d. Grover provides a description of what is inside the box without showing it < *the fulfilling outcome presented* >  
“I brought him X.”
- e. After the child answers, Grover lets the child open the box and see what is inside.
- f. If Grover satisfied the genie, then the spell was resolved.
- g. If Grover failed to satisfy the genie, the child was asked to help Grover correct his mistake so that the character is freed.

4.2.2. Experimental Conditions and Stimuli

The two experimental conditions were created: “*Satisfactory*” *Condition*, in which the demand is logically satisfied by the fulfilling outcome, and thus the demand does not logically imply the fulfillment; “*Unsatisfactory*” *Condition*, in which the demand is not logically satisfied by the fulfilling outcome, and thus the demand does logically imply the fulfillment.

We developed three types of stimuli (i.e., the propositions about “bringing”) to be provided both in “Satisfactory” Condition and “Unsatisfactory” Condition. All the stimuli were listed below. The stimuli can be categorized into the following three types. The first type of the tokens are *Control Item*, listed in (95a) and (96a), which do not contain the universal quantifier *every*; this type served as a control item to test set-/subset-denotation inferences without *every*, in comparison with the ones involving *every*. They are also provided in order also to provide the child a practice session. “*First-Argument*” *Items* served as a test case to provide the items showing the relevant inference with respect to the first argument of *every*, i.e., the ones listed in (95b) and (96b). “*Second-Argument*” *Items* served as a test case to provide the items showing the relevant inference with respect to the second argument of *every*, i.e., the ones listed in (95c) and (96c).

(95) “Satisfactory” Condition

a. Control Item

i) Demand: “Bring me a car”

ii) Response: “I brought you a red car”

b. “First-Argument” Item

i) Demand: “Bring me every gold coin”

ii) Response: “I brought you every coin”

c. “Second-Argument” Item

i) Demand: “Every one of you brings me a cat”

ii) Response: “Every one of us brought you a white cat”

(96) “Unsatisfactory” Condition

- a. Control Item
  - i) Demand: “Bring me a blue train”
  - ii) Response: “I brought you a train”
- b. “First-Argument” Item
  - i) Demand: “Bring me every dog”
  - ii) Response: “I brought you every brown dog”
- c. “Second-Argument” Item
  - i) Demand: “Every one of you brings me a green noodle”
  - ii) Response: “Every one of us brought you a noodle”

4.2.3. Evaluation of the Stimuli

We set out the two points at which the child may evaluate the stimuli. The primary evaluation of the stimuli was made at the point at which Grover asked the child whether he did something good enough, without showing what’s inside his box (i.e., at the point of (94d) in the simplified chart above). This requires the child consider whether what Grover said logically satisfies what the genie demanded, rather than relate the statements to the situation visually presented in front of them as in Experiment I using the Truth Value Judgment task. In the “Satisfactory” Condition, the expected response would be to provide an affirmative answer to Grover’s question, such as “Yes”; we call these “*Yes*” Responses. In the “Unsatisfactory” Condition, the expected response would be to provide a negative answer such as “No,

or uncertain answer, such as “I need to check inside the box”; we call these *Non-“Yes” responses*.

After the primary evaluation, the children were given the second phase to confirm their evaluation. They were asked to open Grover’s box, and check inside to see whether Grover brought something that satisfies the genie (i.e., at the point of (94e) in the simplified chart above).

For the sake of convenience, we call the primary evaluation *Before-Open-the-Box Evaluation* and the secondary evaluation *After-Open-the-Box Evaluation*.

Note that in the “Unsatisfactory” Condition, in which the fulfilling outcome does not *logically* satisfy the demand, the After-Open-the-Box phase removed the logical uncertainty in the fulfillment in the way that the final outcome of the fulfilling turns out not to satisfy the demand. For example, in the trial like (83), in which bringing a red pen was demanded and bringing a pen was provided as the fulfilling outcome, it does not logically satisfy the demand, unless the pen that was brought turns out to be red; the After-Open-the-Box phase reveals that the pen in the box turns out not to be red. Throughout all the trials in the “Unsatisfactory” Condition, the demand has never been satisfied, not only logically but also as a matter of fact upon opening the box.

#### 4.2.4. Interpretation of Responses in Each Experimental Condition

The children’s responses at the two evaluation phases in each experimental condition are interpreted as follows.

What counts as “Yes” Responses, which is expected in the “Satisfactory” Condition, is to answer “Yes” to Grover’s question at the Before-Open-the-Box-Evaluation, and further to confirm the answer at the After-Open-the-Box-Evaluation, with checking what is inside the box.

The Non-“Yes” Responses, which is expected in the “Unsatisfactory” Condition, is scored when the children’s responses met either one the following two conditions: (i) providing negative or uncertain answer to Grover’s question at the Before-Open-the-Box-Evaluation (e.g., “No, you didn’t do something good enough”, or “I don’t know until I see what’s inside your box.”); (ii) providing non-negative answer to Grover’s question at the Before-Open-the-Box-Evaluation (e.g., “Yes” or “I think so”), which is apparently inconsistent with the adult-like evaluation of the inference, but rejecting it at the After-Open-the-Box-Evaluation (e.g., “No, this is not what the genie wanted”).

#### 4.2.5. Notes on the Non-“Yes” Responses

One would wonder why we allowed the two patterns of children’s reactions to be counted as the legitimate Non-“Yes” Responses in the “Unsatisfactory” Condition, as has been just described above. The primary reason why the After-Open-the-Box-Evaluation was installed in the task was as follows. We seriously took the claim that children are by nature “Yes” biased subjects, as has been sometimes observed (e.g., Crain and Thornton, 1998). Children provide the negative responses only when they are completely sure why they negate/reject the stimuli. This means that children may provide “Yes” Responses for the wrong reason, i.e., not only on the basis of their

linguistic evaluation but also on the basis of their uncertainty that comes from some non-linguistic uncertainty, such as obscurity about what they are expected to say. Thus it is important for the experimenters to confirm that children's responses certainly reflect their decision on the basis of the linguistic evaluation of the stimuli, and it is crucial to tease apart the cases in which children say "Yes" because of their linguistic decision and the cases in which they say "Yes" because they do not know what they are expected to say, leaving out the latter scenario from the experimental workspace.

Given the discussion above, the "Demand-Fulfillment" Task and the nature of its request for children to accomplish is not very simple, even though it is a task that has been carefully designed to elicit judgments across linguistically-encoded propositions based on deductive logic, with several pitfalls addressed based on lessons from the previous studies by Philip and De Villiers (1992) and De Villiers (1998). The children's task is to evaluate the logical relation between the demanded outcome and the fulfilling outcome, as to whether the demand-fulfillment is logically satisfactory. Thus, while we took pains to make the initial evaluation as straightforward as possible, we found it still very desirable to have a second opportunity to probe the reason for children's responses. Therefore, the After-Open-the-Box-Evaluation was provided as a second opportunity for the children to demonstrate that their decision is solely based on evaluation of the demand sentence and the attempted fulfillment. In the After-Open-the-Box-Evaluation, they were expected to make a decision as to whether the fulfilling outcome presented visually, in conjunction with the linguistic material, logically satisfies the demanded outcome,

by means of matching what has been demanded and what has been provided as the fulfillment.<sup>26</sup>

#### 4.2.6. Sample Trials

The full script for a sample trial in “Satisfactory” Condition is provided below.<sup>27</sup>

(97) Sample Trial: “Satisfactory” Condition (Control Item)

Lead-in: This is a story about the genie and Grover. The genie is a great magician, but sometimes he uses his magic power to do some tricks on the other people. Now, Grover is visiting the genie’s palace. Let’s see what is going to happen.

Genie: I’ll show you something interesting. Here we have Mickey Mouse (*An image of Mickey Mouse shows up on the monitor of the lap top computer*), and I will turn him into a little monster. (Magic word...) Can you believe that this little creature is in fact Mickey Mouse (*Mickey Mouse disappears and a strange monster appears instead on the monitor*)? I put a spell on Mickey Mouse, and he turned into a little monster. Hahaha.

Grover: Oh-oh, poor Mickey Mouse... Genie, that was a cool magic, but I think Mickey Mouse wants to come back. Free him!

Genie: If you want me to free him, bring me a **car**.

Grover: Ok, I will look for a car for you and will be back right away. But I’m sometimes silly and forgetful, so I have to be careful not to forget the request.

*(Grover leaves the genie’s palace and disappears. And he reappears with a box.)*

Grover: I think I got it. But I might have forgotten exactly what the genie said. So before going back to the genie’s palace, I want

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<sup>26</sup> We will discuss more about the interpretation of the After-Open-the-Box-Evaluation in the later section.

<sup>27</sup> We here demonstrate the sample trials for presenting the “Control Items” instead of the ones for presenting the test items that contain *every*. The reason is to spell out how the basic plot we have demonstrated in (94) was incorporated into the full script in the most straightforward way; the scripts for presenting the test items with *every* contain additional information to make it felicitous to use *every* in the context, which we will discuss later.

to make sure with you (=the child) whether I did something good enough. I brought him a **red car** in this box. Do you think it is good enough and Mickey Mouse will be freed? (=Before-Open-the-Box-Evaluation)

Child: (Expected to say) Yes.

Grover: Ok, now let's open the box and show it to him together.

Child: (Open the box and see what's inside)

Grover: Did you find something good enough to free Mickey Mouse? (=After-Open-the-Box-Evaluation)

Child: (Expected to say) Yes.

The following is the full script of a sample trial of the "Unsatisfactory" Condition. Note that it will be revealed that Grover did not satisfy the genie's demand at the After-Open-Box-Evaluation phase.

(98) Sample Trial: "Unsatisfactory" Condition (Control Item)

Genie: Here we have Donald Duck (*An image of Donald Duck appears on the monitor of the lap top computer*), and I will also put a spell on Donald Duck, and he turned into a little monster (*Donald Duck disappears and a strange monster appears on the monitor*). Hahaha.

Grover: Hey Genie, you are being bad today. Oh poor Donald... Genie, I think it was a cool magic, but Donald Duck wants to come back. You should free him!

Genie: If you want me to free him, bring me a **blue train**.

Grover: Ok, I will look for one for you and will be back right away. But I'm silly and forgetful, so I should be really careful not to forget what the request is.

(*Grover leaves the genie's palace and disappears. And he reappears with a box.*)

Grover: I think I got it. But I might have forgotten exactly what the genie said. So before going back to the genie's palace, I want to make sure with you (=the child) whether I did something good enough. I brought him a **train** in this box. Do you think

Donald Duck will be freed? (=Before-Open-the-Box-Evaluation)

Child: (*Expected to say*) No/I don't know/What kind of train did you bring?/I need to see inside the box... etc.

Grover: Oh-oh, did I make a mistake? Let's check inside the box together.

Child: (*Open the box; there is a yellow train*)

Grover: Do you see something good enough to make the genie happy? (=After-Open-the-Box-Evaluation)

Child: (*Expected to say*) No, it's not a blue train. It's a yellow train!

Genie: Oops, Don't you remember I told you to bring me a blue train?

Exp.: (*Child name*), why don't you help Grover? Here is a blue train he should have brought. Can you give it to genie?

Child: (*Give a blue train to the genie*)

Genie: Very good! Thank you so much, (*Child name*). Now I will free Donald Duck.

#### 4.2.7. Additional Information for the Felicity

For the demand-fulfillment scenarios containing *every*, additional lead-in material was incorporated in the basic plot described above, in order to make it felicitous to use *every* in the context of the story. First, additional information was added to show what counts as “every NP” in the context (e.g., introducing the story by explaining that the genie had every dog he owns escape) for “First-Argument” items, as in (95b) and (96b). The set of what counts as “every NP” (e.g., every dog the genie owns) was visually presented on the screen of the laptop computer, after the genie's spell was shown. Second, to support the presentations “Second-Argument” items, as in (95c) and (96c), two more characters, Big Bird and Cookie Monster, joined Grover to free

characters under the genie’s spell, in order to make it felicitous to use ‘Every NP brings me a cat’.<sup>28</sup>

To sum up, the following table schematically represents the condition and stimuli.

Table 8 The Schema of “Demand-Fulfillment” Task

Types of Items	Demand (D)	Fulfillment in response to the Demand (F)	Pattern of Inference (D) → (F)	Validity of Inference (D) → (F)	Demand Satisfaction
Control	(95a.i) Bring me a <u>car</u> .	(95a.ii) I brought you a <u>red car</u> .	Set-to-subset (Invalid non-DE)	Invalid	Satisfactory (“Satisfactory” Condition)
“1 <sup>st</sup> -Arg.”	(95b.i) Bring me every <u>gold coin</u> .	(95b.ii) I brought you every <u>coin</u> .	Subset-to-set (Invalid DE)		
“2 <sup>nd</sup> -Arg.”	(95c.i) Every one of you brings me a <u>cat</u> .	(95c.ii) Every one of us brought you a <u>white cat</u> .	Set-to-subset (Invalid non-DE)		
Control	(96a.i) Bring me a <u>blue train</u> .	(96a.ii) I brought you a <u>train</u> .	Subset-to-set (Valid non-DE)	Valid	Unsatisfactory (“Unsatisfactory” Condition)
“1 <sup>st</sup> -Arg.”	(96b.i) Bring me every <u>dog</u> .	(96b.ii) I brought you every <u>brown dog</u> .	Set-to-subset (Valid DE)		
“2 <sup>nd</sup> -Arg.”	(96c.i) Every one of you brings me a <u>green noodle</u> .	(96c.ii) Every one of us brought you a <u>noodle</u> .	Subset-to-set (Valid non-DE)		

<sup>28</sup> See Appendix 4A for the full script of all the trials. Also see the footnote 27 for the reason why the scripts for the target trials with *every* have not been described in the main chapter.

### 4.3. Predictions

On the basis of the findings from Experiment I and the suggestive trend in the results from Experiment II, we hypothesized that children demonstrate the adult-like evaluation of the demand-fulfillment pairs that reflect the direction of the inference, as introduced above (see (79)). According to this hypothesis, children would be expected to distinguish the satisfactory and unsatisfactory demand-fulfillment relationships appropriately, depending on the direction of inferences created with respect to the first and second arguments of *every*. In the “Satisfactory” Condition, children would be expected to provide the “Yes” Responses across all types of tokens; in the “Unsatisfactory” Condition, they would provide the Non-“Yes” Responses across tokens. Crucially, in such a scenario, children are expected to judge the demand-fulfillment not relying on the order of set-/subset-denoting nouns presented in the two propositions (e.g., “Yes” Responses across all the tokens holding a set-denoting noun in the demand and a subset-denoting noun in the fulfillment, and Non-“Yes” Responses across all the tokens hosting a subset-denoting noun in the demand and a set-denoting noun in the fulfillment, or vice versa). Instead, they are expected to judge the demand-fulfillment depending on the direction of the inferences. If this prediction were to be borne out, it would demonstrate children’s sensitivity to the direction of the inference, which is crucially determined by the linguistic environment (i.e., the direction of entailment) in the relevant positions, rather than the presentation order of the set-/subset-denotation in nouns in the relevant positions.

Alternatively, if children lack the adult-like sensitivity to the validity in the logical inferences, they would not be able to distinguish the difference in the satisfactory and unsatisfactory demand-fulfillment. One possible scenario would be that they would treat all the tokens consistently on the basis of the order of set-/subset-denoting nouns presented in the two propositions, regardless of the logical satisfaction of the demand. Another possible scenario would be that they would be sensitive to some other unintended feature of the experiment, showing the random pattern in providing the “Yes” and Non-“Yes” Responses, or showing the “Yes” Responses consistently because of their “Yes”-biased nature.

#### Subjects

Sixteen English-speaking children aged from 4;2 to 6;0, whose average age was 4;10, participated in this experiment. The participants were children enrolled for the Center for Young Children at University of Maryland, College Park; all participants had their parental permission to participate in the study. The children were tested one by one in a separate quiet room with the experimenters.

#### 4.4. Results

##### Results: “Satisfactory” Condition

In the “Satisfactory” Condition, children overall demonstrated a high rate of “Yes” Responses, as was expected if children possess adult-like competence in encoding and evaluating logical inferences among propositions. In evaluating the satisfactory

demand-fulfillment in the Control items, in which the inference pattern from the demand to the fulfillment is invalid non-DE pattern, i.e., “set-to-subset” pattern, the percentage of the “Yes” Responses was 81% (13/16). More specifically, in evaluating the satisfactory demand-fulfillment in the “First-Argument” items, in which the inference pattern from the demand to the fulfillment is invalid DE pattern, i.e., “subset-to-set” pattern, the percentage of the “Yes” Responses was 92% (12/13).<sup>29</sup> In evaluating the satisfactory demand-fulfillments in “Second-Argument” items, in which the inference pattern from the demand to the fulfillment is invalid non-DE pattern, i.e., “set-to-subset” pattern, the percentage of the “Yes” Responses was 100% (16/16).

*Results: “Unsatisfactory” Condition*

In the “Unsatisfactory” Condition, the ratio of the “Yes” Responses was significantly lower, as predicted under the hypothesis of adult-like logico-semantic competence. In evaluating the unsatisfactory demand-fulfillment in the Control items, in which the inference pattern from the demand to the fulfillment is valid non-DE pattern, i.e., “subset-to-set” pattern, the percentage of the “Yes” Responses was 19% (3/16). More specifically, in evaluating the unsatisfactory demand-fulfillments in “First-Argument” items, in which the inference pattern from the demand to the fulfillment is valid DE pattern, i.e., “set-to-subset” pattern, the percentage of the “Yes” Responses was 15% (2/13).<sup>30</sup> In evaluating the unsatisfactory demand-fulfillments in “Second-Argument”

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<sup>29</sup> Three children gave up evaluating the demand-fulfillment. No reminder worked out. Their responses were thus excluded from the analysis discussed here for the statistical reason.

<sup>30</sup> Three children could not complete the evaluation task. One was the same child who could not complete the task in the “Satisfactory” Condition as well; he could not complete the task

items, in which the inference pattern from the demand to the fulfillment was valid non-DE pattern, i.e., “subset-to-set” pattern, the percentage of the “Yes” Responses was 6.25% (1/16). These results are illustrated below.

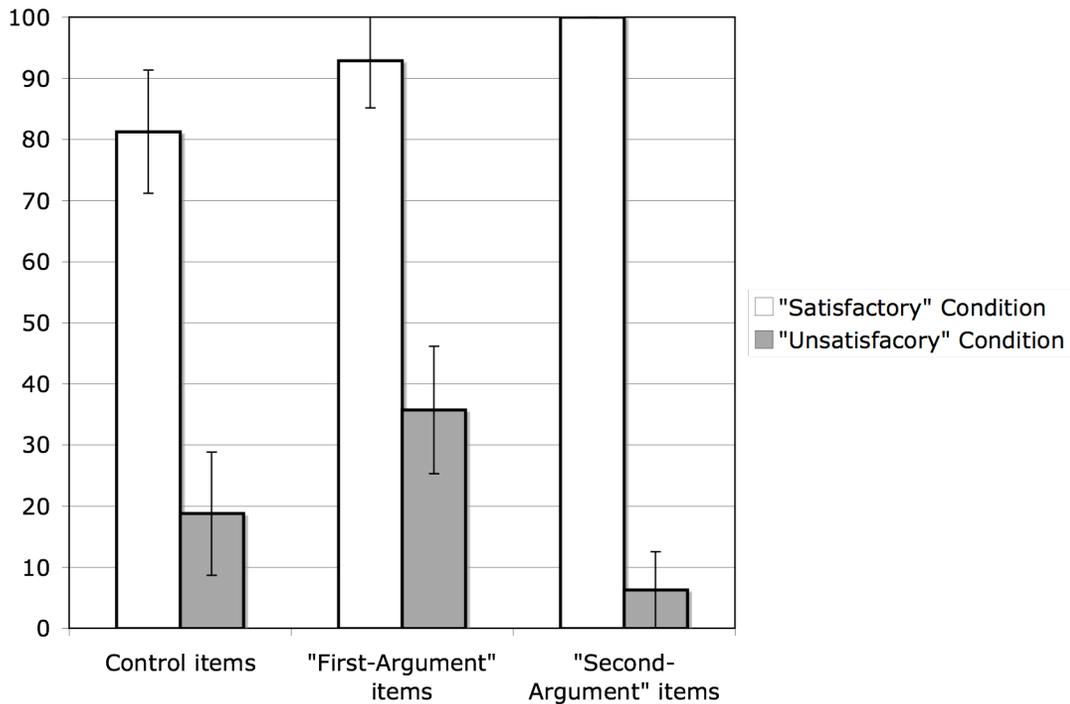
Table 9 Results-Percentages of “Yes” Responses

Condition	Validity of Inference (D) → (F)	Types of Item	Pattern of Inference (D) → (F)	% of “Yes” Responses
“Satisfactory”	Invalid	Control	Set-to-subset (Invalid non-DE)	81% (13/16)
		“First-Argument”	Subset-to-set (Invalid DE)	92% (12/13)
		“Second-Argument”	Set-to-subset (Invalid non-DE)	100% (16/16)
“Unsatisfactory	Valid	Control	Subset-to-set (Valid non-DE)	19% (3/16)
		“First-Argument”	Set-to-subset (Valid DE)	15% (2/13)
		“Second-Argument”	Subset-to-set (Valid non-DE)	6% (1/6)

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with the “First-Argument” items in both conditions (see the foot note 29). The data from these children was excluded from the analysis for the statistical reason.

Figure 15 Percentages of “Yes” Responses



A Wilcoxon Signed-Rank test was conducted to examine whether the number of “Yes” Responses observed in the “Satisfactory” Condition was significantly higher than number observed in the “Unsatisfactory” Condition. The children’s correct responses were calculated in the same way as Experiment II; a “Yes” Response was scored as 1, and a Non-“Yes” Response was scored as 0. Then the sum of the total scores in each condition was compared in terms of whether the total score for the “Satisfactory” Condition was significantly higher than the one for the “Unsatisfactory” Condition with respect to each type of items. According to the test, the total scores for the “Satisfactory Condition” were significantly higher than those for the “Unsatisfactory” Condition with respect to each type of item:  $z = -2.887, p <$

0.005 for the Control Items;  $z = -3.162$ ,  $p < 0.003$  for the “First-Argument” items;  $z = -3.873$ ,  $p < 0.001$  for the “Second-Argument” items.

A *t*-test was also conducted across-conditionally. There was a significant difference in the percentages of “Yes” Responses in each type of token:  $t(15) = 4.083$ ,  $p < 0.001$  for Control Items;  $t(12) = 6.325$ ,  $p < 0.02$  for “First-Argument” items;  $t(15) = 15.000$ ,  $p < 0.001$  for “Second-Argument” items.

#### 4.5. Discussion

The results revealed children’s sensitivity to the validity of the logical inferences between two propositions, which were reflected in the demand-fulfillment contexts, as to whether the demand is logically satisfied by the fulfillment. Therefore, the findings provides empirical evidence in favor of children’s adult-like semantic competence in computing the across-proposition meaning involving *every*.

##### 4.5.1. Children’s Sensitivities to the Entailment Patterns

Recall that the “Demand-Fulfillment” Task took advantage of the fact that the demand-fulfillment is satisfied when the inference from the demand to the fulfillment is not valid, and is not satisfied when the inference from the demand to the fulfillment is valid. Also recall that the entailment pattern determines the direction of inferences, i.e., the DE environment (the first argument of *every*) licenses inferences from a superset-denoting expression to a subset-denoting expression, while the “default” non-DE environment (the second argument of *every*) licenses inferences from a

subset-denoting expression to a superset-denoting expression. In order for children to compute the inferences in an adult-like way, they need to be aware that it is the entailment patterns that determine the direction of inferences, without being influenced by the order of the set-/subset-denoting nouns presented in the two premises. Therefore, in this task they were expected to accept the demand-fulfillment when the demand does not logically imply the fulfillment, and to reject the demand-fulfillment when the demand does logically imply the fulfillment. If children had relied on the presentational order of the set-/subset-denoting nouns, they would have presented the response patterns committing the non-adult-like errors. Thus, if it were the case, the children would have accepted the demand-fulfillment when the demands consistently contain either the superset-denoting nouns or the subset-denoting nouns, and would have rejected the demand-fulfillments when otherwise. In fact, this alternate possibility was not borne out; let us discuss it more in detail in what follows.

The fact that children were found to be aware of the direction of inferences (due to the entailment patterns) would be straightforwardly recognized when it is compared across-conditionally. For example, simply compare the Control items and “First-Argument” items across-conditionally, in terms of the order of the presentation of the set-/subset-denoting nouns.

Figure 16 Across-conditional Comparison of Control Item and Type 1 Item

	A	B	C	D	E
	Demand (D)	Fulfillment (F)	Pattern of Inference (D) $\rightarrow$ (F)	Inference (D) $\rightarrow$ (F)	Demand Satisfaction
Control	Bringing <i>an</i> X'	Bringing <i>an</i> X	Subset $\rightarrow$ Set	Valid	Unsatisfactory
	Bringing <i>an</i> X	Bringing <i>an</i> X'	Subset $\rightarrow$ Set	Invalid	Satisfactory
"First-Arg."	Bringing <i>every</i> X'	Bringing <i>every</i> X	Subset $\rightarrow$ Set	Invalid	Satisfactory
	Bringing <i>every</i> X	Bringing <i>every</i> X'	Set $\rightarrow$ Subset	Valid	Unsatisfactory

Figure 16 above illustrates the basic schema in the difference between these two types of tokens. Note that at the schematic representation above, the Control Item and "First-Argument" Item constitute minimal pairs with respect to the determiner, as Columns A and B contrastively show. If children were not sensitive to this minimal replacement of the determiner across tokens, without knowing the semantic contribution of *every* relevant in this dissertation, then they would evaluate the demand-fulfillment on the basis of the order of superset-/subset-denotations in the nouns, showing systematic errors such as: (i) they consistently provide "Yes"-Responses when the subset-denoting noun precedes the superset-denoting noun, or; (ii) they consistently provide "Yes"-Responses when the superset-denoting noun precedes the subset-denoting noun, regardless of the logical satisfaction of the demand. Let us call the first scenario "Scenario A" and the second "Scenario B" at the moment, and illustrate these possibilities in the following table:

Table 10 Alternate Response Patterns on the Basis of Noun Denotations

	A	B	C	D	E	F
	Demanded (D)	Fulfillment (F)	Pattern of Inference (D) → (F)	“Scenario A”	“Scenario B”	Demand Satisfaction
Cont.	Bringing <i>an</i> X’	Bringing <i>an</i> X	Subset → Set	YES	Non-YES	Unsatisfactory
	Bringing <i>an</i> X	Bringing <i>an</i> X’	Set → Subset	Non-YES	YES	Satisfactory
“1st- Arg.”	Bringing <i>every</i> X’	Bringing <i>every</i> X	Subset → Set	YES	Non-YES	Satisfactory
	Bringing <i>every</i> X	Bringing <i>every</i> X’	Subset → Set	Non-YES	YES	Unsatisfactory

Recall, now, that the patterns of children’s responses drawn from our experiment were indeed consistent with our prediction, i.e., “Yes”-Responses in “Satisfactory” Condition, and Non-“Yes”-Responses in “Unsatisfactory” Condition, rather than either of these two alternative scenarios. Compare Table 10 with Table 11 below, focusing on the contrast between Columns D and E on one hand and Column F/F’ on the other hand.

Table 11 Comparison between Actual and Alternate Response Patterns

	A	B	C	D	E	F'
	Demanded (D)	Fulfillment (F)	Pattern of Inference (D) → (F)	“Scenario A”	“Scenario B”	Observed Responses
Cont.	Bringing <i>an</i> X'	Bringing <i>an</i> X	Subset → Set	YES	Non-YES	Non-YES (Unsatisfactory)
	Bringing <i>an</i> X	Bringing <i>an</i> X'	Set → Subset	Non-YES	YES	YES (Satisfactory)
“First- Arg.”	Bringing <i>every</i> X'	Bringing <i>every</i> X	Subset → Set	YES	Non-YES	YES (Satisfactory)
	Bringing <i>every</i> X	Bringing <i>every</i> X'	Subset → Set	Non-YES	YES	Non-YES (Unsatisfactory)

As can be seen from the comparison, the pattern drawn from across-conditional analysis clearly shows that children’s response patterns reflect evaluation of the demand-fulfillment on the basis of the logical satisfaction of the demand rather than the order of the presentation of set-/subset-denoting nouns in the relevant positions. This demonstrates children’s sensitivity to the direction of inferences, i.e., the very source of the demand-satisfaction patterns.

4.5.2. Evaluations at the Two Phases: Before- and After-Open-the-Box

Now recall that the “Demand-Fulfillment” Task provided the two phases for children to evaluate the test items; the Before-Open-the-Box-Evaluations and the After-Open-the-Box-Evaluations. Recall that children’s responses were interpreted whether “Yes” or Non-“Yes” in terms of each of these evaluation points on the basis of the following criteria.

(99) “Yes” Responses, expected in “Satisfactory” Condition

To answer “Yes” to Grover’s question at the Before-Open-the-Box-Evaluation, AND To confirm the answer at the After-Open-the-Box-Evaluation, with checking what is inside the box.

(100) Non-“Yes” Responses, expected in “Unsatisfactory” Condition

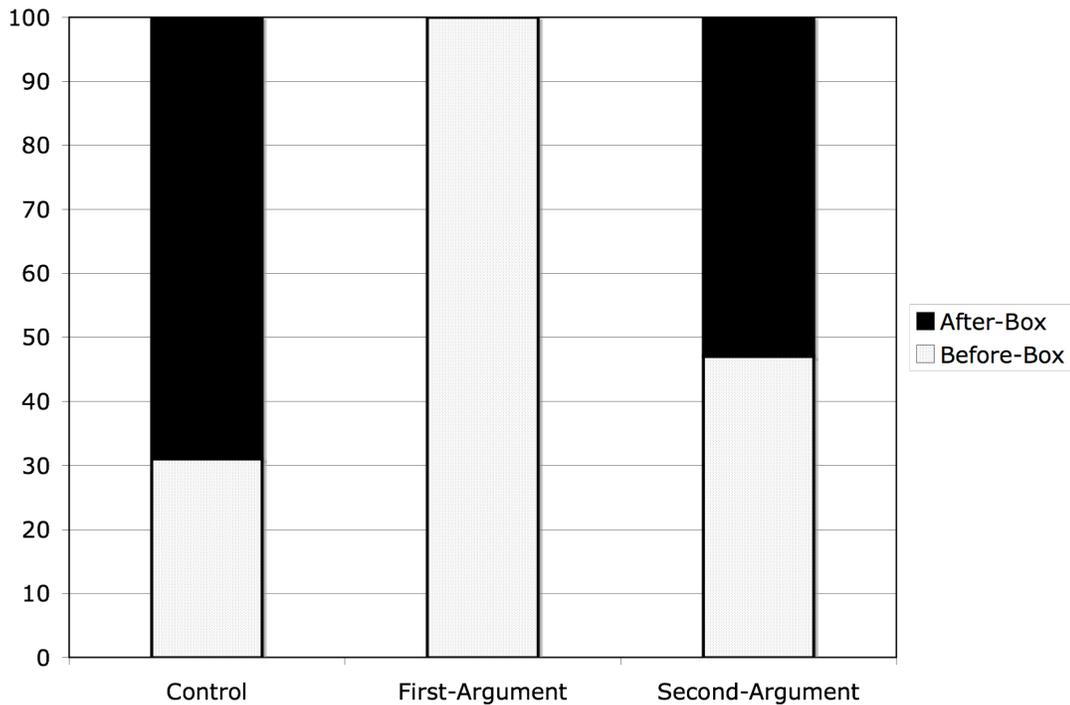
- a. To provide a negative or uncertain answer to Grover’s question at the Before-Open-the-Box-Evaluation (e.g., “No, you didn’t do something good enough”, or “I don’t know until I see what’s inside your box.”),  
OR
- b. To provide a non-negative answer to Grover’s question at the Before-Open-the-Box-Evaluation (e.g., “Yes” or “I think so”), but rejecting it at the After-Open-the-Box-Evaluation (e.g., “No, this is not what the genie wanted”)

As for the legitimate “Yes” Responses observed in the experiment, all of them met the standard in (99). On the other hand, there were two independent criteria for the legitimate Non-“Yes” Responses, (100a) and (100b), and a response can be interpreted as Non-“Yes” if it meets either one. Thus, as for the legitimate Non-“Yes” Responses, it should be an issue how many of them met the standard in (100a) and how many met the standard in (100b). The following table and chart illustrate the percentages of the Non-“Yes” Responses both at the Before-Open-the-Box-Evaluations and the After-Open-the-Box-Evaluations within the “Unsatisfactory” Condition, where the Non-“Yes” Responses were interpreted as “correct”.

Table 12 Percentages of Non-“Yes” Responses at the Before- and After-Open-the-Box-Evaluations in “Unsatisfactory” Condition

	Before-Box	After-Box
Control	31% (4/13)	69% (9/13)
“First-Argument”	100% (11/11)	0% (0/11)
“Second-Argument”	47% (7/15)	53% (8/15)

Figure 17 Percentages of Non-“Yes” Responses at the Before- and After-Open-the-Box-Evaluations in “Unsatisfactory” Condition



As can be seen above, Non-“Yes” Responses in the evaluation of the “First-Argument” items were made only at the Before-Open-the-Box-Evaluation phase, whereas those on the evaluation of the “Control” and “Second-Argument” items were made both at the Before- and After-Open-the-Box-Evaluation phases. Notice that the

“First-Argument” items in “Unsatisfactory” Conditions are the inferences in DE pattern validly created with respect to the first argument of *every*, whereas the rest of the two items (Control and “Second-Argument” items) are the valid inferences in non-DE pattern. Therefore, the contrast in discussion would serve as the additional evidence to confirm our hypothesis in which children have the sensitivity to the difference in the entailment pattern.<sup>31</sup>

Another relevant observation would be that there was an across-conditional distinction in the types of “Yes”-Responses provided at the “Before-Open-the-Box-Evaluation phase. That is, whereas all the “Yes”-Responses recorded in the “Satisfactory” Condition (i.e., the correct responses) were encoded by explicitly saying “Yes”, there were two variations in the “Yes”-Responses observed in the “Unsatisfactory” Condition (i.e., the incorrect responses): (i) by saying “Yes”; (ii) by saying “I think so”. This contrast implies that the children might have shown some sensitivity to the unsatisfactory in the demand-fulfillment, even though they failed to correctly make an explicit negative response at the Before-Open-the-Box-Evaluation in the “Unsatisfactory” Condition.

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<sup>31</sup> Why the “First-Argument” items triggered the Non-“Yes” Responses at the Before-Open-the-Box Evaluation phase (i.e., the genuine logical reasoning without relying on other non-linguistic cues) would be an interesting issue that has been brought up. One potential source of this tendency would be that the denotation of the nouns in the relevant position (i.e., the first argument of *every*) is a set, i.e., the plural objects. Recall that at the experimental workspace, the objects of the relevant set were visually presented on the screen of the laptop computer. This might have caused a saliency effect about what objects were involved in the relevant search of Grover to satisfy Genie’s demand, which might have made it easier for children to evaluate the fulfillment without looking inside Grover’s box. However, such a speculation turns out not to be the case in Experiment VI, in which the “Demand-Fulfillment” in the negative version was conducted with respect to the first argument of *every* under negation (see Chapter 7 for detail). At any rate, this issue still remains an open question at this point.

#### 4.5.3. Notes on the After-Open-the-Box-Evaluation

It should be noted that the Before-Open-the-Box-Evaluation is a genuinely logical assessment of whether the demand was logically satisfied by the fulfilling outcome in the sense that children solely rely on the propositions presented only in the linguistic material. For example, if a child could provide the expected Non-“Yes” Response at the Before-Open-the-Box-Evaluation in the “Unsatisfactory” Condition, following the genuine logical evaluation process, it would be strong evidence to demonstrate that he/she could calculate the logical relation between the demand and the fulfillment, without relying on any other non-linguistic cues. On the other hand, the After-Open-the-Box-Evaluation is made on the basis of a different kind of information, i.e., through matching between what was required in the linguistically addressed demand, and what was actually brought visually presented. Thus, one might wonder whether the After-Open-the-Box-Evaluation reflects anything about children’s logical ability to evaluate the inference between two propositions, and thus whether the After-Open-the-Box-Evaluation *per se* exhibits any aspects of children’s logical calculation between the two premises, rather than merely demonstrating their knowledge of relating what was demanded and what objects appear in the visual scene with the fulfilling outcome. Therefore, if children failed to provide the Non-“Yes” Response at the Before-Open-the-Box-Evaluation, but provided the Non-“Yes” Response at the After-Open-the-Box-Evaluation, there may be concerns whether it constitutes evidence to show their adult-like evaluation on the basis of logical reasoning.

However, we think that the After-Open-the-Box-Evaluation can be considered to be the logical evaluation on a par with the Before-Open-the-Box-Evaluation. Note

that even at the After-Open-the-Box-Evaluation phase, the linguistic description about exactly what Grover brought was not provided; Grover was uncertain about *exactly what object(s)* he brought even when opening the box, merely repeating the same fulfilling outcome verbally. Therefore, at the After-Open-the-Box-Evaluation, the visual information was newly added, but *no extraneous linguistic description* that would supplement the consequence was provided, such that children did not make a decision simply on the basis of the mere matching strategy without following the logical reasoning. What the child is expected to do at the After-Open-the-Box-Evaluation is as follows: (i) checking inside the box and see exactly what object(s) is (are) brought (e.g., collecting the information about the *color* of the object, if it was not addressed previously by what Grover said); (ii) linguistically encoding the final outcome on the basis of the visual information; (iii) evaluating the output representation of the linguistic encoding process, comparing it with the premise linguistically presented previously. Thus, the visual information provided at the After-Open-the-Box-Evaluation would *aid* children to encode the final fulfillment into the linguistic representation about what ended up happening, rather than providing the extraneous information that would guide the children going beyond the logical reasoning. Therefore, the After-Open-the-Box-Evaluation serves as the evaluation phase in which children's decision making is reflected as the output of their logical reasoning, on a par with the Before-Open-the-Box-Evaluation.

#### 4.6. Discussion of Experiments I, II and III

Let us now summarize the experimental findings that have been discussed so far. Experiment I, serving as a pre-test to investigate children's logical ability to evaluate the inferences between propositions containing the universal quantifier *every*, examined their truth value judgments of the entailing and entailed propositions individually. The children demonstrated the adult-like truth value judgments in evaluating the antecedent and the consequence of the relevant inferences, in which the antecedent is falsified and the consequence is verified at the same time in the same context. Consistent with the previous studies about children's knowledge about *every* in computing the within-propositional meanings (Crain, et al., 1996; Meroni, et al., 2000; Gualmini, 2005), Experiment I have ensured that children's sensitivity to the validity of inferences that were consequently reflected at the level of truth-conditional representation.

Experiment II was the first assessment to directly approach children's logico-semantic competence, featuring a newly designed experimental methodology called "Prediction-Rephrase" Task. The task provided the workspace for children to evaluate the two *every*-propositions sequentially presented in the dialogue between two puppets, as to whether the second proposition sounds a "good rephrase" of the first. The results suggested that the older preschoolers around the age of 6 could evaluate the logical inferences between two propositions in the way that adult do, but also highlighted the necessity to improve the experimental design to accommodate

the younger children, especially as concerns the felicity of the dialogue provided in the experimental workspace.

Based on the findings from Experiment II, we developed a modified novel experimental method called the “Demand-Fulfillment” Task. In this task, the two *every*-propositions were provided in the “demand-fulfillment” pragmatic template, in which the first proposition served the demand and the second served as the fulfillment. The crucial observation is that when the demand logically implies the fulfillment, the demand is not logically satisfied by the fulfillment, whereas when the demand does not logically imply the fulfillment, the demand is logically satisfied by the fulfillment. The children’s task was to judge whether the fulfilling outcome exhibited in the story logically satisfied the demand. The results revealed young children’s adult-like ability to distinguish the satisfactory and unsatisfactory demand-fulfillment, which in turn is a reflection of the validity of the inferences.

Taken together, Experiments I, II and III have demonstrated children’s sensitivity to the validity in the logical inferences created between the propositions containing *every*. In particular, they are aware that an inference is licensed from the set-denoting expression to the subset-denoting expression, showing the “non-default” DE pattern, in the first argument of *every*, whereas an inference is licensed from the subset-denoting expression to the set-denoting expression, showing the “default” non-DE pattern, in the second argument of *every*.

Appendix 4A: Full Script of “Demand-Fulfillment” Task

**General Lead-in**

This is a story about the genie and Grover. The genie is a great magician, but sometimes he uses his magic power to do some tricks on the other people. Now, Grover is visiting the genie’s palace. Let’s see what is going to happen.

**Trial 1: Control Item–“Satisfactory” Condition** (=97) on p. 106)

**Demand: Bring me a car.**

**Fulfillment: Bringing a red car.**

**(“Invalid” inference from Demand to Fulfillment)**

Genie: I’ll show you something interesting. Here we have Mickey Mouse (*An image of Mickey Mouse shows up on the monitor of the lap top computer*), and I will turn him into a little monster. (Magic word...) Can you believe that this little creature is in fact Mickey Mouse (*Mickey Mouse disappears and a strange monster appears instead on the monitor*)? I put a spell on Mickey Mouse, and he turned into a little monster. Hahaha.

Grover: Oh-oh, poor Mickey Mouse... Genie, that was a cool magic, but I think Mickey Mouse wants to come back. Free him!

Genie: If you want me to free him, **bring me a car**.

Grover: Ok, I will look for a car for you and will be back right away. But I’m sometimes silly and forgetful, so I have to be careful not to forget the request.

*(Grover leaves the genie’s palace and disappears. And he reappears with a box.)*

Grover: I think I got it. But I might have forgotten exactly what the genie said. So before going back to the genie’s palace, I want to make sure with you (=the child) whether I did something good enough. **I brought him a red car** in this box. Do you think it is good enough and Mickey Mouse will be freed? (=Before-Open-the-Box-Evaluation)

Child: *(Expected to say)* Yes.

Grover: Ok, now let's open the box and show it to him together.

Child: (*Open the box and see what's inside*)

Grover: Did you find something good enough to free Mickey Mouse?  
(=*After-Open-the-Box-Evaluation*)

Child: (*Expected to say*) Yes.

**Trial 2: Control Item--“Unsatisfactory” Condition** (=98) on p. 107)

**Demand: Bring me a blue train.**  
**Fulfillment: Bringing a train.**  
**(“Valid” inference from Demand to Fulfillment)**

Genie: Now we have Donald Duck (*An image of Donald Duck appears on the monitor of the lap top computer*), and I will also put a spell on Donald Duck, and he turned into a little monster (*Donald Duck disappears and a strange monster appears on the monitor*). Hahaha.

Grover: Hey Genie, you are being bad today. Oh poor Donald... Genie, I think it was a cool magic, but Donald Duck wants to come back. You should free him!

Genie: If you want me to free him, **bring me a blue train**.

Grover: Ok, I will look for one for you and will be back right away. But I'm silly and forgetful, so I should be really careful not to forget what the request is.

(*Grover leaves the genie's palace and disappears. And he reappears with a box.*)

Grover: I think I got it. But I might have forgotten exactly what the genie said. So before going back to the genie's palace, I want to make sure with you (=the child) whether I did something good enough. **I brought him a train** in this box. Do you think Donald Duck will be freed? (=Before-Open-the-Box-Evaluation)

Child: (*Expected to say*) No/I don't know/What kind of car did you bring?/I need to see inside the box... etc.

Grover: Oh-oh, did I make a mistake? Let's check inside the box together.

Child: *(Open the box; there is a yellow train)*

Grover: Do you see something good enough to make the genie happy?  
*(=After-Open-the-Box-Evaluation)*

Child: *(Expected to say)* No, it's not a blue train. It's a yellow train!

Genie: Oops, Don't you remember I told you to bring me a blue train?

Exp.: *(Child name)*, why don't you help Grover? Here is a blue train he should have brought. Can you give it to genie?

Child: *(Give a blue train to the genie)*

Genie: Very good! Thank you so much, *(Child name)*. Now I will free Donald Duck.

### **Trial 3: "First-Argument" Item—"Satisfactory" Condition**

**Demand: Bring me every gold coin.**

**Fulfillment: Bringing every coin.**

**("Invalid" inference from Demand to Fulfillment)**

Genie: Now, I will tell you something that happened yesterday. Look at my magic screen (*=the monitor*), these are my coins, the gold ones and the silver ones (*Gold and silver coins are shown on the monitor of a lap top computer*). But while I was taking a walk yesterday, I lost them somewhere. They are my treasures, and I'm not happy at all! So I will put a spell on Peter Pan here, and look, now he is a little monster, too (*The monitor shows Peter Pan, and then replaces it with a monster*). Hahaha.

Grover: Oh-oh. You are bad Genie. Free Peter Pan!

Genie: Hum, I'll tell you something. My gold coins are really precious. I want them back. I really don't care about silver coins because they are not so precious as gold ones, but the gold ones are really valuable. So, if you want me free Peter Pan, **bring me every gold coin!**

Grover: Ok, I will do so and will be back right away. But I should not be forgetful this time.

*(Grover leaves the genie's palace and disappears. He reappears with a box.)*

Grover: Ok I think I found them! But I'm afraid I might have forgotten what the request was. So before going back to the palace, I want to make sure with you (the child). **I brought him every coin**. Do you think it is good enough and Peter Pan is freed? (=Before-Open-the-Box-Evaluation)

Child: (*Expected to say*) Yes.

Grover: Thank you, (*Child name*). Genie, here is my box. (*Child name*), can you open it for him?

Child: (*Open the box. All the coins are inside.*)

Grover: Did I do something good enough to make the genie happy? (=After-Open-the-Box-Evaluation)

Child: (*Expected to say*) Yes.

Genie: Wonderful! Thank you. Now I will free Peter Pan.

#### **Trial 4: “First-Argument” Item–“Unsatisfactory” Condition**

**Demand: Bring me every dog.**

**Fulfillment: I brought you every brown dog.**

**(“Invalid” inference from Demand to Fulfillment)**

Genie: Mmm, I remember something bad that happened yesterday. I'll show you. Here is what happened to me yesterday. Look at my magic screen (=the monitor). I have cute little dogs. Brown ones and white ones (*The monitor shows the images of three of brown and white dogs*). But, they escaped from my palace! I really miss my dogs. Since I'm not happy without my dogs, I will put a spell on Nemo (*The monitor shows Nemo*). Look, now he is a little monster (*Nemo turns into a strange monster in the monitor*). Hahaha.

Grover: You should free him!

Genie: Well, I will be happy again when my dogs are back. Remember my dogs that escaped yesterday? Brown ones and white ones? So, if you want me free Nemo, **bring me every dog**!

Grover: Ok, I will do so and will be back right away. But I'm silly and forgetful, so I have to be really careful not to forget what the request is!

*(Grover leaves the genie's palace and disappears. He reappears with a box.)*

Grover: Ok I think I found them! But I'm afraid I might have forgotten what the genie said. So before going back to the palace, I want to make sure with you (the child). **I brought him every brown dog**. Do you think it is good enough and if Goofy is freed? (=Before-Open-the-Box-Evaluation)

Child: (Expected to say) No!

Grover: Oh-oh, did I make a mistake? (*Child name*), can you open the box and check insider together for him?

Child: (*Open the box. Found only the brown dogs.*)

Grover: Did I do something good enough to make the genie happy?

Child: No, you forgot the white dogs.

Genie: What? I told you to bring me every dog. Something is wrong! (*Child name*), can you help Grover to satisfy me?

Child: (*Get the white dogs from the experimenter and give them to the genie.*)

Genie: Great! Now every dog of mine has come back to me! I will free Nemo.

### **Trial 5: "Second-Argument" Item—"Satisfactory" Condition**

**Demand: Every one of you brings me a cat**

**Fulfillment: Every one of us brought you a white cat**  
**("Valid" inference from Demand to Fulfillment)**

*(At the genie's place: Big Bird (BB) and Cookie Monster (CM) joined Grover(G).)*

BB & CM: Grover, we came here to join you! Let's free the poor people from the genie's spell.

Grover: Thank you, my friends. Genie, now three of us are here. You cannot do anything bad any more!

Genie: Do you think so? Let's see. Here we have pretty Snow White (*Snow White appears on the monitor*), and... Hahaha I will put

a spell on her and look (*The monitor shows a strange monster, replacing with Snow White.*), can you believe that this little monster is in fact Snow White? Hahaha.

Three: You should free her!

Genie: Ok I will let him, if **every one of you brings me a cat**, I will free her.

Three: Got it. We will be back!

Grover: We know sometimes we are silly and forgetful. So let's now forget what the request is!

*(They disappear, and reappear with a box each.)*

Three: We think we did it! But it was so hard that we might have forgotten what the request was. So before going back to the genie's palace, let's make sure if we are right. (*Child name*), what do you think? **Every one of us brought him a white cat**. Is it good enough and Snow White freed? (=Before-Open-the-Box-Evaluation)

Child: (*Expected to say*) Yes!

Grover: Thank you, (*Child name*)! Genie, here are our boxes. (*Child name*), can you open them for genie?

Child: (*Open the boxes. Each box has a white cat.*)

Genie: Fabulous! It's a cat, a white one. Thank you. Now I will free Snow White.

### **Trial 6: "Second-Argument" Item—"Unsatisfactory" Condition**

**Demand: Every one of you brings me an orange noodle.**

**Fulfillment: Every one of us brought you a noodle.**

**("Valid" inference from Demand to Fulfillment)**

*(At Genie's Palace: Big Bird (BM) and Cookie Monster (CM) joined Grover.)*

Genie: I won't stop it, because it's fun to turn people to monsters! Now we have Simba here (*The monitor shows Simba*). I'm going to change him into a little monster too... (*Simba turns*

*into a monster on the monitor.)* Can you believe that this little monster is in fact Simba the Lion King? Hahaha.

Three: Stop being nasty! Free him!

Genie: Ok, then you all have to do something for me. I'm hungry, and want eat my favorite food, noodle... Especially I love orange ones, so remember; **every one of you brings me an orange noodle**. Then I will free him.

Three: Got it. We will be back!

Grover: Here comes another request- let's not be silly and forgetful!

*(They disappear, and reappear with a box each.)*

Heroes: We think we did it! But it was so hard that we might have forgotten what the genie said. So before going back to the genie's palace, let's make sure if we are right. (Child name), what do you think? **Every one (of us) brought a noodle**. Is Nemo freed? (=Before-Open-the-Box-Evaluation)

Child: *(Expected to say)* No/I need to see inside the box...

Grover: Oops, did we make mistakes? Let's see what genie is going to say. Genie, here are the boxes we brought. (Child name), can you open them for him?

Child: *(Open the boxes one by one. One of the boxes has an orange noodle, but two of them have a green noodle each.)*

Genie: This one has an orange noodle. Good. But this one and this one have a green noodle! These green noodles seem to be spinach flavored. I don't like spinach. I told every one of you to bring me an orange noodle!

Exp.: Maybe you can help them, (Child name). Here are some orange noodles. You can give them to genie.

Genie: Wow, orange noodles! Yummy. Thank you so much (Child name). Ok, now I will free Simba.

*Appendix 4B: Individual Responses of the Subjects*

Subject #	Age	Control (S)	Control (U)	First (S)	First (U)	Second (S)	Second (U)
Subject 1	4;2	Y	N2	Y <sup>(1)</sup>	N/A <sup>(1)</sup>	Y	N2
Subject 2	4;2	Y	N1	Y	*Y	Y	*Y
Subject 3	4;4	Y	N1	Y	N1	Y	N1
Subject 4	4;4	Y	N2	Y	N1	Y	N2
Subject 5	4;5	Y	*Y	Y	N1	Y	N2
Subject 6	4;5	*N1	N2	Y	N1	Y	N1
Subject 7	4;5	*N1	*Y	Y	*Y	Y	N2
Subject 8	4;8	Y	N2	Y	N1	Y	N2
Subject 9	4;10	*N1	N2	N/A <sup>(1)</sup>	*Y <sup>(1)</sup>	Y	N1
Subject 10	4;10	Y	N1	Y	N1	Y	N1
Subject 11	5;0	Y	N1	Y	N1	Y	N1
Subject 12	5;1	Y	N2	N/A <sup>(1)</sup>	N/A <sup>(1)</sup>	Y	N1
Subject 13	5;5	Y	N2	*N1	N1	Y	N2
Subject 14	5;6	Y	*Y	Y	N1	Y	N2
Subject 15	5;7	Y	N2	Y	N1	Y	N1
Subject 16	6;0	Y	N2	Y	N1	Y	N2

Control = Control Item

First = “First-Argument” Item

Second = “Second-Argument” Item

(S) = “Satisfactory” Condition

(U) = “Unsatisfactory” Condition

Y = “Yes” Response

N1= Non-“Yes” Response by rejection at the Before-Open-the-Box-Evaluation

N2= Non-“Yes” Response by rejection at the After-Open-the-Box-Evaluation

N/A= No answer

\* = Incorrect responses

<sup>(1)</sup>= The responses in the shaded cells were excluded from the analyses.

## Chapter 5. Reversed Entailments: Semantic Interaction with Negation

### 5.1. Semantic Interaction with Negation—The Phenomenon

The previous chapters have discussed children's ability to compute the logical inference involving the universal quantifier *every*. The experimental findings demonstrated children's competence in applying the semantic property of *every* to the computation of the logical relations between the entailing and entailed pairs of *every*-sentences. The discussion so far thus has pointed toward positive answers to both research questions we began with (originally addressed in (34)):

- (101) a. Can children compute inferences from subsets to supersets and vice versa appropriately?
- b. Does their knowledge about the universal quantifier *every* extend to the computation of the valid and invalid inferences created between propositions involving *every*?

However, in order to have a full picture of what children do or do not know regarding the encoding of meaning from sentences involving quantifiers such as *every* and the computation of inferences across related sentences involving quantification, there are additional properties to consider. As we will see, investigating these factors

will tell us more about what children know about the linguistic encoding of quantification, while providing important further testing grounds for whether children indeed compute inferences involving *every* from these linguistic structures.

So far, we have been considering the entailment patterns of the universal quantifier *every* in the ‘positive’ context. In the present chapter, we will switch our perspective to the ‘negative’ context, which will reveal an interesting feature of entailment and addresses an important issue about children’s semantic competence.

To begin, recall that the first argument of *every* yields a DE environment. As a consequence, inferences between two se-referring expressions go from set (e.g., *dog*) to subset (e.g., *brown dog*). In the sentences below, since the first argument of *every* is DE, the inference is licensed from (102a) to (102b). That is, when (102a) is true, (102b) is also true, but not vice versa.

- (102) a. The vet vaccinated [every dog in town].  
b. The vet vaccinated [every brown dog in town].

Next, recall that negation, like the first argument of *every*, triggers DE environment, as mentioned in Chapter 1. As the following example shows, both arguments of the negative quantifier *no* are DE environment (cf., Milserk 1977; Barwise and Cooper 1981, among others).

- (103) a. Elliot is interested in *no* movies.  
b. Elliot is interested in *no* French movies.

(104) Elliot is interested in *no* movies.

→ Elliot is interested in *no* French movies.

Note that (103a) which has a set-denoting expression (*movies*) entails (103b) which contains its subset-referring expression (*French movies*), but not vice versa, yielding the inference from set to subset. This typically demonstrates the pattern of a DE operator.

### Every and Negation

Keeping this in mind, let us consider the example in (105) below, in which *every* and negation both appear. Now, the *every NP* phrase shown in (102) is embedded in the first argument of a second quantifier, *no*.

(105) a. *No* vet vaccinated [every dog in town].

b. *No* vet vaccinated [every brown dog in town]. (Ludlow 2002)

(106) *No* vet vaccinated [every brown dog in town]. (= (105a))

→ *No* vet vaccinated [every dog in town]. (= (105b))

Notice that *every dog* does not entail *every brown dog* any longer, as it did in the positive context. In particular, the entailment pattern of *every* is now reversed; now *every brown dog in town* entails *every dog in town*, but not vice versa, as (106) illustrates. Consequently, the inference created between these sentences has been flipped as well, and thus we now have the opposite inference, from subset (*brown*

*dog*) to its set (*dog*). In sum, the first argument of *every* by nature DE, but its entailment is influenced by the linguistic environment in which it occurs (e.g., in context of negation), as a consequence of which the reversed pattern of entailment is generated.

These observations point to an important issue about how entailment is linguistically represented: the entailment pattern created by the universal quantifier *every* is sensitive to the linguistic environment in which it occurs. In the next section, we consider this property in more detail.

## 5.2. Entailment and Scope

The mechanism behind the phenomenon discussed in the previous section relates to the interaction between the two scope-bearing operator (negation and *every* in the present discussion), and how their scope relations are represented at the LF level. In principle, if the multiple scope-bearing operators appear in the subject and object positions in a sentence, it has been assumed that the ambiguity is yielded by the two possible LF representations, with respect to which operator takes wider scope over the other. In particular, if a scope-bearing operator appears in the subject position and another in the object position, this sentence generates the following two LF representations: one demonstrates the *isomorphic* scope representation, in which the subject is higher than the object on a par with the surface representation; the other exhibits the *inverse* scope representation, in which the object is higher than the

subject. For example, the following is one of the typical cases that demonstrate this phenomenon, as has been widely quoted.

- (107) Some professor admires every student. (May 1985)
- (108) a. For some professor  $x$  (for every student  $y$ ,  $x$  admires  $y$ ). ( $\exists > \forall$ )  
b. For every student  $y$  (for some professor  $x$ ,  $x$  admires  $y$ ). ( $\forall > \exists$ )

This ambiguity is due to the two possible LF representations assigned to the sentences (107), as illustrated in (109).

- (109) a.  $[_{IP1} \text{some professor}_i [_{IP2} \text{every student}_j [_{IP3} t_i \text{ admires } t_j]]]$  ( $\rightarrow(108a)$ )  
b.  $[_{IP1} \text{every student}_j [_{IP2} \text{some professor}_i [_{IP3} t_i \text{ admires } t_j]]]$  ( $\rightarrow(108b)$ )

The relevant technical observation is that quantifiers can undergo raising at the LF representation. The inverse scope interpretation as in (108b) is generated by the raising of the lower operator *every* to the higher position than the position in which *some* is generated, which is called *Quantifier Raising* (QR). QR has been discussed from various points of view in the past. One of the primary hypotheses about this phenomenon is the one proposed mainly by May (1977), which claimed that QR applies uniformly to all Quantifier Phrases (QPs), and in principle, any QP can be raised and adjoined to any non-argument XP.<sup>32</sup>

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<sup>32</sup> For the technical details about the QR, see May (1977, 1985) and Aoun and Li (1989). In particular, for the debate about what restrictions QR is sensitive to, see May (1977), Chomsky (1981, 1986) and Kayne (1981); for the debate about what the landing site of the QRs is, see Koopman and Sportiche (1982) and Chomsky (1986); for the debate about whether LF serves

On the other hand, it has been pointed out that the scope ambiguity due to the interaction between the multiple operators is not uniformly generated by all combinations of scope-bearing operators<sup>33</sup>; crucially, the relation between *every* in the object position and negation is one of such cases in which the scope relation between them cannot be interchangeably represented at the LF. Negation and *some* behave differently in terms of whether or not they allow *every* to raise higher than the position that they are generated; in particular, unlike the case in (107), in which the *every*-QP in the object position can raise higher than the other operator *some* in the subject position, the object *every*-QP cannot take the wide scope over the negation in the higher position. For example, Beghelli and Stowell (1997) categorized the various QPs into five major classes, and proposed the hierarchical positions for each class of QPs (Beghelli and Stowell, 1997); in that account, the LF position for the QP headed by *every* is lower than that for the negation. Putting the technical details aside at the moment,<sup>34</sup> the relevant part in their claim is that the case of the universal quantifier *every* and negation is a case in which there is no scope ambiguity; the QP headed by the universal quantifier *every* in the object position does not QR over the negation in the higher position. Ben-Shalom (1993) also discussed that the QPs with the universal quantifier *every* in the object position does not take the wide scope over the negation in simple negative sentences, taking the following sentence as an example.

(110) John did not read *every* book. ( $\neg > \forall$ ,  $*\forall > \neg$ ) (Ben-Shalom, 1993)

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as the ground for QRs to take place, see Aoun et al. (1980), Hornstein (1984) and Huang (1982), among others.

<sup>33</sup> There has been a debate about in what circumstances the scope ambiguity is yielded, as pointed out by Pietroski and Hornstein (2002).

<sup>34</sup> We will discuss their argument more in detail later.

Therefore, the universal quantifier *every* in object position of the sentences with negation (including both negative sentences containing the negative operator *no* as in (105) and simple negative sentences as in (110)) is obligatorily under the influence of the negation.

The interaction between *every* and negation at the LF level crucially triggers the reverse of the entailment that *every* evokes. More accurately, there must be a c-commanding relation<sup>35</sup> (e.g., Reinhart, 1976; Chomsky, 1986) between negation and *every*, as the following examples contrastively show.

- (111) a. No vet has vaccinated every dog in the town  
           \* → No vet has vaccinated every brown dog in the town
- b. No vet has vaccinated every brown dog in the town  
           → No vet has vaccinated every dog in the town
- c. The vet [with no experience] has vaccinated every dog in the town  
           → The vet [with no experience] has vaccinated every brown dog in the town
- d. The vet [with no experience] has vaccinated every brown dog in the town  
           \* → The vet [with no experience] has vaccinated every dog in the town

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<sup>35</sup> In the current discussion, we will assume that children possess the hierarchical structural representation, which provides the c-commanding relation, as has been positively discussed in a number of previous studies (e.g., Crain, 1991; Crain, Gardner, Gualmini and Rabbin, 2002; Lidz and Musolino, 2002; Meroni, Minai, Gualmini and Crain, 2003; Minai, 2004; Minai and Crain, 2004).

Therefore, as a result of being c-commanded by the higher negation at the LF, the DE environment which *every* creates in its first argument by nature is canceled by the interaction with the negation, and thus its first argument is no longer DE.

### 5.3. Issues in Child Language

The discussion in the previous sections constitutes an important set of issues in child language; (i) whether children are aware that the QPs in the object position headed by the universal quantifier *every* is under the influence of the negation; (ii) whether they are aware that, as a result of the interaction between *every* and *negation*, the entailment of *every*-QPs in the object position is reversed. Considering these issues directly relate the research question addressed in (34a), i.e., whether children are able to compute the superset-to-set and set-to-superset inferences appropriately, expanding this question to a new aspect of linguistic-to-logical mapping (logico-semantics), namely the non-local dependency among the universal quantifier and negation. In what follows, we will revisit the research questions, taking the reversed entailment into our consideration.

### Research Questions Revisited

The interactions among operators in yielding logical forms are a critical ingredient in logico-semantic competence. Probing children's knowledge of these interactions will bring us closer to the goal of fully understanding children's logico-semantic competence, and more deeply understanding the linguistic knowledge that children

bring to bear on this task. In particular, in order for a child to compute the reversed inferences due to the reversed entailment appropriately, he/she has to be aware of the semantic interaction between operators such as *every* and negation. In order for him/her to compute the semantic interaction between the negation and the universal quantifier *every* in an adult-like way, they must know the following facts.

- (112) a. The universal quantifier *every* constitutes a DE environment in its first argument.
- b. The universal quantifier *every* does not QR over the negation in the higher position, and thus it must be interpreted under the scope of the negation.<sup>36</sup>
- c. Consequently, the entailment created in the first argument of *every* is reversed due to the influence of the negation, and thus it is no longer DE in this environment.

Considering the above scenario, we now have a new testing ground by which to extend the research questions addressed in (34) regarding children's ability to validate the logical inference as a consequence of the entailment structure that *every* creates.

The reversed entailment discussed here thus constitutes another important case for the current discussion of children's ability to compute the inferences appropriately, in which the inferences should be evaluated appropriately, not only on the basis of the semantic feature of *every* but also on the basis of the linguistic

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<sup>36</sup> This fact itself relies on computations over hierarchical representations using c-command, as noted above.

environment that *every* appears. Hence it expands the original question in (34); if children are able to compute the inferences from subset to superset and vice versa appropriately, they should be sensitive to the reversed version of the entailment created in the *every*-QP under the negation. Answering the question in this way would consequently be informative regarding the status of the properties described in (112b) and (112c) in children's grammar; for example, an investigation of *every* and negation, which probes whether children can represent the scope relation between *every* and negation in an adult-like way, may shed light the nature of children's knowledge of scope phenomena, which is of crucial interest in understanding how children construct meanings from surface structures.

Additional relating issue, regarding what children know about the properties of quantificational elements in their grammar, involves whether and how children know that a scope ambiguity is not yielded by the interaction between the negation and *every* in the lower position; this problem is made clear when we see that while the universal quantifier *every* in the object position does not QR over the negation in the higher position, other highly similar quantifiers, such as *each*, do not share this property with *every*. We describe this important contrast and its impact on representing and testing semantic knowledge in children, and the suggestive implication from our experiments in Chapter 8.

The phenomena of reversed entailment described above thus provides an important additional ground for us to consider whether children are able to compute the valid and invalid inferences containing *every* appropriately, and what that implies about children's linguistic knowledge. Let us revisit our major research questions, in

light of the reversed entailment properties that have been shown to be a part of the syntax, semantics and logic of quantification.

(113) Research Question – Revisited

Can children compute inference from subsets to supersets and vice versa appropriately, not only on the basis of the entailment property of an operator but also on the basis of the semantic interaction between two operators? In particular:

- a. Do they know that the truth conditions of each sentence involved in an inference licensed by the reversed entailment?
- b. Can they compute the valid inference between sentences in which the relevant entailment is reversed under the influence of the semantic interaction between the two operators?

In the following chapters, we report the experiments to consider this question. On a par with the discussion of the Experiments I, II and III, we utilize the Truth Value Judgment Task in order to examine whether children are aware of the truth values of the entailing and entailed sentences individually (Experiments IV and V). Then we will move ahead to report Experiment VI, utilizing the “Demand-Fulfillment” Task, in order to directly test children’s ability to compute the reversed direction in which logical inferences are licensed across *every*-sentences with reversed entailments in the *every*-QP under negation.

## Chapter 6. Experiments IV and V: Truth Conditional Evaluation of Each Proposition–Reversed Entailment

### 6.1. EXPERIMENT IV

In this chapter, we will consider children’s knowledge regarding the reversed entailment of *every*-QP under negation, focusing on whether children are able to compute the relevant inferences licensed in an opposite way compared with *every*-QP in positive contexts, due to reversed entailment. Before directly assessing children’s sensitivity to the changes in inference pattern due to reversed entailment patterns in *every* under negation, we first ensure whether children are able to evaluate the truth values of the antecedent and the consequence of the relevant inference, using the Truth Value Judgment task (Crain and McKee, 1985; Gordon, 1996; Crain and Thornton, 1998). Thus, Experiment IV was designed to investigate the following issue: whether children are aware of the reversed entailment pattern in the first argument of *every* appearing in the negative context, and its consequence in determining the truth conditions of the entailed and entailing negative sentences containing *every*-QP in object position. Hence, in Experiment IV we investigate the object-position *every*-QP embedded in the scope of the subject-position negative operator *nobody* as a case study, focusing on children’s interpretation of the minimal-paired sentences as in (114).<sup>37</sup>

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<sup>37</sup> Gualmini and Crain (2002) have revealed children’s knowledge that the partitive expression *none of the Ns* creates a DE environment in both first and second arguments. Given that *nobody* is semantically equivalent to *none of the Ns*, we assume that children

- (114) a. Nobody fed every dog.  
b. Nobody fed every brown dog.

In order for children to compute the meanings of minimal-paired *every*-sentences that also contain *nobody* as in (114), they need to know the following factors that determine the truth-conditional meanings of these sentences: (i) the entailment property of *every*-QP (i.e., DE); (ii) the entailment property of *nobody* (i.e., DE); (iii) the structural relation between *every*-QP and *nobody* (i.e., c-command).

To what extent do children know about the three linguistic devices above? Here are the insights from the previous studies. As for (i), we have thus far discussed children's highly sophisticated knowledge about the universal quantifier *every*, which were found to be applied not only at the level of composition of meanings (i.e., the evaluation of the truth conditional meaning of sentences with *every*) but also at the level of comparison of meanings (i.e., the evaluation of the inferential relations between sentences with *every*). As for (ii) and (iii), a number of studies have reported children's highly sophisticated knowledge about DE property of negation (e.g., Crain, et al., 2002; Gualmini and Crain, 2002) and about the hierarchical linguistic representation via c-command (e.g., Crain, 1991; Crain, et al., 2002; Lidz and Musolino, 2002; Meroni, et al., 2003; Minai, 2004; Minai, in press).

Given these findings, Experiment IV aims at investigating the following hypothesis.

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know that *nobody* is DE in both first and second arguments, as well as that *every* is DE in its first argument.

(115) Hypothesis: Experiment IV

Children would be able to correctly compute the truth values assigned to the entailing and entailed sentences that contain *every* and *nobody*, on the basis of their knowledge about the DE property of *every* and *nobody* and the interaction between them via c-commanding dependency.

6.1.1. Logic

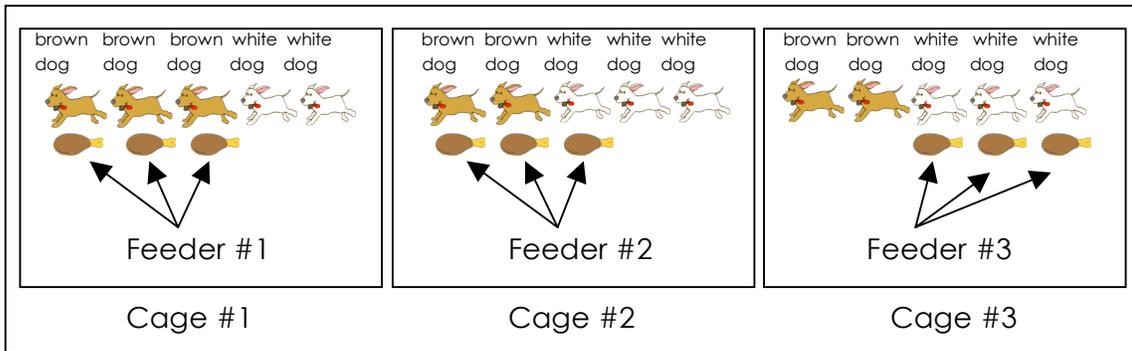
The experimental design of Experiment IV is virtually the same as that of Experiment I. That is, two virtually minimal-paired sentences, entailing and entailed, were presented in the same context, which assigns contrastive truth values to the two sentences, based on the inference patterns due to the entailment of the quantifier *every*. In Experiment IV, the *every*-QP was crucially in the object position and the negative operator *nobody* is the subject. Hence the relevant entailment with respect to *every*-QP is no longer DE due to the interaction with *nobody*. Consequently, the relevant inference pattern is the default (non-DE) pattern, from the subset-denoting expression to its related superset-denoting expression.

Consider the sample minimal-paired sentences as in (114), repeated below as in (116).

- (116) a. Nobody fed every dog.  
b. Nobody fed every brown dog.

Imagine a situation in which there are three cages for dogs, each of which contains a few brown dogs and white dogs. Suppose that there are three feeders, and that each feeder goes to a cage and feeds a few of the dogs in that cage, as illustrated in Figure 18.

Figure 18 Basic Paradigm



Note that the feeder #1 fed all the brown dogs but not the white dogs in his cage; the feeder #2 fed one of the white dog and two of the brown ones, but not the rest in his cage; the feeder #3 fed all the white dogs but not the brown dogs in his cage. Consider the description as in (116a) presented in the context as in Figure 18; it is true in the situation illustrated above that “Nobody fed every dog”, because none of the characters fed all the dogs in his cage. Now, consider the sentence (116b), in which the noun *dog* is replaced with its subset-denoting noun *brown dog*; it is false in the same situation, because the feeder #1 fed all the brown dogs, even though he did not feed all the dogs in his cage. Therefore, we say that (116b) entails (116a); as a consequence, it licenses the inference from the subset-denoting noun *brown dog* in

(116b) to the set-denoting noun *dog* in (116a), showing the “default” non-DE pattern, i.e., the reversed DE in *every*-QP under negation.

Hence, we have observed the following relation between the sentences in (116).

- (117) a. Nobody fed every dog (=116a)  
          \* → Nobody fed every brown dog (=116b)  
      b. Nobody fed every brown dog (=116b)  
          → Nobody fed every dog (=116a)

Experiment IV was designed on the basis of the above paradigm, and thus the experimental stimuli were virtually the same as the entailing and entailed pair of sentences shown in (116); likewise, the stimuli were presented in a context virtually identical to that illustrated in Figure 18.

### 6.1.2. Experimental Design

Two experimental conditions, the “True” Condition and the “False” Condition, were generated; the true sentences and false sentences were presented in virtually identical contexts. The sentences prepared for each condition were listed below.

(118) “True” Condition

a. Nobody could clean every chocolate guy.

b. Nobody could rescue every dolphin.

(119) “False” Condition

a. Nobody could feed every big koala bear.

b. Nobody could reward every black horse.

Each child was presented all the sentences above, with an equal number of fillers; the full set of trials was balanced regarding the number of expected affirmative and negative responses.

Contexts:

There are always the three domains in all the contexts, in each of which a character has to take care of five props in a certain way. The five props in each domain can be divided into two groups according to size or color, providing the needed set-subset relations. The three characters always succeed to take care of three props in the domain, which sometimes includes all the members of a subset, but none of them succeed to take care of all the props in the domain. This is the crucial context that assigns the contrasting truth conditions to the minimal-paired sentences containing a set/subset-referring expression in the first argument of *every*.

“True” Condition

Let us review the experimental conditions. A typical trial for “True” Condition is presented in (120) below.

(120) Sample trial: “Cleaning the Chocolate Guys” Story

This is a story about the children from the Simpsons cartoon. Bart (big brother), Lisa (little sister) and Maggie (baby girl) are each in their own room. There are five chocolate containers, M&M’s Chocolate Guys (M&M’s characters which are hollow, and come filled with chocolate), in each room. A few of them in each room are red, and a few of them are green. They used to be full of chocolate, but now they are empty because the Simpsons children have eaten all of the chocolate. So the chocolate guys feel really empty and they want to be filled up once again. Bart, Lisa and Maggie decide to clean the chocolate guys first before they fill them up with chocolates, so they have brought chocolate-guy-cleaning kits (cotton swabs) with them. Bart cleaned all three green chocolate guys on the left hand side in his room, but then he found his cleaning kit bag empty. So he apologized to the green chocolate guys, which he could not clean. Lisa said; “I can do it better. I will start from the opposite side than Bart did.” She started cleaning the green chocolate guys on the right hand side in her room. She cleaned all the green chocolate guys, and then it was the red chocolate guys’ turn to be cleaned. She finished cleaning the first red one, but then she also found that she ran out of the cleaning kits. So she apologized the rest of the green chocolate guys, which she could not clean. Little Maggie said: “I can do it better. I will start with the red ones. That should be the way!” She started cleaning the red chocolate guys. She cleaned all the red chocolate guys and finally it was the green ones’ turn to be cleaned, but, alas, Maggie also found that her cleaning kit was empty. She could not go on any more, and apologized the green chocolate guys.

The final outcome of this story is shown in the picture below.

Figure 19 “Cleaning the Chocolate Guys” Story: The Final Outcome

 Green M&M's   Green M&M's   Green M&M's   Red M&M's   Red M&M's	 Green M&M's   Green M&M's   Red M&M's   Red M&M's   Red M&M's	 Red M&M's   Red M&M's   Red M&M's   Green M&M's   Green M&M's
 Bart	 Maggie	 Lisa
 = unclean chocolate guy;  = cleaned chocolate guy		
Target sentence presented in this outcome: (118a) Nobody could clean every <u>chocolate guy</u> . (True) (cf. Nobody could clean every <u>red chocolate guy</u> . (=122))		

The test sentence (118a) (repeated in (121) below) was presented at the end of this story in the same way as Experiments I, i.e., the puppet described what he thinks happened in the story.

(121) Nobody could clean every chocolate guy.

Note that this sentence is true, since none of them succeeded to clean all the chocolate guys in their rooms.

Compare (121) with the sentence (122) below, in which *chocolate guy* is replaced with *red chocolate guy*.

(122) Nobody could clean every red chocolate guy.

Note that (122) is virtually the same as the test sentences in “False” Condition that will be described below, had we replaced the set-denoting expression *chocolate guy* with its subset-denoting expression *red chocolate guy*; this sentence becomes false in the same context, since Maggie cleaned all the red chocolate guys, even though she could not clean the green chocolate guys.

### “False” Condition

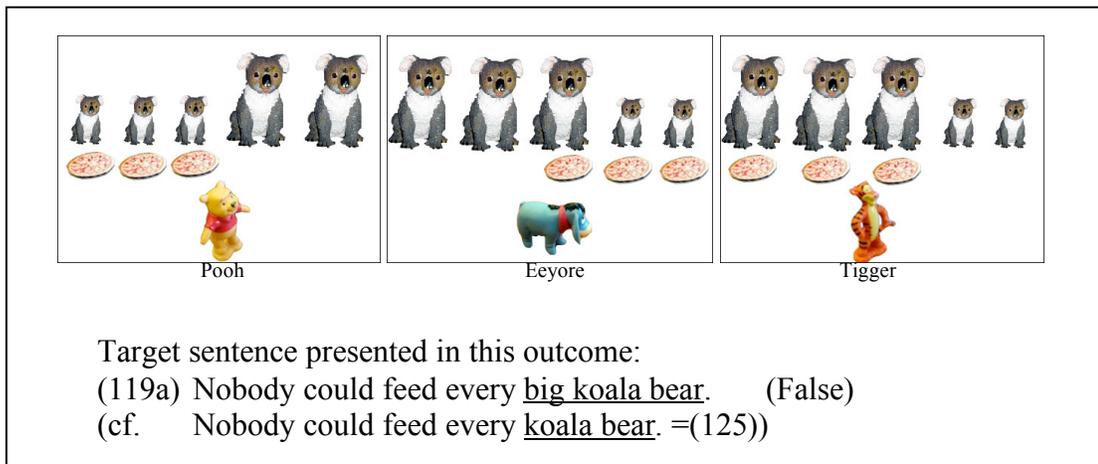
Now, let us survey the other condition. The following is a sample trial of “False” Condition, in which the predicted response is ‘wrong’. Note that the plot is eventually the same one in “True” Condition.

#### (123) Sample trial: “Zoo” Story

This is a story about a zoo. There are three zoo-keepers, and they have to feed 5 koala bears each. The koala bears are divided among three different cages. The three zoo-keepers are Eeyore, Tigger and Winnie the Pooh. Each zoo-keeper’s job is to feed the five koala bears in one of the cages. In Eeyore’s cage, there are three small koala bears and two big ones. In Tigger and Winnie the Pooh’s cages, there are three big koala bears and two small koala bears. Eeyore has a bunch of pizzas and he starts feeding the small koala bears, but he soon realizes that he doesn’t have enough pizzas to feed the big koala bears. Then it’s Tigger’s turn. He says: “I will do better than you.” He starts feeding the small koala bears in his cage, and he manages to give a pizza to both of the small koala bears in his cage and to one of the big ones, before running out of pizzas. Finally, it’s Winnie the Pooh’s turn. He says: “I know why you didn’t make it! You have to start by feeding the big koala bears!” So he gives a pizza to each of the big koala bears in his cage, but he also runs out of pizzas, so the two small koala bears in his cage do not get fed.

The final outcome of this story is shown in Figure 20 below.

Figure 20 “Zoo” Story: The Final Outcome



The relevant observation is as follows: Tigger has managed to feed all the big koala bears in his cage, but no zoo-keeper has managed to feed all of the koala bears in his cage.

(124) Nobody could feed every big koala bear.

Given the context that is described above, the sentence is false, because Tigger managed to feed all of the big koala bears in his cage, although the small koala bears in the cage were not fed. The puppet narrated the sentence (46) in describing what he thinks happened in the story, after the story was acted out.

Compare (124) with (125) below, in which *koala bear* is substituted for *big koala bear*.

(125) Nobody could feed every koala bear.

Note that (125) is virtually the same as the sentences used in “True” Condition, such as (121). Crucially, presented in the same context, (125) becomes true, because all of them failed to feed all of the koala bears in their cage. This is virtually the identical situation presented in “True” Condition.

### 6.1.3. Predictions

If children are aware of the fact that the entailment pattern with regard to *every*-QP in the object is reversed because of the interaction with *nobody* in the subject, as we have hypothesized in (115), then they are expected to be able to appropriately compute the truth values of the entailing and entailed sentences containing *nobody* and *every*.

Alternatively, let us consider the following hypothesis, in which children would show the non-adult-like truth value judgments in interpreting the target sentences. Recall that, in order for children to compute the truth values of the test sentences in an adult-like way, they ought to know the outcomes addressed in (169) and (170), which is condensed and repeated below.

- (126) a. The universal quantifier *every* constitutes a DE environment in its first argument.
- b. The universal quantifier *every* does not QR over the negation, and thus it must be interpreted under the scope of negation; on the other hand,

another universal quantifier *each* obligatorily QRs over the negation, and thus it must be interpreted over the scope of the negation.

- c. Consequently, the entailment created in the first argument of *every* is reversed due to the influence of the negation, and thus it is no longer DE.

As for (126a), we have already concluded that children know this; the experiments that have been discussed in the previous chapters (Experiments I, II and III), as well as the previous studies demonstrating children's adult-like knowledge about *every* (e.g., Crain, et al., 1996; Meroni, et al., 2000; Gualmini, 2005), have suggested children's highly sophisticated knowledge about *every*, applying to their semantic computation.

Therefore, if children would not be aware of the reversed entailment, and thus would compute the truth values of the sentences as if *every* remained DE under negation, it would reflect their lack of knowledge about the restriction barring *every*'s QR over negation. Children would allow *every*-QP in the object position to raise at the higher LF position (e.g., the Spec of the DistP, as Beghelli and Stowell (1997) claimed), as a result of which *every*-QR remains free from being bound by the negation and thus remains a DE environment. An alternate scenario for this possibility would be that children would wrongly treat *every* as if it were equivalent to *each*, ignoring the fact that *each*, unlike *every*, is not influenced by the negation to reverse the entailment *each*-QR licenses, on the basis of (126b).

### Subjects

Twenty-one English-speaking children aged from 4;0 to 6;2 (mean age 4;11) participated in this experiment. The participants were children enrolled for the Center for Young Children at University of Maryland, College Park; all participants had their parental permission to participate in the study. The children were tested one by one in a separate quiet room with the experimenters.

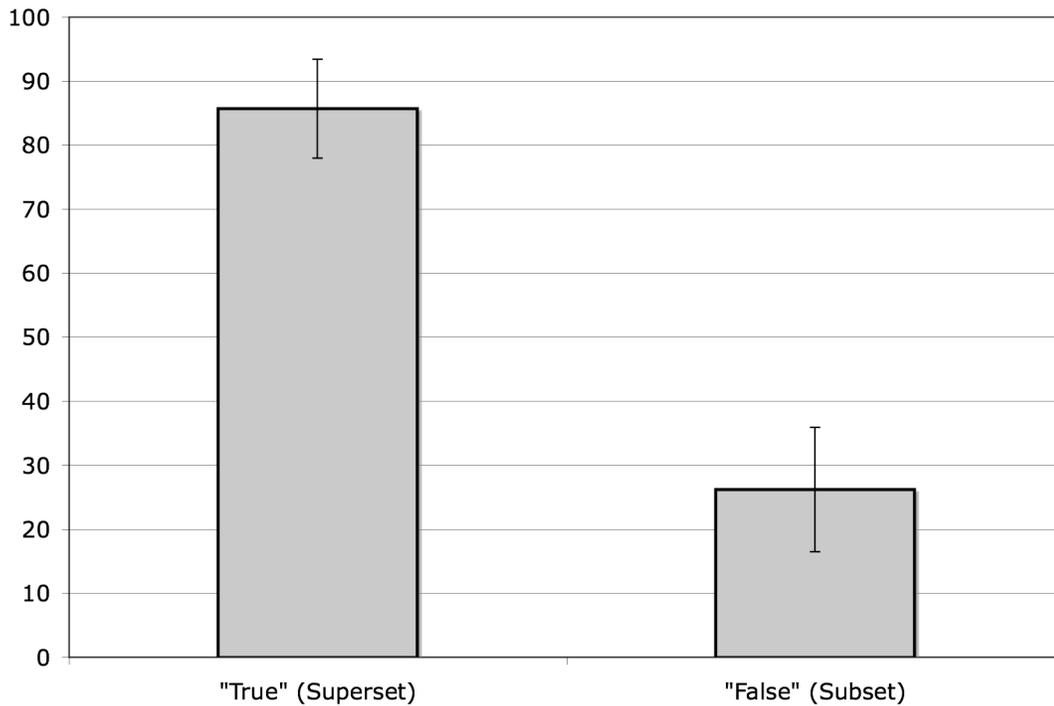
### 6.1.4. Results

We calculated the percentages of the acceptance, i.e., “true” judgments, in each condition. In “True” Condition, in which the acceptance was expected, children accepted the test sentences 86% of the time (36/42; Standard Error = 5.465); on the other hand, in “False” Condition, in which the acceptance was not the expected adult-like responses, their ratio of acceptance was significantly lower, 26% of the time (11/42; Standard Error = 6.867). These results are schematically illustrated below.

Table 13 Percentages of the Acceptances

	“True” Condition	“False” Condition
Percentage of Acceptances	86% (36/42)	27% (11/42)

Figure 21 Percentages of the Acceptances



A Wilcoxon Signed-Rank test was conducted to examine whether there is a significant difference in the rates of acceptance between the “True” Condition and the “False” Condition. Each acceptance was scored as 1, and the total scores were compared condition by condition. According to the test, the rates of acceptances observed in “True” Condition was significantly higher than that observed in “False” Condition,  $z = -4.642$ ,  $p < 0.001$ .

A  $t$ -test was also conducted to examine whether the percentage of acceptances in the “True” Condition was significantly higher than that in the “False” Condition. According to the  $t$ -test, there was a significant difference between conditions,  $t(41) = 6.574$ ,  $p < 0.0001$ , Standard Error Mean = 9.055.

### 6.1.5. Discussion

On the basis of the results, we reject the null hypothesis, concluding that children are aware of the fact that the *every*-QP in the object of the sentences with *nobody* in the subject is no longer DE, and thus the entailment pattern and the truth value assignment to the entailing and entailed sentences containing *nobody* and *every*-QP are reversed. Experiment IV thus revealed children's sophisticated interpretations of quite complex sentences, such as those in (117) and (118), in which a quantifier phrase is embedded in the scope of another quantifier.<sup>38</sup>

In the following part of this chapter, we will report a control experiment in which another quantifier which patterns in the opposite direction regarding entailment is substituted for *every*. If children are indeed accessing the deep logic behind the surface forms to compute sentence meaning, they will be sensitive to the opposite truth conditions that are assigned due to the opposite entailment patterns created by the substituted quantifier. Thus, if this prediction would be borne out in the control experiment, the conclusion that was drawn from Experiment IV would be supported by further empirical evidence.

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<sup>38</sup> Minai (2004), Minai and Crain (2004) and Minai (in press) pointed out that, to the extent that a model lacks the representation of such non-local dependency via c-command, the model would face difficulties to account for the findings that children are aware of the non-local dependency between *nobody* and *every*-QP (cf., Goldberg, 2003; Tomasello, 1995, 2000, 2003).

## 6.2. EXPERIMENT V: CONTROL

Experiment V was thus conducted as a control in order to confirm whether children's interpretation of two quantifiers in a sentence is due to the consequences of the deep logic that underlies their behavior, and that their computation of the individual sentence meanings is based on the interaction between the two quantifiers. Except for the following minimum change in stimuli, the experimental design was virtually the same as Experiment IV; the crucial difference in the stimuli is that *every* is substituted for by another quantifier, *lots of*, which yields the opposite entailment pattern compared with *every*, by its being non-DE operator by nature.<sup>39</sup> Thus, due to this substitution, the adult-like entailment patterns become the opposite of those in Experiment IV. In examining whether children are sensitive to this minimum substitution that would crucially reverse the entire patterning of the truth value assignments, we aim at confirming children's ability to compute the semantic interaction at a deeper level.

In order for children to correctly compute the entailing and entailed sentences that contain *lots of* and *nobody*, they need to be sensitive to the following linguistic devices: (i) the entailment properties of *lots of* (i.e., non-DE by nature); (ii) the entailment properties of *nobody* (i.e., DE by nature); (iii) the hierarchical linguistic representation (i.e., c-commanding dependency between *lots of* and *nobody* that triggers the reverse of the entailment of *lots of*).

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<sup>39</sup> As we will discuss later, we treat *lots of* as the semantic equivalence of *many*, assuming Barwise and Cooper's (1981) categorization in which *many* is a non-DE operator.

Thus far we have discussed children's highly sophisticated knowledge regarding (ii) and (iii) that were proven in a number of past studies (see 6.2. in the current chapter). Thus the remaining issue is to what extent children know about *lots of*, as described in (i) above. According to Krämer (2005), children are found to be able to compute the meanings of sentences containing *many*.<sup>40</sup> On the basis of their findings, we would assume that children possess the ability to compute the semantics of *lots of*, and would hypothesize as follows, with respect to their truth value judgments of the minimal-paired sentences that contain *nobody* and *lots of*.

(127) Hypothesis: Experiment V

Children would be able to correctly compute the truth values assigned to the entailing and entailed sentences that contain *lots of* and *nobody*, on the basis of their knowledge about the non-DE property of *lots of* and *nobody* and the interaction between them via c-commanding dependency, resulting in reversing the entailment that *lots of* evokes.

If this hypothesis is borne out, it would provide the additional evidence to supplement the findings from Experiment IV, demonstrating children's sensitivity to the semantic interaction between *every* and *nobody* on one hand and *lots of* and *nobody* on the other.

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<sup>40</sup> In what follows, we will briefly describe that the interpretation of *many* is ambiguous with respect to (i) cardinality under "weak" interpretation (ii) proportion under "strong" interpretation (Partee 1989). Krämer pointed out children's preference for cardinal (weak) interpretations of *many*, which contrasts with the adults' preference for proportional (strong) interpretations in a context. However, in an adjusted experimental context children showed the adult-like interpretation, demonstrating that the apparent non-adult preference is not the evidence of their lack of knowledge.

### 6.2.1. Logic

The basic design adopted in Experiment IV was replicated, and virtually the same contexts were prepared for presentation with the test sentences. Crucially, we substitute *lots of* for *every* in the sentences used in the previous experiment, yielding the pairs of sentences listed below, which have similar apparent meaning to those in (117) and (118). Two of the target sentences, containing subset-referring expressions as listed in, are targets for which the expected adult-like answer is “True” (“True” Condition below). The other two target sentences, containing set-referring expressions, have “False” adult-like responses (“False” Condition below).

(128) “True” Condition

- a. Nobody could catch lots of blue aliens.
- b. Nobody could carry lots of striped cats.

(129) “False” Condition

- a. Nobody could get lots of dogs.
- b. Nobody could eat lots of noodles.

Each child heard all the test sentences listed above. Each child was also presented with an equal number of fillers to balance the number of the expected true and false responses.

Notes on the Use of the Weak Quantifier Lots Of

The substitution of *every* with *lots of* brings up a few additional issues that merit discussion. In particular, *lots of* may introduce other factors that would interfere with children's interpretation, when presented in the experimental workspace, and that might blur our experimental objective.

First, assuming that *lots of* is a semantic equivalent of another quantifier *many*, we see the categorical distinction between *lots of/many* and *every*; *many* is categorized as a weak quantifier, while universal quantifiers including *every* are classified as strong quantifiers (Milsark, 1977; Barwise and Cooper, 1981). The distinction between weak and strong quantifiers is based on the difference in their behavior in some linguistic environment. Milsark's (1977) original diagnosis in determining the strong/weak quantifiers, which was essentially preserved in Barwise and Cooper's detailed categorization of quantifiers, is whether a quantifier creates noun phrases acceptable in sentences after *there is* or *there are*. According to this diagnosis, the major quantifiers in English language can be categorized as follows.

(130) Strong/Weak Quantifiers in English (cf., Barwise and Cooper 1981)

Weak	Strong
<i>a</i>	<i>the 1, the 2, ...</i>
<i>some</i>	<i>both</i>
<i>one, two, three ...</i>	<i>all</i>
<u><i>many</i></u>	<u><i>every</i></u>
<i>a few</i>	<i>each</i>
<i>few</i>	<i>most</i>
<i>no</i>	<i>neither</i> (negative strong)

In addition, there is also a clear distinction between *many/lots of* and *every* with respect to their interpretations. The interpretation of *many/lots of* requires some sense of context dependence, and thus how many counts as *lots of* is determined depending on the context. Furthermore, Partee (1989) pointed out that the interpretation of *many* evokes the ambiguity between *cardinal reading* and *proportional reading*, and the context dependence holds in either meaning. On the other hand, the interpretation of *every* is not context dependent.

Given the discussion above, in order to make *lots of* felicitous on both readings, we conducted a pilot study to test what children require for proportional and cardinal readings. In particular, we examined how many objects children accept as referring to *lots of* Xs, i.e., how many objects can be accepted as a minimal cardinality. According to this study, there should be at least five of the X's in the experimental workspace to license *lots of* X's. As for the proportional reading, our pilot revealed that children accepted the two-thirds of objects as being *lots of*.

Taken together, our observations determined that there should be at least five objects, to allow for a minimal cardinality of objects for *lots of*, and two-thirds of the objects should be included under *lots of* in the experimental workspace, in order to proportionally license *lots of*. Therefore, we combined the toy props so that that each subset had 6 or 7 members, so that we could felicitously represent *lots of* within a subset; since we presented two subsets that can be referred to as one set in one domain, each domain had 13 objects. This pattern was used in each of the target stories used in Experiment V.

### 6.2.2. Experimental Design

In order to investigate the above hypothesis, Experiment V was designed in the following way.

#### “True” Condition

A typical trial for the “True” Condition is presented below.<sup>41</sup>

#### (131) Sample trial: “Alien Catching Game” Story

This is a story about three children from the Rugrats cartoon: Chucky, Tommy and Lil. They came to a theme park, and decided to play the “alien catching game”. Each of them has got his/her own playing field where there are 13 aliens, 6 blue aliens and 7 red aliens. Using a catching tool, each of them took a turn. First, Chucky tried. He could only catch four aliens, two blue ones and two red ones. Second, Tommy tried. He, too, could only catch four aliens, two blue ones and two red ones. Finally, it was Lil’s turn. Before starting, she thought of a good idea: to make the catching tool bigger, in order to catch many aliens. With this brilliant idea, she could do a great job; she caught 9 aliens including all seven of the red aliens, even though she could only catch two of the blue aliens.

The final outcome that is presented in the end of this story is illustrated in the following figure.

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<sup>41</sup> Full script of all the stories used in this experiment will be presented in Appendix 7B.

Figure 22 “Alien Catching Game” Story: The Final Outcome

blue = blue alien; red = red alien; = was caught

Target sentence presented in this outcome:  
 (128a) Nobody could catch lots of blue aliens. (True)  
 (cf. Nobody could catch lots of aliens. =(132))

The test sentence (128a), which is repeated below in (132), was presented, by which the puppet’s offering his description of what he thinks happened in the story.

(132) Nobody could catch lots of blue aliens.

Given such a situation, the test sentence (132) should be judged as true, since none of the characters succeeded to catch many blue aliens, even though one of the characters, Lil, could catch many aliens (i.e., she caught all the red aliens but only two blue aliens, which still makes the total 9 out of 13).

Compare (132) with the sentence (133), in which *blue alien* is replaced with its superset-denoting counterpart, *aliens*.

(133) Nobody could clean lots of aliens.

Given the same context as described above, (133) becomes false, since Lil caught 9 aliens out of 13, which can count as *lots of* according to our calculation. Note that, despite the fact that *lots of* is similar to *every* in the surface meaning in the sense that both quantifiers denote a plural number of set members, the sentences in (132) and (133), validate the inference from subset-denoting expression to its set-denoting expression (*aliens* and *blue aliens*).

### “False” Condition

The following is a typical trial for “False” Condition.

#### (134) Sample trial: “Noodle Party” Story

This is a story about Hello Kitty, who invented a brand new recipe for noodles. She cooked many green noodles and orange noodles, and invited three friends of hers, Skinny Genie, Big Genie and Blue Genie, to her “Noodle Party”. The three genies happily came to the party and had a noodle dish served to each of them, which had 7 orange noodles and 6 green noodles. Skinny Genie said, “Wow many noodles, green ones and orange ones. But honestly speaking, I don’t like noodles so much... but it’s very nice of Kitty to serve her new recipe, so I will try to eat this many.” He took 2 orange noodles and 2 green noodles. Big Genie said, “Wow I love noodles! But I was silly, I ate a big chocolate cake right before I came here, so I’m not so hungry... It’s a shame, but I cannot eat so many noodles!” He took 2 orange noodles and 2 green noodles. Blue Genie said, “Wow I love noodles! They look yummy, but, I don’t like spinach, and the green noodles look like spinach flavored. So I will eat this many.” He took all the orange noodles and put them on his plate, and two of the green noodles.

The final outcome of this story is shown in the following picture.

Figure 23 “Noodle Party” Story: The Final Outcome

green = green noodle; orange = orange noodle; = was eaten

Target sentence presented in this outcome:  
 (129b) Nobody could eat lots of noodles. (False)  
 (cf. Nobody could eat lots of green noodles. =(136))

With this situation presented, the puppet describes what he thinks happened in the story, which gave the test sentence (129b), which is repeated in (135) below.

(135) Nobody could eat lots of noodles.

Given the context illustrated above, this test sentence is false, the Blue Genie ate 9 noodles out of 13, which counts as *lots of* in our observation.

Compare (135) with the sentence (136) below, in which *noodles* is replaced with its subset-denoting counterpart, *green noodles*.

(136) Nobody could eat lots of green noodles.

Given the same context as described above, (136) becomes true, since all the characters, including Blue Genie who ate the most, only ate two of the green noodles served, which does not count as *lots of*.

### 6.2.3. Predictions

The experimental hypothesis was that children would not respond based on the apparent similar meaning of the quantifiers *lots of* and *every*. Thus, when they would evaluate the sentences in (128a) and (129b) relative to the context in (131) and (134), respectively, they would be able to judge the entailing and entailed sentences in the way that they reflect which entails which in the opposing truth values. In particular, they should know that the entailments with regard to the denotation of *lots of*-QPs under negation pattern on a par with the DE operator as a consequence of the semantic interaction between them. Therefore, they could falsify the sentence containing the set-denoting noun in the *lots of*-QP, which is entailing the other, relative to the context; contrarily, they could verify the sentence containing the subset-denoting noun in the *lots of*-QP, which is entailed by the other, relative to the context.

On the other hand, another hypothesis would predict the reverse pattern in children's responses. In particular, children would treat *lots of* as if it were a DE operator by nature (on a par with *every*), and thus would reverse its DE property under negation, resulting in a non-DE pattern. Thus, children falsify the sentence with the subset-denoting noun in the *lots of*-QP (i.e., entailing sentence) relative to the

context, and verify the sentence containing the set-denoting noun in the *lots of*-QP (i.e., entailed sentence) relative to the context. If this would be borne out, it could be suggested that children may have been influenced by the similar surface meaning that *every* and *lots of* share, and that they would treat both as if they were semantically equivalent in terms of the entailment representation. Under such a scenario, one might reconsider whether children's apparently adult-like truth value judgment observed in Experiment IV was actually the output of their semantic computation accessing the interaction between *nobody* and *every*.

### Subjects

Twenty-two English-speaking children aged from 3;11 to 6;3, whose average age is 5;0, participated in this experiment. The participants were children enrolled for the Center for Young Children at University of Maryland, College Park; all participants had their parental permission to participate in the study. The children were tested one by one in a separate quiet room with the experimenters.

### 6.2.4. Results

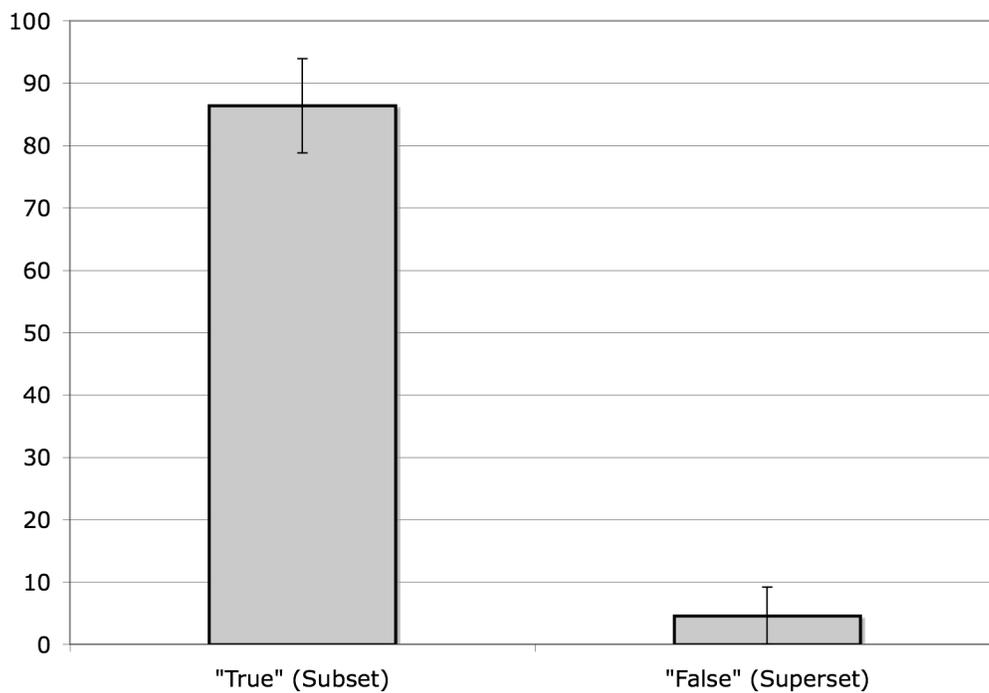
We calculated the percentage of the acceptance of the sentences in each condition. In "True" Condition, in which the acceptance was the expected responses, children showed 86% of acceptance (38/44; Standard Error = 5.233); in "False" Condition, in which the acceptance counted as the incorrect responses, their percentage of

acceptance was 5% (2/44; Standard Error = 3.177). These results are illustrated below.

Table 14 Percentages of the Acceptance

	"True" condition	"False" condition
Percentage of Acceptance	86% (38/44)	5% (2/44)

Figure 24 Percentages of the Acceptance



A Wilcoxon Signed-Rank test was conducted to examine whether there is a significant difference in the rates of acceptance between the "True" Condition and the "False" Condition. Each acceptance was scored as 1, and the total scores were

compared condition by condition. According to the test, the rates of acceptance observed in the “True” Condition were significantly higher than those observed in the “False” Condition,  $z = -6.000, p < 0.0001$ .

A *t*-test was also conducted, which revealed a significant difference across condition,  $t(43) = 13.91, p < 0.0001$ , Standard Error Mean = 5.882.

Therefore, the results were consistent with the experimental hypothesis, in which children were sensitive to the replacement of the elements in the sentences, *every* with *lots of*, even though they share the similar apparent meaning. Despite the reversed pattern of entailments, children could interpret the test sentences presented in the crucial context in an adult-like way.

#### 6.2.5. Discussion

The findings demonstrate the following two points. First, children were not influenced by the apparent similar meaning of quantifiers on the surface. Secondly, children computed the sentence meaning accessing the logic beneath surface forms. These points are consistent with the discussion about their ability to distinguish *every* and *each*, which we have discussed in Chapter 5. The relevant implication is that even though *every* and *each* are hugely similar, children would not confuse them either, knowing that *every* does not have the movement property that *each* has.

In pursuing further studies in the same vein, the most direct way to approach these issues would be to use the original two operator, *every* and negation, but put them outside the c-commanding relationship. Based on our conclusion that children

are sensitive to the mechanisms of the semantic interaction between two operators, i.e., the reverse entailment due to the c-commanding relationship at the LF, we could predict that children are aware of the following facts: *every*-QP, without being c-commanded by the upper negation, remains DE; thus the sentences like (137) create an inference in a DE pattern, i.e., from a set-denoting expression (*dog*) to a subset-denoting expression (*brown dog*); thus in a certain context, (137a) is false and (137b) is true.

- (137) a. The boy with no hat fed every dog.  
b. The boy with no hat fed every brown dog.

### 6.3. Discussion of Experiments IV and V

Experiment IV was conducted to examine whether children are able to compute the meanings of the *every*-sentences forming a minimal-pair with respect to the *every*-QP that appears in the scope of *nobody*. This objective in turn questions whether children are sensitive to the reversed entailment pattern evoked by *every* under the influence of *nobody* and its consequence represented in the reversed pattern of the opposing truth values assigned to the entailing and entailed sentences. The findings demonstrated children's adult-like ability to compute the truth values of the minimal-paired sentences containing *every* and *nobody* and their sensitivity to the interaction between *every* and *nobody*.

Experiment V, serving as the control of Experiment IV, revealed children's adult-like interpretation of the minimal-paired sentences containing *lots of* instead of *every* (which yield the opposite patterns of entailment, and by extension, the opposite direction of inference created between sentences). Recall that the minimum replacement of *every* with *lots of* in the paradigm crucially reverses the entailment pattern, and thus reverses the truth value assignments to the entailing and entailed sentences, although the quantifiers share a similar "surface" meaning. The findings suggest that children had no difficulty discriminating among these two quantifiers despite the similar surface meaning of *lots of* and *every*; this in turn suggests that they accessed the semantic features of these two quantifiers, confirming their adult-like computation of the truth values of the minimal-paired *every*-sentences with *nobody*, even when the relevant entailment was reversed due to the interaction between *every* and *nobody*.

Having shown that children are able to compute the individual sentence meanings at the within-propositional level even when this involves a semantic interaction between two quantifiers, we are ready to move ahead to investigate whether children are able to compute the semantic interaction between the two quantifiers for encoding across-proposition meaning. To do so, we turn once again to the "Demand-Fulfillment" Task in Experiment VI, which will be reported in the following chapter.

*Appendix 6A: Full Sentences and Stories provided in Experiment IV*

**Trial** (=120) on p. 152)

Story: This is a story about the children from the Simpsons cartoon. Bart (big brother), Lisa (little sister) and Maggie (baby girl) are each in their own room. There are five chocolate containers, M&M's Chocolate Guys (M&M's characters which are hollow, and come filled with chocolate), in each room. A few of them in each room are red, and a few of them are green. They used to be full of chocolate, but now they are empty because the Simpsons children have eaten all of the chocolate. So the chocolate guys feel really empty and they want to be filled up once again. Bart, Lisa and Maggie decide to clean the chocolate guys first before they fill them up with chocolates, so they have brought chocolate-guy-cleaning kits (cotton swabs) with them. Bart cleaned all three green chocolate guys on the left hand side in his room, but then he found his cleaning kit bag empty. So he apologized to the green chocolate guys, which he could not clean. Lisa said; "I can do it better. I will start from the opposite side than Bart did." She started cleaning the green chocolate guys on the right hand side in her room. She cleaned all the green chocolate guys, and then it was the red chocolate guys' turn to be cleaned. She finished cleaning the first red one, but then she also found that she ran out of the cleaning kits. So she apologized the rest of the green chocolate guys, which she could not clean. Little Maggie said: "I can do it better. I will start with the red ones. That should be the way!" She started cleaning the red chocolate guys. She cleaned all the red chocolate guys and finally it was the green ones' turn to be cleaned, but, alas, Maggie also found that her cleaning kit was empty. She could not go on any more, and apologized the green chocolate guys.

Target sentence: (1) Nobody could clean every chocolate guy. (True)

**Trial 2**

Story: This is a story about three farmers who have five horses their farms each. Each of them has a few of black horses and brown horses in his farm. One day, they decided to give them a reward because they have been working so hard these days. The first farmer started to give a reward. He rewarded all the first black horses in his farm, and it is brown horses' turn to be rewarded. However, the farmer found him out of rewards already! So he apologized to the brown horses. The second farmer started to give a reward. He rewarded all the first black horses in his farm, and he gave a reward to one of the brown horses. However, he found him out of rewards already, even though he still has two brown

horses to reward. So he apologized the brown horses. Now, the third farmer started. He gave a reward to all the brown horses in his farm, and it is the black horses' turn to receive rewards. However, the farmer found him out of rewards already! So he apologized the black horses.

Target sentence: (2) Nobody could reward every black horse. (False)

### **Trial 3**

Story: This is a story about three pirates who are sailing a big ocean. One day, a big wave attacked each of their ship. Their ships were fine, but each of them found that there were a few of black dolphins and gray dolphins launched on the deck! There is no water on their deck, so the dolphins are having a hard time! So they decided to rescue the dolphin into the small pool that they loaded on their ship. The first pirate started to rescue the dolphins in his ship. He rescued all the black dolphins in his ship, putting them in his pool. Now it is gray dolphins' turn to be rescued. But the pirate found that his little pool is already full. So he went to the cabin of his ship to find something else to put the water and the gray dolphins. The second pirate started to rescue the dolphins in his ship. He rescued all the black dolphin and one gray dolphin in his ship, putting them in his pool. But he found that his little pool is already full, even though he still has two gray dolphins to be saved! So he ran into the cabin to look for another pool. The third pirate started. He rescued all the gray dolphins in his ship, putting them in his pool. Then he found that his little pool is already full, even though the black dolphins are still on the deck to be saved! So he dashed into the cabin to look for another pool.

Target sentence: (3) Nobody could rescue every dolphin. (True)

### **Trial 4** (=123) on p. 154)

Story: This is a story about a zoo. There are three zoo-keepers, and they have to feed 5 koala bears each. The koala bears are divided among three different cages. The three zoo-keepers are Eeyore, Tigger and Winnie the Pooh. Each zoo-keeper's job is to feed the five koala bears in one of the cages. In Eeyore's cage, there are three small koala bears and two big ones. In Tigger and Winnie the Pooh's cages, there are three big koala bears and two small koala bears. Eeyore has a bunch of pizzas and he starts feeding the small koala bears, but he soon realizes that he doesn't have enough pizzas to feed the big koala bears. Then it's Tigger's turn. He says: "I will do better than you." He starts feeding the small koala bears in his cage, and he manages to give a pizza to both of the small koala bears in his cage and to one of the big

ones, before running out of pizzas. Finally, it's Winnie the Pooh's turn. He says: "I know why you didn't make it! You have to start by feeding the big koala bears!" So he gives a pizza to each of the big koala bears in his cage, but he also runs out of pizzas, so the two small koala bears in his cage do not get fed.

Target sentence: (4) Nobody could feed every big koala bear. (False)

*Appendix 6B: Individual Responses of the Subjects: Experiment IV*

Subject #	Age	Target (1) (T)	Target (2) (F)	Target (3) (T)	Target (4) (F)
Subject 1	4;0	*W	*R	*W	*R
Subject 2	4;0	R	W	R	*R
Subject 3	4;5	R	W	R	W
Subject 4	4;5	R	R	R	W
Subject 5	4;6	R	RW <sup>(2)</sup>	R	RW <sup>(2)</sup>
Subject 6	4;7	R	W	R	W
Subject 7	4;8	R	*R	R	*R
Subject 8	4;9	*W	W	*W	W
Subject 9	4;10	R	W	R	W
Subject 10	4;10	R	W	R	W
Subject 11	4;10	R	W	R	W
Subject 12	4;10	R	W	R	W
Subject 13	4;11	R	*R	R	W
Subject 14	5;0	R	W	R	W
Subject 15	5;1	R	W	R	*R
Subject 16	5;1	*W	W	*W	W
Subject 17	5;1	R	*R	R	*R
Subject 18	5;5	R	W	R	W
Subject 19	5;6	RW <sup>(1)</sup>	W	R	*R
Subject 20	5;8	R	W	R	W
Subject 21	6;2	R	W	R	W

(T) = “True” Condition

(F) = “False” Condition

R = “Right” responses (Judged as “True”)

W = “Wrong” responses (Judged as “False”)

\* = Incorrect responses

<sup>(1)</sup> = provided the correct description with the incorrect response (interpreted as “correct”)

<sup>(2)</sup> = provided the correct description with both correct and incorrect response (“yes and no”; interpreted as “correct”)

*Appendix 6C: Full Sentences and Stories provided in Experiment V*

**Trial 1** (=131) on p. 166)

Story: This is a story about three children from the Rugrats cartoon: Chucky, Tommy and Lil. They came to a theme park, and decided to play the “alien catching game”. Each of them has got his/her own playing field where there are 13 aliens, 6 blue aliens and 7 red aliens. Using a catching tool, each of them took a turn. First, Chucky tried. He could only catch four aliens, two blue ones and two red ones. Second, Tommy tried. He, too, could only catch four aliens, two blue ones and two red ones. Finally, it was Lil’s turn. Before starting, she thought of a good idea: to make the catching tool bigger, in order to catch many aliens. With this brilliant idea, she could do a great job; she caught 9 aliens including all seven of the red aliens, even though she could only catch two of the blue aliens.

Target sentence: (1) Nobody could catch lots of blue aliens. (True)

**Trial 2**

Story: This is a story about a funny game called “Dog-calling game”. The three characters, Cookie Monster, Grover and Big Bird, will participate in this game. Each of them is in a field, where there are several brown dogs and spotted dogs. They each will show a tasty food to the dogs in his field, and make as many dogs as possible come toward him. Let’s see how many dogs they can attract with their food. Cookie Monster said: “I’ll go first. I have the tastiest food in the world, a cookie! I’m sure that dogs also love cookies, and that I can make many of them come. OK, dogs, if you want to have a bite, please come to me now.” In the end, two brown dogs and two spotted dogs came to Cookie Monster. Now, Grover is ready. He said: “Hey, look at this, dogs! The tastiest food in the world, a donut! Please come to me if you want to have a bite!” In the end, Grover got two brown dogs and two spotted dogs. Now, it’s Big Bird’s turn. He said: “I know much about dogs, and I’m sure that their favorite food is this--- a bone! Hey dogs, look, I have a big yummy bone for you. If you want to have a bite, come to me right now!” Big Bird had a better idea than the others. Finally he got many of them, all the brown dogs and two of the spotted dogs.

Target sentence: (2) Nobody could get lots of dogs. (False)

### **Trial 3**

Story: This is a story about three islands, each of which has several white cats and striped cats on it. They are called cats' islands! But, the cats look a bit sad, because they want to leave the islands and go back to their home. Unfortunately, they cannot go back by themselves, because they have to swim in the ocean to get out of the islands--- they are afraid of water! So, three characters, Dwarf, Smurf and Gumby, stood up to pick up the cats. They each sailed the ocean in their ships and arrived at three islands each. Dwarf talked to the cats in the first island: "Hey cats! I'm here with my cool ship to pick you up. Let's go home together, and ride on my ship!" The cats were happy, but when two of the white cats and two of the striped cats got on his ship, Dwarf found that his ship is already full. So he said to the rest of the cats: "Oops, sorry my ship is already full. I have to go now, but I will be back very soon." Now, Smurf arrived at another island and talked to the cats there: "Hey cats! Don't be afraid because I'm here to pick you up. Get on my ship now." The cats were really happy, but when two of the white cats and two of the striped cats got on his ship, Smurf found that his ship is already full. So he said to the rest of the cats: "Oops, sorry, my ship was a bit too small. I have to go now, but I will be back after I send these cats back." Now, Gumby arrived at the other island. He talked to the cats there: "Hey, here I am with my big ship! Get on my ship, and let's go home together!" The cats were really happy. But, Gumby's big ship was also a bit too small; when all the white cats and two of the striped cats got on, it's already out of space! So Gumby said to the rest of the cats: "Oh-oh, my ship is still too small! But don't worry, I will be back soon after I send these cats back. So wait for me."

Target sentence:       (3)     Nobody could carry lots of striped cats. (True)

### **Trial 4** (=134) on p. 168)

Story: This is a story about Hello Kitty, who invented a brand new recipe for noodles. She cooked many green noodles and orange noodles, and invited three friends of hers, Skinny Genie, Big Genie and Blue Genie, to her "Noodle Party". The three genies happily came to the party and had a noodle dish served to each of them, which had 7 orange noodles and 6 green noodles. Skinny Genie said, "Wow many noodles, green ones and orange ones. But honestly speaking, I don't like noodles so much... but it's very nice of Kitty to serve her new recipe, so I will try to eat this many." He took 2 orange noodles and 2 green noodles. Big Genie said, "Wow I love noodles! But I was silly, I ate a big chocolate cake right before I came here, so I'm not so hungry... It's a shame, but

I cannot eat so many noodles!” He took 2 orange noodles and 2 green noodles. Blue Genie said, “Wow I love noodles! They look yummy, but, I don’t like spinach, and the green noodles look like spinach flavored. So I will eat this many.” He took all the orange noodles and put them on his plate, and two of the green noodles.

Target sentence: (4) Nobody could eat lots of noodles. (False)

*Appendix 6D: Individual Responses of the Subjects: Experiment V*

Subject #	Age	Target (1) (T)	Target (2) (F)	Target (3) (T)	Target (4) (F)
Subject 1	3;11	R	W	R	W
Subject 2	4;1	*W	W	*W	W
Subject 3	4;1	*W	W	R	W
Subject 4	4;2	R	W	*W	W
Subject 5	4;5	R	*R	R	*R
Subject 6	4;6	R	W	R	W
Subject 7	4;6	R	W	R	W
Subject 8	4;8	R	W	R	W
Subject 9	4;10	R	W	R	W
Subject 10	4;10	R	W	R	W
Subject 11	4;11	R	W	R	W
Subject 12	4;11	R	W	R	W
Subject 13	5;2	R	W	R	W
Subject 14	5;2	R	W	R	W
Subject 15	5;3	R	W	R	W
Subject 16	5;3	R	W	R	W
Subject 17	5;5	R	W	R	W
Subject 18	5;9	R	W	R	W
Subject 19	5;10	*W	W	*W	W
Subject 20	5;11	R	W	R	W
Subject 21	6;3	R	W	R	W
Subject 22	6;3	R	W	R	W

(T) = "True" Condition

(F) = "False" Condition

R = "Right" responses (Judged as "True")

W = "Wrong" responses (Judged as "False")

\* = Incorrect responses

## Chapter 7. Experiment VI: Evaluation of Inference between Propositions–Reversed Entailment

Given that children were found to be aware of the truth conditions of the entailing and entailed sentences containing *every* and *nobody*, in which the entailment regarding *every* is reversed due to the interaction with *nobody*, this chapter will be devoted to reporting Experiment VI, investigating whether children are able to compute the inferences created between entailing and entailed sentences with *every* and *nobody*.

Recall that we have discussed the following findings thus far: (i) children know the asymmetric entailments that the first and second arguments of *every* yield in the composition of the truth conditional meanings for the individual entailing and entailed *every*-sentences (Experiment I); (ii) children know the asymmetric entailments that the first and second arguments of *every* yield in the comparison of the inferential relations between the entailing and entailed *every*-sentences (Experiments II and III); (iii) children know the fact that the pattern of the DE that *every*-QP creates is reversed by the interaction with *nobody* that c-commands *every*-QP in the composition of the truth conditional meanings for the individual entailing and entailed sentences containing *every* and *nobody* (Experiments IV and V). Given these findings that we have drawn thus far, we will provide the hypothesis as in (138) to be investigated in Experiment VI.

(138) Hypothesis: Experiment VI

Children would be able to evaluate the validity of inferences that are created between the entailing and entailed sentences that contain *every* and negation, on the basis of the logical consequence (i.e., the reverse of DE in *every*-QP under the c-commanding negation) that determines the pattern of inferences.

In order to examine this hypothesis, we have developed a negative version of “Demand-Fulfillment” Task, adopting the same basic logic as for Experiment III (“Demand-fulfillment” in positive context), discussed in Chapter 4. In designing the negative version of this task, the additional attention was paid in order to create a felicitous context in which a “negative demand” can be naturally uttered, in order to exclude the risk that some infelicitous factor would interfere with children’s judgments.

7.1. Logic

We once again rely on the logical foundation of the Demand-Fulfillment task discussed in Chapter 4 in designing Experiment VI: the “demand-fulfillment” context is capable of reflecting the direction of inferences by virtue of whether the demand can be logically satisfied by the fulfillment. Let us start with reviewing the logic that underlies the demand-fulfillment contexts which represents the inferential relation between the two premises.

Repeated below is the summary of the basic logic behind the “Demand-Fulfillment” Task.

Figure 25 Relation among Sentences in Inference and Demand-Satisfaction (= Figure 8)

Demanded Outcome (D)	Fulfillment Outcome (F)	Inference (D) → (F)	Demand Satisfaction
John brings a <u>pen</u>	John brings a <u>red pen</u>	Invalid	Satisfactory
John brings a <u>red pen</u>	John brings a <u>pen</u>	Valid	Unsatisfactory

In Experiment VI, the negative versions of the outcomes illustrated above were prepared. On a par with Figure 25, the demand-fulfillment paradigm in the negative version is schematized in Figure 26 below.

Figure 26 Relation among Negative Sentences in Inference and Demand-Satisfaction

Demanded Outcome (D)	Fulfillment Outcome (F)	Inference (D) → (F)	Demand Satisfaction
John doesn't bring any <u>pen</u>	John doesn't bring any <u>red pen</u>	Valid	Unsatisfactory
John doesn't bring any <u>red pen</u>	John doesn't bring any <u>pen</u>	Invalid	Satisfactory

As Figure 26 show, demand-fulfillment can serve as an indicator of direction of inference; next, we review the design of Experiment VI, including specific aspects of the contexts which served to make specifically ‘negative’ demands felicitous.

## 7.2. Experimental Design–“Demand-Fulfillment” Task, Negative Version

We aim to investigate the above hypothesis in designing the experiment featuring the “Demand-Fulfillment” Task in Negative Version, which will be discussed in detail in what follows.

### 7.2.1. Basic Plot

First, let us review the basic plot or story line in which each demand-fulfillment will take place. The basic structure of the plot will be virtually identical to that of the “Demand-Fulfillment” task in Experiment III. In the present plot, Ursula, the queen of the ocean who has the magic power, served as the demander. Ursula put spells on various characters (the process of putting a spell on each character was presented in animated images in Microsoft PowerPoint format on the monitor of a laptop computer, which was called Ursula’s ‘magic screen’ in the story). Grover serves as the main fulfiller; Big Bird and Cookie Monster occasionally join (depending on the type of item, which we will discuss below) or replace him (simply for the purpose of entertaining children). Ursula demanded that Grover bring her something, but, crucially, not to bring certain other objects. Grover served as the fulfiller of her demand, who is slightly forgetful and always doing something that is very close, but not exactly, what the demander requested.

Grover leaves for a while to find the things Ursula wants. The object(s) that Ursula referred to in the negative demand, and the one(s) that Grover avoids bringing in the fulfilling outcome are related, forming set-subset relations; for example, Ursula

demands Grover not to bring a car, and Grover does not bring a red car (bringing something else), Ursula demands Grover not to bring a blue train, and Grover does not bring a train (bringing something else), and so on.

Just as in Experiment III (demand-fulfillment in positive context), what Grover brought was carried in the closed bag, and what Grover did not bring was also kept out of the visual scene (this was done by having Grover search for objects outside of the participant's sight, as we will see below). What the child could see was only a depiction of the entire set of potential objects which Grover would work on in responding Ursula's demand, shown up on the laptop (i.e., "Ursula's magic screen").

Grover, when he comes back from the search, tells the child what he did not bring to Ursula, attempting to follow her rule, without showing what is in his bag, and asks the child whether what he did met Ursula's rule about what he was forbidden to bring. After the child answered Grover's question, he/she was asked to open the bag and to show what is inside to Ursula. If it turned out that Grover could satisfy Ursula's demand, not bringing the objects she did not like, the spell was removed and the character was set free on the screen. If it turned out that Grover failed to satisfy Ursula's demand, bringing something that violated her prohibition, the child was asked to help Grover correct his mistake. In the end, the character was freed as well.

The following shows an outline of the basic plot.

(139) Basic Plot (Negative Version) – Simplified Outline

- a. Ursula puts a spell on a character. (The transformation of the character is shown in the animation on the display of the laptop computer “Ursula’s magic screen”.)
- b. Ursula presents the demand < *the negative demand presented* >  
“If you want me to free this character, you should bring me more than one thing, but remember one condition; don’t bring me X.”
- c. Grover leaves for a while and comes back with a bag.
- d. Grover tells the child what is inside the bag, and what was left, without showing it < *the fulfilling outcome presented* >  
“I brought her some things, but I didn’t bring her X’ (using a set- or subset- denoting phrase (e.g., a red ball, every ball, etc).”
- e. After the child answers, Grover lets the child open the bag and see what is inside.
- f. If Grover satisfies Ursula, then the spell was resolved.
- g. If Grover failed to satisfy Ursula, then the child was asked to correct Grover’s mistake, helping the character being freed.

7.2.2. Experimental Conditions and Stimuli

As in Experiment III, two experimental conditions were generated: “Satisfactory” Condition, in which the demand is logically satisfied by the fulfilling outcome (e.g., the request *don’t bring me a red pen* is logically satisfied by the fulfillment *I didn’t bring you a pen*), and thus the demand does not logically imply the fulfillment (e.g.,

*there are no red pens, \*therefore there are no pens*); “Unsatisfactory” Condition, in which the demand is not logically satisfied by the fulfilling outcome (e.g., the request *don’t bring me a pen* is not logically satisfied by the fulfillment *I didn’t bring you a red pen*), and thus the demand does logically imply the fulfillment (e.g., *there is no pens, therefore there is no red pens*).

We prepared the three types of stimuli (i.e., the propositions about “bringing”) to be used both in “Satisfactory” Condition and “Unsatisfactory” Condition. The stimuli can be categorized into the following three types: *Negative Control Item* served as a control item presenting simple negative sentences without *every*; “*Simple Negation*” items served as a test case in which the simple negative sentences including *every*-QP in the object position; “*None-Every*” items served as another test case, in which the sentence include *none* in the subject position and *every*-QP in the object position, respectively. All the stimuli were listed below.

(140) “Satisfactory” Condition

a. Negative Control Item

i) Demand: “Don’t bring me any red ring.”

ii) Response: “I didn’t bring you any ring.”

b. “Simple Negation” Item

i) Demand: “Don’t bring me every apple.”

ii) Response: “I didn’t bring you every red apple.”

- c. “None-Every” Item
  - i) Demand: “None of you should bring me every candy.”
  - ii) Response: “None of us brought you every red candy.”

(141) “Unsatisfactory” Condition

- a. Negative Control Item
  - i) Demand: “Don’t bring me any robot.”
  - ii) Response: “I didn’t bring you any red robot.”
- b. “Simple Negation” Item
  - i) Demand: “Don’t bring me every gold coin.”
  - ii) Response: “I didn’t bring you every coin.”
- c. “None-Every” Item
  - i) Demand: “None of you should bring me every red crab.”
  - ii) Response: “None of us brought you every crab.”

7.2.3. Notes on Felicity in Presenting Negative Demands

A crucial methodological issue in presenting negative demands in the experiment is how to create a context in which the negative demand is presented as part of a felicitous exchange. We determined that a major prerequisite for a negative demand to be felicitous in context would be that it is presented as a condition to be met in order to satisfactorily complete an affirmative demand. In our case, this can be achieved by introducing the negative demand as a condition to be met in order to successfully complete an affirmative request to bring objects: thus Ursula’s whole request would not simply be “don’t bring X”; rather, the request is for bringing of

objects selectively among a set, such as “You should bring me X, but don’t bring me Y”. Therefore, care was taken for the negative demands to be presented as a condition or further specification of an affirmative request.

In order for these demands to be plausible in the story context, information should be explicitly provided as to what the demander wants and doesn’t want— and crucially, why. That is, a suitable context further requires that the demander should selectively requests some of the objects among a set, but selectively leave the others out of the request, for some plausible reason. In doing so, the set of objects among which the demander selectively requests ought to be presented in the lead-in and demander’s speech in such a way that it becomes obvious what she wants/needs/likes among the objects, and what she doesn’t.

Keeping this information in mind, let us observe each item prepared for this experiment one by one as to how the felicity described above was controlled.<sup>42</sup>

(142) “Simple Negation” Item

- a. Demand: “You should bring me apples from the garden, but remember; *don’t bring me every apple.*”
- b. Ursula’s reason: she has a small box for each apple to be held, but the number of the boxes that can really hold apples is smaller than all the apples she has (she accidentally crushed one box that she brought for this purpose).

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<sup>42</sup> Here we examine how felicity conditions were met for the conditions involving *every*-sentences. For how felicity was controlled in presenting Negative Control Items, see the sample trials shown in (146) and (147) below.

(143) “Simple Negation” Item

- a. Demand: “You should bring me coins from the chest, but remember; *don’t bring me every gold coin.*”
- b. Ursula’s reason: she has some gold coin boxes and silver coin boxes for each coin to be held individually, and she wants to put the coins that will be brought back in boxes of matching color (each gold coin-its own gold box, each silver coin-its own silver box). But the number of the gold boxes is smaller than the number of all the gold coin she has (she accidentally crushed one gold box that she brought for this purpose).

(144) “None-Every” Item

- a. Demand: “You should bring me candies from your kitchen, but remember; *none of you should bring me every candy.*”
- b. Ursula’s reason: she has three bags, and she wants to put the candies which each character brings each in a separate bag. But the bags are so small that she suddenly realized that they couldn’t hold all the candies.

(145) “None-Every” Item

- a. Demand: “You should bring me crabs from your tank, but remember; *none of you should bring me every red crab.*”
- b. Ursula’s reason: she has a blue cage and a red cage, and she wants to put the crabs (there are red crabs and blue crabs) that each of the character brings into the matching-color cage (blue crabs-blue cage,

red crabs-red cage). But she suddenly realizes that the red cage is much smaller than the blue cage and that it cannot hold all the red crabs that could potentially be brought.

#### 7.2.4. Evaluation of the Stimuli

The child was asked to evaluate the demand-fulfillment in the same way as the “Demand-Fulfillment” Task in Experiment III. That is, there were two points at which children were asked to make a decision about whether Grover did a satisfactory job or not. The first was the Before-Open-the-Box-Evaluation, i.e., the evaluation at the point that Grover asked the child whether he did something good enough without showing the inside of his box (i.e., at the point of (139d) in the trial structure above). Recall that this requires the child consider whether what Grover said logically satisfies what Ursula demanded solely based on the linguistically-presented description of the fulfillment (i.e., Grover’s sentence about what he did), rather than relating the propositions to the situation visually presented in front of them, as in the experiment using the Truth Value Judgment task. In the “Satisfactory” Condition, the expected response was providing the affirmative answer to Grover’s question, such as “Yes”; we call it “Yes” Responses, just as in Experiment III. In the “Unsatisfactory” Condition, the expected response was providing the negative answer such as “No, or uncertain answer, such as “I need to check inside the box”; we call it Non-“Yes” responses, as in Experiment III.

After the primary evaluation, children were given a second phase to confirm their evaluation, which was referred to as the After-Open-the-Box-Evaluation. Recall

that children were asked to open Grover’s bag, and check insider to see whether Grover brought something that satisfies Ursula (i.e., at the point of (139e) in the trial structure above).

### 7.2.5. Sample Trials

The following is the sample script in “Satisfactory” Condition.

(146) Sample Trial: “Satisfactory” Condition (Negative Control Item)

- Ursula: Look. Here we have Winnie the Pooh (*The monitor shows an image of Winnie the Pooh*). I will put a spell on him and turn her into a little monster! Hahaha! (*Winnie the Pooh turned into a monster on the monitor*)
- Grover: Wow! It’s a cool magic, but, poor Pooh, I’m sure he wants to come back. Why don’t you free him?
- Ursula: You want me to free him? Ok, then, you have to do something for me.
- Grover: Ok, I’m listening.
- Ursula: I have my magic chest behind this magic curtain. Inside of it, I have lots of accessories; I have many rings and combs in many colors such as red, blue and yellow, as my magic screen shows you (*All the rings and combs are presented in the monitor*). You have to go behind the curtain and bring me something from the chest. You can bring as many things as you want, but, look (*showed the red rings*) I have already gotten enough red rings with me, and I don’t need any more red rings.<sup>43</sup> So remember: ***don’t bring me any red ring***. If you forget this, I won’t free Pooh.
- Grover: Ok, I will put it in my bag carefully and will be back right away. I know that sometimes I’m forgetful and careless, so I should be careful not to forget... let me make sure; I will not bring you ... (*prompts the child*).

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<sup>43</sup> This part serves as Ursula’s reason for not wanting any more red rings.

Child: *(Expected to help Grover repeat the demand)*<sup>44</sup> You should not bring her any red ring!

Grover: Right! Thank you for the reminder. Ok let me go and work. *(Leaves behind the curtain)*

Ursula: *(Speak to the child while Grover is away)* What do you think, *(the child)*? Can Grover satisfy me to free Pooh? Remember what I said? I don't want to have any more red rings, so I really hope that Cookie Monster is doing something good enough for me. Can you make sure if he is going to do something good enough for me when he is back, OK?

Grover: *(Came back with his carrying bag)* Mmm, it was so hard that I forgot what Ursula said! But I did my best as much as I could remember, and I want to make sure with you *(the child)* before meeting Ursula again. In this bag, I brought her something. I can't remember exactly what, but I remember that ***I didn't bring her any ring***. Do you remember what she said? Is it good enough to save Pooh?

Child: *(Expected to say)* Yes. (=Before-Open-the-Box-Evaluation)

Grover: Great. Now can you (=the child) open my bag and show it to Ursula? *(Show what he brought in the bag)*

Child: *(Open the bag. There are only combs in the bag.)*

Grover: Did I do what Ursula wants?

Child: *(Expected to say)* Yes. (=After-Open-the-Box-Evaluation)

Ursula: Let me see. Good. As I promised you, I will free Pooh now.

Now, the following is the sample script for the “Unsatisfactory” Condition.

(147) Sample Trial: “Unsatisfactory” Condition (Negative Control Item)

Ursula: Look, we have Ariel here *(the monitor shows an image of Ariel)*, and I will put a spell on her! Now she is a little monster *(Ariel became a monster on the monitor)*!

Big Bird: Wow, you did it again. It's cool, but Ariel may want to come back. You should free Ariel.

Ursula: You want me to free her? Ok, you have to do something for me.

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<sup>44</sup> Letting the child repeat Ursula's “condition (i.e., what Grover is prohibited to bring)” serves as a reminder, as well as reinforcing Grover's being forgetful.

Big Bird: Ok, I'm ready to listen.

Ursula: I have a box of magic toys behind this magic curtain, and I have so many magic toys in there; I have many robots and teddy bears in many colors such as red, blue and yellow, as you can see on my magic screen (*all the items presented on the monitor*). You have to go behind the curtain, and bring me anything from there, but look, (*show many of red, blue and yellow robots*) I have already had enough robots with me, and I don't need any more robots.<sup>45</sup> So remember: ***don't bring me any robot!*** If you forget this, I will never free Ariel.

Big Bird: Ok, I won't forget this, well, I will not bring you ... (*prompts the child*)

Child: (*Expected to help Big Bird repeat the demand*) You should not bring her any robot.

Big Bird: Right! Ok, thank you for your reminder. Let me go and work. (*Big Bird leaves behind the curtain and disappears.*)

Ursula: (*Speak to the child while Big Bird is away*) What do you think, (*the child*)? Can Big Bird satisfy me to free Ariel? I don't want to have any more robot, so I really hope that Big Bird can do something good enough for me. Can you make sure if he is going to do something good enough for me when he is back, OK?

Big Bird: (*Came back with his carrying bag*) Oops, that was so hard that I might have forgotten exactly what Ursula said! But I did my best as much as I could remember, so let me make sure with you; I brought her something in my bag, but ***I didn't bring her any red robot.*** Do you remember what she said? Is it good enough to free Ariel?

Child: (*Expected to provide Non-“Yes” Response*) We have to make sure that you didn't bring any robot, not only red robots... (=Before-Open-the-Box-Evaluation)

Big Bird: Well, why don't you open the bag?

Child: (*Open the bag. There are a few blue and yellow robots as well as teddy bears.*)

Big Bird: Do you think the queen would be happy with this?

Child: No, because you brought these robots! (=After-Open-the-Box-Evaluation)

Ursula: I don't want see robots, return them! Then I will free Ariel.

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<sup>45</sup> This part serves as Ursula's reason for not wanting any more robots.

Child: (Asked to help Big Bird, and return the robots)

Ursula: Great. Now I got what I wanted, so I will free Ariel.

To sum up, the following table schematically represents the conditions and stimuli.

Table 15 The Schema of “Demand-Fulfillment” Task-Negative Version

Types of Items	Demand (D)	Fulfillment in response to the Demand (F)	Pattern of Inference (D) → (F)	Validity of Inference (D) → (F)	Demand Satisfaction
Neg. Control	(140a.i) Don't bring me any <u>red ring</u> .	(140a.ii) I didn't bring you any <u>ring</u> .	Subset-to-set (Invalid genuine DE)	Invalid	Satisfactory (“Satisfactory” Condition)
“Simple Neg.”	(140b.i) Don't bring me every <u>apple</u> .	(140b.ii) I didn't bring you every <u>red apple</u> .	Set-to-subset (Invalid reversed DE)		
“None-Every”	(140c.i) None of you brings me every <u>candy</u> .	(140c.ii) None of us brought you every <u>red candy</u> .	Set-to-subset (Invalid reversed DE)		
Neg. Control	(141a.i) Don't bring me any <u>robot</u> .	(141a.ii) I didn't bring you any <u>red robot</u> .	Set-to-subset (Valid genuine DE)	Valid	Unsatisfactory (“Unsatisfactory” Condition)
“Simple Neg.”	(141b.i) Don't bring me every <u>gold coin</u> .	(141b.ii) I didn't bring you every <u>coin</u> .	Subset-to-set (Valid reversed DE)		
“None-Every”	(141c.i) None of you brings me every <u>red crab</u> .	(141c.ii) None of us brought you every <u>crab</u> .	Subset-to-set (Valid reversed DE)		

### 7.3. Predictions

Recall again that we have ensured in Experiments IV and V that children are sensitive to the reversed entailment that was reflected in the pattern of opposing truth conditions assigned to the entailing and the entailed sentences that contain *nobody* and *every*. Thus our hypothesis addressed in (138) would predict that children would be able to compute the reversed pattern of inferences created between two propositions containing negation and *every*. If this prediction were borne out, then it would further support the argument that children are able to compute set-to-subset and subset-to-set inferences appropriately with respect to the properties on the elements in the propositions and their interaction in the linguistic environment.

### Subjects

Fifteen English-speaking children aged from 4;4 and 6;0, whose mean age was 5;1, participated in this experiment. These subjects were the children enrolled for the Center for Young Children at the University of Maryland, College Park, and the ones enrolled for the Greenwood Nursery School, Hyattsville, Maryland; all participants had their parental permission to participate in the study. The children were tested one by one in a separate quiet room with the experimenters.

#### 7.4. Results

The percentages of the “Yes” Responses were calculated in each condition, token by token.

##### Results: “Satisfactory” Condition

In the “Satisfactory” Condition, in which the “Yes” Responses were expected, children showed the following percentages. In evaluating the demand-fulfillment presented in Negative Control items, in which the inference from the demand to the fulfillment is licensed in the set-to-subset pattern (i.e., the genuine DE pattern due to negation), the percentage of the “Yes” Responses was 87% (13/15). In evaluating the demand-fulfillment presented in “Simple Negation” items, in which the relevant inference is licenses in the subset-to-set pattern (i.e., the reversed DE pattern in the first argument of *every* due to the influence from negation), the percentage of the “Yes” Responses was 93% (14/15). In evaluating the demand-fulfillment presented in the “None-Every” items, in which the relevant inference is licensed in the subset-to-set pattern (i.e., the reversed DE pattern in the first argument of *every* due to the influence from *none*), the percentage of the “Yes” Responses was 93% (14/15).

##### Results: “Unsatisfactory” Condition

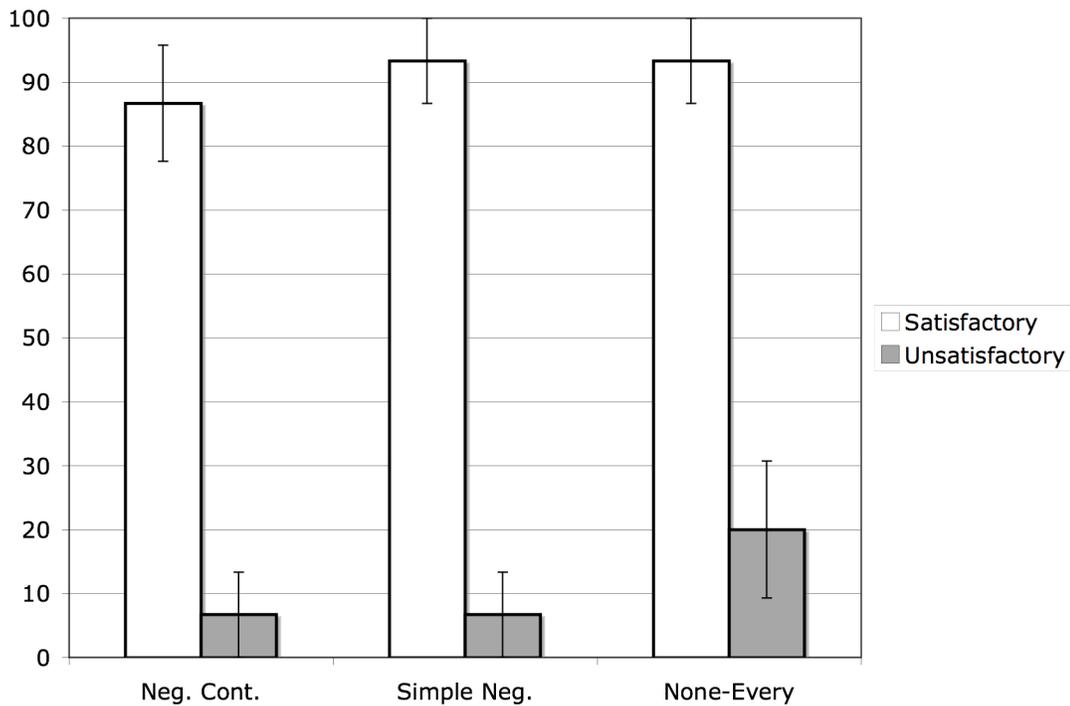
In the “Unsatisfactory” Condition, in which the “Yes” Responses were not expected, children’s ratio of showing the “Yes”-Responses was significantly lower. In evaluating the demand-fulfillment presented in Negative Control items, in which the

inference from the demand to the fulfillment is licensed in the set-to-subset pattern (i.e., the genuine DE pattern due to negation), the percentage of the “Yes” Responses was 7% (1/15). In evaluating the demand-fulfillment presented in “Simple Negation” items, in which the relevant inference is licenses in the subset-to-set pattern (i.e., the reversed DE pattern in the first argument of *every* due to the influence from negation), the percentage of the “Yes” Responses was 7% (1/15). In evaluating the demand-fulfillment presented in the “None-Every” items, in which the relevant inference is licensed in the subset-to-set pattern (i.e., the reversed DE pattern in the first argument of *every* due to the influence from *none*), the percentage of the “Yes” Responses was 20% (3/15). These results were illustrated below.

Table 16 Percentages of the “Yes” Responses

Condition	Validity of Inference (D) → (F)	Types of Item	Pattern of Inference (D) → (F)	% of “Yes” Responses
“Satisfactory”	Invalid	Negative Control	Subset-to-set (Invalid genuine DE)	87% (13/15)
		“Simple Negation”	Set-to-subset (Invalid reversed DE)	93% (14/15)
		“None-Every”	Set-to-subset (Invalid reversed DE)	93% (14/15)
“Unsatisfactory”	Valid	Negative Control	Set-to-subset (Valid genuine DE)	7% (1/15)
		“Simple Negation”	Subset-to-set (Valid reversed DE)	7% (1/15)
		“None-Every”	Subset-to-set (Valid reversed DE)	20% (3/15)

Figure 27 Percentages of the “Yes” Responses



A Wilcoxon Signed-Rank test was conducted to examine whether the rates of “Yes” Responses observed in the “Satisfactory” Condition were significantly higher than those observed in the “Unsatisfactory” Condition. Once again, the children’s correct responses were calculated in the following way; a “Yes” Response was scored as 1, and a “Non”-Yes Response was scored as 0. The total scores in each condition were compared in terms of whether the total scores for the “Satisfactory” Condition were significantly higher than those for the “Unsatisfactory” Condition, with respect to each type of item. According to the test, the total scores for the “Satisfactory” Condition were significantly higher than those for the “Unsatisfactory” Condition with respect to each type of item:  $z = -3.464, p < 0.01$  for the Negative Control items;

$z = -3.606, p < 0.001$  for the “Simple Negation” items;  $z = -3.317, p < 0.01$  for the “None-Every” item.

A  $t$ -test was also conducted across-conditionally. There was a significant difference in the percentages of “Yes” Responses between the “Satisfactory” Condition and the “Unsatisfactory” Condition with respect to each type of item:  $t(14) = 7.438, p < 0.001$  for the Negative Control items;  $t(14) = 9.539, p < 0.001$  for the “Simple Negation” items;  $t(14) = 6.205, p < 0.001$  for the “None-Every” items.

### 7.5. Discussion

According to the results, our prediction on the basis of the findings from Experiment IV and V were borne out; children’s responses were consistent with adults’ inference patterns created between the negative propositions.

#### 7.5.1. Evaluations at the Two Phases: Before- and After-Open-the-Box

Note that the children’s responses at the two evaluation phases in each experimental condition were interpreted in the same way as Experiment III. What counted as “Yes” Responses, which is expected in the “Satisfactory” Condition, and what counted as the Non-“Yes” Responses, which is expected in the “Unsatisfactory” Condition, were determined based on the following standards summarized in (99) and (100), which are repeated in (148) and (149) respectively.

(148) “Yes” Responses, expected in “Satisfactory” Condition

To answer “Yes” to Grover’s question at the Before-Open-the-Box-Evaluation, AND To confirm the answer at the After-Open-the-Box-Evaluation, with checking what is inside the box.

(149) Non-“Yes” Responses, expected in “Unsatisfactory” Condition

- a. To provide a negative or uncertain answer to Grover’s question at the Before-Open-the-Box-Evaluation (e.g., “No, you didn’t do something good enough”, or “I don’t know until I see what’s inside your box.”),  
OR
- b. To provide a non-negative answer to Grover’s question at the Before-Open-the-Box-Evaluation (e.g., “Yes” or “I think so”), but rejecting it at the After-Open-the-Box-Evaluation (e.g., “No, this is not what the genie wanted”)

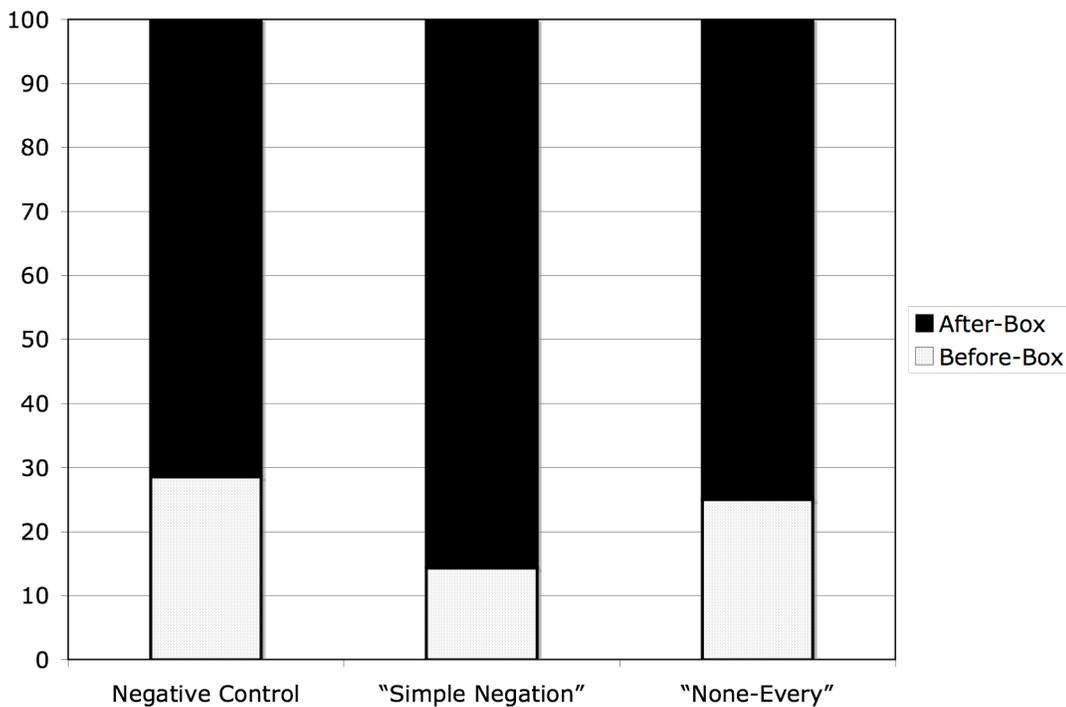
Keeping them in mind, let us now discuss the detailed percentages of the responses both at the Before- and the After-Open-the-Box-Evaluations observed in each condition.

As for the legitimate “Yes” Responses observed in this experiment, all of them met the standard in (148). As for the legitimate Non-“Yes” Responses, the following table and chart illustrate the percentages both at the Before- and the After-Open-the-Box-Evaluations observed in the “Unsatisfactory” Condition, where the Non-“Yes” Responses were interpreted as “correct”.

Table 17 Percentages of Non-“Yes” Responses at the Before- and the After-Open-the-Box-Evaluations in “Unsatisfactory” Condition

	Before-Box	After-Box
Negative Control	29% (4/14)	71% (10/14)
“Simple Negation”	14% (2/14)	86% (12/14)
“None-Every”	25% (3/12)	75% (9/12)

Figure 28 Percentages of Non-“Yes” Responses at the Before- and the After-Open-the-Box-Evaluations in “Unsatisfactory” Condition



As can be seen above, the Non-“Yes” Responses that were correctly made in the “Unsatisfactory” Condition were mostly made at the After-Open-the-Box-Evaluation phase regardless of the type of the item.

Remember the contrast we have observed in Experiment III; all the Non-“Yes” Responses that were correctly made in the “Unsatisfactory” Condition were made at the Before-Open-the-Box-Evaluation phase when children evaluate the “First-Argument” items whose relevant inferences pattern in a DE fashion, whereas children relied on After-Open-the-Box-Evaluation phase in order to provide the Non-“Yes” Responses in the “Unsatisfactory” Condition when they evaluate the Control items and the “Second-Argument” items whose relevant inferences pattern in a non-DE (default) fashion. As the chart illustrates above, such contrast disappeared in children’s response patterns in Experiment VI.<sup>46</sup>

Also recall that in Experiment III, there were two types of “Yes” Responses observed in “Unsatisfactory” Condition (i.e., the incorrect responses), i.e., responses by saying “Yes” and the ones by saying “I think so”, at the Before-Open-the-Box-Evaluation phase. We have concluded that this variation might have shown children’s sensitivity to the unsatisfactory of the demand-fulfillment based on the deductive logic (i.e., the validity of the inference created from the demand to the fulfillment), even though children failed to explicitly reject it before visually checking the fulfilling outcome. Such variation in the “Yes” Responses in the “Unsatisfactory”

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<sup>46</sup> Recall that we have pointed out a problem that remains open, i.e., why children could show the Non-“Yes” Responses robustly at the Before-Open-the-Box-Evaluation phase in evaluating the demand-fulfillment represented in the “First-Argument” items in Experiment III (see the footnote 31). Note that the “Simple Negation” items utilized in Experiment VI were the negative variations of the “First-Argument” items in Experiment III (“Don’t bring me every X”–“I didn’t bring you every X” vs. “Bring me every X”–“I brought you every X”). As we have briefly mentioned in the foot note 31, the fact that there was no robust Before-Open-the-Box rejections for the demand-fulfillments represented in the “Simple Negation” items implies that it is not the number of the denotation that triggered the robust Before-Open-the-Box rejection for the “First-Argument” demand-fulfillments. Thus, what the source of children’s robust Before-Open-the-Box rejection observed in Experiment III for the “First-Argument” demand-fulfillments would be still remains an open question.

Condition has not been robustly observed in Experiment VI. Virtually all the children said “Yes” before opening the box, and rejected the outcome after opening the box (i.e., the legitimate Non-“Yes” Responses that met in the second standard repeated in (149b) above).

Taken together, children have shown some difficulty in evaluating the negative demand-fulfillments, compared to the evaluation of the simple affirmative demand-fulfillments, to the extent that their detailed responses were less adult-like.

### 7.5.2. Additional Discovery

Experiment VI has revealed an additional interesting discovery. In the pilot versions of this experiment, the test items were presented in the following order in the trial: (i) Negative Control Item; (ii) “Simple Negation” Item; (iii) “None-Every” Item. Interestingly, a number of children were biased by the initial presentation of Negative Control Item; they wrongly treat the “Simple Negation” Item (i.e., “Don’t bring me *every* apple”) as if it were the same as Negative Control Item (i.e., “Don’t bring me *any* apple”). Not only did they treat “Simple Negation” items oppositely in the evaluation, i.e., they showed the reversed pattern of demand-fulfillment evaluation, but also they substituted *any* for *every* when they were told to repeat Ursula’s demand in the trial. Such an order effect has completely disappeared when we have scrambled the order of the presentation of the items in the later version. At this point, we have no explanation about what this order effect tells us about children’s responses; this issue should be pursued in the future research.

Experiment VI thus revealed children's adult-like computation of the logical inferences that pattern as a consequence of the reversed entailment due to the interaction between the negation and *every*. In Chapter 8, we consider the findings from all the experiments we have reported so far, and discuss the possible answers to the research questions and the implications to the future researches.

Appendix 7A: Full Script of “Demand Fulfillment” Task, Negative Version

**General Lead-in**

Ursula, the queen of the ocean, has the powerful magic power. She can do whatever she wants to do. She is sometimes a good queen, and she uses her magic power in a good way. But other times she is evil, and she uses her magic power in a mean way. Today, Grover, Big Bird and Cookie Monster visit her palace. Let’s see what happens next. How does the queen treat these three guests? Let’s see what is going to happen in the stories together. In the middle of the stories, you (the child) will need to help these people. They really need your help. Could you do that?

**Trial 1: “Simple Negation” Item–“Satisfactory” Condition**

**Demand: Don’t bring me every apple.**  
**Fulfillment: I didn’t bring you every red apple.**  
**(“Invalid” inference from Demand to Fulfillment)**

Ursula: Welcome to my palace! You want to see my welcome treatment? Look at my magic screen. Here we have Pikachu (*The monitor shows an image of Pikachu*). I will put a spell on him and turn her into a little monster (*Pikachu becomes a monster on the monitor*)! Hahaha!

Grover: Wow! It’s a cool magic, but, poor Pikachu. It may not be a good thing to do, Ursula. You should free Pikachu.

Ursula: Oh well, Grover, you seem to want to free Pikachu. Then, you need to do something for me. In my magical garden behind the curtain, there are many apples ready to be picked up, three red apples and three blue apples, as you can peek through my magic screen (*The monitor shows the entire set of apples, three red apples and three blue apples*). I need them back to my palace...

Grover: Got it! You want me to bring some apples back to this palace from the garden! Am I right?

Ursula: Right, you should bring me more than one apple from there. I will then put each apple you bring in a box (*Shows pictures of five boxes and one crashed box*), but, look, I crushed one of the boxes yesterday; look (*points to the crushed box*), this one

cannot hold anything. So listen very carefully: **don't bring me every apple**. If you forget this, I will never free Pikachu!

Grover: Ok, I won't forget. Let me make sure with you, (*the child*). I should bring Ursula some apples, but I shouldn't bring ... what did she say (*asked the child*)?

Child: (*Asked to help Grover repeat Ursula's demand*)

Grover: That's right! Thank you, (*the child*). I should be careful not to forget. Ok, let me go behind the curtain and work. See you soon!

(*Grover leaves behind the curtain.*)

Ursula: (*Speak to the child while Grover is away*) What do you think, (*the child*)? Can Grover satisfy me and free Pikachu? I don't want to have every apple, because, remember, I broke one of the boxes. So I really hope that he is doing something good enough for me. Can you make sure if he does something good enough for me when he is back, OK?

Grover: (*Comes back with a bag*) There are so many apples there! I started filling this bag, but I don't know which ones I picked! But I did my best as much as I could remember... Can you help me to check if I did something good, (*the child*)? Here is what I remember I did; I brought her apples, but **I didn't bring her every red apple**. I cared about the color. Do you remember what the queen said? Does the color matter? Is it good enough to free Pikachu?

Child: (*Expected to say*) Yes. (=Before-Open-the-Box-Evaluation)

Grover: Good. (*To the child*) Can you open the bag and show inside?

Child: (*Opens the bag. There are a couple of blue apples and a red apple.*)

Ursula: Good. As I promised you, I will free Pikachu now!

### **Trial 2: "Simple Negation" Item—"Unsatisfactory" Condition**

**Demand:** Don't bring me every gold coin.

**Fulfillment:** I didn't bring you every coin.

(**"Valid" inference from Demand to Fulfillment**)

Ursula: My magic trick goes on, and now I put a spell on Hamutaro! Look, he is a little monster and nobody can see that this little monster is in fact lovely Hamutaro (*The monitor shows that Hamutaro becomes a monster*)! Hahaha!

Big Bird: That's not fair. Hamutaro did not do anything to you, Ursula. Why don't you free him?

Ursula: You seem so eager to free Hamutaro, Big Bird. Ok, I will give you a chance. Big Bird, it's your turn. In my magic cave behind the curtain, there are beautiful coins hidden everywhere, three gold coins and three silver coins, as you can peek through my magic screen (*The monitor shows the set of three gold coins and three silver coins*). I need them back to my palace ...

Big Bird: I got it! So you want me to bring you some coins from there! Am I right?

Ursula: Right, you should bring me more than one coin from there. I will put each of the coins you bring in the color matching coin chest (*Shows three gold boxes and three silver boxes; one of the gold boxes is crushed*), but, look, one of the gold chests is pinched and it does not work anymore. So listen very carefully: **don't bring me every gold coin**. If you forget this, I will never free Hamutaro!

Big Bird: Ok, I won't forget. Let me make sure with you, (*the child*). I should bring Ursula coins, but I shouldn't bring ... what did she say (*asked the child*)?

Child: (*Asked to help Big Bird repeat the demand*)

Big Bird: That's right! Thank you, (*the child*). I should be careful not to forget. Ok, let me go behind the curtain and work. See you soon!

(*Big Bird leaves behind the curtain.*)

Ursula: (*Speak to the child while BB is away*) What do you think, (*the child*)? Can Big Bird satisfy me to free Hamutaro? I don't want to have every gold coins carried here at once, because one of the gold envelopes is torn, and so I really hope that he is doing something good enough for me. Can you make sure if he is going to do something good enough for me when he is back, OK?

- Big Bird: (*Comes back with a bag*) There are so many things there! I started filling this bag, but I don't know which ones I picked! But I did my best as much as I could remember. (*the child*), can you check with me whether I did something good? Here is what I remember I did; I brought her coins, but **I didn't bring her every coin**. I didn't care so much about the color. Do you remember what the queen said? Is it good enough to save Hamutaro?
- Child: (*Expected to say*) We have to check which color of coins you did (not) bring. (=Before-Open-the-Box-Evaluation)
- Big Bird: Ok, can you (=the child) open the bag and check what's inside?
- Child: (*Opens the bags and sees the inside. There are three gold coins and a silver coin.*) You brought all the gold coins!
- Ursula: You brought them all!? Too bad. (*the child*), you can help Big Bird return them very carefully, then I will free Hamutaro.

### **Trial 3: “None-Every” Item–“Satisfactory” Condition**

**Demand:** None of you should bring me every **candy**.  
**Fulfillment:** None of us brought you every **red candy**.  
**(“Invalid” inference from Demand to Fulfillment)**

- Ursula: Do you think I'm satisfied? Not yet, not yet. Now, I put a spell on Tigger, and look, he turned into a monster, too (*The monitor shows Tigger, and then a monster*). Funny!
- Grover: Wow, you did it again!
- Big Bird: Poor Tigger.
- Cookie M.: You should free Tigger.
- Ursula: Sounds like you are ready to do something for me... Ok, now each of you should do something for me again.
- Three: What do you want us to do?
- Ursula: Now, I'll change the scene! (*The magic curtain disappears, and the three curtains show up*) Here, I have three magic kitchens behind those curtains. In each of my magic kitchens, there are magic candies, three red candies and three blue

candies, as you can see through my magic screen (*The monitor shows three red candies and three blue candies in the three domains each*). You each have to go to one of my kitchens, and bring me more than one candy from there. (*Shows a small bag*) I will then put the candies you bring in a bag and carry them together, but I realized that my bag is a little bit small to fit many. So, don't forget the following; **none of you should bring me every candy (from your kitchen)**. If you forget this, I won't free Tigger.

Three: Ok, each of us will bring you something from your kitchen, and we'll make sure that none of us brings you ... what did Ursula say, (*the child*)?

Child: (*Asked to help three characters repeat Ursula's demand*)

Three: That's right! Thank you. We should not forget this.

(*Three leaves behind each of the three curtains*)

Ursula: (*Speak to the child while they are away*) What do you think, (*the child*)? Can they satisfy me to free Tigger? I don't want them to bring every candy, because my bag is a little too small. So I really hope that they are doing something good enough for me. Can you make sure if he is going to do something good enough for me when they are back, OK?

(*Three characters come back from behind the curtains with a bag each*)

Grover: There are so many things there! I started filling this bag, but I don't remember which ones I picked!

Big Bird: Me, too!

Cookie M: Me, too!

Three: That's too bad. (*the child*), can you check if we did a good job? Here is what we remember we did; each of us brought her candies, but **none of us brought her every red candy**. We cared about the color. Do you remember what Ursula said? Is it good enough to free Tigger?

Child: (*Expected to say*) Yes. (=Before-Open-the-Box-Evaluation)

Three: Good. Can you (=the child) open the bags?

Child: *(Open the bags and see inside. One bag has a red candy and two blue candies, the other each have two red candies and a blue candy.)*

Three: *(To the child) did we do something good enough?*

Child: *(Expected to say) Yes.*

Ursula: Good job. Now I will free Tigger.

#### **Trial 4: “None-Every” Item–“Unsatisfactory” Condition**

**Demand:** None of you should bring me every red crab.

**Fulfillment:** None of us brought you every crab.

**(“Valid” inference from Demand to Fulfillment)**

Ursula: Do you think I’m satisfied? Not yet, not yet. Now, I put a spell on Piglet, and look, she turned into a monster, too. Funny!

Grover: It’s not funny, Ursula!

The two: Right, stop doing that.

Ursula: Sounds like you are ready to do something for me... Ok, now each of you should do something for me.

Three: What do you want?

Ursula: Well, I have three magic aquariums behind those curtains. In each of my magic aquarium, there are magic crabs, three red crabs and three blue crabs. I will then put them in the matching colored separate cages, but I realized that the red cage is a little too small to fit many. So listen very carefully: **none of you should bring me every red crab (from your aquarium)**. If you forget this, I won’t free Piglet.

Three: Ok, each of us will bring you something, and we’ll make sure that none of us brings you ... (prompts the child) every red crab!

(Each of the three leaves with a bag, and come back one by one)

Ursula: (Speak to the child while they are away) What do you think, (the child)? Can they satisfy me to free Piglet? I don’t want them to bring every red crab, because the red cage is a little too

small, as I said. So I really hope that they are doing something good for me. Can you make sure if he is going to do something good enough for me when they are back, OK?

Grover: There are so many things there! I started filling this bag, but I don't know which ones I picked!

BB: Me, too!

CM: Me, too!

Three: So all we know is that **none of us brought her every crab**. Do you remember what Ursula said? Is it good enough to free Piglet?

Child: (*Expected to say*) No, we have to check the color of the crabs that you brought. (=Before-Open-the-Box-Evaluation)

(*See inside the bags. One of them brought three red crabs from the aquarium.*)

Child: You brought all the red crabs!

Ursula: Too many red crabs! You brought all of them from your aquarium! Return them, or I won't free Piglet!

**Trial 5: Negative Control Item—"Satisfactory" Condition** (=146) on p. 195)

**Demand:** Don't bring me any red ring.

**Fulfillment:** I didn't bring you any ring.

(**"Invalid" inference from Demand to Fulfillment**)

Ursula: Look. Here we have Winnie the Pooh (*The monitor shows an image of Winnie the Pooh*). I will put a spell on him and turn her into a little monster! Hahaha! (*Winnie the Pooh turned into a monster on the monitor*)

Grover: Wow! It's a cool magic, but, poor Pooh, I'm sure he wants to come back. Why don't you free him?

Ursula: You want me to free him? Ok, then, you have to do something for me.

Grover: Ok, I'm listening.

- Ursula: I have my magic chest behind this magic curtain. Inside of it, I have lots of accessories; I have many rings and combs in many colors such as red, blue and yellow, as my magic screen shows you (*All the rings and combs are presented in the monitor*). You have to go behind the curtain and bring me something from the chest. You can bring as many things as you want, but, look (*showed the red rings*) I have already gotten enough red rings with me, and I don't need any more red rings. So remember: **don't bring me any red ring**. If you forget this, I won't free Pooh.
- Grover: Ok, I will put it in my bag carefully and will be back right away. I know that sometimes I'm forgetful and careless, so I should be careful not to forget... let me make sure; I will not bring you ... (*prompts the child*).
- Child: (*Expected to help Grover repeat the demand*) You should not bring her any red ring!
- Grover: Right! Thank you for the reminder. Ok let me go and work. (*Leaves behind the curtain*)
- Ursula: (*Speak to the child while Grover is away*) What do you think, (*the child*)? Can Grover satisfy me to free Pooh? Remember what I said? I don't want to have any more red rings, so I really hope that Cookie Monster is doing something good enough for me. Can you make sure if he is going to do something good enough for me when he is back, OK?
- Grover: (*Came back with his carrying bag*) Mmm, it was so hard that I forgot what Ursula said! But I did my best as much as I could remember, and I want to make sure with you (*the child*) before meeting Ursula again. In this bag, I brought her something. I can't remember exactly what, but I remember that **I didn't bring her any ring**. Do you remember what she said? Is it good enough to save Pooh?
- Child: (*Expected to say*) Yes. (=Before-Open-the-Box-Evaluation)
- Grover: Great. Now can you (=the child) open my bag and show it to Ursula? (*Show what he brought in the bag*)
- Child: (*Open the bag. There are only combs in the bag.*)
- Grover: Did I do what Ursula wants?

Child: *(Expected to say)* Yes. (=After-Open-the-Box-Evaluation)

Ursula: Let me see. Good. As I promised you, I will free Pooh now.

**Trial 6: Negative Control Item–“Unsatisfactory” Condition** (=147) on p. 196)

**Demand: Don’t bring me any robot.**

**Fulfillment: I didn’t bring you any red robot.**

**(“Valid” inference from Demand to Fulfillment)**

Ursula: Look, we have Ariel here (*the monitor shows an image of Ariel*), and I will put a spell on her! Now she is a little monster (*Ariel became a monster on the monitor*)!

Big Bird: Wow, you did it again. It’s cool, but Ariel may want to come back. You should free Ariel.

Ursula: You want me to free her? Ok, you have to do something for me.

Big Bird: Ok, I’m ready to listen.

Ursula: I have a box of magic toys behind this magic curtain, and I have so many magic toys in there; I have many robots and teddy bears in many colors such as red, blue and yellow, as you can see on my magic screen (*all the items presented on the monitor*). You have to go behind the curtain, and bring me anything from there, but look, (*show many of red, blue and yellow robots*) I have already had enough robots with me, and I don’t need any more robots. So remember: **don’t bring me any robot**! If you forget this, I will never free Ariel.

Big Bird: Ok, I won’t forget this, well, I will not bring you ... (*prompts the child*)

Child: (*Expected to help Big Bird repeat the demand*) You should not bring her any robot.

Big Bird: Right! Ok, thank you for your reminder. Let me go and work.

(*Big Bird leaves behind the curtain and disappears.*)

Ursula: (*Speak to the child while Big Bird is away*) What do you think, (*the child*)? Can Big Bird satisfy me to free Ariel? I don’t want to have any more robot, so I really hope that Big

Bird can do something good enough for me. Can you make sure if he is going to do something good enough for me when he is back, OK?

Big Bird: *(Came back with his carrying bag)* Oops, that was so hard that I might have forgotten exactly what Ursula said! But I did my best as much as I could remember, so let me make sure with you; I brought her something in my bag, but **I didn't bring her any red robot**. Do you remember what she said? Is it good enough to free Ariel?

Child: *(Expected to provide Non-“Yes” Response)* We have to make sure that you didn't bring any robot, not only red robots... *(=Before-Open-the-Box-Evaluation)*

Big Bird: Well, why don't you open the bag?

Child: *(Open the bag. There are a few blue and yellow robots as well as teddy bears.)*

Big Bird: Do you think the queen would be happy with this?

Child: No, because you brought these robots! *(=After-Open-the-Box-Evaluation)*

Ursula: I don't want see robots, return them! Then I will free Ariel.

Child: *(Asked to help Big Bird, and return the robots)*

Ursula: Great. Now I got what I wanted, so I will free Ariel.

*Appendix 7B: Individual Responses of the Subjects: Experiment VI*

	Age	"Simple Negation" (S)	"Simple Negation" (U)	"None-Every" (S)	"None-Every" (U)	Negative Control (S)	Negative Control (U)
Subject #1	4;4	Y	N2	Y	N2	Y	*Y
Subject #2	4;6	Y	*Y	Y	N1	Y	N1
Subject #3	4;6	*N2	N1	Y	N2	*N1	N1
Subject #4	4;6	Y	N2	Y	N2	Y	N2
Subject #5	4;7	Y	N2	Y	N2	Y	N2
Subject #6	4;8	Y	N2	Y	N2	Y	N2
Subject #7	5;0	Y	N1	Y	N1	*N1	N1
Subject #8	5;1	Y	N2	Y	N2	Y	N2
Subject #9	5;1	Y	N2	*N1	N1	Y	N1
Subject #10	5;3	Y	N2	Y	*Y	Y	N2
Subject #11	5;7	Y	N2	Y	N2	Y	N2
Subject #12	5;7	Y	N2	Y	N2	Y	N2
Subject #13	5;9	Y	N2	Y	*Y	Y	N2
Subject #14	5;10	Y	N2	Y	*Y	Y	N2
Subject #15	6;0	Y	N2	Y	N2	Y	N2

(S) = "Satisfactory" Condition

(U) = "Unsatisfactory" Condition

Y = "Yes" Responses

N1= Non-"Yes" Responses by rejecting at the Before-Open-the-Box-Evaluation

N2= Non-"Yes" Responses by rejecting at the After-Open-the-Box-Evaluation

\* = Incorrect responses

## Chapter 8. General Discussions

### 8.1. Summary of Experimental Findings

The previous chapters have discussed several experiments designed to investigate children's knowledge about the universal quantifier *every* with respect to its property of creating entailment structure asymmetrically in both arguments. This chapter will be devoted to summarizing the findings from the experiments.

The experiments were conducted in order to consider the following research questions, originally addressed in (34) repeated here as (150).

#### (150) Research Questions

- a. Can children compute inference from subsets to supersets and vice versa appropriately?
- b. Does their knowledge about the universal quantifier *every* extend to the computation of the valid and invalid inferences created between the propositions involving *every*?

Experiment I revealed children's ability to judge the truth values assigned to minimal pairs of entailing and entailed *every*-sentences, between which the relevant inferences are created regarding the first and the second arguments of *every*. The results demonstrated that children could calculate the truth values of the antecedent

and consequence of the relevant inferences, providing the basic ground for us to move ahead to directly approach their ability to evaluate the inferences.

Experiment II was the first attempt to directly investigate children's ability to compute the inferences between pairs of entailing and entailed *every*-sentences. A new methodology was designed for this experiment, the "Prediction-Rephrase" Task, which allowed us to access older children's ability to evaluate the validity of inferences involving *every*. The results drawn from the older children's data suggested that they were able to distinguish the valid and invalid inferences regarding *every*. On the other hand, this methodology exposed the difficulty in providing an experimental context such that young children are also able to participate in the task.

Given that the "Prediction-Rephrase" Task limited young children's participation, an improved novel methodology, the "Demand-Fulfillment" Task, was designed for Experiment III, with the aim of testing younger children's sensitivity to the validity of inferences with *every*-sentences. Taking the advantage of the fact that inferential relations between two *every*-propositions are reflected in the demand-fulfillment context by whether or not the demand is logically satisfied by the fulfilling outcome, we were able to elicit children's evaluation of the inferential relations between two *every*-propositions. The results drawn in this experiment extend the initial findings from the "Prediction-Rephrase" Task and further demonstrate even young children's ability to evaluate the logical relations between two propositions involving *every*.

Experiments IV, V and VI were designed to further specify the nature and extent of children's logico-semantic competence regarding universal quantification,

entailment and inference, by investigating a new domain, reversed entailment. Specifically, these experiments investigated whether children are indeed sensitive to the influence of the linguistic environment (i.e., the effects of the non-local structural dependency among negation and universal quantifiers) to flip the entailment pattern licensed by *every*.

Experiment IV revealed children's awareness of the truth values of the entailing and entailed *every*-sentences determined by reversed entailment when *every* appears in a negative context. Experiment V, conducted as a control for Experiment IV, supported the conclusion that children calculated these truth values on the basis of reversed entailment rather than some extraneous surface pattern, as children were sensitive to the distinct effects of negation on the similar quantifiers *every* and *lots of*. Their adult-like ability to compute the truth values due to the reversed entailment licensed by *every* in the negative context also demonstrated children's knowledge about the nature of the scope interaction between *every* and negation.

Given the results from Experiments IV and V, Experiment VI attempted to assess children's ability to evaluate the direction of inferences which were determined by the property of reversed entailment in *every* appearing in the negative context (i.e., under the scope of c-commanding negation). Featuring the negative version of the "Demand-Fulfillment" Task, this experiment revealed children's adult-like evaluation of the inferences due to the reversed entailment.

Taken together, the findings can be summarized as follows. Children are found to be aware of the various consequences that follow from the entailment properties of the universal quantifier *every*: (i) the universal quantifier *every* creates

asymmetric entailment patterns in its first and second arguments<sup>47</sup>; (ii) entailment patterns influence the logical relation between sentence meanings, i.e., across-propositional meanings; (iii) entailment patterns are influenced by the semantic interaction with other logical words in particular structural relations. Therefore, children’s adult-like knowledge about *every* was revealed in these six experiments involved not only at the within-propositional meaning level but also at the across-propositional meaning level — demonstrating that children’s knowledge regarding the universal quantifier *every* is indeed applied to the computation of inferences created between the two propositions containing *every*, which are licensed in part based on the semantic feature of *every* that determines the entailment patterns among its two arguments.

### 8.2. Learning of the Universal Quantifier(s)

These findings raise the question about the origin of children’s adult-like semantic representation for quantifiers like *every*. From a learning perspective, this can be rephrased as how children settle on “ $\forall \Leftrightarrow \textit{every}$ ”.

To begin with, let us review the entailment patterns in the first and second arguments of a selection of determiners in English.

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<sup>47</sup> The findings thus were consistent with the Full Competence View (e.g., Crain, et al., 1996; Gualmini, 2005), providing further evidence to support this approach from the viewpoint of inferences and entailments.

(151) Set-to-subset inference with respect to the first argument

a. Every/each dog ran

→ Every/each brown dog ran

b. All the/no dogs ran

→ All the/the/no brown dogs ran

c. Some/many/most<sup>48</sup> dogs ran

\* → Some/many/most brown dogs ran

(152) Subset-to-set inferences with respect to the first argument

a. Every/each brown dog ran

\* → Every/each dog ran

b. All the/no brown dogs ran

\* → All the/the/no dogs ran

c. Some/many/most brown dogs ran

→ Some/many/most dogs ran

(153) Set-to-subset inferences with respect to the second argument

a. Every/each dog chased a cat

\* → Every/each dog chased a brown cat

b. All the/some/many/most dogs chased a cat

\* → All the/the/some/many/most dogs chased a brown cat

c. No dogs chased a cat

→ No dogs chased a brown cat

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<sup>48</sup> There seems to be a controversy as to whether *most* is non-DE, or it is neither DE nor non-DE. For the purpose of discriminating *most* from the universals (*every*, *each* and *all*) as the genuine DE operators in the current discussion, we would categorize it as a non-DE quantifier, following Barwise and Cooper's (1981) classification among quantifiers in terms of the direction of entailment that each of them evokes.

(154) Subset-to-set inferences with respect to the second argument

- a. Every/each dog chased a brown cat  
     → Every/each dog chased a cat
- b. All the/some/many/most dogs chased a brown cat  
     → All the/the/some/many/most dogs chased a cat
- c. No dogs chased a brown cat  
     \* → No dogs chased a cat

The following table is a summary of the above across-quantifier analyses.

Table 18 Across-Quantifier Analyses of the Inference Patterns: Summary

	First argument		Second argument	
	Set-to-subset inference	Subset-to-set inference	Set-to-subset inference	Subset-to-set inference
Every	√	*	*	√
Each	√	*	*	√
All	√	*	*	√
Some	*	√	*	√
Many	*	√	*	√
Most	*	√	*	√
No	√	*	√	*

Based on the above analyses, it is observed that the sentences that pattern the same as those containing *every* are those containing *each* and *all*.<sup>49</sup> Therefore, the crucial

<sup>49</sup> Plural definite NPs headed by *the* also behave in the same way as the QPs headed by the universal quantifiers on the basis of the maximality assumption, in which the denotation

observation here is that to know these determiners is to know their DE property as the positive universals, and their asymmetric DE/non-DE representations across arguments.<sup>50</sup> In other words, the asymmetric entailment representation that *every* creates, which children are found to know, directly follows from *every*'s being a positive universal. To consider why the positive universals including *every* are asymmetric with respect to entailments they create would go beyond the goal of the current discussion, but one related speculation about this aspect of linguistic knowledge children have would be as follows; the logical constant  $\forall$  has been specified as a DE environment creator. The range on which its nature as a DE operator spreads over would be determined when  $\forall$  is implemented as a linguistic expression such as *every* in the way that its DE property influences only over the DP domain, but not over the predicate VP domain (Ladusaw 1979, 1980). From such a perspective, children's adult-like knowledge about *every* is considered to be the evidence for their adult-like linguistic representation.<sup>51</sup>

In sum, children are found to know that the universal quantifier *every* is DE in its first argument and is non-DE in its second argument. Given that the asymmetric

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should be maximalized in the domain. There has been a debate as to whether children can implement the maximality assumption in the representation of the definite determiner. According to *Maximality Trouble Hypothesis* by Wexler (2003), children's semantics of the definite article *the* lacks the maximality assumption. On the other hand, the recent study by Syrett, Lidz and Kennedy (2006) has experimentally demonstrated children's awareness of the maximality assumption denoted in the definite plural. For the purpose of the current discussion, we won't make any commitment regarding this debate, and will exclude plural definite NPs from our analysis.

<sup>50</sup> A further prediction on the basis of the current discussion would be that children can distinguish the valid and invalid inferences involving other representations of the universal  $\forall$ , such as *all* and *each*.

<sup>51</sup> This is consistent with the claim of Minai (2004) and Minai and Crain (2004), which is that children's sensitivity to the interaction between *nobody* and *every* would demonstrate their ability to implement the structural representation.

patterns of entailment/inference under discussion directly follow from the semantic properties of *every*, children have learned its semantics correctly.

The findings that demonstrate children's adult-like semantics about *every* would motivate us to consider an important debate about learnability, i.e., how children come to know about the semantic property of *every*. In what follows, we will survey a possible learning model from the perspective of lexical learning.

As we have just discussed, *every*, *each* and *all* are the set of the universal quantifiers in English. Therefore, let us now assume that the semantic property of *every* that creates the asymmetric entailment structure is the representation of the logical property  $\forall$  in natural language. Given this, the learning of *every* can be attributed to be *mapping* between the universal quantifier symbolized as  $\forall$  and the phonological form *every*.<sup>52</sup>

Lexical learning by means of mapping constitutes an important problem; in order for children to learn a word by mapping of the semantic properties onto the relevant form, they need to (i) identify possible meanings and (ii) isolate possible forms. This is called the *mapping problem* (e.g., Clark, 1993). Let us now consider how the learning of *every* would be achieved from the perspective of mapping.

In order for children to relate the logical constant  $\forall$  to the lexical form *every* (and/or vice versa), they need the evidence to convince themselves that it is indeed the case that " $\forall \Leftrightarrow \textit{every}$ ". Suppose now that the target sentence with which children learn the meaning of *every* is represented as follows.

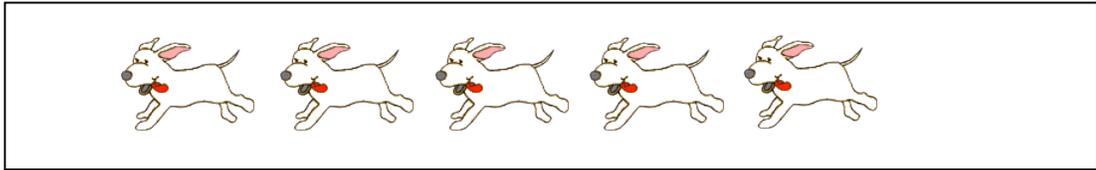
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<sup>52</sup> For the detailed discussion about the mapping problem, see Bowerman (1978), Carey (1978), Clark (1973, 1993) and Gleitman, Cassidy, Nappa, Papafragou and Trueswell (2005), among others.

(155) [Q] dog is running

Suppose that, in (155), [Q] stands for the placeholder for any quantifier. What children aim to do is to uncover which quantifier(s) can fit in [Q] to make (155) a true description in which contexts. Now, suppose that the sentence (155) is presented in the context in which there are five dogs, and they all are running, as is illustrated below.

Figure 29 Context 1



The “true” descriptions for the above context would be listed as follows.<sup>53</sup>

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<sup>53</sup> The quantifiers listed in (156) are not the complete set of all the competing quantifiers, and other quantifiers such as *several* or *many*, and also complex quantificational expressions such as *more than two*, *less than ten*, *about half a dozen* and so on would be included in the set of possible candidates. For the sake of illustrating this possible learning model, we keep our discussion to the above set of quantifiers (i.e., the set in example (156)), and exclude the above-mentioned, relatively complex candidates from our demonstration.

- (156) a. All the dogs are running.  
 b. Every dog is running  
 c. Each dog is running  
 d. Some<sup>54</sup> dogs are running  
 e. Five dogs are running

The underlined quantifiers above are the candidates for [Q] in (155) to hold in order to serve as a true description of Context 1. Given this, the sentence (155) is considered to be ambiguous among the interpretations listed in (156) above. Among them, *all*, *every* and *each* are the representations of the universal  $\forall$ . Therefore, the possible “candidates” to fit in the placeholder [Q] to make (155) true in the Context 1 will be summarized as follows.

- (157) a.  $\forall$  (*every, each, all*)  
 b. *some*  
 c. *five* (5)

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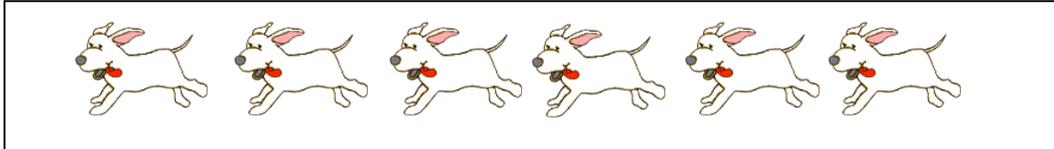
<sup>54</sup> Note that the quantifier *some* can be ambiguous between the following two possible interpretations:

- (vii) *Some* children are swimming  
 a.) pure plurality  
 b.) “Not  $\forall$ ”

Between these two interpretations, the first is the purely semantic contribution of *some*, whereas the second is a *derived* interpretation at the pragmatic level, which is called a *Scalar Implicature* (SI). The relevant meaning in the current discussion is the first interpretation based on the semantic contribution of *some*, in which it denotes “genuine plural”. For a detailed discussion on the SIs, see Grice (1989); for a discussion on SIs and children’s knowledge, see Papafragou and Musolino (2003).

Now suppose another context, illustrated in Figure 30 below, which has six running dogs, and consider which of the items summarized in (157) makes (155) a true description.

Figure 30 Context 2



Given Context 2, among the listed candidates in (156), the numeral *five* in (156e) is no longer a candidate for [Q] in (155). Children's analysis across Context 1 and Context 2 in examining the sentence (155) as a true description, thus, gives them the evidence to discriminate the numeral *five* and the rest of the candidates.

The distinction between the number word *five* on one hand and the quantifiers  $\forall$  and *some* on the other would be clear from the following perspective. Number words are on a par with other quantifiers in the sense that they both predicate over sets of individuals. On the other hand, while the number words such as *five* index the distinct numerosity of the sets, the quantifiers  $\forall$  and *some* specify the size of the sets in terms of inclusion between sets. It may be worthwhile to note here that some researchers attribute number word learning to be a process initially guided by means of the capacity to capture the numerosity of small sets of items, up to three (e.g., Wynn, 1990; Wynn, 1992; Spelke, 1994). Such a guiding would not be applicable when children learn quantifiers, since they do not denote the numerosity. Thus, one

possibility is that the number words and the other quantifiers would be easily distinguished by children, distinctively mapping number words to numerosities.

Another potential cue, which would even strongly lead children to discriminate numerals from other quantifiers including  $\forall$ , would be provided in the behavioral difference between the non-numeral quantifiers such as  $\forall$  and *some* on one hand and the numeral quantifiers such as *five*. Bloom and Wynn (1997) pointed out that the former (e.g., *every*) is not compatible with the definite article *the*, whereas the latter (e.g., *five*) is, as (158) illustrates below.

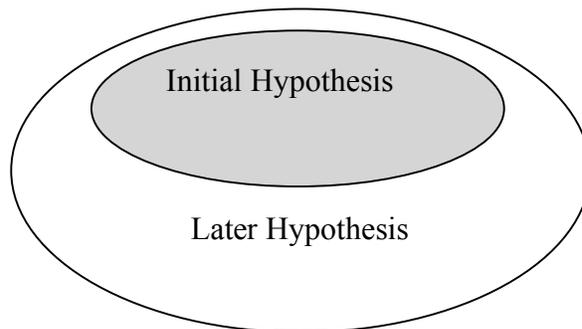
- (158) a. \*The *every* dog ran.  
b. The *five* dogs ran.

Given such observation, Bloom and Wynn claimed that numerals can be discriminated genuinely on a distributional basis. Hence, at any rate, the across-context inferential process to determine what [Q] can host in (155) can potentially distinguish *five* from the other candidates. If the numeral *five* is distinctively recognized and removed from consideration for [Q], then (155) is ambiguous in two ways, i.e., between “[Q]  $\Leftrightarrow \forall$ ” and “[Q]  $\Leftrightarrow \textit{some}$ ”.

Now the question is how these two quantifiers could be distinctively recognized. Children need a tool to distinctively recognize these hypothesized interpretations for the target sentence (155). One such tool would be provided by the *Subset Principle* (Berwick, 1985). The Subset Principle plays an important role in language acquisition, providing an ordering of hypotheses for language learning.

According to this principle, when there are multiple available options for children to learn, children initially hypothesize the “narrowest” possible option; then, positive evidence would reveal other broader options. This principle can be illustrated as follows.

Figure 31 The Subset Principle



The Subset Principle more specifically helps children ordering the multiple available interpretations to an ambiguous sentence. Crain and his colleagues (e.g., Crain, 1992; Crain and Philip, 1993; Crain, Ni and Conway, 1994) have argued for a role for this principle at the semantic level, as follows:

(159) *Semantic Subset Principle*

Suppose that the interpretive component of Universal Grammar makes two interpretations, A and B, available for a sentence, S. If so, then see if S is true in a narrower range of circumstances on interpretation A than on interpretation B. If so, then A will be hypothesized before B in the course of language development. (Crain and Thornton 1998)

A related issue in attributing the current learning model to the Semantic Subset Principle is what the source of the “strength” that constitutes the set-subset relation would be. Here we will adopt the Semantic Subset Principle on the basis of the assumption that the strength that constitutes the set-subset relation lies in the truth conditional meanings of the possible interpretations, with respect to which one holds as a “true” description in broader circumstances.<sup>55</sup>

Keeping this in mind, let us go back to the sentence (155), repeated in (160) below. Given that, for [Q] in the sentence in (160), the interpretive component provides two available interpretations,  $\forall$  and *some*, as illustrated in (161) below, the Semantic Subset Principle helps children distinguish  $\forall$  and *some* by determining which would be initially hypothesized.

(160) [Q] dog is running

- (161) a.  $\forall$  dog is running  
b. some dogs are running

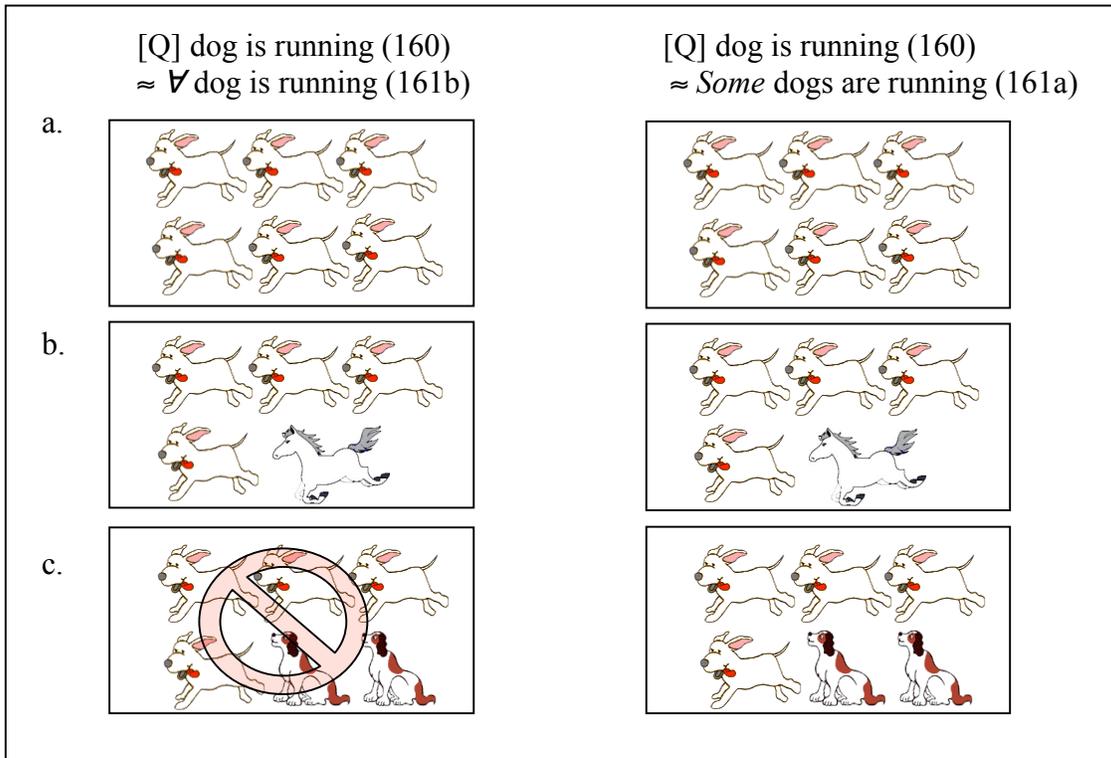
Now, we need to determine which interpretation between (161a) and (161b) would be the “narrower” possible option, and which interpretation would be the “broader” possible option that will be revealed by the positive evidence. The

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<sup>55</sup> Hence, we won’t consider other types of strength (e.g., Gricean strength in pragmatics that would influence the sentence interpretations) in the current discussion, and thus don’t intend to argue against any other models that rely on other types of strength; we show one way, using the Semantic Subset Principle, that may lead children to the correct meaning of logical words like *every*. Whether alternative scenarios based on other notions of strength could also succeed would highly depend on what the exact nature of the strength would be.

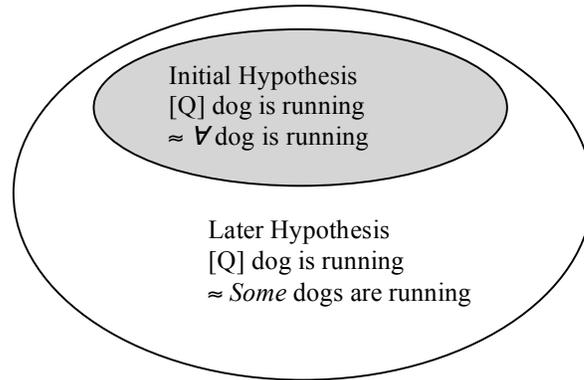
following figure shows the contexts corresponding to the candidate interpretations of sentence (160), [Q] dog is running.

Figure 32 Sets of Contexts Corresponding to the Alternative Interpretations of Sentence (160)



The left side of Figure 32 shows the contexts in which [Q] hosts  $\forall$ , whereas the right side shows the contexts in which [Q] hosts *some*. The contexts in the (a) and (b) pictures make both interpretations true. On the other hand, the context in the (c) pictures makes the interpretation (161a) (i.e., Q = “some”) true, but the interpretation (161b) (i.e., Q =  $\forall$ ) false. Therefore, (161b) constitutes the initial hypothesis, as is illustrated below.

Figure 33 Alternative Hypotheses for the Interpretation of (161)



Thus, in this way children would come to distinguish the possible candidates for [Q] to host in order to make (161) a true description of Context 1 in Figure 29, resulting in reaching the conclusion that (161) serves as a true description of Context 1, relating [Q] onto  $\forall$  (and indeed, this initial interpretation is the adult interpretation of *every*, which would suggest that the correct mapping “ $\forall \Leftrightarrow \textit{every}$ ” was successful).<sup>56</sup>

### 8.3. Remaining Issues

The next step would be that children relate  $\forall$  with *every*, isolating it from the other possible forms such as *all*, *each* and *the* (as the definite plural maximalized in the domain). One implicative cue to solve this problem would be that children need to rely on some other distinctive feature among these candidates, such as distributivity.

Among the universal quantifiers, *all* on one hand and *every* and *each* on the other indeed behave distinctly in terms of distributivity. We will borrow Beghelli and

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<sup>56</sup> The current model would predict that children might treat *some* as if it were equal to *every* or *all* at the initial stage, in which the discrimination among  $\forall$  and *some* by means of the Subset Principle has not yet taken place in child grammar. At this point, it is an open question whether it is a case, which should be pursued in future researches.

Stowell's (1997) terminologies to distinctively label these two classes of the quantifier phrases; quantifier phrases headed by *all* are *Group-denoting Quantifier Phrases* (GQPs),<sup>57</sup> and those headed by *every* or *each* are *Distributive Quantifier Phrases* (DQPs). The difference in distributivity between GQPs and DQPs is exhibited the following examples.

- (162) a. All the boys surrounded the fort.  
 b. ?Every boy surrounded the fort.  
 c. ?Each boy surrounded the fort. (Beghelli and Stowell, 1997)
- (163) a. All the men gathered at the stroke of the midnight.  
 b. \* Every man gathered at the stroke of the midnight.  
 c. \* Each man gathered at the stroke of the midnight. (Gil, 1992)

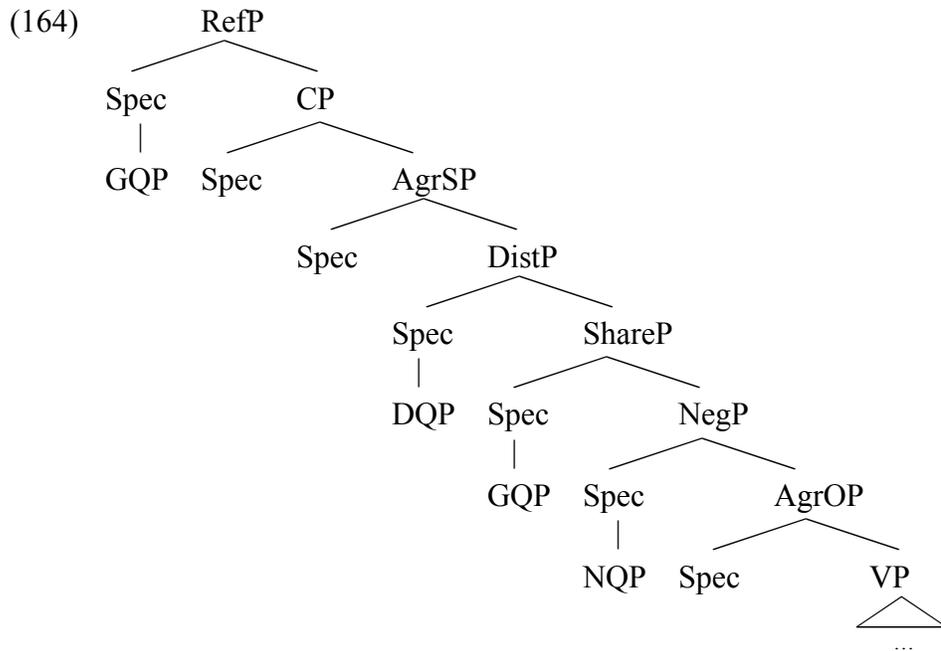
The verbs *surround* and *gather* which appear in the above examples semantically construe actions in which the multiple doers as a group must be involved. The compatibility between the GQPs and these verbs demonstrates that the quantification by *all* ranges over the entities as a group, rather than distributively. Likewise, the incompatibility between the DQPs with *every* and *each* and these verbs demonstrates the semantic mismatch between the distributive QPs and the group-selecting verbs.

Beghelli and Stowell (1997), assuming the conventional distinction between *all* on one hand as a group construer and *every* and *each* on the other as the

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<sup>57</sup> According to the analysis by Beghelli and Stowell (1997), GQPs include the QPs headed by *a*, *some*, *several*, bare-numeral QPs like *one student*, *three students*..., and definite QPs like *the students*, as well as QPs headed by *all*. For the sake of the current discussion, we will not refer to the other GQPs than *all*-QPs.

distributors (e.g., Vendler, 1967; Gil, 1982), have shown that the distributive construers *every* and *each* yield distinct scope representations in relation with the negation. Assuming the following functional structures, they posited the different LF scope positions to the GQPs and DQPs.



According to Beghelli and Stowell, the scope representations are explained, assuming the functional tree in (164) and that the QR is motivated by feature checking. In particular, GQPs need to check their group reference feature [+group ref] under agreement with an existential operator head,  $\exists$ , which is located in both Share<sub>0</sub> and Ref<sub>0</sub>; thus GQPs may selectively land in the Spec of RefP or the Spec of ShareP, resulting in the different interpretations that they receive. DQPs, on the other hand, land in the spec of DistP, motivated by the checking of their distributive feature [+Dist] under agreement with a distributive operator hosted in Dist<sub>0</sub>.

Given the discussion above, one speculation would be as follows. Children would come to know that the universal quantifier *every* is distinct from other natural language universals through across-context analyses not with respect to inclusivity, but with respect to differences in representation regarding distributivity of the universals. Proposing any concrete solution for this issue, however, goes beyond the scope of this dissertation.<sup>58</sup>

That said, our experimental findings do provide an interesting implication hinting that children have indeed solved this problem with respect to *each* and *every*. Crucially, Beghelli and Stowell (1997) pointed out that the DQPs headed by *every* and those headed by *each* behave differently with respect to the interaction with negation. Consider the following example.

- (165) a. John didn't read every book.  $(\neg > \forall)$   
 b. ??John didn't read each book.  $??(\neg > \forall)$

Whereas *every* is interpreted under the scope of negation as in (165a), *each* prefers to take wide scope over the negation in (165b).<sup>59</sup> Thus, in Beghelli and Stowell's implementation, in (165), DQPs headed by *each* raise and land in the Spec of DistP higher than the NegP, whereas DQPs headed by *every* stay in the VP under the AgrOP.

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<sup>58</sup> Brooks and Braine (1996) has reported that children are able to discriminate *each* and *all* among the universal quantifiers in English, although whether they are sensitive to the distinction between *every* and *each* has not yet reported at this point, to the best of my knowledge.

<sup>59</sup> The contrast observed in the examples as in (165) would be a piece of potential evidence that leads children to distinguish *every* and *each* on a distributional basis.

In order to account for this distinction, Beghelli and Stowell focused on the following distinct behaviors between *every* and *each*, with respect to their possibility of the generic construal.

- (166) a. Every dog has a tail.  
b. Each dog has a tail.

The crucial observation is that *dog* in (166a) can be construed as dogs in general, whereas *dog* in (166b) is construed as the definite set of dogs that has been previously introduced in the discourse.<sup>60</sup>

The following comparison by Gil (1992) also makes the same point, observing that *each*-DQPs pattern with the definite GQPs, whereas *every*-GQPs pattern with generically construed GQPs headed by *all*.

- (167) After devoting the last three decades to a study of lexical semantics, George made a startling discovery.
- a. Every language has over twenty color words.  
b. All languages have over twenty color words.  
c. ?Each language has over twenty color words.  
d. ?The languages have over twenty color words.

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<sup>60</sup> The lack of generic interpretation in (166b) would also serve as the data that tells children about the difference between *each* and *every* with respect to the distributivity.

(168) George has just discovered ten hitherto-unknown languages in the Papua New Guinea highlands.

- a. ?Every language has over twenty color words.
- b. ?All languages have over twenty color words.
- c. Each language has over twenty color words.
- d. The languages have over twenty color words.

Gil accounts for this by attributing to *each* a feature [+Definite], while *every* lacks this feature.

On the basis of the above observations, Beghelli and Stowell claimed the following. *Every* and *each* both introduce discourse referents, in the form of set variables. The set variable of *each* must be bound by a definite operator, while the set variable introduced by *every* can be bound by other operators as well, such as generic and negation. Hence, whereas *each*-QPs are endowed with a [+Dist] feature, which must be checked off in the Spec of the DistP obligatorily, *every*-QPs are underspecified for the feature [Distributive], and thus they selectively move to the Spec of DistP to check off their [Dist] only when their set variable is not bound by a lower operator, such as negation; thus, when there is a lower operator such as negation, *every*-DQPs are bound by it, and the [Distributive] feature checking does not occur.

Let us summarize the discussion so far. In the discussion above, we have observed the commonality and differences among the universal quantifiers, *every*, *each* and *all*. The comparisons among them have exhibited that they all yield the

asymmetric entailment structures in their first and second arguments, but that they behave differently in terms of distributivity and its consequence for the interaction with negation. Relevant to this dissertation is the difference between *each* and *every* in terms of the scope interaction with negation; while *each*-DQPs in the object position obligatorily take wider scope over the negation, with QRing possibly driven by their [+Dist] feature checking, *every*-DQPs in the object position are bound by the negation and thus they do not QR.

Recall that we have introduced the mechanism of reversed entailment in *every* under the scope of negation in Chapter 5, in which we discussed reversed entailment and began considering how the investigation of whether children are sensitive to this phenomenon relates to our major research questions. Given that *every* and *each* behave contrastively in terms of the semantic interaction with negation (which triggers reversed entailment only for *every*), we then raised questions regarding whether children are able to tease apart the two universal quantifiers, *every* and *each*, in terms of scope representation. In what follows, we will show that studying reversed entailment with *every* can not only teach us more about the nature of children's semantic knowledge concerning *every* (including entailment and its relation with scope in linguistic structure) but also addresses the latter problem (whether children distinguish *every* and *each*) in an interesting way which has not been shown in previous Truth Value Judgment studies on the universal quantifier.

Recall that in order for children to be aware of the phenomenon of reversed entailment in *every*-QPs under the scope of negation in an adult-like way, they should be sensitive to the following features listed in (112), repeated as (169) below.

- (169) a. The universal quantifier *every* constitutes a DE environment in its first argument.
- b. The universal quantifier *every* does not QR over the negation in the higher position, and thus it must be interpreted under the scope of the negation.
- c. Consequently, the entailment created in the first argument of *every* is reversed due to the influence of the negation, and thus it is no longer DE.

Given the difference among the universal quantifiers *every* and *each*, in which *each*, but not *every*, QRs over the negation, the item in (169b) should be revised as follows.

- (170) The universal quantifier *every* does not QR over the negation, and thus it is interpreted under the scope of negation; this distinguishes *every* from *each*, i.e., another universal quantifier *each* which obligatorily QRs over the negation, and thus it is interpreted over the scope of the negation.

Given these considerations, if children were to be tested regarding reversed entailments in *every* under the scope of negation, and found to be able to compute the reversed entailment and logical inferences licensed by *every*-QP under negation, it would suggest that their adult-like ability reflects their knowledge about the mechanisms that determine this phenomenon. Interestingly, such results would also suggest that children know that *every* does not work on a par with *each*, as can be

seen most clearly when we consider possible non-adult-like behavior regarding *every* and negation.

Let us consider a possible pattern of responses in which children do not demonstrate adult-like knowledge. Suppose that children do not share the same grammar as adults with respect to the representation of reversed entailment. Specifically, suppose that children inappropriately treat *every*-QP in the object position of sentences with negation uniformly as DE. This non-adult pattern of responses may arise from any of the following potential origins for their errors.

- (171) a. Ignorance of the presence of negation
- b. Ignorance of negation's linguistic contribution to flip the entailment of *every*-QP under its scope (i.e., its DE property)
- c. Ignorance of the universal quantifier *every*
- d. Ignorance of *every*'s linguistic contribution (i.e., its DE property)
- e. Confusion of the universal quantifier *every* with another universal quantifier *each* (recall that, while highly similar, *each* and *every* behave differently with respect to reversed entailment)

Considering these hypotheses, the first four may be unlikely based on previous findings of various studies on children's awareness of the universal quantifier *every* and of negation (e.g., Lidz and Musolino, 2002; Gualmini, 2005). However, we should consider the fifth possibility, which is stated in (171e) in more detail. Notice that, at the truth-conditional level, *each* and *every* are interchangeable

most of the time, especially in the typical truth-value judgment experimental workspace. Consider the following examples.

- (172) a. Every dog is running in the field.  
b. Each dog is running in the field.

Suppose that these sentences are provided as the description in which all the dogs are running in the field. In such a context, the above sentences are equivalent at the truth-conditional level. Thus, from this context we cannot conclude whether children take the phonological form *every* to mean adult *every* or *each*. Since *every* and *each* yield the same truth conditions in such contexts, notice that children's truth-value judgments of these sentences do not reflect anything about their ability to distinguish *every* and *each*.

However, the paradigm of reversed entailment under negation *does* tease apart *every* and *each*, in context of testing entailment and inference in *every*, because these experiments focus on the universal quantifier *every* under negation. Recall that only *every* undergoes reversed entailment under negation, whereas *every* and *each* pattern the same in positive contexts. Adult-like sensitivity to entailment and inference in this context, then, not only argues for knowledge of entailment and inference, but also shows that *every* is *adult every* and not *each*, because in this paradigm unlike positive contexts, adult *every* and *each* predict different results. The reversed entailment by *every*-QP under negation, thus, provides an interesting test case to examine whether children are aware of the distinction between *every* and *each*, as well as for further

exploring our original research questions about children’s ability to compute logical inferences appropriately, on the basis of the direction of entailments between propositions.

Although this *every/each* distinction has not been systematically tested, Experiment VI reported in this dissertation indeed provides evidence in favor of the position in which children *did* distinguish the difference between *every* and *each* in terms of scope interaction with negation. Recall the “Simple Negation” Items prepared for the “Demand-Fulfillment” Task in Experiment VI. The trial that is crucial here is repeated in (173) and (174) below.

(173) “Simple Negation” Item – “Satisfactory” Condition (=140b) on p. 190

a. Demand: “Don’t bring me every apple.”

b. Response: “I didn’t bring you every red apple.”

(174) “Simple Negation” Item – “Unsatisfactory” Condition (=141b) on p. 191

a. Demand: “Don’t bring me every gold coin.”

b. Response: “I didn’t bring you every coin.”

The crucial logic behind these trials is as follows. Recall that, since *every*-QP above is under negation, the entailment pattern is flipped because of the influence from negation, and thus is no longer DE; consequently, the valid inference is licensed from a subset-denoting expression (*red apple, gold coin*) to a set-denoting expression (*apple, coin*). Therefore, an invalid inference is created from (173a) to (173b) (i.e., *I didn’t bring every apple \*→ I didn’t bring every red apple*), whereas a valid

inference is created from (174a) to (174b) (i.e., *I didn't bring every gold coin → I didn't bring every coin*). Recall crucially that the demand is logically satisfied by the fulfillment when the demand does not logically imply the fulfillment; thus (173) demonstrates the satisfactory demand-fulfillment (i.e., the request *don't bring me every apple* can be logically satisfied by the fulfillment *I didn't bring every red apple*). On the other hand, the demand is not logically satisfied by the fulfillment when the demand does logically imply the fulfillment; thus (174) demonstrates the unsatisfactory demand-fulfillment (i.e., the request *don't bring me every gold coin* cannot be logically satisfied by the fulfillment *I didn't bring every coin*).

Suppose now that children would treat *every*-QP in these items on a par with *each*-QP, as hypothesized in (171e), in which they were confused by the huge similarity between *every* and *each*. If this were the case, children's evaluation of the demand-fulfillment presented in the above tokens would have been reversed, since *each*-QP, unlike *every*-QP, undergoes QR in this linguistic environment, i.e., under simple negation (i.e., in children's evaluation, the request *don't bring me every gold coin* would have been satisfied by *I didn't bring every coin*, if *every* were taken to be *each* for children, since the request *don't bring me each gold coin* is logically satisfied by *I didn't bring each coin*).

However, Experiment VI revealed that it was not the case; children demonstrated the expected demand-fulfillment evaluation for "Simple Negation" Items reviewed above, judging that (173) was satisfactory whereas (174) was not. Thus, this data argues that *every* was not mapped to adult *each*, based on these findings.

Therefore, the findings from Experiment VI would suggest one direction in which to expand the current investigation. One possible way to further move ahead would be to test whether children's *each* is mapped onto adult *each* or adult *every*. A promising test case would be these quantifiers' interactions with negation, as we have discussed, in which the difference between *each* and *every* becomes obvious. In addition, it would be promising to focus on children's evaluation of across-proposition meanings in doing so, since it would contrast the distinctive behavior of *each* and *every* regarding the interaction with negation, by means of their distinctive behavior with respect to reversed entailment (i.e., *each* scopes over negation and thus the entailment pattern remains DE, whereas *every* stays under the scope of negation and thus the entailment pattern is reversed by the influence from negation). Hence, an interesting further testing ground for exploring the nature of semantic competence in child language would be to investigate the precise role of scope representation in the interaction of quantification and negation; in this way, we may gain a better understanding of the role of children's logico-semantic knowledge in across-proposition meaning generation.

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