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Implicit Alternatives Insufficient for Children's Implicatures with Some

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1. Introduction

Human communication often expresses more than what is explicitly said. To convey and retrieve additional information beyond what is literally encoded, speakers and hearers exploit certain inferential principles, often called *implicatures*. This paper is concerned with one well-known such case of pragmatic inference, namely scalar implicatures (SIs) with the quantifier *some*. Take (1) as an illustration. Though the literal meaning of the sentence in (1a) is equivalent to (1b), (1a) communicates (1c):

(1) a. John ate some of the cookies.
b. John ate one or more cookies. (= possibly all)
c. It is not the case that John ate all of the cookies.

Under the traditional Gricean (1975) account, the hearer arrives at (1c), an SI, using the following line of reasoning. Assuming the speaker of (1a) is co-operative, she would have uttered a more informative sentence with *all* if John had indeed eaten all of the cookies. Since the speaker chose not to do so, the hearer infers that she is not in a position to offer the stronger statement, most likely because the stronger statement does not hold. Such reasoning about alternative sentences that could have been said instead leads to SIs as in (1c).

Computing implicatures is a multi-step process, which we can generalize to an algorithm as in (2) (e.g., Sauerland 2004, Katzir 2007):

(2) **Step 1:** Compute the literal meaning of a sentence S
*John ate **some** of the cookies. (= one or more, possibly all)*

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Step 2: Generate a set of alternatives, ALT(S), by substituting *some* with appropriate lexical items of the same category, or *scalemates*
{*John ate **all** of the cookies*, *John ate **most** of the cookies…*}

Step 3: Negate those sentences in ALT(S) that are logically stronger than S
{¬*John ate **all** of the cookies,* ¬*John ate **most** of the cookies*…}

Step 4: Strengthen the basic meaning of S by conjoining it with the negated alternatives in Step 3
{*John ate some of the cookies and it is not the case that John ate all of the cookies…*}

Upon hearing a sentence with a scalar term like *some,* the listener first calculates the basic or literal meaning of the expression. Next, she must generate a set of sentences that may have been uttered instead, by replacing *some* with its scalemates. Those alternatives in the set, which are more informative than the original sentence S are then negated, resulting in the "strengthened" meaning of the utterance (e.g., *some, but not all*).

2. Developmental work

In order to become competent communicators, children need to be able to make use of an algorithm as in (2). A number of studies on children's scalar implicatures, however, suggest that children under age 6 have considerable difficulties in this realm (Noveck 2001, Papafragou & Musolino 2003, Huang & Snedeker 2009, Barner et al. 2011). Preschool-aged children often accept "weak" readings with *some* when a stronger statement with *all* would have been felicitous. For example, in a study by Papafragou and Musolino (2003), children were shown a scenario with three horses, all of which jumped over a fence. A puppet then described the scene using the sentence "Some of the horses jumped over the fence." When asked whether the puppet's statement was a good description of the situation, adults said "No," but children responded affirmatively. This pattern of behavior has been taken to mean that children do not enrich the meaning of *some* in the prompted sentence to *some*, *but not all*.

Children's performance improves drastically under certain experimental manipulations. They are adult-like when given training, or when the task involves direct comparison of alternatives. In a series of studies by Chierchia et al. (2001) and Gualmini et al. (2001), children who, in the classic Truth Value Judgment paradigm, appeared insensitive to the exclusivity implicature triggered by the disjunctive operator *or* (i.e. "*p* or *q*, but not *p* and *q*") showed adult-like accuracy in a task that asked them to compare under-informative/weak sentences and informative sentences. Two puppets offered statements that differed in strength, and children were asked to reward the puppet who "said it better". Children overwhelmingly rewarded the puppet who uttered the informationally stronger sentence, revealing their capacity to assess alternatives when they are explicitly provided. More recently, it has been showed that simply *priming* the stronger alternative, e.g., an *all* statement, in the experiment context improved performance (Foppolo et al. 2012, Skordos and Papafragou 2014). When the critical *some*-trials are preceded by *all*-trials, children can draw on this contrast to derive a strengthened *some, but not all* meaning.

The above findings tell us that though children do not always calculate implicatures, the general cognitive machinery necessary for pragmatic enrichment is in place. So, what is behind their underperformance to begin with? To put differently, which steps of the algorithm in (2) do children find difficult? An answer is put forth in Barner, Brooks and Bale (2011), who argue that the difficulty lies in Step 2 of the algorithm: children cannot spontaneously generate the alternatives, likely because they have trouble retrieving the relevant lexical items with which to replace the relevant scalar term. On the other hand, if the alternatives are given to them, they successfully compute the strengthened meaning.

Support for this hypothesis comes from findings that children continue to have trouble even when strengthening is *required* by the grammar, e.g. when you have an overt exhaustifier like *only*. In their experiment, the authors showed that children accept statements like "Only some of the animals are sleeping" in contexts where all of the animals were sleeping. On the other hand, when the relevant animals were individuated, as in "Only the cat and the dog are sleeping," they performed at ceiling. The authors argue that in the latter case, the relevant scalemates (e.g., *the cat*, *the dog*) are readily available to them because it is explicitly listed in the prompt.

Barner, Brooks and Bale (2011) predict, then, that children should perform like adults even in SI-tasks when the burden of spontaneous alternative-generation is removed, that is, when the stronger alternative is available in the context. The high performance in, e.g., Chierchia et al's (2001) felicity judgment task and Foppolo et al.'s (2012) alternative-priming task is consistent with their hypothesis: in both cases, the relevant alternative sentence is readily accessible in the context.

The present study further explores the role of accessible alternatives in children's performance with scalar implicatures with *some*. Specifically, we were interested in whether children benefited from having the stronger alternative salient in the experimental context, but crucially, not provided as a linguistic object. We contrasted *some, but not all* and *all* by visually representing the two sets side by side. The child was then asked to choose the set that best represented a *some*-sentence. Findings from the word-learning literature show that even at very young ages, children are able to consider contrastive alternatives even when they are not verbally-encoded (Carey 1978, Markman 1989). We reasoned that the visual contrast between *all* and *some* should point children in the right direction as to which alternative to generate and negate. Contrary to our expectations, children did not reliably discriminate between the *some, but not all* and *all* sets until after 6 years of age.

3. Experiment

We asked whether making the *some*-*all* contrast salient by depicting *all* alongside *some, but not all* (henceforth *some*) would improve children's rate of SIs. Children were given a four-choice picture selection task, where the choices were sets in which *some, all, none*, or *some part* of the objects satisfied a given predicate. The prompt always involved *some*. The alternative with *all*, though never explicitly given, is easily construable from the context. If children benefit from the *contextual* availability of the stronger alternative, we should find them performing like adults, strengthening the prompted sentence and choosing the *some* set.

3.1. Methods

Our data are part of a large, longitudinal study on cognitive, linguistic and socio-emotional development (Landry 2010). The study was conducted over the course of 4 years, with each participant being tested 4 times. Thus, we were able to track the time-course of SI-development on the same group of children.

3.1.1. Participants

353 children from subsidized schools in Texas and Florida participated in our study. Testing time 2 took place 8 months after Time 1, Time 3 took

place a year after Time 2, and Time 4, a year after Time 3. Children began the study when they were 4-years-old (Mean Age at Time 1 = 4.53) and completed it when they were approximately 7-years-old (Mean Age at Time 4 = 7.06).

3.1.2. Design and Materials

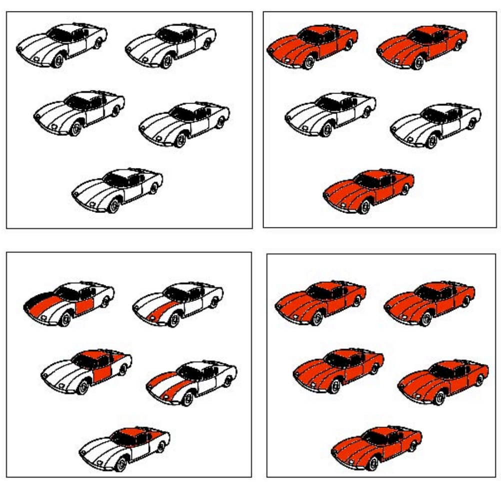
There were two items with the quantifier *some*, given in (3). The small number of critical items was due to time-constraints imposed by the large battery of tests being run with each child.

(3) Scalar Implicature items

a. Some cars are red.
b. Some birds are blue.

Children were given a four-choice picture-selection task, as exemplified in Figure 1 below[1]. The array included pictures where *some, all, none,* or *parts* of the cars were red.

Figure 1: Picture array in task



Participants were asked to point to the picture where "Some cars are red," and instructed to select only one of the 4 sets. We expected that adults in the task would draw the SI and strengthen "Some cars are red" to "Some but not all cars are red," resulting in a selection of the top-right set in Figure 1. Selecting the *some (but not all)* picture was therefore considered a

[1] These materials were inspired by early work by Roeper and Matthei (1975).

"correct" response in this task. Any other selection was coded as an "incorrect" response.

3.2. Results

3.2.1. SI-computation over Time

We found that at the earlier stages, children do not consistently choose the target set, but performance increases steadily over Time. The *some*-set is not the predominant choice until Time 3, when the participants are around 6 years old. The rate of accuracy at each time is given in Table 1:

Table 1: Accuracy by Time

Time	Mean Age	Accuracy	SD
1	4.53	.27	.44
2	5.06	.36	.48
3	6.07	.55	.50
4	7.06	.80	.40

A maximally-specified mixed-effects model confirmed this trend: Time was a significant predictor of performance on SIs. Our model was specified such that the accuracy at one time was compared to the accuracy at the next time: Time 1 is thus compared to Time 2, Time 2 to Time 3, and Time 3 to Time 4. We find that performance did not change significantly between Times 1 and 2 ($\beta = 0.29$, Odds Ratio = 1.33, $p = 0.1$). However, children are significantly more likely to correctly choose the *some*-set at Time 3 than they were at Time 2 ($\beta = 1.61$, Odds Ratio = 5.02, $p < .001$), and much more likely to choose *some* at Time 4 than at Time 3 ($\beta = 4.11$, Odds Ratio = 61.16, $p < .001$).

A closer look at the children's responses reveals that even at the earliest stage, they know the logical meaning of *some*: the *none* and *part* responses are rarely selected, as illustrated in Table 2:

Table 2: Children's Response Types

Time	all	none	part	some
1	54%	7%	12%	27%
2	48%	6%	11%	36%
3	30%	4%	11%	55%
4	12%	2%	6%	80%

In spite of their *semantic* knowledge of the quantifier, children do not consistently strengthen the *some*-sentence to *some, but not all*. The *all*-set is frequently chosen as the best representation of the prompted sentence, especially by the younger children, who show a preference for the *all* set. So, in spite of salient contrast between the *some* and *all*, children do not appear to be calculating an implicatures at the earlier stages.

The behavior of participants in this study is thus reminiscent of children's behavior in the early Truth-Value Judgment Tasks (e.g., Noveck 2001). Our data provide further corroborating, *longitudinal* evidence in support of these earlier findings that adult-like, automatic calculation of implicatures is an ability that develops over time: the same child is more likely to compute an implicature at age 7 than she was at age 4.

3.2.1. Linguistic & cognitive predictors of SIs

Scalar implicatures are phenomena that sit at the intersection of language and cognition. On the one hand, implicatures are triggered by specific lexical items. On the other, they involve a complex reasoning process that takes into account an array of linguistic and extra-linguistic information. Thus, the inferential process involved in pragmatic enrichment likely calls upon linguistic capacities as well as domain-general cognitive machinery. It is of interest, then, to see whether children's abilities with other aspects of language and cognition have an impact on their performance with scalar implicatures. Since our SI-task was part of a larger study on linguistic and cognitive development, we were able to investigate precisely this question.

At Times 1 and 2, measures were also taken of children's Executive Functioning ability ("Knock Tap Test", Korkman, Kirk & Kemp 1998), Vocabulary (*Expressive One Word Picture-Vocabulary* test), and syntax (*Wh*-questions subtest on the DELV Language Assessment, Seymour, Roeper & de Villiers 2005). We conducted analyses on a subset of the data consisting of these two testing times to see whether these measures predicted accuracy on the scalar-implicature task. In other words, are children who are better at inhibitory control or different aspects of language also more likely to compute implicatures with *some*?

We specified logistic mixed-effects models with participant and item as random effects and Time, Executive Functioning, Vocabulary and *Wh*-questions (with the corresponding interaction terms) as fixed effects. The model revealed no main effect for any of the factors, but it did show a significant Time*Executive Function interaction ($\beta = 1.36$, p=.05) and a

Time*Wh-Question interaction (β = .35, p=.05). At Time 1, there appears to be little relationship between Executive Functioning or *Wh*-Questions on accuracy with scalar implicatures—performance is near-constant irrespective of ability on either of these measures. However, at Time 2, a clear trend emerges where children who have higher scores on Executive Functioning and *Wh*-questions are also better performers on scalar implicatures.

Perhaps unsurprisingly, the development of scalar implicatures does not seem to be an isolated phenomenon, but rather, one that interfaces with the development of other aspects of cognition such as syntax and executive functioning. The particular patterns of these relationships are also informative: the *lack* of effect at Time 1 of either Executive Functioning or *Wh*-questions might be indicative of a stage in development where children simply do not have the resources to make SI-related calculations, irrespective of their abilities in other domains.

4. Discussion

The present study set out to test whether children can draw implicatures of the form '*some* → ¬*all*' when an implicit contrast between *some* and *all* is made in the context. We provided longitudinal data on a large sample, replicating findings that i) 4-year-olds know the logical meaning of *some*, but ii) children younger than 6 are happy to accept a *some and possibly all* reading in contexts that implicate *some, but not all* for adults. Although the trials depicted both *all* and *some (but not all)* sets, at the earlier stages, the *all*-set was chosen as representing a *some*-sentence at least as often as the target *some*-set. Our findings suggest that the availability of the *all*-alternative in the context did not sufficiently encourage children to compute a *not-all* implicature.

Previous studies have shown that children strengthen *some*-statements when the contrast with *all* is explicit, e.g., when they had to directly compare sentences with *some* and *all* or when the critical *some*-trial was preceded by an *all*-trial (Chierchia et al. 2001, Foppolo et al. 2012, Skordos and Papafragou 2014). Why are they unable to make use of the *implicit* contrast between *some* and *all* in the present study? One reason might be that identifying the intended contrast might itself be more challenging in our task. Compare our picture-selection task with the felicity judgment task as in Chierchia et al. (2001), where two sentences where evaluated relative to a single picture. The task itself makes unambiguous that there is a lexical contrast between the two scalar elements compared. Our task, on the other hand, involves a single sentence and two *semantically compatible* situations or sets. Given that the task calls for the "best possible choice," adults infer that a contrast is intended between the two sets that make the sentence literally true. However, children might not take a similar step in reasoning, and may even be assuming different criteria (e.g., a greater number of items satisfying the predicate) for choosing the best answer.

Secondly, unlike tasks that involved linguistically-encoded alternatives, our task could not guarantee that upon seeing the array, the child (or adult) encoded the relevant set using an *all*-proposition. Upon initial encounter, one could just as well describe the critical sets in Figure 1 as, for example, "Three cars are red" and "Five cars are red." If this is the case, the contrasts depicted cannot be expected to aid the retrieval of an alternative sentence with *all*.

The present study and much of the previous work demonstrate that in spite of having the cognitive machinery for pragmatic strengthening from early on, adult-like computation of scalar implicatures is an ability that continues to develop well into the early primary-school years. Adults compute implicatures with *some* by default, canceling the inference only when the situation demands it. Children, on the other hand, seem to compute scalar implicatures only when unambiguously required by the context. Since the communicative contexts are bound to vary with different experimental materials and methodology, we also expect varying performance from children. The complex, at times conflicting, set of findings in the developmental literature is illustrative of precisely this.

Why isn't computing implicatures a default step for children, as it appears to be for adults? Prior studies have shown that computing scalar implicatures comes at a processing cost (e.g., Bott and Noveck 2004, Breheny, Katsos and Williams 2006). It might be that children, who arguably have fewer cognitive resources available to them, may prefer not to incur these costs unless absolutely necessary. This would also be consistent with our finding that there is a positive link between executive functioning and the ability to compute implicatures. However, the precise nature of the differences between adult and child implicature generation remains an important, open question.

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