At the Semantics/Pragmatics Interface in Child Language

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1. Introduction

This paper investigates scalar implicatures and downward entailment in child English. In previous experimental work we have shown that adults' computation of scalar implicatures is sensitive to entailment relations. For instance, when the disjunction operator *or* occurs in positive contexts, an implicature of exclusivity arises. By contrast when the disjunction operator occurs within the scope of a downward entailing linguistic expression, no implicature of exclusivity is computed. Investigations on children's computation of scalar implicatures in the same contexts have led to a slightly different picture. In particular it has proven difficult to demonstrate that children compute scalar implicatures (in *non*-downward entailing contexts) using the Truth Value Judgment task, a technique that has been used successfully in showing children's sensitivity to other semantic phenomena. Adopting a different experimental technique called the Felicity Judgment task, however, we demonstrated children's knowledge of the prerequisites to the computation of scalar implicatures (Chierchia, Crain, Guasti, Gualmini and Meroni, 2001).

The present study extends this research by investigating children's preferences for interpreting sentences containing the scalar terms *or* and *and* in a downward entailing context. We present the results of an experiment using the Felicity Judgment task. The study draws upon the observation that scalar implicatures are sensitive to entailment relations, which are reversed in downward entailing contexts In section 2 we illustrate the phenomenon under investigation, and we describe the Semantic Core model, a recent account of such phenomenon (see Chierchia, 2001). Section 3 reviews previous research on children's knowledge of scalar implicatures motivated by the Semantic Core model and presents the findings of a new experiment. Section 4 presents a discussion of the experimental findings and section 5 provides the conclusions.

2. Scalar Implicatures and Downward Entailment

The standard neo-Gricean view of scalar implicatures maintains that the interpretation of logical words results from an interaction between semantic and pragmatic principles (see e.g., Grice, 1975; Horn, 1972, 1989; Levinson, 1983). On this view, principles of semantics account for the basic interpretation of logical words, but pragmatic principles also influence the interpretation of logical words in ordinary conversational contexts. To illustrate the interaction between

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semantic and pragmatic principles, consider the interpretation of the disjunction operator *or*. The interpretation of disjunction that is licensed by semantic principles can be described as inclusive-*or*. However, *or* is often understood exclusively. Consider, for example, the following sentence:

(1) John learned English or German.

Typically the utterance in (1) carries with it a scalar implicature. More precisely, upon hearing (1) one infers that John learned either English or German, but not both languages. Intuitively, the implicature of exclusivity arises because, if the speaker meant to say that John learned both English and German, a more effective means of expression would be (2).

(2) John learned English and German.

According to the Principle of Cooperation, the speaker is expected to convey the intended message as accurately as possible. Since the speaker did not use (2), the utterance in (3) is interpreted as:

(3) John learned English or German, but not both.

This is how the exclusive interpretation of *or* comes about, according to the neo-Gricean view.

Scalar implicatures (SIs) place statements against the background of a set of relevant alternatives that differ in the 'quantity' of information that they convey. As discussed extensively by Horn (1972), one can view logical words like *or* and *and* as constituting a scale. In particular, the set of circumstances that verify a (positive) statement like *A and B* is a subset of the circumstances that verify *A or B*, so the logical words contained in these statements can be ordered through the subset/superset relationship: *and* $\subseteq$ *or*. The same reasoning can be extended to all scalar items, such as quantifiers (*every* $\subseteq$ *most* $\subseteq$ *many* $\subseteq$ *some*) and numerals (...*two* $\subseteq$ *three* $\subseteq$...). Within this framework, the process through which implicatures are computed can be characterized as follows.

(4) Suppose α and β are part of a scale such that $\alpha \subseteq \beta$. Then if the speaker utters *S*(β) (i.e., the logically weaker scalar term), such a statement is interpreted as *S*(β) *and not S*(α).

In a way, the computation of SIs resembles the interpretation of sentences with a focus operator. In both cases the interpretation of a sentence *S* requires the comparison of *S* against a set of alternative propositions, *ALT*, which have been introduced in the conversational background (e.g., Rooth, 1992; Krifka, 1995). The choice of a sentence *S* from *ALT* implicates the negation of all stronger propositions in *ALT*.

It is pertinent to observe that the process outlined above leads to a more informative interpretation than the basic interpretation of the speaker's utterance.[1]

This can be seen if we compare the circumstances which verify the basic interpretation of (1) and those which verify its derived interpretation (i.e., (3)). On its basic interpretation, (1) is true in all the situations in (5).

(5) $situation_1$=John learned English
$situation_2$=John learned German
$situation_3$=John learned English and John learned German

Once the implicature is added (with *or* construed exclusively), the statement in (1) is true in only two of these sets of circumstances, namely $situation_1$ and $situation_2$. In short, the exclusive-*or* interpretation rules out one set of circumstances that is allowed by inclusive-*or* and, thus, yields a more informative interpretation.

According to the view just sketched, one first computes the (compositional) meaning of a sentence. Then, the semantic interpretation is processed by the pragmatic component of the language apparatus (where Gricean maxims are located) and as a result, implicatures are factored in. This modular view of the semantics-pragmatics interface suggests that implicatures are added at the level of root-sentences, i.e. after the grammar has completed its job. As illustrated in (4), it is in *uttering* a certain sentence that one compares it with its scalar alternatives. This has as a consequence that one should not find *embedded* implicatures, because implicatures come about by negating alternatives to whole utterances (as in (3)).

This view of scalar implicatures has recently been challenged by Chierchia (2001). One of the arguments Chierchia uses is the following. Consider a complex sentence such as:

(6) Mary is working at her paper or seeing some students.

Let us focus on the embedded implicature, i.e. the one associated with *some*. With respect to that, the natural implication of the sentence is that Mary is working at her paper or seeing some (though not all) students. However, if implicatures only come about at the root level, this is not what one would expect. One would expect to negate some kind of alternative to sentence (6) as a whole. But this would yield the wrong results. To derive the negated alternative for *some* where it intuitively arises (namely *within* the second disjunct), the implicature has to be computed at the level of the embedded clause.

Based on considerations of this sort, Chierchia proposes that implicatures are computed recursively, through a simple modification of the standard recursive procedure. The basic idea is the following. The syntactic tree is processed bottom up. Whenever we find an implicature trigger, the corresponding implicature is added at the first available site (say, at the first node of type *t* containing the trigger). For instance, in processing (6), the implicature associated with *some* is added at the level of the second disjunct, while the implicature associated with *or* is introduced at the root level.

Now, if implicatures are (or can be) introduced at any embedded level of embedding, the question arises as to whether they are always preserved under

embedding. This is clearly not so. Developing an observation due to Horn (1989), Chierchia observes that there are embedded contexts from which the (ordinary) scalar implicatures are systematically cancelled. For example, in all of the following contexts, the disjunction operator receives an inclusive-*or* interpretation.

(7) a. John did not learn French or Italian.
b. Did John learn French or Italian?
c. I doubt John learned French or Italian.
d. If John learned French or Italian, he could apply for this job.
e. John learned English before French or Italian.

Interestingly, the same linguistic environments in (7) share another property: they license negative polarity items, like the word *any* in English:

(8) a. John did not learn any Romance language.
b. Did John learn any Romance language?
c. I doubt John learned any Romance language.
d. If John learned any Romance language, he could apply for this job.
e. John learned English before any Romance language.

On the basis of the examples in (7) and (8), Chierchia (2001) and Chierchia et al. (2001) advanced the following generalization.

(9) (Ordinary) scalar implicatures are absent from linguistic environments that license *any*.

Supposing that *any* (as well as other negative polarity items) is licensed in downward entailing linguistic contexts (see Ladusaw, 1979), the generalization in (9) becomes:

(10) (Ordinary) scalar implicatures are absent from downward entailing linguistic environments.

What is interesting about the generalization in (10) is that a morphosyntactic phenomenon (the distribution of *any*) and a pragmatic phenomenon (the computation of scalar implicatures) are sensitive to the very same environments. The generalization in (10) casts doubt on the neo-Gricean account that places the phenomena of negative polarity licensing and the computation of scalar implicatures in separate modules of the language apparatus. Clearly, the same (semantic) principles govern both phenomena.

Chierchia's Semantic Core model proposes an account that unifies the phenomena. We will not be able to fully review the model within the limits of the present work. In so far as implicatures are concerned, however, the basic idea is the following. SI computation is subject to one general condition, which Chierchia (2001) calls the Strength Condition. According to this condition, the

computation of scalar implicatures cannot lead to a weaker statement than the corresponding sentence without the implicature. Thus, at any point in the recursive procedure, if adding an implicature leads to a weaker statement than its plain counterpart, the implicature is cancelled. Consider for example (1), repeated here as (11).

(11) John learned English or German.

Upon encountering (11), the hearer factors in the implicature, constructing the 'derived' interpretation which can be paraphrased as in (12).

(12) John learned English or German and it is not the case that John learned English and German.

Suppose that sentence (11) is embedded under *believe*. Since the result is stronger than its plain counterpart, the implicature is kept and the corresponding sentence is interpreted along the following lines:

(13) I believe that John learned English or German (but not both).

Suppose, however, that the same sentence is embedded under *doubt*. In such a case, adding the implicature results in a weaker statement than its plain counterpart. Hence the implicature is removed, and the resulting sentence will be interpreted as follows.

(14) I doubt that John learned English or French ~~(but not both).~~

So far so good. Implicatures are construed locally as the value of a clause is computed bottom up. And as soon as a downward entailing (DE) functor comes into the picture, the Strength Condition forces us to remove any implicature that has been added thus far. But this is not all. The interaction of negation (or a DE functor) with an embedded scalar term can also give rise to novel implicatures. To illustrate, consider the following sentence:

(15) Many papers were read by students.

In isolation, this sentence will trigger the implicature that not all the relevant papers were read. If embedded under *believe*, the implicature will be kept. If the clause is embedded under *doubt*, the implicature will be removed:

(16) I doubt that many papers were read by students.

This shows that sentence (16) induces a novel implicature, which can be paraphrased as follows:

(17) I believe that some papers were read by students.

This implicature arises because the alternatives relevant to the interpretation of (16) are:

(18) I doubt that some papers were read.
I doubt that many papers were read.
I doubt that every paper was read.

Since *doubt* reverses the strength of the items to which it applies, the strongest alternative to (18) is *I doubt that some papers were read*. Consequently, this is what gets negated, and gives rise to the implicature in (17). So, DE functors not only remove implicatures that were previously added in, they also recalibrate the scales, leading to novel implicatures. Following Chierchia, let us use the term *direct implicature* to refer to the implicatures that are added in at scope sites immediately containing the trigger. Direct implicatures are to be contrasted with *indirect implicatures*. These are implicatures that arise in applying a DE functor to an argument containing a scalar term. As we will see below, this distinction (motivated on both descriptive and theoretical grounds) has interesting psycholinguistic consequences.

It is time to take stock. In developing the Semantic Core model, Chierchia (2001) proposes an explicit algorithm for calculating implicatures recursively and compositionally. Implicatures are no longer thought of as being added in at the level of root sentences. Rather, it is as if each phrase (as opposed to root sentences) is shipped off to the pragmatic component. The Semantic Core model avoids certain difficulties (such as dealing with implicatures embedded under disjunction), and it paves the way for a (new) account of the generalization in (10): both SI calculation and *any* licensing are driven by the need to optimize informational strength. With this characterization of adult languages in mind, let us consider whether the same generalization also holds for child language.

3. Scalar Implicatures and Downward Entailment in Child Language

The previous section showed that the interpretation of the negative polarity item *any* and the computation of scalar implicatures are governed by the same recursive semantic principles (see Chierchia, 2001). In a series of experiments motivated by the Semantic Core model, Chierchia et al. (2001) investigated the computation of scalar implicatures in children and adults.

The linguistic contexts investigated by Chierchia et al. (2001) are the restrictor and the nuclear scope of the universal quantifier *every*. As shown by (19a), the restrictor of the universal quantifier *every* is downward entailing and, therefore, licenses the negative polarity item *any*. By contrast, the nuclear scope of the universal quantifier *every* is not downward entailing, as attested by the ungrammaticality of (19b).

(19) a. Every student who learned any Romance language is welcome.
b. *Every student learned any Romance language.

As we saw in section 2, the Semantic Core model explains why scalar implicatures are cancelled in downward entailing (DE) environments, as the computation of scalar implicatures would lead to less informative statements in these environments. Accordingly, the Semantic Core model predicts that the implicature of exclusivity for disjunction will arise in sentences like (20b), but not in sentences like (20a).

(20) a. Every student who learned English or German is welcome.
b. Every student learned English or German.

Adult intuitions about the sentences in (20) conform to the predictions of the model. First, in (20a), adult speakers concede that if every student learned English and German, they would be welcome. Second, adult speakers of English judge (20b) to be infelicitous as a description of a context in which every student learned English and German. To see if children's interpretation of sentences like (20) also conforms to the predictions of the Semantic Core model, Chierchia et al. (2001) conducted two experiments using the Truth Value Judgment task.

The Truth Value Judgment is an experimental technique that allows researchers to investigate whether a specific interpretation of a target sentence is licensed by children's grammars (Crain and McKee, 1985; Crain and Thornton, 1998). The task requires two experimenters. One acts out short stories in front of the child, using props and toys. The second experimenter manipulates a puppet who watches the stories alongside the child. Each story constitutes the context against which a target sentence is evaluated. The acceptance of the target sentence is interpreted as indicating that the child's grammar licenses at least one interpretation that makes the sentence true in that context. By contrast, the consistent rejection of the target sentence is interpreted as evidence that child's grammar does not license any interpretation of the sentence that makes it true in the context under investigation.[2]

3.1. *Experiment I: The disjunction or in the first argument of every*

The first experiment in the Chierchia et al. study tested children's acceptance of the inclusive-*or* reading of disjunction in the restrictor of the universal quantifier *every*. On a typical trial, children were told a story about Snow White and four dwarves. Snow White promised a jewel to any dwarf that ate healthy food. Three of the dwarves wanted a jewel, so they chose fruit. In particular each of these dwarves chose both a banana and a strawberry, and then received a jewel from Snow White. One of the dwarves chose potato chips, however, and did not receive a jewel. At the end of this story, the puppet produced the following target sentence.

(21) Every dwarf who chose a banana or a strawberry received a jewel.

It is important to observe that the target sentence is true only if the disjunction operator *or* is interpreted under the inclusive-*or* reading. Because the restrictor of *every* is downward entailing, the experimental hypothesis was that children would not compute the implicature of exclusivity for (21), and would therefore, accept the test sentences on the inclusive-*or* reading. However, if children (and adults) did compute the implicature and interpret the target sentence under the (derived) exclusive-*or* reading of disjunction, then they should have rejected the puppet's assertion. This did not happen, however. Fifteen children (age from 3;7 to 6;3 - mean age: 4;11) participated in the experiment. These children correctly accepted the target sentence 55 times out of 60 trials (92%). A control group of 11 English-speaking adults correctly accepted the target sentence 42 times out of 44 trials (96%).

3.2. *Experiment II: The disjunction or in the second argument of every*

The second experiment reported in the Chierchia et al. study tested children's acceptance of the inclusive-*or* reading of disjunction in the nuclear scope of the universal quantifier *every*, a *non*-DE context. On a typical trial, children were told a story about four boys at a summer camp who were about to choose some toys to play with. After considering their options, the four boys each decided to take both a skate-board and a bike. Following the conclusion of the story, the puppet produced the following target sentence.

(22) Every boy chose a skate-board or a bike.

Since the disjunction operator occurs in a *non*-downward entailing environment in (22), the Semantic Core model predicts that the implicature of exclusivity should be calculated. As a consequence, the child subjects should reject the target sentence, on the grounds that the corresponding statement with *and* would have yielded a more informative description of the story. This was only partly true. Fifteen different children (age from 3;5 to 6;2 - mean age: 5;2) participated in the experiment. They accepted the target sentence 30 times out of 60 (50%).[3] Eight English-speaking adults served as control group, and the adult controls never accepted the target sentences.

3.3. *The Processing Limitation Hypothesis*

The responses of the adult controls are entirely consistent with the Semantic Core model. First, the implicature of exclusivity was cancelled in the restrictor of the universal quantifier *every* (a DE environment), whereas the implicature of exclusivity was computed in its nuclear scope (a *non*-DE environment). As for children, however, only some child subjects behaved as expected on the model.

In order to illustrate how Chierchia et al. (2001) explained the pattern of *non*-adult behavior, it is important to decompose the task that children were asked to perform in judging a sentence like (22), repeated below.

(22) Every boy chose a skate-board or a bike.

Since (22) contains a scalar term, the child subjects must (mentally) perform at least the following three steps in computing the scalar implicature. First, the child must recognize that an alternative sentence is available as a description of the context under consideration, namely (23).

(23) Every boy chose a skate-board and a bike.

The second step is based on the observation that the puppet used (22), and not (23). As a consequence, the child should construct a derived interpretation of the target sentence. The derived interpretation results from the conjunction of (22) and the negation of the alternative statement in (23), yielding (24).

(24) Every boy chose a skate-board or a bike, and it is not the case that every boy chose a skate-board and a bike.

For the third step, the child must compare the relative information strength of (22) and (24). Since (24) is more informative than (22), the child should adopt (24) as the interpretation of the target sentence, and should therefore reject the target sentence. It is pertinent to observe that children are not expected to evaluate the target sentence (on either interpretation) until all the steps involved in the computation of the implicature have been executed. We are now prepared to offer an account of children's non-adult behavior in interpreting disjunction (as inclusive-*or*) in the nuclear scope of *every* in Experiment II. Recently, Reinhart (1999) has proposed that limited working memory capacity is the source of children's difficulty with linguistic phenomena that involve the comparison between alternative representations of a sentence. We call this the Reference Set hypothesis. Here is how Reinhart (1999; p. 16) states the hypothesis in discussing children's *non*-adult interpretation of ordinary pronouns:

> "Assuming that all linguistic knowledge is innate, children know that they have to construct a reference set, keep two representations in working memory, and check whether the interpretation needed in the given context justifies selection of coreference. So they start execution. But their working memory is not big enough to hold the materials needed to complete the execution of this task. Hence they give up and resort to a guess."

Extending Reinhart's proposal to scalar implicatures, Chierchia et al. (2001) entertain the possibility that children may have mastered the relevant linguistic knowledge underlying the computation of scalar implicatures, but that they fail to compute these implicatures due to limited computational resources. They call this the Processing Limitation hypothesis.

The Processing Limitation hypothesis is inspired by the Reference Set hypothesis. According to the Processing Limitation hypothesis, children know that the interpretation of a sentence containing a scalar term involves the computation of an implicature. The local comparison involved in the computation of the implicature, however, exceeds children's limited processing capacities. It is important to observe that the Processing Limitation hypothesis put forth by Chierchia et al. (2001) differs from other proposals about children's knowledge of pragmatic principles. In particular, the Processing Limitation hypothesis isolates one aspect of children's pragmatic knowledge that can be assessed experimentally. The Processing Limitation hypothesis predicts that children should behave like adults in any task that does not require the construction of alternative representations. For instance, children are expected to behave like adults in tasks that assess their knowledge of information strength. In order to evaluate this prediction, Chierchia et al. (2001) developed a new experimental technique, called the Felicity Judgment task.

3.4. *Experiment III: The disjunction or and the conjunction and in the second argument of every*

The Felicity Judgment task involves the presentation of pairs of assertions. The two assertions are presented to children as alternative descriptions of a specific situation, much like in a Truth Value Judgment task. Using the Felicity Judgment task, Chierchia et al. (2001) presented children with one sentence containing the disjunction operator *or*, and one containing the conjunction operator *and*. Importantly, if children did not compute the implicature of exclusivity, both alternatives would have been true descriptions of the context. If the source of children's *non*-adult behavior (when *or* was in the second argument of *every*) was the processing cost associated with maintaining different representations of the target sentence in memory, then presenting children with two explicit representations should facilitate their ability to perform the task. By contrast, if children completely lacked pragmatic knowledge, including the notion of information strength, they should not detect any difference between the two sentences. Similarly, if children could not maintain the alternative sentences in memory in order to evaluate their relative information strength, then they should resort to guessing.

On one trial, children were told a story about some farmers cleaning their animals. After looking at all the animals, each farmer decided to clean both a horse and a rabbit. At this point, the two puppets provided their description of the story (e.g., (25) and (26)), and the child was asked to reward the puppet "who said it better."

(25) Every farmer cleaned a horse or a rabbit.

(26) Every farmer cleaned a horse and a rabbit.

Fifteen children (age from 3;2 to 6;0 - mean age: 4;7) participated in the experiment.[4] They correctly favored the puppet who had used the conjunction operator *and* on 56 out of the 60 trials (93.3%). The explanation offered by Chierchia et al. for this set of findings is that children have knowledge of the relative information strength of sentences with *or* versus ones with *and*, and they also use information strength as the basis of their preference for sentences with *and*. However, children seem unable to perform the recursive procedure necessary for computing the scalar implicature associated with *or*. Overall, the findings support the Processing Limitation hypothesis, but they are inconsistent with the more general Reference Set hypothesis. In fact children were able to maintain two alternative statements in memory, and decide between them. Children do seem unable, however, to construct the relevant alternatives on-line, such that they fail to compute implicatures if the alternatives are not explicitly presented to them.

3.5. *Experiment IV: The disjunction or and the conjunction and in the first argument of every*

Experiment IV was designed to determine whether English-speaking children know that a statement containing the disjunction operator *or* is more informative than a statement containing the conjunction *and* in the scope of a downward entailing linguistic trigger. Fifteen children (age from 4;6 to 6;1 – mean: 5;3) participated in a Felicity Judgment task.

On a typical trial, children were told a story about an Easter Bunny who was getting ready to hide the Easter eggs. The Easter Bunny had a lot of things that he could not take with him, however. In particular, the Easter Bunny has four bunches of flowers, four turtles and two teddy bears. Six girls who were good friends of the Easter Bunny offered to take care of the Easter Bunny's belongings. The girls started to choose what to care for among the flowers, the turtles and the teddy bears. Initially, each girl took one object, except for one girl who took both teddy bears. Afterwards three of the girls who had taken only one object decided to take a second object. When all the girls had made their choices, the child subject could see that three girls had taken both a turtle and a bunch of flowers, one girl had only taken a turtle, one girl had only taken a bunch of flowers, and the last girl had taken both of the teddy bears. The Easter Bunny was thankful, and he wanted to make sure that the girls had everything they would need. In particular, he gave some water to the girls who had chosen a turtle and to the girls who had chosen a bunch of flowers. Importantly, the Easter Bunny did not give any water to the girl who had chosen the teddy bears. We represent the outcome of the story in the following diagram.

(27) $girl_1$ → turtle & bunch of flowers → bottle of water

$girl_2$ → turtle & bunch of flowers → bottle of water

$girl_3$ → turtle & bunch of flowers → bottle of water

$girl_4$ → turtle → bottle of water

$girl_5$ → bunch of flowers → bottle of water

$girl_6$ → 2 teddy bears

At this point, the two puppets produced the following test sentences:

(28) Every girl who picked a turtle or a bunch of flowers received a bottle of water.

(29) Every girl who picked a turtle and a bunch of flowers received a bottle of water.

It is important to observe that both sentences are true on their basic interpretation. The sentence containing the conjunction *and*, however, raises an implicature, resulting from the interaction of the scalar term *and* and the quantifier *every*, which is downward entailing on its first argument. More specifically, the implicature consists of the negation of the strongest statement, (i.e., the statement in (28)). When this is added to the plain interpretation of (29), the result is the derived interpretation, which can be paraphrased as in (30), and more perspicuously as in (31).

(30) Every girl who picked a turtle and a bunch of flowers received a bottle of water, and it is not the case that every girl who picked a turtle or a bunch of flowers received a bottle of water.

(31) Every girl who picked a turtle and a bunch of flowers received a bottle of water, and some girl who picked a turtle or a bunch of flowers did not receive a bottle of water.

Importantly, the implicature is not met in the context. This makes (29) infelicitous, and this, in turn, should lead children to choose the statement in (28), which constitutes the stronger alternative.

The computation of the implicature for (29) is not the only reason children might prefer the sentence in (28). Suppose such an implicature is not calculated. Under this hypothesis, children might prefer the use of the disjunction operator *or* because it is more informative than the corresponding sentence with the conjunction operator *and*.[5]

Here are the results. Children expressed a preference in 40 out of 60 trials. In keeping with the Semantic Core model, children chose the sentence containing the disjunction operator in 36 out of these 40 trials (90% of the time) on which they expressed a preference for one statement over the other. The findings show that English-speaking children know that the use of the disjunction operator *or* yields a more informative assertion in a downward entailing context. Moreover, the findings reveal another context in which children are capable of making inferences based on pragmatic information, namely information strength.

As the reader might observe, the context employed in the present experiment differs from the one used in the Truth Value Judgment task conducted by Chierchia et al. (2001) assessing the same linguistic context. In short, in the context employed by Chierchia et al. (2001) all the relevant characters had chosen a pair of objects, whereas in the present experiment two characters chose exactly one object. The difference is crucial, however. For ease of exposition, let us sketch the context used by Chierchia et al. (2001) through the following scheme.

(32) $\text{dwarf}_1 \rightarrow$ banana & strawberry $\rightarrow$ jewel

$\text{dwarf}_2 \rightarrow$ banana & strawberry $\rightarrow$ jewel

$\text{dwarf}_3 \rightarrow$ banana & strawberry $\rightarrow$ jewel

$\text{dwarf}_4 \rightarrow$ potato chips

The findings reported by Chierchia et al. (2001) show that in such context English-speaking children consistently accept a sentence like (33). This result is perfectly expected on the Semantic Core model, since the disjunction operator occurs in the first argument of the quantifier *every*, a downward entailing environment.

(33) Every dwarf who chose a strawberry or a banana received a jewel.

Let us now consider what children could do if they were asked to choose between (33) and (34), in the same context.

(33) Every dwarf who chose a strawberry or a banana received a jewel.

(34) Every dwarf who chose a strawberry and a banana received a jewel.

Since children were presented with a context in which all of the dwarves who received a jewel had chosen both a banana and a strawberry, it is possible that they would prefer the assertion in (34). Such result would not be immediately explained under the Semantic Core model. In our view, however, the reason children (and adults) could prefer (34) over (33) is independent of the computation of the implicature for (34) or the difference in information strength between (33) and (34). Suppose that the implicature associated with conjunction

had not been computed. Under this scenario, one could either accept both sentences on the grounds that they are both true, or one could even prefer the use of the weaker statement. In particular, a prudent speaker who did not calculate the implicature for (34), might reject the sentence containing disjunction because this sentence conveys more information that the speaker has evidence for. More precisely, the sentence containing the disjunction operator could lead the hearer to expect that if a dwarf had chosen only a banana, he would have also received a jewel. The speaker does not have any evidence that this would have happened, however. Since one should only say what one has evidence for, the hearer is invited to choose (34). It is important to observe that, according to this hypothesis, the choice of (34) over (33) would be dictated by the Principle of Cooperation, and would not denote lack of pragmatic knowledge. This potential problem of the context outlined in (32) explains why a different context was used in Experiment IV, as compared to Experiment I.

To sum up, we described three experiments by Chierchia et al. (2001) and one experiment original to the present study. Two experiments employed the Truth Value Judgment task. These experiments were concerned with children's interpretation of the disjunction operator in the first and the second argument of the universal quantifier *every*. Two further experiments employed the Felicity Judgment task and assessed the relative information strength of sentences containing the connectives *and* and *or* in the first argument of the universal quantifier *every*, and in its second argument. The findings of the experiments are consistent with the Semantic Core model. In the next section we discuss some further consequences and loose ends related to our experimental findings.

4. Discussion

A few comments about the experimental results of Experiment IV are in place. In particular, one needs to explain why children did not make any choice in one third of the trials. In our view, one should be cautious in interpreting these results as showing that children lack pragmatic knowledge.[6] Rather, one needs to bear in mind the weakness of indirect implicatures (as compared to direct implicatures), and the complexity of the task that children were asked to perform. Let us consider each issue in turn.

The implicature that accompanies the use of the conjunction *and* results from the interaction between the scalar term *and* and the downward entailing operator *every*. As we saw in section 2, implicatures of this type are indirect implicatures. In order to motivate the distinction between direct and indirect implicatures, Chierchia (2001) draws upon the results of an experimental study conducted by Gualmini (2001). Gualmini (2001) presented English-speaking adults with sentences like (35) in a context in which each of the pirates looked for, but failed to find the jewel and the necklace that had been hidden by an Indian.

(35) None of the pirates stole the jewel and the necklace.

The interaction between the conjunction *and* and the downward entailing environment created by *none of the* creates an implicature that can be paraphrased as follows:

(36) Some pirate found either the jewel or the necklace.

In a context in which no pirate found the jewel and no pirate found the necklace, the implicature is not met. Therefore, adult speakers of English should reject (35) on the grounds that the alternative statement in (37) provides a more informative description of the context.

(37) None of the pirates found the jewel or the necklace.

The adults that Gualmini (2001) interviewed, however, consistently accepted (35) in the situation in which (37) was true.

In a second experiment, Gualmini (2001) used the Felicity Judgment task. In this case, adult speakers of English were asked to choose between (35) and (37). The main finding was that whenever the subjects favored one sentence over the other (i.e., in half of the trials), they overwhelmingly chose the sentence with the disjunction operator *or*. Overall, these results are interpreted by Chierchia (2001) as showing that adult speakers of English do compute indirect implicatures, although these are weaker than direct implicatures.

Let us now consider the complexity of the task. Two types of behavior revealed that children experienced difficulty. First, some children repeatedly asked the puppets to repeat themselves, thereby showing that children were experiencing some difficulty in comparing the target sentences. A second, and possibly more interesting, sign of children's difficulty comes from the responses of those children who rejected the use of the disjunction operator. When these children were asked to motivate their choice, and say "what really happened," they consistently refrained from using the universal quantifier and resorted to sentences like (38):

(38) This girl chose a turtle and a bunch of flowers and she got some water, and this girl chose a turtle and she got some water, and this girl got a bunch of flowers and she also got some water, and these two girls chose a turtle and a bunch of flowers and they got some water.

In our view, it would be misleading to take such response as denoting lack of pragmatic knowledge. Rather, we think that sentences containing the disjunction *or* and the universal quantifier *every* raise an additional problem, which was orthogonal to our current concern. Namely, children experienced difficulty with sentences containing the disjunction *or* when they expressed generalizations over individuals.[7] Importantly, one could eliminate this possible confounding factor by presenting children with a different scalar term (e.g., the indefinite article *a*).

5. Conclusion

This paper reviewed the main assumptions of the Semantic Core model of scalar implicatures and some experimental research motivated by that model. We also presented a new experiment designed to investigate children's knowledge of the relative information strength of sentences containing alternative scalar terms in the restrictor of the universal quantifier *every*, a downward entailing environment. The experimental findings provide evidence that young children have mastered the prerequisites to the computation of scalar implicatures, including the notion of information strength.

Endnotes

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1. See Kadmon and Landman (1993) on the role of information strength in the theory of negative polarity items.
2. This reasoning is supported by the observation that children and adults are known to accept an ambiguous sentence on any (grammatically well-formed) interpretation that makes the sentence true in a context.
3. The children who participated in Experiment II of the Chierchia et al. study can be divided in two distinct groups: one group of children consistently applied scalar implicatures (like adults), and a second group consistently ignored scalar implicatures (unlike adults). We refer the reader to the original study for a discussion of the individual results.
4. The children who participated in this experiment were different from the children who were tested in Experiments I and II using the Truth Value Judgment task.
5. Intuitively, there is an additional factor that could lead children to prefer (28) over (29) in the context under consideration. The sentence containing the disjunction operator extends to more characters (i.e., $girl_1$, $girl_2$, $girl_3$, $girl_4$, and $girl_5$) than the sentence containing the conjunction operator (i.e., $girl_1$, $girl_2$, $girl_3$). Further research is needed to determine if this difference in 'empirical coverage' is invoked by children.
6. It is pertinent to observe that even if one wants to interpret the results as supporting the Pragmatic Delay hypothesis, the data suggest that this explanation is more limited in scope than previously assumed. Moreover, one would need to explain why the pragmatic delay affects the computation of indirect implicatures to a greater extent than the computation of direct implicatures.
7. A similar phenomenon has been discussed by Boster and Crain (1993). Boster and Crain (1993) discovered some non-adult behavior in children's interpretation of the sentences containing the disjunction *or* in the scope of the universal

ghostbuster will choose a dog or a pig in a context in which every ghostbuster had chosen exactly one object. However, almost every child imposed an additional restriction on the interpretation of *Every ghostbuster will choose a dog or a pig*. One group of children expected the kind of animal chosen by the ghostbuster to be the same for all ghostbusters, and a second group of children expected the kind of animal chosen by the ghostbuster *not* to be the same for all ghostbusters. We refer the reader to the original paper for discussion of the results.

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