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Why children aren't universally successful with quantification

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Abstract

This paper explores preschooler's knowledge of the linguistic principles (syntactic, semantic and pragmatic) regulating the interaction between universally quantified noun phrases and negation. Previous work has shown that 5-year-olds differ systematically from adults in the way they interpret sentences containing these elements (Musolino, 1998; Musolino, Crain and Thornton, 2000). On the basis of these results, Musolino et al. have come to the conclusion that the grammar of 5-year-olds generates only a subset of the interpretations available in the adult grammar. We present here a series of experiments whose results challenge this conclusion. First, we demonstrate that under certain contextual conditions, 5-year-olds can be shown to access the same range of interpretations which characterize the adult system. Second, we show that while 5-year-olds do not differ from adults grammatically, their command of the pragmatic principles associated with the use of quantified statements is much more fragile than that of adults. We further suggest that children's immature pragmatic abilities is what gave rise to Musolino et al.'s findings in the first place. In doing so, we tie together research on grammatical development with a growing body of work on the development of pragmatic abilities and sentence processing in young children (Noveck, 2001; Papafragou and Musolino, in press; Trueswell, Sekerina, Hill, and Logrip, 1999; Hurewitz, Brown-Schmidt, Thorpe, Gleitman and Trueswell, 2000). Finally, we show that our results have interesting methodological implications for the study of grammatical development.

Key words: language acquisition, quantification, negation, scope ambiguity, pragmatics, processing, competence/performance.

* The authors are engaged in a continuing collaboration in which the order of names alternates from one paper to the next.

1. Introduction

In recent years, children's comprehension of sentences containing quantified expressions has received considerable attention from investigators in the field of psycholinguistics (Philip and Aurelio, 1991; Drozd and Philip, 1993; Philip, 1995, 1996; Philip and Lynch, 2000; Brooks and Braine 1996; Crain, Thornton, Boster, Conway, Lillo-Martin and Woodams, 1996; Crain, 2000; Drozd, 2000; Musolino, Crain and Thornton, 2000; Krämer, 2000; Lidz and Musolino, 2002; Papafragou and Musolino, in press; among many others). Because quantificational phenomena involve the interplay of multiple levels of linguistic analysis (i.e., syntactic, semantic and pragmatic), the grammar of quantification represents a paradigm particularly well-suited for investigating the development of a broad range of linguistic principles.

A central question emerging from this line of research concerns the nature of the linguistic representations underlying preschoolers' quantificational competence and the extent to which these representations differ from those of adults. This question arises from the observation that preschoolers often differ from adults in the way they interpret sentences containing quantified expressions (*ibid*). While the validity of this observation is now beyond dispute, the factors giving rise to the phenomenon have been the subject of vigorous debate (Philip, 1995; Crain, Thornton, Boster, Conway, Lillo-Martin and Woodams 1996; Drozd and van Loosbroek, 1999; Philip, 1996; Philip and Lynch, 2000; Crain 2000).

To be sure, determining why children differ from adults in the way they interpret quantified sentences involves the delicate task of teasing apart the effect of a large number of variables, ranging from the contribution of the various linguistic factors giving

rise to quantificational phenomena to the influence of particular experimental techniques on the child's performance. In this paper we take up this task – if only within a much narrower domain – by exploring preschooler's knowledge of the linguistic principles (syntactic, semantic and pragmatic) regulating the interaction between universally quantified NPs and negation. Previous work has shown that 5-year-olds differ systematically from adults in the way they interpret sentences containing these elements (Musolino, 1998; Musolino, Crain and Thornton, 2000). On the basis of these results, Musolino et al. have come to the conclusion that the grammar of 5-year-olds generates only a subset of the interpretations available in the adult grammar. We present here a series of experiments whose results challenge this conclusion. First, we demonstrate that under certain contextual conditions, 5-year-olds can be shown to access the same range of interpretations characteristic of the adult grammar. Second, we show that while 5-year-olds do not differ from adults grammatically, their command of the pragmatic principles associated with the use of certain quantificational expressions is much more fragile than that of adults. We further suggest that children's immature pragmatic abilities is what gave rise to Musolino et al.'s findings in the first place. In doing so, we tie together research on grammatical development with a growing body of work on the development of pragmatic abilities and sentence processing in young children (Noveck, 2001; Papafragou and Musolino, in press; Trueswell, Sekerina, Hill, and Logrip, 1999; Hurewitz, Brown-Schmidt, Thorpe, Gleitman and Trueswell, 2000). We also show that our results have methodological implications for the study of child language and in particular that they call for a refinement of some the assumptions associated with the use of the Truth Value Judgment Task of Crain and Thornton (1998). We conclude, with

Crain and Thornton (1998), that the study of grammatical development cannot proceed without a careful consideration of children's growing language processing and pragmatic abilities.

The discussion is organized as follows: We begin by introducing the phenomenon we shall be concerned with (section 2.1.) as well as previous studies on the acquisition of this phenomenon (section 2.2). Section 3 and 4 are the main experimental sections of the paper. Section 5 summarizes our results and presents an integrated account of our findings followed by a discussion of their implications for the development of quantificational competence and, more generally, for the study of grammatical development.

2. Preliminaries

2.1 Theoretical background

A well-known property of quantificational expressions is their ability to interact with one another to create scope ambiguity (Horn, 1989; Jackendoff, 1972; Lasnik, 1972; May 1977 among many others). Consider for example the interaction between the universal quantifier and negation in the sentence in (1).

- (1) Every student can't afford a new car.
- a. $\forall x [\text{student}(x) \rightarrow \neg \text{can afford a new car}(x)]$
 - b. $\neg \forall x [\text{student}(x) \rightarrow \text{can afford a new car}(x)]$

On one reading, (1) can be paraphrased as *Every student is such that s/he cannot afford a new car*. In this case, the universally quantified subject is interpreted outside the scope of

negation (abbreviated *every* > *not*), as indicated by the logical representation in (1a). On another reading, (1) can be paraphrased as *Not every student can afford a new car*. Here, *every student* is interpreted within the scope of negation (abbreviated *not* > *every*), as shown in (1b).

This example illustrates a core property of language that we will refer to as ‘covert displacement’, namely the fact that, in the absence of overt syntactic movement, certain expressions are interpreted in a position different from the one in which they occur (Rodman 1976; May 1977, 1985; Hornstein 1995; Reinhart 1997). In our example above, notice that the phrase *every student* c-commands the negative clitic *n’t* in the surface syntax. This configuration naturally leads to the interpretation given in (1a) via a straightforward, isomorphic mapping between (surface) syntactic structure and semantic structure. However, in (1b), this configuration is reversed – negation now takes scope over the universal quantifier – thereby illustrating a mismatch between surface syntactic structure and semantic interpretation. This is the phenomenon of covert displacement in evidence. In sum, while the quantificational expression *every student* c-commands negation in the surface syntax, either scope relation between these two elements is possible in the semantics.

Interestingly, not all sentences containing a universally quantified NP and negation appear to give rise to scope ambiguity. This can be seen by comparing (1), which finds the universally quantified NP in subject position and is perceived to be ambiguous, and (2), which finds the universally quantified NP in object position and is not perceived to be ambiguous. To be sure, the most natural interpretation of (2) is one on which the

professor talked to some of the students but not to other(s). In other words *every student* is interpreted within the scope of negation, as shown in (2a).

(2) The professor didn't talk to every student.

a. $\neg \forall x [\text{student}(x) \rightarrow \text{talked to}(\text{professor}, x)]$

At this point, it is relevant to observe that while the most natural interpretation of (2) is one which the professor talked to only some of the students, but not all of them (i.e. not > every), this sentence would also be true in a situation in which the professor had talked to none of the students (i.e. every > not)¹. This is so because every situation which satisfies the truth conditions of the *every > not* (i.e. none) reading also satisfies the truth condition of the not > every (i.e. not all) reading. In other words, if none of the students are such that the professor talked to them, it follows that not all the students are such that the professor talked to them; but not vice-versa. These entailment patterns are shown in (3).

(3)	a.	$\forall x[\neg P(x)] \rightarrow \neg [\forall x [P(x)]]$	none \rightarrow not all
	b.	$\neg [\forall x[P(x)]] \rightarrow \# \forall x[\neg P(x)]$	not all \rightarrow # none

What is interesting about such entailment patterns is that they give rise to a well-known class of conversational inferences called scalar implicatures (Horn, 1972, 1989 among many others). Scalar implicatures typically arise in examples like (4) where the speaker's use of *some* indicates that s/he had reasons not to use a stronger (i.e. more

¹ Because the truth conditions of the 'none' reading are a subset of the truth conditions of the 'not all' reading, we are unable to tell whether the grammar generates this reading directly. That is, the fact that the sentence can be true in situations that are consistent with a representation in which the universal takes scope over negation does not indicate that this representation is actually produced.

informative) term, e.g. *all*. The use of *some* in (4) thus gives rise to the inference or implicature in (5).

(4) Some students can afford a new car.

(5) Not all students can afford a new car.

What defines informational strength here is precisely the presence of entailment relations. So for example, *all the students can afford a new car* entails that *some students can afford a new car*, but not vice-versa. In other words, the proposition that all the students can afford a new car is true in a subset of the set of circumstances which verify the truth conditions of the proposition that some students can afford a new car. This situation is represented schematically in (6).

(6) $\forall x [P(x)] \supset \exists x [P(x)]$

Assuming that the speaker is trying to be co-operative and will say as much as s/he truthfully can that is relevant to the exchange (Grice 1957, 1989), the fact that s/he chose the weaker term (i.e. *some*) gives the listener reason to think that s/he is not in a position to offer an informationally stronger statement (i.e. *All students can afford a new car*). This leads to the inference that the stronger statement does not hold, i.e. to (5). The inference in (2) is typically referred to as a *scalar implicature* (Horn, 1972, 1989).

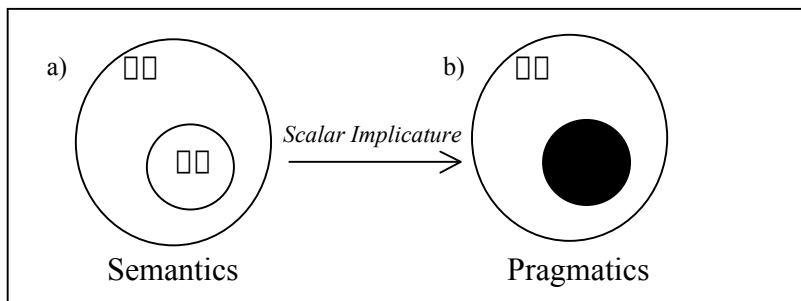
We can now return to our example in (3), repeated here as (7), and see that the entailment relation between the ‘none’ (i.e. every > not) and the ‘not all’ reading (i.e. not > every) gives rise to the same kind of phenomenon as the one described above. In other

words, the use of *not every* in (7) gives rise to the inference that the stronger term on the scale, i.e. ‘none’ does not hold, i.e. (7.1).

(7) The professor didn’t talk to every student

(7.1) It is not the case that the professor didn’t talk to any students

This explains why, even though (7) is true in a context in which none of the students are such that the professor talked to them, it is most naturally interpreted on a ‘not all’ reading (for similar considerations regarding the interpretation of sentences like (1), see section 5 and the extensive discussion offered by Horn, 1989). Thus, while (7) is semantically compatible with both a ‘none’ and a ‘not all’ reading, it is pragmatically only compatible with a ‘not all’ reading. The diagram below illustrates this situation².



Finally, an important property of scalar implicatures is that they are cancelable, as shown by (8).

- (8) a. Some of my students got an A. In fact, they all did.
 b. Not all of my students got an A. In fact, none of them did.

² The account presented here essentially follows standard neo-Gricean lines (i.e. Horn, 1972, 1989 among others). For a different view, see Chierchia et al. (2001).

Moreover, there are specific contexts in which scalar implicatures fail to arise. Such contexts include situations of uncertainty such as predictions or bets. Imagine for example that someone were to make a bet that some of the students in her class will get an A. Suppose now that all of the students end up getting an A. In this case, it seems obvious that the bet is won. In other words, the use of a weaker term in the statement of the bet (i.e. some students will get an A) appears to be consistent with a situation in which all of the students get an A.

To summarize, we have seen that the interpretation of sentences containing universally quantified expressions and negation involves the interplay of syntactic (i.e. c-command relations), semantic (i.e. entailment relations) and pragmatic (i.e. conversational inferences) factors. Given the complexity and abstract nature of the facts described above, explaining when - and more importantly *how* - learners become aware of these facts raises important psychological questions (Chomsky, 1965, Crain, 1991, Pinker, 1989 among many others). The need to elucidate these questions and to evaluate the claims from previous studies is what led us to the research presented here. Accordingly, we begin by reviewing earlier work investigating children's comprehension of the interaction between negation and other quantificational expressions.

2.2 Previous studies

Several studies on children's comprehension of the interaction between quantifiers and negation can be found in the literature on language acquisition (Roeper and Matthei, 1975; Boysson-Bardies, 1977; Drozd and Philip 1993, O'Leary & Crain, 1994; Thornton, 1995; Krämer, 2000, Lidz and Musolino, 2002; Gualmini, in preparation). One study

designed to investigate the acquisition of scopal interactions between quantificational NPs and negation is Musolino, Crain and Thornton (2000) (based on Musolino, 1998). In a series of experiments using the Truth Value Judgment Task (Crain and Thornton, 1998), Musolino et al. (2000) tested children's and adults' interpretation of sentences like (10) and (11).

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

- a. $\neg x$ [horse (x) \wedge \neg jump over the fence (x)]
- b. $\neg \neg x$ [horse (x) \wedge jump over the fence (x)]

(11) The Smurf didn't buy every orange

- a. $\neg \neg x$ [Smurf (x) \wedge buy (x, orange)]

As discussed in section 2.1, sentences like (10) are ambiguous between a 'none' and a 'not all' reading (10a and 10b respectively). Using Musolino et al.'s terminology, (10a) corresponds to an isomorphic interpretation (because of the isomorphic mapping between syntactic and semantic scope) while (10b) corresponds to a non-isomorphic interpretation. By contrast, (11) seems only to allow an isomorphic, i.e. 'not all' interpretation (but see discussion in section 2.1). The main finding from Musolino et al.'s study is that while adults can easily access the non-isomorphic interpretation of sentences like (10) and the isomorphic interpretation of sentences like (11), 5-year-olds systematically assign (10-11) an isomorphic interpretation only. In other words, 5-year-olds never assign sentences like (10) a non-isomorphic interpretation. This is what Musolino et al. call the 'Observation of Isomorphism'.

In order to account for the observation of isomorphism - as it pertains to universally quantified NPs and negation - Musolino et al. observe that in Chinese, the equivalent of a sentence like (10) allows only an isomorphic, i.e. ‘none’ interpretation. This situation creates the following, well-known, learnability problem (Berwick, 1985; Pinker, 1989; Crain, 1991; Crain and Thornton, 1998; Wexler and Manzini, 1987 among others). Suppose a learner of Chinese were to begin acquisition with the (incorrect) hypothesis that his/her grammar allows both the isomorphic and the non-isomorphic interpretation. Such a learner might never be able to recover from this hypothesis because all of the data s/he encounters will be consistent with it. Consequently, the subset argument leads to the conclusion that the initial state must contain the Chinese hypothesis. This hypothesis would be correct for children learning languages that allow only the isomorphic reading and easily disconfirmed for children learning languages that allow both the isomorphic and the non-isomorphic readings. Thus, Musolino et al. explain the observation of isomorphism by claiming that when children fail to access the non-isomorphic reading, it is because they are in a stage of development in which their grammar of quantification is essentially Chinese.

The observation of isomorphism and the account offered by Musolino et al. raise a number of interesting questions. First, one may wonder whether the difference between 5-year-olds and adults observed by these authors does indeed have a grammatical basis. This question is prompted by the observation that the ambiguity shown in (1) arises from the operation of core grammatical mechanisms which many would assume are in place by the time children reach their fifth birthday.³ An alternative possibility would be that

³ The mechanism involved in interpreting a universal subject inside the scope of negation requires the subject to be interpreted internal to VP (Ladusaw 1988, McCloskey 1996), whether this is achieved by a

children and adults have similar grammars but that they display different interpretive preferences regarding sentences like *Every horse didn't jump over the fence*. In other words, children may be aware of the fact that such sentences are ambiguous but they may find the non-isomorphic interpretation more difficult to access than the isomorphic one.

As Andrea Gualmini pointed out to us, it is interesting to observe in this respect that negative statements have been argued to be easier to process when certain felicity conditions are met⁴ (Wason, 1965; Horn, 1989). Horn (1989:172), citing Wason and others summarizes this idea as follows:

“Very simply, the function of negative sentences is ‘generally to emphasize that a fact is contrary to an expectation’ (1965:7). Negative statements by their nature ‘assume and depend on a prior state of affairs, either existent or supposed . . . It is unlikely that the sentence “It is not x” would be uttered unless there were good reason to suppose that it might have been “x” or that someone thought that it might’ (Cornish and Wason 1970:113). Thus, *5 is not even* is harder to process and takes longer to verify than *5 is odd*, but the difficulty is mitigated if we set up a ‘context of denial’: *4 is even {and / but} 5 is not even* (cf. Greene 1970a:18; Wason 1972:28). Psychologically, if not ontologically, negation seems to require – or at least to strongly prefer – an affirmative context against which to operate.”

This observation provides an interesting test for Musolino et al.’s grammatical account: to the extent that children’s apparent inability to access non-isomorphic interpretations reflects a grammatical difference between children and adults, presenting children with sentences like *Every horse didn't jump over the fence* in a context which satisfies the felicity conditions described above should yield no significant improvement in performance. Conversely, if performance improves in such contexts, we would then have

lowering operation (cf. Diesing 1992) or by interpreting only the “copy” of the subject which occurs in [spec, VP] and pronouncing only the “copy” in [spec, IP] (cf. Chomsky 1993).

⁴ We would like to thank Andrea Gualmini for pointing out this fact to us, as well as its implications for our account.

evidence against a competence explanation and in favor of a performance account⁵. In the next section, we present an experiment designed to test these predictions.

Regarding sentences like (11), Musolino et al.'s study shows that 5-year-olds can easily access the 'not all' interpretation which, in this case, corresponds to an isomorphic interpretation. What Musolino et al. didn't test however, is whether children also know that sentences like (11) are true in a 'none' context (see discussion in section 2.1). This question is worth asking though, for the following reason: since sentences like (11) are true in 'none' contexts by virtue of the entailment relations between 'none' and 'not all' (see discussion in section 2.1), showing that children accept such sentences in 'none' contexts would provide evidence that they have knowledge of the relevant entailment relations. Put another way, since sentences like (11) are typically used in 'not all' contexts (for pragmatics reasons, as discussed in section 2.1), it is hard to see how children would know that they are also true in 'none' contexts if they didn't have knowledge of the relevant entailment relations between 'none' and 'not all'. Moreover, testing children (and adults') interpretation of sentences like (11) would give us the opportunity to directly test for the pragmatic bias giving rise to the preference for the 'not all' reading discussed in section 2.1. In section 4, we present an experiment designed to address these issues.

3. Experiment 1

Our first experiment was designed to test the competence account of Musolino et al. (2000). In order to do so, we tested children in two conditions. The first condition was

⁵ For similar considerations in the case of sentences of the form *NP didn't V some N*, see Gualmini, in preparation.

designed to replicate Musolino et al.'s (2000) findings. Children were therefore tested using the same method and similar materials as the ones used by Musolino et al. (2000), i.e. sentences like (12) below. In the second condition, children we presented with the same sentences as in condition 1 but, in order to satisfy the felicity conditions on the use of negative statements described in the previous section, these sentences were all preceded by affirmative statements which differed from their negative counterparts only in the object NP, as shown in (13).

(12) Every horse didn't jump over the fence.

(13) Every horse jumped over the log but every horse didn't jump over the fence.

3.1 Method

Subjects

We tested 20 English-speaking children (8 boys and 12 girls) between the ages of 5;0 and 5;11 (mean 5;4). One child was replaced in the design because she could not provide justifications to her answers. We chose 5-year-olds because previous studies, in particular Musolino et al. (2000), showed that children in that age range gave non-adult responses to ambiguous sentences containing a universally quantified subject and negation. The children were selected from daycare centers in the Philadelphia and in the Bloomington (Indiana) areas. In addition to the children, we also tested a control group of 20 adult native speakers of English. The adult subjects were all undergraduate students at the University of Pennsylvania and Indiana University.

Procedure

As in Musolino et al.'s study, we tested children using the Truth Value Judgment Task methodology (TVJT) (Crain and Thornton, 1998). The TVJT typically involves two experimenters. The first experimenter acts out short stories in front of the subjects using small toys and props. The second experimenter plays the role of a puppet who watches the stories alongside the subjects. At the end of the story, the puppet makes a statement about what he thinks happened in the story. The subjects' role is to decide whether the puppet's statement is 'right' or 'wrong'. Finally, subjects are asked to justify their answers by explaining why they think that the puppet was right or wrong. For a more detailed description of the TVJT, see Crain and Thornton (1998).

The children were first introduced to the task as a group and then tested individually in a quiet room away from the class. Each child received two pretest stories and if the child could answer those appropriately (including appropriate justifications for their answers), they would then hear seven more stories: four test stories and three control stories, administered in a pseudo-random order.

Adult subjects were shown a videotaped version of the stories witnessed by the children, including the pretest stories. They were given a score sheet and were instructed to indicate, for each story, whether the puppet was right or wrong. They were also asked to provide justifications for their answers.

Materials

In condition 1, whose purpose was to replicate Musolino et al.'s findings, children were tested on their interpretation of sentences like (12), repeated here as (14).

(14) Every horse didn't jump over the fence.

In the story corresponding to (14), for example, three horses decided to test their skills by jumping over various obstacles. First, the horses considered jumping over a barn but they realized that it was too tall and therefore that it might be dangerous. Next, the horses considered jumping over a fence. The first two horses cleared the fence but the third one, who had hurt its leg the day before, decided not to jump. At the end of the story, the puppet described the situation using the sentence in (14), see picture 1.

Picture 1



“Every horse didn't jump over the fence”

Notice that in the context of the story just described, (14) is false on an isomorphic (i.e. ‘none’) reading since it is not the case that none of the horses jumped over the fence. So if subjects access the isomorphic interpretation of (14), we expect them to reject the puppet's statement. By contrast, (14) is true on a non-isomorphic interpretation (i.e. not all) since it is true that not all the horses jumped over the fence, i.e. two did and one

didn't. So if subjects access the non-isomorphic interpretation, we expect them to accept the puppet's statement.

In condition 2, children were presented with the same sentences as those used in condition 1, but these sentences were preceded by affirmative statements, as shown in (15).

(15) Every horse jumped over the log but every horse didn't jump over the fence.

The stories corresponding to sentences like (15) were very similar to the ones used with sentences like (14). In the case of (15), three horses decided to test their skills by jumping over various obstacles. First, the horses all jumped over a log and then only two of them jumped over the fence. In the end, therefore, the situation is fully parallel to the one described in condition 1: the isomorphic reading is false in this context since it is not the case that none of the horses jumped over the fence whereas the non-isomorphic reading is true since not all the horses jumped over the fence (see picture 2).

Picture 2



“Every horse jumped over the log but every horse didn't jump over the fence”

The complete sets of test sentences used in condition 1 and 2 is given in tables 1 and 2 below.

Table 1

Puppet's statements on test stories in Condition 1

Test story 1	'Every horse didn't jump over the fence'
Test story 2	'Every Smurf didn't buy a cat'
Test Story 3	'Every bunny didn't play on the merry-go-round'
Test story 4	'Every dinosaur didn't eat a tree'

Table 2

Puppet's statements on test stories in Condition 2

Test story 1	'Every horse jumped over the log but every horse didn't jump over the fence'
Test story 2	'Every Smurf bought a dog but every Smurf didn't buy a cat'
Test Story 3	'Every bunny played on the swing but every bunny didn't play on the merry-go-round'
Test story 4	'Every dinosaur ate a bug but every dinosaur didn't eat a tree'

In addition to the four test stories, children also heard three control stories. Unlike the test items, the statements made by the puppet on the control stories were not ambiguous. The experimenter holding the puppet had a choice between two different statements for each of the control stories. One statement was true in the context of the story and the other was false. If the child had answered YES to a given test story, the experimenter holding the puppet was instructed to pick the statement for the following control story corresponding to a NO answer, and vice-versa. This precaution was taken to ensure that children could provide either kind of answer, i.e. YES or NO, when appropriate⁶.

⁶ There is by now overwhelming evidence that children as young as 3;5 – and certainly 4 and 5 year-olds – experience no difficulty whatsoever with the task and are perfectly capable of giving either 'Yes' or 'No'

The list of statements made by the puppet on control stories is given in Table 3.

Table 3

Puppet's statements on control stories in both conditions

Control story 1	Donald found all of his friends	TRUE
	Donald only found two of his friends	FALSE
Control story 2	The big guy ate all the pizza	FALSE
	The big guy only ate two slices of pizza	TRUE
Control Story 3	The big guy put all the elephants on the table	FALSE
	The big guy only put two elephants on the table	TRUE

Finally, the 40 subjects (20 children and 20 adults) were randomly assigned to each of the two conditions, yielding a 2 by 2 design with age (children vs. adults) and condition (condition 1 vs. condition 2) as between subject factors and 10 subjects per cell. The group of children assigned to condition 1 ranged in age between 5;2 to 5;11 (mean 5;7) and the children assigned to condition 2 ranged in age between 5;0 to 5;9 (mean 5;2).

3.2 Results

In the analyses below, we used as our dependent measure the proportion of YES responses to the puppet's statements. Beginning with test items, we found that in condition 1 (our replication condition), children almost never accepted the puppet's statements, i.e. 15% of the time whereas adults almost always did so, i.e. 92.5 % of the time ($t(18) = 6.83, p < .0001$). By contrast, we found that children in condition 2 accepted the puppet's statement reliably more often, i.e. 60% of the time⁷ (compared to 15% in

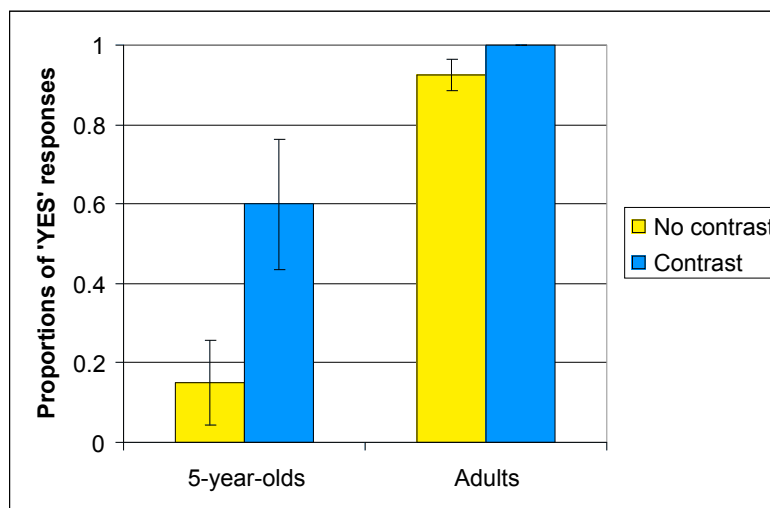
answers when appropriate (Crain and Thornton, 1998; Musolino et al., 2000; Lidz and Musolino, 2002; Papafragou and Musolino, in press).

⁷ In fact, six of the ten children always accepted the puppets statements (i.e. 4 times out of 4) whereas the remaining four children never did (0 times out of 4).

condition 1, $t(18) = 2.3, p < .05$)⁸. Adults in condition 2 always accepted the puppet's statements, i.e. 100% of the time.

The proportions of YES responses to the test items were entered into an analysis of variance (ANOVA) with two factors: age (children vs. adults) and condition (condition 1 vs. condition 2). The analysis revealed a significant main effect of age ($F(1,36) = 34.94, p < .0001$), a significant main effect of condition ($F(1,36) = 6.97, p = .01$) and a marginally significant interaction between age and condition ($F(1,36) = 3.55, p = .06$), see graph 1.

Graph 1



Proportion of 'Yes' responses to the puppet's statements for children and adults in both conditions

⁸ Also notice that the children in the replication condition, i.e. those who *did not perform like adults*, were on average reliably *older* than the children in condition 2, who performed in a more adult-like fashion (mean 5;2 vs. mean 5;7, $t(18) = -3.45, p < .01$).

On control items, children gave correct responses 100% of the time in condition 1 and 96% of the time in condition 2. Adult subjects always gave correct answers, i.e. 100% of the time in both conditions.

In condition 1, children rejected the puppet's statements 85% of the time. When asked why the puppet was wrong, children typically invoked the fact that two of the horses did jump over the fence. By contrast, adults – who almost always accepted the puppet's statements (i.e. 92.5% of the time) – typically said that the puppet was *right* because not all the horses jumped over the fence, i.e. two did but one didn't. In condition 2, the children who rejected the puppet statements invoked the same reasons as the children in condition 1, namely the fact that two horses did jump over the fence. By contrast, the children who accepted the puppet's statements justified their answers in the same way that adults did, namely by invoking the fact that while two horses had made it over the fence, one didn't.

3.3 Discussion

First, it is important to observe that our results replicate the findings of Musolino et al. (2000) in the case of sentences like *Every N didn't VP*. That is, we found, as did Musolino et al., that while adults can easily access the non-isomorphic (i.e. not all) interpretation of such sentences (i.e. 92.5 % of the time, including appropriate justifications), 5-year-olds almost never do so (i.e. 15% of the time⁹). More importantly however, our results show that children's ability to access the non-isomorphic interpretation increases dramatically when these sentences are preceded by affirmative

⁹ Notice here too that the justifications provided by children in our replication condition match those reported by Musolino et al. (2000). In other words, in both studies, children overwhelmingly rejected the puppet's statements that *Every N didn't VP* by invoking the fact that two Ns had indeed Ved.

statements as in *Every N VP but every N didn't VP* (i.e. 15% vs. 60% acceptance rate, $p < .05$). That children are indeed accessing non-isomorphic interpretations – rather than simply saying ‘Yes’ more often because they may be confused by the more complex statements – is clearly demonstrated by the justifications they provide. Recall that children who accept the puppet statements in condition 2 typically explain that the puppet is right because two of the horses jumped over the fence but the third one didn't; in other words, not all the horses jumped over the fence.

Showing that children's ability to access the not all, non-isomorphic interpretation of sentences like *Every N didn't VP* improves under certain contextual manipulations casts serious doubts on the grammatical account proposed by Musolino et al (2000)¹⁰. Such a ‘competence’ account makes a strong, falsifiable prediction: since children's non-adult interpretations reflect a lack of grammatical knowledge, contextual support should have no effect on the child's ability to access the non-isomorphic interpretation of sentences like *Every N didn't VP*. Clearly, the facts presented here indicate otherwise and so the grammatical account must be abandoned.

As we have seen, the data presented so far seem to indicate that 5-year-old children do have the grammatical competence to generate the non-isomorphic interpretation of sentences like *Every horse didn't jump over the fence*. However, one possible explanation of the findings that we have reported is that Musolino et al. were right to conclude that children fail to generate the non-isomorphic interpretation but that some other factor explains their apparent abilities in our contrast condition. In particular, it is possible that children believe that “but” contains a negation operator in its semantic representation. If this were so, then the non-isomorphic reading would not arise from a movement

¹⁰ For a similar conclusion regarding sentences like *NP didn't V some N*, see Gualmini, in preparation.

operation inverting the scopes of “every” and “n’t” but rather from the fact that there is a negative operator that c-commands the universal quantifier on the surface, namely the one inside “but”. On this view, the “not every” interpretation would be isomorphic since the relevant negation would be inside “but”.

In order to test this hypothesis, we tested a group of 10 children between the ages of 4;6 to 6;1 (mean 5;4) on their interpretation of sentences like (16) where *but* was replaced by *and* (the mean ages of the children in the ‘but’ and in the ‘and’ condition, i.e. 5;2 and 5;4 respectively, do not differ significantly, i.e. $t(18) = -1.09$, $p = .28$). The procedure and materials used in this condition were otherwise identical to the ones used in condition 2.

(16) Every horse jumped over the log and every horse didn’t jump over the fence.

What we found is that in response to sentences like (16) children accessed the non-isomorphic interpretation (i.e. accepted the puppet’s statements and provided appropriate justifications) 55% of the time, compared to 60% of the time in response to sentences containing *but*. No reliable differences were found between these two acceptance rates ($t(18) = 0.2$, $p = 0.8$). We therefore conclude that it is the presence of an affirmative statement preceding sentences of the form *Every N didn’t VP* and not a negative operator contained in “but” that gives rise to the effect we have observed. In other words, the non-isomorphic reading IS generated by children’s grammars, contra Musolino et al. (2000), but this reading requires the contextual support provided by the affirmative statement in order to be detected.

Another possibility has to do with the potential effect of prosody on the resolution of ambiguous sentences like *Every horse didn't jump over the fence*. It is sometimes claimed in the linguistics literature (e.g. references cited in Horn 1989) (although, crucially, never demonstrated experimentally¹¹) that the 'none' and the 'not all' readings may be associated (at least in English) with different intonational contours. On the assumption that this is the case, and awaiting confirming experimental evidence, one could speculate that preschoolers, unlike adults, are insensitive to the prosodic contour associated with the 'not all', non-isomorphic interpretation and therefore that they so often fail to access such interpretations. Interestingly, the claim that young children often fail to use prosodic cues to resolve syntactic ambiguity has recently received experimental support (Snedeker & Trueswell, 2001). So far so good. Severe complications arise however, when one tries to make sense of children's improved performance in response to sentences of the form *Every N VP but/and every N didn't VP*. One could hypothesize that once embedded within such larger structures, sentences like *Every N didn't VP* receive a different prosodic contour which may facilitate children's access to the 'not all' interpretation. However such an account leads to the following paradox: in order to account for children's difficulty with the 'not all' interpretation in the first place, i.e. in the case of sentences like *Every horse didn't jump over the fence*, one needs to assume that children CANNOT use prosodic cues to resolve such ambiguities. However, in order to account for the fact that children are better with sentences like *Every horse jumped over the log but every horse didn't jump over the fence*, one now needs to assume that children CAN use prosodic information to resolve such ambiguities – hence the paradox. Thus an

¹¹ It remains an entirely open question whether such prosodic cues do indeed exist and, if so, whether listeners would use them to resolve ambiguous sentences like *Every N didn't VP*. We are currently investigating this issue experimentally.

account on which prosody is the sole variable affecting children's differential rates of success with the 'not all' interpretation of sentences like *Every N didn't VP* does not appear to be very promising. Moreover, notice that even if such an account turned out to be correct, it would not affect our claim that children's difficulty with the 'not all' interpretation results from *performance* rather than *competence* factors.

Let us take stock. We've been concerned here with children's knowledge of the linguistic principles regulating the interaction between the universal quantifier and negation in sentences like (17) and (18) below:

(17) Every N didn't VP

(18) NP didn't V every N

As discussed in section 2.1, the interpretation of such sentences involves the interplay of syntactic, semantic and pragmatic factors. So far, we have shown - contra Musolino et al. (2000) - that 5-year-olds can access both interpretations of sentences like (17) (i.e. the 'not all' and the 'none' interpretation). This result demonstrates that preschoolers know that such sentences are scopally ambiguous and therefore that they must have knowledge of covert displacement.

Our next task involves determining whether preschoolers have adult-like knowledge of the set of truth conditions associated with sentences like (18). Since Musolino et al. established that 5-year-olds know that sentences like (18) are true in a 'not all' context, we ask whether children also know that such sentences are true in a 'none' context (see section 2.1). In addition, we ask whether we can find experimental evidence, in children and in adults, for the pragmatic bias associated with the use of such sentences (see section

2.1). Our goal therefore, is to determine whether children have knowledge of the syntactic, semantic and pragmatic principles associated with the interpretation of sentences like (17-18).

4. Experiment 2

This experiment was designed to test children and adults' interpretation of sentences like (19). As discussed above, such sentences are TRUE in situations in which either 'none' or 'not all' of the elephants were placed on the table. However, the use of 'not every' in (19) (as opposed to the stronger 'not any') gives rise to the implicated meaning in (20) (see section 2.1).

(19) The strong guy didn't put every elephant on the table.

(20) It is not the case that the strong guy didn't put any of the elephants on the table.

Recall from our discussion in section 2.1. however, that there are contexts in which such implicated meanings fail to arise. An interesting consequence of this fact for experimental design is that contexts can be constructed in which the implicated meaning either arises or fails to arise which allows the experimenter to directly test subject's sensitivity to such a pragmatic bias. In the experiment described below, we tested children and adults' interpretation of sentences like (19) in contexts which either licensed or failed to license the implicated meaning in (20) based on a technique discussed in Chierchia, Crain, Guasti and Thornton (1998). The basic idea is to present statements like (19) either as a description of a set of events that took place in a story (in which case an implicated meaning is expected to arise) or as a prediction (or a bet) regarding what will

happen in a story (in which case the implicated meaning is not supposed to arise). For further discussion of this technique, see Chierchia et al. (1998).

4.1 Method

Subjects

We tested 20 English speaking children (9 boys and 11 girls) between the ages of 5;0 and 5;10 (mean 5;4). Three children were replaced in the design because they were either too shy or could not provide justifications to their answers. The children were selected from daycare centers in the Philadelphia area. In addition to children, we also tested a control group of 20 adult native speakers of English. The adult subjects were all undergraduate students at the University of Pennsylvania.

Procedure

As in experiment 1, we tested subjects using the TVJT. Statements like (19) were presented either as a description of the story witnessed by the subjects (i.e. descriptive mode), in which case subjects were asked whether the puppet ‘said it right’ or ‘said the right thing’¹² or as a prediction made by the puppet about what was going to happen in the story (i.e. predictive mode)¹³, in which case subjects were asked whether the puppet made a correct prediction. Recall from our discussion in section (2.3) that an important property of scalar implicatures is that they can be cancelled. Moreover, scalar implicatures are typically cancelled in the context of a prediction or a bet. By using such

¹² Since we were interested in pragmatic judgments – and not judgments about truth conditions – we avoided asking subject whether what the puppet had said was TRUE or FALSE or RIGHT or WRONG. Instead, by asking subjects whether the puppet ‘said it right’ or ‘said the right thing’ we hoped to direct subjects’ attention to the pragmatic nature of the task. For further discussion of this point, see Papafragou and Musolino, in press.

¹³ The terms ‘description mode’ and ‘prediction mode’ are borrowed from Chierchia et al. 1998.

contexts, we were therefore able to create situations in which the scalar implicature associated with sentences like (19) was not expected to arise. By contrast, a scalar implicature was expected to arise when statements like (19) were used as a description of the stories witnessed by our subjects.

Let us illustrate these points by taking a closer look at the story used to test subjects' interpretation of sentences like (19). In the descriptive mode, the story begins with a strong guy, three dogs and three elephants. In order to test his strength, the strong guy tries to lift the animals one by one and to put them on a large table behind him. The strong guy begins with the dogs and easily manages to place each of them on the table. He then turns to the elephants and tries to lift the bigger one. Unfortunately, the big elephant is far too heavy for the strong guy who cannot even lift it off the floor. The strong guy then turns to the medium elephant, hoping that it is lighter. Still no luck though – elephants are heavy! Finally, the strong guy tries to pick up the smaller elephant but he still fails to lift it off the ground. In the end therefore, the strong guy was able to put all the dogs on the table but none of the elephants. At this point, the puppet describes what happened by saying that “The strong guy didn't put every elephant on the table”. In this case, the puppet's use of a weaker expression (i.e. ‘not every’) to describe a situation which satisfies the truth conditions of a stronger term on the scale (i.e. ‘not any’) gives rise to pragmatic infelicity due to the scalar implicature associated with the use of the expression ‘not every’. To the extent that subjects are sensitive to scalar implicatures, we expect them to find the puppet's statements to be ‘bad’ descriptions of the stories they witnessed.

In the predictive mode, subjects are shown the strong guy, the dogs and the elephants and they are told that the strong guy is going to try to put all the animals on the table behind him. At this point, the puppet remarks that the elephants look heavy and predicts that “The strong guy won’t put every elephant on the table”. The story then unfolds as described above¹⁴ and at the end, subjects are asked whether the puppet’s prediction was correct. Here, since the scalar implicature associated with the use of ‘not every’ is cancelled, we expect subjects to find that the puppet’s prediction was correct.

Picture 3



“The strong guy didn’t/won’t put every elephant on the table”

As before, children first heard two pretest stories and then four test stories involving sentences like (19) and three control stories, administered in a pseudorandom order. The complete sets of statements made by the puppet on the critical and control trials are given in Tables 4-6 below.

¹⁴ In fact, after the strong guy fails to put the first two elephants on the table the puppet reiterates his prediction that the strong guy won’t be able to put all the elephants on the table. This step was taken to ensure that children would remember what the prediction was.

Table 4

Puppet's statements on test stories in descriptive and predictive conditions

Test story 1	'The strong guy didn't/won't put every elephant on the table'
Test story 2	'Joe didn't/won't buy every plane'
Test Story 3	'The karate guy didn't/won't break every brick'
Test story 4	'The painter Smurf didn't/won't paint every balloon'

Table 5

Puppet's statements on control stories in the descriptive condition

Control story 1	'Donald found all of his friends'	FALSE
	'Donald only found two of his friends'	TRUE
Control story 2	'Minnie bought all the rings'	FALSE
	'Minnie only bought two of the rings'	TRUE
Control Story 3	'All the girls played on the merry-go-round'	FALSE
	'Only two of the girls played on the merry-go-round'	TRUE

Table 6

Puppet's statements on control stories in the predictive condition

Control story 1	'Donald won't find all the rings'	FALSE
	'Donald will only find two of the rings'	TRUE
Control story 2	'Minnie won't buy any of the balloons'	FALSE
	'Minnie will only buy two of the balloons'	TRUE
Control Story 3	'The girl won't buy a bird'	FALSE
	'The girl will buy a bird and a cat'	TRUE

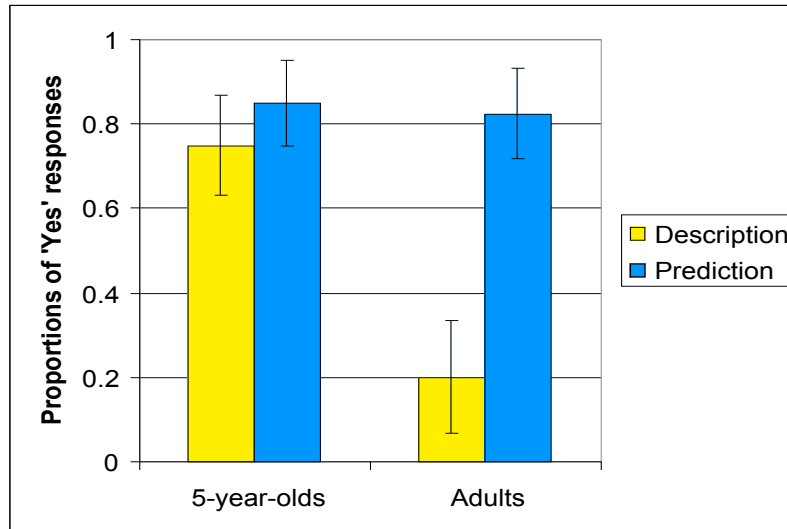
As before, controls were designed to ensure that children could provide both YES and NO responses: the experimenter holding the puppet had a choice between two different statements for each of the control stories. One statement was true in the context of the story and the other was false. If the child had answered YES to a given test story, the experimenter holding the puppet was instructed to pick the statement for the following control story corresponding to a NO answer, and vice-versa.

Finally the 40 subjects (20 children and 20 adults) were randomly assigned to the two conditions (i.e. descriptive vs. predictive) which gave rise to a 2 x 2 design with age and testing mode as between subject factors and 10 subjects per cell. The group of children assigned to the descriptive condition ranged in age between 5;0 and 5;10 (mean 5;5) and the one assigned to the predictive condition ranged in age between 5;0 and 5;9 (mean 5;4). These two means did not differ significantly, i.e. $t(18) = 1.01$, $p = .32$.

4.2 Results

In the analysis below, we used as our dependent measure the proportion of YES responses to the puppet's statements. Beginning with subjects' responses to test items, we found that in the predictive mode, both children and adults overwhelmingly accepted the puppet's statements, i.e. 85% and 82.5% of the time, respectively. In the descriptive mode however, we found that while adults' acceptance rate was reliably lower as compared to their acceptance rate in the predictive mode, i.e. 20% acceptance rate vs. 82.5%, respectively ($t(18) = - 3.67$, $p = .0017$), children's acceptance rate remained high and did not differ significantly across the two conditions, i.e. 85% in the predictive mode vs. 75% in the descriptive mode ($t(18) = - 0.64$, $p = .52$). The proportion of YES responses were entered into a 2 (children vs. adults) x 2 (predictive vs. descriptive mode) analysis of variance (ANOVA). The analysis revealed a significant main effect of age ($F(1,36) = 6.2$, $p = .01$), a significant main effect of condition ($F(1,36) = 9.9$, $p = .003$) and a significant interaction between age and condition ($F(1,36) = 5.2$, $p = .02$), see graph 2.

Graph 2



Proportion of 'Yes' responses to the puppet's statements for children and adults in both conditions

On control items, children gave correct responses 93% of the time in both conditions. Adults gave correct responses 100% of the time in the descriptive condition and 96% of the time in the predictive condition.

Finally, turning to justifications, we found that adults rejected the puppet's statements 80% of the time in the descriptive condition. When asked why the puppet 'said it wrong', adults typically invoked the fact that the main character *didn't V ANY of the Ns*, thereby making direct reference to the stronger term on the scale (i.e. *not any* vs. *not every*). By contrast, children *accepted* the puppet's statements 75% of the time. When asked for justifications, children typically answered that the puppet had said 'the right thing' because the main character *didn't V the Ns/every N on the table*. We also found that children were perfectly capable of repeating the puppet's statements. In the predictive condition, both children and adults overwhelmingly accepted the puppet's statements (i.e. 85 and 82.5% of the time, respectively). When asked for justifications as to why the puppet should win his bet, both groups typically invoked the fact that *none of the Ns had*

been Ved. Here again, children were perfectly capable of repeating the puppet's predictions that the main character won't V every N.

4.3 Discussion

We found that in accordance with the predictions of pragmatic theory, adults overwhelmingly rejected statements like “The strong guys didn't put every elephant on the table” (i.e. 80 % of the time) when they were used to describe a situation in which none of the elephants (i.e. ‘not any’) were placed on the table. Moreover, when asked to justify their negative answers, adults typically explained that the puppet didn't say the right thing “because the strong guy didn't put ANY elephant on the table” thereby directly invoking the stronger term on the scale (i.e. *not any*). By contrast, adults overwhelmingly accepted such statements when they were offered as predictions regarding the stories they were about to witness (i.e. 82.5% of the time).

The second, noteworthy observation is the remarkable lack of sensitivity displayed by 5-year-olds vis-à-vis scalar implicatures. While adults in the descriptive condition rejected the puppet's infelicitous statements 80% of the time, children only did so 25% of the time. What is interesting here is that adults' semantic knowledge of the universal quantifier (revealed fully in the descriptive condition) is masked by pragmatic factors in the descriptive condition, thereby giving the illusion of 'illogical' behavior (see Noveck, 2001 for a similar conclusion). 5-year-olds, on the other hand, seem to not yet be sensitive to the pragmatic bias seen in adults (but see Papafragou and Musolino, in press). Children's 'logical' behavior can therefore be construed as a direct reflection of their semantic knowledge of the universal quantifier. Finally, note that these results comport

well with other recent findings on the development of pragmatic abilities also showing that preschoolers are remarkably insensitive to scalar implicatures (Noveck, 2001; Chierchia G., S. Crain, M. T. Guasti, A. Gualmini and L. Meroni (2001); Papafragou and Musolino, in press).

5. General discussion

In this study, we investigated children's knowledge of the linguistic principles governing the interaction between the universal quantifier and negation, in sentences like (21) and (22).

(21) Every N didn't VP

(22) NP didn't V every N

We observed that interpreting such sentences involves (a) a proper calculation of the scope relations between the universal quantifier and negation, based on syntactic principles such as c-command and covert displacement (b) semantic knowledge of the truth conditions associated with such sentences based in part on entailment relations holding between different interpretations and (c) the ability to derive certain conversational inferences, associated with the use of these quantificational elements.

Our results indicate that 5-year-olds have adult-like knowledge of the truth conditions associated with sentences like (21) and (22). In the case of sentences like (21), we have shown – contra Musolino et al. (2000) - that children could access both the isomorphic (i.e. 'none') and non-isomorphic interpretation (i.e. not all) – albeit with different rates of success. This finding is important because it demonstrates, among other things, that

children have knowledge of the covert displacement operation that is responsible for the non-isomorphic interpretation. This is a remarkable discovery because covert displacement, by its very nature, is very abstract and presumably impossible to detect in the surface form of the input.

Regarding sentences like (22), previous results, i.e. Musolino et al. (2000), indicate that children are able to access the isomorphic (i.e. not all) interpretation. Our present study further demonstrates that children also know that such sentences are true in a ‘none’ context. This too is interesting since sentences like (22) are rarely, if ever, used to express the equivalent of sentences like *NP didn't V any N*, i.e. the ‘none’ reading. This finding therefore suggests that children have knowledge of the entailment relations discussed earlier. That is, they know that sentences like (22) are true in a ‘none’ context - presumably not because they have heard them being used in such contexts but rather because they have implicit knowledge of the fact that ‘none’ entails ‘not all’ and therefore that ‘none’ situations satisfy the truth conditions of sentences like (22). Entailment relations, just like covert displacement, are not the kind of relations that can be easily detected in the input. Their apparent mastery by 5-year-olds should therefore be regarded as an impressive achievement.

What we have shown so far is that differences in the way 5-year-olds and adults interpret sentences containing the universal quantifier and negation do not reflect grammatical differences between the two groups. That is, 5-year-olds have adult-like knowledge of the grammatical mechanisms responsible for the interpretation of such sentences (scope and covert displacement, i.e. *syntactic* knowledge¹⁵) and, consequently,

¹⁵ For a demonstration that children compute scope relations on the basis of c-command relations, see Lidz and Musolino, 2002.

adult-like knowledge of the set of truth conditions associated with such sentences (i.e. *semantic* knowledge). Children do differ from adults in two important respects however: first, 5-year-olds and adults display opposite preferences regarding their interpretation of sentences like *Every horse didn't jump over the fence*. Adults show a preference for the 'not all', non-isomorphic interpretation whereas children display a preference for the 'none', isomorphic interpretation.

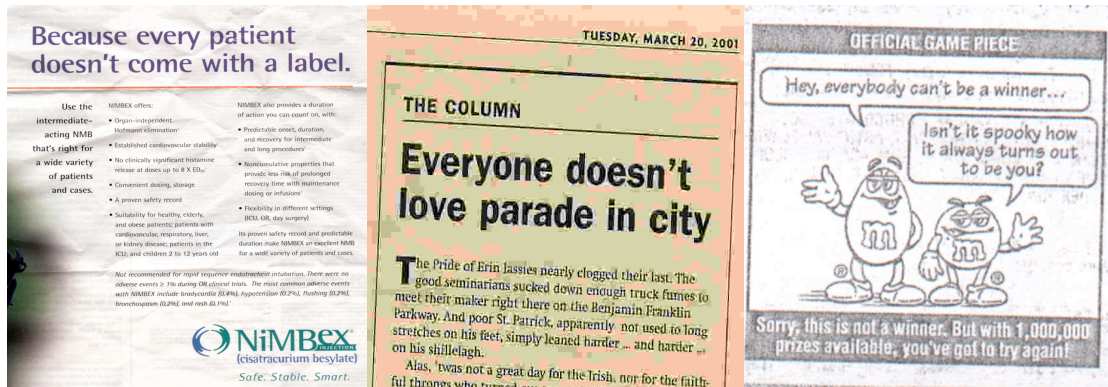
At this point, it is important to emphasize that the preference displayed by adults for the 'not all' interpretation of sentences of the form *Every N neg VP* goes beyond the data reported in experiment 1. In this regard, it is interesting to consider spontaneous uses of sentences like *every/all N neg VP*. In a corpus compiled by Musolino, we find that such constructions are frequently used in TV commercials (e.g., "All salad dressings/cars/shampoos are not the same") or at train stations ("All doors will not open"). However, their use is not the exclusive province of train conductors and marketing directors: they can also be found in magazines (26), newspapers (26), fortune cookies (e.g., "Everything is not yet lost", "Everybody doesn't have to be the same") and other texts (26), and they are spontaneously used by people all over the United States, ranging from distinguished academics (23-25) to restaurant waitresses ("All the deserts aren't on the menu"), landlords ("Everybody doesn't pay the same rent") and insurance brokers ("Everybody doesn't keep receipts for the things they buy") (see Horn, 1989 for more examples).

- (23) "There are extra copies of the handout on the chair here, in case everybody didn't get one."
Kenneth Wexler, linguistics colloquium, University of Maryland, October 16, 1998.
- (24) "All the birds don't seem to be quite the same"

Lila Gleitman, *Psych 135 Lecture, University of Pennsylvania, February 25, 1999.*

(25) “All semantic features are not going to be under direct syntactic control”
Merrill Garrett, IRCS Colloquium talk, February 26, 1999.

(26)



Crucially, one finds that spontaneous examples of sentences of the form *Every/all N neg VP* are *invariably* used on a ‘not all’ interpretation (only one of the dozens of examples from the Musolino corpus was used to convey a ‘none’ reading¹⁶). Given the fact that the grammar of English makes available two interpretations for such sentences, i.e. ‘not all’ and ‘none’, one may wonder why adult speakers of English display such a strong preference for the ‘not all’ interpretation, both in production and comprehension. Given the nature of the alternative interpretations of sentences like *Every/all N neg VP*, the preference for the ‘not all’ reading has all the attributes of a Gricean phenomenon (see section 2.1). That is, adult speakers of English prefer to produce/interpret sentences like *Every/all N neg VP* on a ‘not all’ interpretation because of the availability of sentences of the form *Nobody/no-none VP* to express the alternative interpretation, i.e. the ‘none’ reading (for a more detailed account, along essentially similar lines, see Horn 1989).

¹⁶ The example in question was: “This is the case where all the variables are not equal to zero”, uttered by a student in a statistics class at the University of Pennsylvania. In the case that the student was referring to, none of the variables was equal to zero.

An important consequence of the account discussed above regarding the nature of adult preferences - to the extent that it is along the right lines - is that it paves the way to a better understanding of children's difficulty with the 'not all' reading of sentences like *Every horse didn't jump over the fence* (as witnessed by Musolino et al.'s findings and our replication of their results in experiment 1). The explanation would be that children fail to access the 'not all' reading of such sentences because they are less sensitive to the pragmatic factors which gives rise to the adult preference. What is attractive about this hypothesis is that it is in perfect agreement with the results of experiment 2, which directly show that adults are sensitive to the kind of pragmatic factors described above, but that 5-years aren't. Seen in this light, children's difficulty with sentences like *Every horse didn't jump over the fence* loses its idiosyncratic character and can now be seen to follow from a much more general - and by now well documented (Noveck, 2001; Chierchia et. al, 2001; Papafragou and Musolino, in press) - fact about 5-years-olds, namely their lack of sensitivity to the pragmatic effects of entailment relations.

Another way to view the problem is in terms of current models of sentence processing. Over the past 15 years or so, advances in psycholinguistic research on human sentence processing have led investigators to conclude that the recovery procedure whereby a comprehender extracts meaning from the speech signal involves the rapid integration of multiple, probabilistic sources of information (linguistic and contextual) and that this procedure is best captured by a constraint-satisfaction model (MacDonald et al., 1994; Trueswell & Tanenhaus, 1994). In the case at hand, i.e. the resolution of ambiguous sentences like *Every horse didn't jump over the fence*, syntactic factors (i.e. the surface hierarchical relations between the quantified subject and negation) and

pragmatic factors (as discussed above) exert antagonistic influences: the former favors a ‘none’, isomorphic interpretation while the latter favors a ‘not all’, non-isomorphic interpretation. In adults comprehenders, we find that the resolution of this conflict leads to a situation where pragmatic factors are able to override syntactic factors– hence the ultimate bias towards the ‘not all’ reading. In children however, pragmatic factors do not yet exert such a potent influence and syntactic factors have the last word, ultimately leading to the selection of the ‘none’ interpretation.

Interestingly, this situation comports well with recent findings on the development of processing abilities in preschool children (Trueswell et al. 1999). These authors have found that when resolving syntactic ambiguities (e.g. PP attachment ambiguities like *Put the frog on the napkin in the box*) “adults showed sensitivity to ... discourse constraints at the earliest possible stages of processing, and were capable of revising incorrect parsing commitments.” (p.89) but that “Five Year Olds *did not take into account relevant discourse/pragmatic principles* [our italics] when resolving temporary syntactic ambiguities and showed little or no ability to revise initial parsing commitments.” (p. 89). In other words, Trueswell et al. found, as we did, that children relied more heavily on linguistic factors (in this case lexical biases) than they did on discourse/pragmatic factors and that this led to “systematic differences in how children and adults process spoken language ...” (p.89).

What remains to be explained, of course, is why children’s difficulty with the ‘not all’ reading of sentences like *Every horse didn’t jump over the fence* greatly diminishes when such sentences are preceded by affirmative statements, as in *Every horse jumped over the log but every horse didn’t jump over the fence*. Given the account developed so far,

another way to put the question is to ask why the presence of a preceding affirmative statement boosts children's sensitivity to the relevant pragmatic properties and thus eventually leads them to access the 'not all' interpretation. First, it is important to note that contextual manipulations akin to the one discussed above have been shown to increase children's sensitivity to pragmatic phenomena such as scalar implicatures (Papafragou and Musolino, in press). In fact, this conclusion agrees with a large body of work which emphasizes the role of context and verbal instructions in children's performance on a variety of linguistic and non-linguistic tasks (Bever, Mehler and Epstein 1968, Gelman and Greeno 1989, Greeno, Riley and Gelman 1984, Shipley 1979, Markman and Seibert 1976, Rose and Blank 1974, Samuel and Bryant 1984, McGarrigle and Donaldson 1974).

As to the precise mechanics of the account, we can at this point only offer some speculative remarks. As discussed above sentence processing is now viewed as involving the rapid integration of probabilistic cues from multiple sources of information. While adults can carry out this task very efficiently, we have discussed evidence that preschoolers are not yet as savvy as adults in this domain, especially when it comes to the integration of certain contextual/pragmatic factors (e.g., Trueswel et al. 1999); perhaps because of certain limitations on working memory. A case in point might be the on-line calculation of certain pragmatic inferences such as scalar implicatures. To the extent that negative statements are easier to process when they are preceded by affirmative statements, "Thus, *5 is not even* is harder to process and takes longer to verify than *5 is odd*, but the difficulty is mitigated if we set up a 'context of denial': 4 is even {and / but} 5 is not even (cf. Greene 1970a:18; Wason 1972:28)." (Horn, 1989: 172), the reduction in

processing load associated with the presence of a preceding affirmative statement might free up some of the computational resources deployed by children during language comprehension and thus permit the child to now attend to the pragmatic factors leading to the relevant preference. In the absence of such contextual support, children are found to rely heavily on a strong factor pulling in the opposite direction, namely the surface syntactic structure of the sentence, leading to over-isomorphic interpretations (Lidz and Musolino, 2002).

As we mentioned earlier, we believe that the results presented here have interesting implications for experimental methodology. First, it has long been argued that children's non-adult behavior on tasks designed to tap grammatical knowledge are often due to violations of the felicity conditions associated with the use of certain linguistic constructions (e.g., Hamburger and Crain, 1982 in the case of relative clause and, more recently, Crain et al., 1996; Crain, 2000; Meroni et al., 2001 in the case of sentences containing the universal quantifier). To quote Meroni et al. (2001:7):

“If this is correct, then children’s non-adult behavior is simply due to the difficulty they experience in responding to sentences in infelicitous contexts. This means that there is just one difference in the linguistic skills of children and those of adults – adults are apparently better able to ignore infelicities than children are.”

What is interesting about the results of experiment 2 (as well as the results of other recent studies of scalar implicature, e.g., Noveck 2001; Chierchia et al., 2001; Papafragou and Musolino, in press) is that they suggest just the opposite, namely that adults are highly sensitive to ‘infelicities’ associated with under-informative statements whereas children blatantly ignore them. These two findings need not be contradictory though. In fact, they raise interesting questions for future research on the development of pragmatic abilities.

It is no longer sufficient to say that children are or are not sensitive to ‘felicity’ conditions. We now need to ask why children are sensitive to certain felicity conditions (e.g., those discussed by Crain and colleagues and the ones discussed in experiment 1) but not to others (e.g., those arising from certain conversational inferences).

In this regard, our results, along with other recent results (i.e. Trueswell et al., 1999; Hurewitz et al., 2000; Papafragou and Musolino, in press), indicate that children’s sensitivity to pragmatic factors in language comprehension tasks should not be regarded as an all or nothing affair. In other words, the relevant question should not be whether children are sensitive to pragmatics or not but rather when, and in what circumstances, do pragmatic factors affect children’s (and adults’) comprehension. The interesting challenge for future research will be to specify when, how and under what circumstances children’s (and adults’) comprehension of spoken language is affected by pragmatic/contextual factors (for a specific proposal, see Papafragou and Musolino, in press). In the present case, such an account would amount to providing a principled explanation of children’s differential sensitivity to the pragmatic effects seen in adults in the case of sentences like *Every N didn’t VP* and *NP didn’t V every N* on the one hand (where children aren’t sensitive to the effect) and *Every N VP but/and every N didn’t VP* on the other (where children display increased sensitivity to the effect). Until further research illuminates these issues, it is fair to conclude from the present data that (a) preschooler’s pragmatic abilities are more fragile than that of adults and (b) that children’s sensitivity to pragmatic factors can be boosted under certain contextual manipulations.

With these considerations in mind, let us now turn to the implications of our results for experimental methodology. While there is no doubt that Crain and Thornton's (1998) TVJT has been enormously successful and has enabled researchers to learn a great deal about children's developing linguistic knowledge, certain features of the technique should nevertheless not be overestimated. In particular, two assumptions often associated with the use of the TVJT may need to be refined in light of the results presented here. The first one has to do with the kinds of inferences regarding children's underlying linguistic competence that can be made based on behavioral data collected using the TVJT. To quote Crain and Thornton (1998:4):

“A second reason for discussing these two tasks in particular is that, when used properly, they are relatively free from the influence of performance factors that have been found to mask children's linguistic knowledge in other tasks. Properly designed studies adopting the truth value judgment task and the elicited production task have resulted in extremely consistent and reliable performance by children – indeed, performance that is often on a par with that of adults. Even when children's behavior differs from that of adults, the pattern of children's responses is so consistent that the responses can be confidently attributed to linguistic knowledge and not to performance factors.”

As the present study demonstrates however, use of the TVJT does not necessarily guarantee adult-like performance, *even when children do not differ from adults grammatically*. In other words, the TVJT, like other tasks, is not impervious to the influence of performance factors. An important consequence of this fact is that differences between children and adults arising from the use of the TVJT should not necessarily lead investigators to conclude that such discrepancies reflect differences in linguistic competence between children and adults; a conclusion that, it turns out, was erroneously embraced by Musolino et al. (2000) regarding children's interpretation of sentences like *Every horse didn't jump over the fence*. In any given case, it therefore

remains an empirical matter whether children's non-adult behavior reflects a difference in grammatical competence or the influence of performance factors.

A second, related assumption often associated with the use of the TVJT regards the biases that children are claimed to exhibit when faced with the task of interpreting ambiguous sentences. To quote Crain and Thornton again (1998: 111, 211):

“In our experience with children, we have been able to identify several factors that conspire to determine which reading of an ambiguous sentence is selected. First, children pick the reading that makes an ambiguous sentence true in the context, assuming that both readings are consistent with the context”

“Suppose that the child has a preference for one interpretation over another and that the preferred interpretation corresponds to the “false” reading in the context that has been presented. It has been found that many children nevertheless give a high proportion of positive responses. *The assumption is that children want the puppet to say things that are true. That is, the child prefers to say “Yes” if possible* [our italics]. This bias to say “Yes” is apparently enough to boost the dispreferred interpretation of an ambiguous sentence in the child's mind, thereby making it easier for the child to generate that interpretation ...”

Here again, our results indicate that the ‘Yes’ bias described by Crain and Thornton should be treated with caution. Recall from experiment 1 that children were presented with contexts in which either a ‘Yes’ or a ‘No’ response to sentences like *Every horse didn't jump over the fence* was in principle possible. However, in this case, children did not prefer to say ‘Yes’, even though this was clearly an option in the context of the experiment and, more importantly, an option that is allowed by the child's grammar (as we have learned from experiment 2). This fact suggests that there may not be any hard and fast rules determining how children will behave when interpreting ambiguous sentences. Claims that children will tend to select a ‘Yes’ answer whenever one is made available by their grammar should therefore be treated with caution as they could lead, in the absence of disconfirming empirical evidence, to erroneous inferences regarding

children's grammatical knowledge (i.e. concluding that children's grammar does not generate the reading corresponding to a Yes answer if children persist in selecting the 'No' answer of an ambiguous sentence, as in the case of Musolino et al. 2000).

In sum, while the TVJT remains a powerful tool in the arsenal of the developmental psycholinguist, methodological assumptions alone and confidence in one's experimental technique are no substitute for empirical evidence when it comes to disentangling the role of competence and performance factors in studies designed to assess children's linguistic knowledge.

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