Comparing plurality inferences and scalar implicatures in acquisition

Summary: Recently a scalar implicature approach has been applied to plurality inferences. To evaluate this unified approach, the present study compared children's and adults' comprehension of sentences containing plural morphology and sentences containing the scalar term *some*. There were two main findings. First, both children and adults computed more plurality inferences (PIs) in upward-entailing than in downward-entailing linguistic environments. Second, children computed much fewer PIs and scalar implicatures from sentences with *some* (SIs) than adults did. The findings are consistent with previous research demonstrating children's relative insensitivity to scalar inferences, and provide support for an SI approach to PIs.

Background: The plural-singular distinction is the source of a long-standing puzzle (Sauerland 2003, Spector 2007, a.o.): (1a) appears equivalent to (1b) and different from (1c), suggesting that English plural morphology is associated with a meaning like 'more than one' (Lasersohn, 1995, a.o.). Under negation, however, the expected "not more than one" meaning (2b) is absent; the negated plural in (2a) is better paraphrased as the negation of a singularity, as in (2c).

(1) a. Tiger fed pigs.
b. Tiger fed more than one pig.
c. Tiger fed a pig.

(2) a. Tiger didn't feed pigs.
b. Tiger didn't feed more than one pig.
c. Tiger didn't feed a (single) pig.

In response to this puzzle, a scalar implicature approach to plurals has been proposed. On such an approach (Spector 2007; Magri 2014), both the singular and the plural have the meaning in (3a) (in a model with three pigs, Jill, Mary, and Fran). The singular is typically compared to (3b), yielding the SI in (4a). By contrast, the plural is directly compared to the singular enriched with its SI (4a). Once the enriched singular is negated, the plurality inference is generated (4b).

(3) a. $[\![\textbf{pigs}]\!] = [\![\textbf{pig}]\!] = \{j, m, f, j \oplus m, j \oplus f, f \oplus m, j \oplus m \oplus f\}$
b. $[\![\textbf{more than one pig}]\!] = \{j \oplus m, j \oplus f, f \oplus m, j \oplus m \oplus f\}$

(4) a. $[\![\textbf{pig}]\!] \wedge \neg [\![\textbf{more than one pig}]\!] = \{j, m, f\}$
b. $[\![\textbf{pigs}]\!] \wedge \neg([\![\textbf{pig}]\!] \wedge \neg [\![\textbf{more than one pig}]\!]) = \{j \oplus m, j \oplus f, f \oplus m, j \oplus m \oplus f\}$

Given that SIs are typically not derived when scalar terms appear in downward-entailing contexts, the SI approach predicts the pattern of interpretation observed in (1) and (2). The SI approach can also account for an additional reading of (2a) that excludes singularity, namely that in (5) (typically read with emphasis on the plural *-s*); this involves postulating a local SI in the scope of negation.

(5) Emily didn't feed giraffe**s**, because she fed only one!

If PIs are derived as a kind of SI, the pattern of children's PIs is expected to mirror their performance with other SIs. A consistent finding from the literature on the development of SIs is that children compute SIs less than adults do (Noveck 2001; Chierchia et al., 2001; Papafragou & Musolino, 2003, a.o.). Against this background, Sauerland et al. (2005) tested the computation of PIs by 3-5-year-olds', using polar questions such as *Does a dog have tails?* They reported that children accepted these more often than adults did. As the authors (and Pearson et al. 2011) point out however, the study had some potential limitations: first, PIs typically disappear in polar questions, and, second, the stimuli involved generic interpretations, which could have been misinterpreted by children as containing dependent plurals. The SI approach also finds support in Tieu et al. (2014), which reports that 4-5-year-old children are less likely than adults to generate PIs. However, this study did not test SIs, and does not afford us a direct comparison between PIs and SIs.

Experiment: To avoid these potential limitations, and to test the SI account further, we used a Truth Value Judgment Task to directly compare SIs and PIs in children and adults. Participants watched short stories on a laptop computer. Following each story, a puppet was asked a question about the story, and the participant's task was to judge the puppet's answers. To investigate comprehension of plural morphology, we used a 2x3 design with GROUP (adults vs. children) and CONDITION (SI vs. PI.POS vs. PI.NEG) as factors. The PI and SI trials were presented in randomized blocks. We tested 17 monolingual English-speaking children (4;01-5;05, M=4;07) and 27 adults. Each participant saw ten test stories and eight controls.

PI condition: Three of the test stories were associated with a positive plural sentence, e.g., *Tiger fed pigs*, and three with a negative plural sentence, e.g., *Frog didn't feed birds* (Fig. 1-(i,ii)). In a typical story, a main character executed an action on only one of a set of objects. For example, in Fig. 1-(i), Tiger has enough food to feed only one pig. If participants computed the PI in the positive condition, they were expected to reject the test sentence; in the negative condition, participants were expected to reject the sentence *Frog didn't feed birds* (although they might accept it if they accessed a meaning like (5)).

SI condition: Participants also saw four SI trials, in which a character carried out an action with all four objects in the context, e.g., Lion carried all of the apples (Fig. 1-(iii)); the puppet's statement contained *some*, e.g., *Lion carried some of the apples*. The SI and PI stories were completely parallel in structure, to ensure that one kind of inference was not encouraged more than the other.

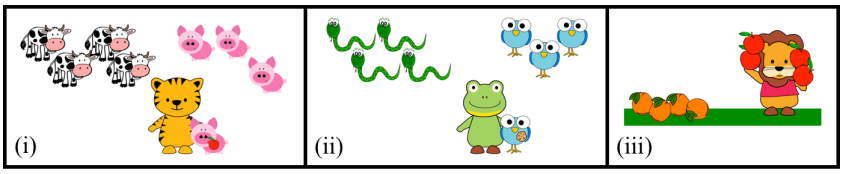

Figure 1: Final images accompanying the test sentences: (i) *Tiger fed pigs*; (ii) *Frog didn't feed birds*; (iii) *Lion carried some of the apples*. We present here only the final image of the relevant stories; actual test trials involved full stories presented through a sequence of images in PowerPoint.

Controls: Each participant also received two positive and two negative plural controls: two positive plural sentences in contexts that satisfied the PI, and two negative plural sentences in contexts that did not satisfy the PI. All participants also received four negation controls (e.g., *Zebra didn't paint the bowls*). Only participants who passed at least six of the eight controls were included in the analysis.

Results & Discussion: Fig. 2 displays the percentage of *yes*-responses across conditions. A 2x2 mixed-effects logistic regression model of the SI and positive PI conditions revealed main effects of condition (z=-2.67, p<.01) and group (z=5.36, p<.001), but no interaction. A 2x2 mixed-effects logistic regression model of the positive and negative plural conditions revealed a main effect of polarity (z=5.56, p<.001), no effect of group (z=1.24, p=.22), and a significant interaction between polarity and group (z=5.10, p<.001). The main findings can be summarized as follows. Children and adults computed more PIs in the positive than in the negative condition; this finding is in line with SI approaches to PIs, which predict PIs in upward-entailing but not downward-entailing environments. As seen in Fig. 2, a few adults appeared to access the interpretation in (5) on the plural negative trials, made available by locally computing the PI in the scope of negation (cf. (5)). Children computed fewer PIs than adults in both plural conditions. This pattern was directly comparable with performance in the SI condition, where children also computed fewer inferences than adults. These findings from the PI and SI conditions are consistent with previous literature indicating children's relative difficulty with scalar inferences. Finally, a comparison of children's rates of PIs and SIs suggests that they may compute more SIs than PIs. Following an approach like Spector (2007), one possibility is to attribute the greater difficulty of PIs to the recursive nature of the exhaustification in (4). However, children have been shown to be adult-like in computing free choice inferences, which are also argued to involve recursive exhaustification (Tieu et al. 2015). We suggest, instead, that the observed difference between children's performance on PIs and SIs may be tied to their knowledge of the relevant alternatives. This suggestion is in line with recent approaches that attribute children's difficulty with SIs to a problem accessing the required alternatives (Barner et al. 2011, a.o.). While the co-scalar alternatives *some* and *all* correspond to distinct lexical items, the alternatives required to compute the PI are more abstract: they involve singular and plural features that do not map directly to free morphemes. This may make their acquisition more challenging for the child learner.

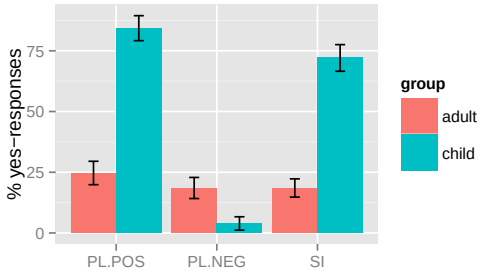

Figure 2: Yes-responses across conditions.

Conclusion: Our findings strongly support an SI approach to PIs. Differences in the patterns of behavior between children and adults were similar for both PIs and SIs, and replicated previous findings of such between-group differences for SIs. Moreover, the present study avoided the possible limitations of Sauerland et al. (2005) and Tieu et al. (2014). First, we examined both upward-entailing and downward-entailing linguistic contexts, so there is no clear way in which our stimuli could have been misinterpreted as involving dependent plurals. Second, we tested classical SIs in addition to PIs, so we could directly compare the patterns of performance by children and adults in response to inferences of both kinds.

Selected References • **Pearson et al. 2011.** Even more evidence for the emptiness of plurality: An experimental investigation of plural interpretation as a species of scalar implicature. *SALT20 Proceedings.* • **Sauerland et al. 2005.** The plural is semantically unmarked. *Linguistic Evidence: Empirical, Theoretical, and Computational Perspectives.* • **Spector 2007.** Aspects of the pragmatics of plural morphology: On higher-order implicatures. *Presupposition and Implicature in Compositional Semantics.* • **Tieu et al. 2014.** Plurality inferences are scalar implicatures: Evidence from acquisition. *SALT24 Proceedings.*