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The Acquisition of Distributivity in Pluralities

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1. Introduction

Sentences with plural expressions can often be interpreted in many ways, as has been established and investigated in formal semantics (see Landman, 1995, Lønning, 1997 for summaries and references). This multitude of interpretations has also been studied in language acquisition (see Avrutin and Thornton, 1994, Brooks and Braine, 1996, Ferenz and Prasada, 2002, Musolino, 2009, Roeper et al., 2011, Syrett and Musolino, submitted, among others). In this paper, we focus on the acquisition of readings available to non-quantificational plural noun phrases. In particular, we focus on the interpretation of definite plural noun phrases (NPs).

Consider the following example:

- (1) The boys lifted two boxes.

This sentence can be true if the boys lifted two boxes in one joint action (*collective* reading). In this case, it is not individual boys who are agents of (1), rather, their collection is. The sentence can also be true if each boy acted as an agent, thus lifting two boxes on his own (*distributive* reading). Within the distributive reading we can further distinguish two types. First, (1) could be true if each boy lifted different boxes so in total twice as many boxes as there are boys were lifted. The sentence could also be true if all the boys lifted the same two boxes. We will call the first reading the *dependent* distributive reading

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(because intuitively, which boxes were lifted depends on which particular boy we are talking about) and the second reading the *independent* reading.

It has been observed that adults fully accept collective readings of non-quantificational noun phrases but they find distributive readings marginal (for conjunction of proper names, see Frazier et al., 1999; for plural pronouns, see Kaup et al., 2002; for definite plural NPs, see Dotlačil, 2010 and discussion of the experiment below). Crucially, this is true even when both readings are equally plausible, as shown quite clearly in the eye-tracking study of Frazier et al. (1999). This leaves us with two issues which we would like to address in the current paper:

1. Why are distributive readings with non-quantificational noun phrases degraded?
2. How is the degraded status of distributive readings with non-quantificational noun phrases acquired?

The paper is structured as follows. In the next section we discuss a pragmatic explanation of the first question and we show that the analysis makes a prediction regarding the acquisition of definite plural NPs. In Section 3 we turn to the language acquisition study and we show that the prediction is corroborated. In Section 4 we end with a short conclusion.

2. Pragmatics of definite plural NPs

2.1. Why distributive readings are degraded

Recall that adults can straightforwardly interpret (1) in the collective reading but they find the distributive reading marginal.

Following Dotlačil (2010), we assume that definite plurals are ambiguous between collective and distributive readings and the marginal status of the latter reading follows from principles of conversation. To see this imagine (1) as part of a conversation, for instance, as Perry's answer to Sue's question:

- (2) What did the boys do?

In this context, it is relevant what the boys did. By uttering (1) Perry makes clear that there was some box lifting going on. However, he leaves further details unanswered. In particular, since (1) is true under both the collective and the distributive reading Sue does not know whether each boy lifted two boxes on his own or whether the boys cooperated in lifting two boxes together.

However, at this point, Sue can reason as follows:

1. Perry said (1).
2. There is another sentence, *each boy lifted two boxes*, which is more informative than (1) since it excludes the collective reading.
3. But Perry did not say *each boy lifted two boxes*. Assuming he follows conversational principles and, in particular, he tries to be as informative as

required (Grice's Maxim of Quantity), he wants me to infer that *each boy lifted two boxes* is not true.

4. Thus, (1) conveys the collective interpretation.

Under this approach, the dispreferred distributive reading of (1) is a case of a conversational implicature. Semantically speaking, the reading is present. However, in the actual conversation it is often not considered.

There are various issues with this account which we cannot discuss in much detail here. First, an observant reader might have noticed that by the same reasoning, Sue might conclude that (1) only conveys the distributive reading. For this erroneous conclusion on Sue's part, it suffices that she would wonder why Perry did not use the sentence *the boys together lifted two boxes*, which is more informative than (1) but excludes the distributive reading.¹ The second problem is that it might not be clear how the same reasoning could extend to the degraded status of the distributive reading with other non-quantificational NPs, like conjunction of proper names. (3) does not have a clear counterpart with *each* unless we consider floating or binominal quantifiers or partitive constructions.

- (3) Lucy and Min lifted two boxes.

Both of these issues revolve around the question of what exactly are the alternative expressions that Sue might have considered when deciding what (1) means (see Horn, 1989, for a general discussion). For the purpose of this paper, we assume that adverbs (like *together*) are not possible alternatives to non-quantificational noun phrases. Only quantified noun phrases are, either by hosting a quantifier (as in *each boy*) or a floating quantifier (as in *Lucy and Min each*). For a more detailed analysis, see Dotlačil (2010).

2.2. Prediction in language acquisition

It is known that children show non-adult like interpretation of *each*. Brooks and Braine (1996) and Syrett et al. (submitted) show that children are much more liberal than adults. More concretely, they can interpret *each* collectively.

This brings a straightforward prediction to the analysis sketched in the previous section. We expect that children should fully accept distributive readings with non-quantificational noun phrases. To see why, consider (1) again. A child that hears this sentence cannot reason that there is a more informative sentence, namely, *each boy lifted two boxes*, which would exclude the collective reading, because in her understanding, this sentence is just as ambiguous as (1).

¹See Syrett et al. (submitted) for more detailed discussion on the collective interpretation of the adverb *together*.

Since *each boy lifted two boxes* does not exclude any reading, she cannot conclude that (1) only carries the collective reading.

In more detail our predictions are thus as follows: first, we expect that in language development the rejection of distributive readings with non-quantificational noun phrases should *follow* the acquisition of *each*; second, we expect that for individual children the level of acquisition of *each* predicts whether they will reject distributive readings or not.

In the rest of the paper we discuss the experiment which tested these predictions.

3. Experiment

3.1. Design and procedure

The experiment is a Truth-value Judgment Task (TVJT), run in Italian. Subjects are shown a picture on a computer screen. Then, a puppet manipulated by one of the experimenters utters the target sentence. The subject is then asked to judge the sentence as a correct or incorrect description of the picture by giving the puppet either a golden coin, in case the puppet's sentence is judged as correct, or a less valued green coin, in case the puppet's sentence is judged as incorrect (this holds for children; adult subjects were simply asked to say whether the target sentence was a correct description of the picture).

The experiment includes four experimental conditions. In each condition participants are asked to judge an Italian transitive sentence in the context of a picture. The sentences are of the form Subject-Verb-Indefinite object. In Conditions A and B, the subject of the sentence is a distributive NP: it includes a distributive quantifier *ciascun* 'each'. In Conditions C and D, the subject of the sentence is a non-quantificational NP: a definite plural. In the first condition (Condition A), participants are asked to judge an Italian transitive sentence with a distributive subject in the context of a picture depicting a distributive state of affairs. An example of such sentence is in (4), its accompanying picture is in Figure 1.

- (4) Ciascuna bambina costruisce un castello di sabbia
Each girl build.3Psing.PRES a castle of sand
'Each girl is building a sand castle.'

A 'true' answer to a condition A item is interpreted as indicating that the participant accepts the distributive interpretation of the distributive subject.



Figure 1: Picture accompanying the target sentence (4)

In the second condition (Condition B), participants are asked to judge a transitive sentence with a distributive subject and an indefinite object in the context of a picture depicting a collective action. An example of such sentence is in (5), its accompanying picture is in Figure 2.

- (5) Ciascun bambino costruisce un pupazzo di neve
 Each boy build.3Psing.PRES a puppet of snow
 'Each boy is building a snowman.'

A 'true' answer to a condition B item is interpreted as indicating that the participant accepts the collective interpretation of the distributive subject.



Figure 2: Picture accompanying the target sentence (5)

In the third condition (Condition C), participants are asked to judge a transitive sentence with a definite plural subject and an indefinite object in the context of a picture depicting a distributive state of affairs. An example of such sentence is in (6), its accompanying picture is in Figure 3.

- (6) Le bambine costruiscono un pupazzo di neve
 The girl.PL build.3PPl.PRES a puppet of snow
 'The girls are building a snowman.'

A 'true' answer to a condition C item is interpreted as indicating that the participant accepts the distributive interpretation of the definite plural subject.



Figure 3: Picture accompanying the target sentence (6)

In the fourth condition (Condition C), participants are asked to judge a transitive sentence with a definite plural subject and an indefinite object in the context of a picture depicting a collective action. An example of such sentence is in (7), its accompanying picture is in Figure 4.

- (7) I bambini costruiscono una torre
 The boy.PL build.3PPL.PRES a tower
 'The boys are building a tower.'

A 'true' answer to a condition D item is interpreted as indicating that the participant accepts the collective interpretation of the definite plural subject.



Figure 4: Picture accompanying the target sentence (7)

- To summarize, the experiment includes four experimental conditions:
 Condition A: *Ciascuno* 'each'; Distributive picture.
 Condition B: *Ciascuno* 'each'; Collective picture.
 Condition C: Plural definite; Distributive picture.
 Condition D: Plural definite; Collective picture.

Each condition includes 6 sentence-picture pairs. Subjects are presented 24 experimental items in total. In each condition, the sentences are constructed using the following 6 verbs: *dipingere*, *portare*, *mangiare*, *costruire*, *sollevare*, *riparare* (En. 'paint', 'carry', 'eat', 'build', 'lift', 'repair').

The experiment also includes 36 filler items, of whom 24 false and 12 true. We chose to design more false than true fillers to prevent children's yes-bias. As is well-known, children generally avoid saying that something is wrong. By answering false fillers, children become confident and aware that the puppet's statements can be wrong.

Experimental items are presented in pseudo-random order. Care is taken that no experimental item is followed by an experimental item belonging to the same condition. Experimental items are interspersed with filler items in such a way that each experimental item is separated from the next by either one or two filler items.

Finally, the whole experiment is preceded by two warm-up items.

Two different versions of the experiment were developed, differing in the order of presentation of filler and experimental items. Subjects were assigned randomly to one of the two versions.

Subjects were tested individually in a silent classroom. The pictures were displayed on a laptop screen. In the case of younger children, the target sentences were uttered by a puppet maneuvered by one of the experimenters. In the case of children older than 11 years and adults, the sentences were simply read aloud by one of the experimenters.

3.2. Subjects

One-hundred-eighty-nine children aged between 4 and 13 years and 97 adults were tested in the experiment. Subjects were divided into 11 groups depending on their age. The main features of the groups are summarized in Table 1. Children were recruited from primary and secondary schools in the province of Verona, Italy. Adults were MA students at the University of Verona. Subjects were tested individually in a silent classroom.

Table 1

Group	Number of subjects	Group mean age (with standard deviations)
4YO	12	4;4 (0;3)
5YO	20	5;5 (0;3)
6YO	16	6;6 (0;3)
7YO	20	7;4 (0;3)
8YO	22	8;6 (0;3)
9YO	21	9;5 (0;3)
10YO	20	10;4 (0;3)
11YO	15	11;8 (0;2)
12YO	17	12;7 (0;4)
13YO	26	13;9 (0;5)
AD	97	21;5 (2;2)

3.3. Results and discussion

All subjects were able to complete the test. Subjects answered incorrectly to filler items 2% of the times. Errors are evenly distributed across filler items; therefore, they can not be attributed to one or more specific filler items.

Table 2 reports the mean proportion of ‘true’ answers (with standard deviations) for each group and for each condition.

The descriptive statistics suggests that children consistently accept the distributive interpretation of the distributive quantifier from the age of 4 years. Children are also consistent in accepting the collective interpretation of definite plural noun phrases. The results of Condition B suggest that 4 and 5-year-old children also accept the collective interpretation of the distributive quantifier; then, starting from the age of 6 years, they start rejecting this interpretation and move gradually toward the adult stage, which is reached at the age of 11 years. The results of Condition C indicate that the younger children accept the distributive interpretation of definite plural noun phrases; adults accept the distributive interpretation of definite plural noun phrases around half of the times; children start rejecting the distributive interpretation of definite plural noun phrases around the age of 9/10 years; however, even by the age of 13 children do not seem to have completely reached the adult stage. In conclusion, the descriptive statistics suggests that the acquisition of the meaning of the distributive quantifier precedes the acquisition of the meaning of the definite plural.

Table 2

Group	Proportion of 'true' answers			
	Cond. A	Cond. B	Cond. C	Cond. D
4YO	96 (8)	89 (25)	96 (10)	93 (11)
5YO	100 (0)	92 (23)	99 (4)	97 (7)
6YO	98 (6)	81 (34)	98 (6)	99 (4)
7YO	100 (0)	67 (45)	99 (4)	100 (0)
8YO	100 (0)	49 (46)	95 (18)	100 (0)
9YO	100 (0)	39 (42)	92 (15)	96 (10)
10YO	100 (0)	26 (33)	88 (24)	98 (5)
11YO	100 (0)	10 (27)	76 (24)	98 (6)
12YO	98 (6)	11 (22)	71 (29)	100 (0)
13YO	99 (3)	11 (19)	72 (30)	98 (5)
AD	96 (10)	9 (18)	50 (32)	98 (13)

We analyzed the data in a multi-level logistic regression model. The dependent variable was the response (0 for rejecting a sentence, 1 for accepting it). The predictors were: CONDITION, AGE and the interaction of the two. Finally, we included two random effects for the intercept: PARTICIPANTS and ITEMS.

When fitting the model we considered two modifications of the variable AGE. First, rather than considering real age of adults, we pinned them all to the

age of 21 (mean value). We did this because we expected that adults do not any more learn the meaning of quantifiers and definites and thus, using their real age leads to overfitting the data. Second, we did log-transformation of age. This reflects the fact that we expect differences in age to play a bigger role in younger children than in older children. Both modifications significantly improved the model fit so we kept them in our analysis.

In the resulting model, AGE was a significant predictor ($z=-2.9$, $p<.01$), So was CONDITION B (*ciascun* 'each' with a collective interpretation; $z=-2.9$, $p<.01$). Furthermore, two interactions were significant: AGE with CONDITION B ($z=-5.3$, $p<.001$) and AGE with CONDITION C (plural definite with a distributive interpretation; $z=-5.4$, $p<.001$). Other conditions and their interactions with AGE were not significant. Finally, adding random effects for subjects and items accounted for significant portion of variance (for subjects, std. deviation was 1.6, for items it was 0.6). To sum up, we see that within our experiment, 'each' in the collective interpretation is rejected more than other conditions. Furthermore, with higher age, 'each' in the collective interpretation and definites in the distributive interpretation are accepted less. Thus, only those two conditions have to be acquired, the other two conditions remain stable, practically fully acceptable, throughout all age groups. The model without random effects is graphically summarized in Figure 5. As we can see in the graphical summary, all conditions start as being fully acceptable. 'Each' in the collective interpretation is the first condition that children start to reject, followed by definites in the distributive interpretation, as we expected.

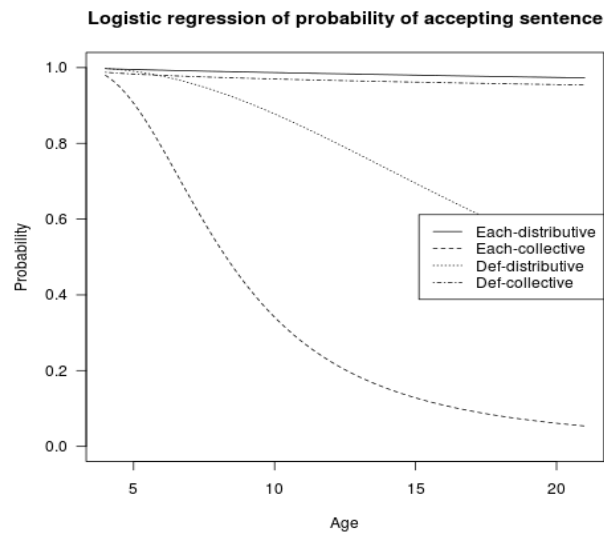


Figure 5. The logistic regression model, ignoring random effects

However, more importantly, we were interested in the direct role that 'each' in the collective interpretation (Condition B) plays in the acceptance of the distributive reading of definite plurals (Condition C). For that we focused only on children data. We studied the correlation between each child's acceptance of Condition C and his or her acceptance of Condition B. More concretely, we assumed that the level of acceptance is expressed in our experiment by the number of items that a child accepted in a condition. We thus measured the correlation between the proportion of items accepted in Condition B and the proportion of items accepted in Condition C. Using Spearman's rank correlation, we found a significant positive correlation between the two conditions ($\rho=0.5$, $p<.001$). No other condition correlated significantly with Condition B. The correlation between the two conditions can also be nicely seen in Figure 6, which shows how many times each child accepted Condition C (on x-axis) and B (on y-axis). Importantly, there are no data points in the upper left part of the plot: these would be children that reject distributive readings with definite plural NPs but accept collective readings with 'each'. Given our analysis, we predict this to be impossible and the data support our conclusion.

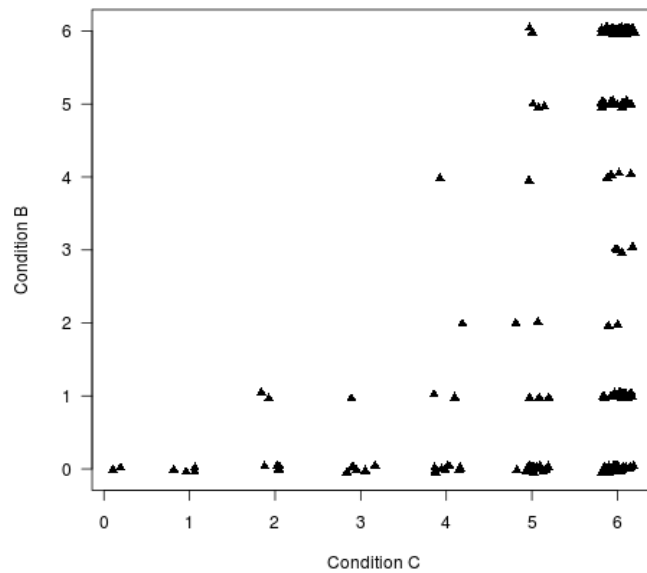


Figure 6. Correlation between Condition B and C

Unfortunately, using Spearman's rank correlation to analyze these data is not fully appropriate. The problem is that both Conditions B and C highly correlate with age and therefore, the correlation between them could just be an artifact of their correlation with the third factor, age. Since our position is that

regardless of age rejection in Condition B should lead to rejection in Condition C we want to exclude this possibility. We did so by considering quasibinomial logistic regression in which the dependent variable was the number of times a child accepted Condition C. The independent variables were AGE and how many times a child accepted Condition A, B or D (coded here as CONDITION A, CONDITION B and CONDITION D). As expected, we found that AGE is a significant predictor ($z=-3.4$, $p<.001$). However, much more importantly, we also found that CONDITION B is a significant predictor ($z=3.7$, $p<.001$). Surprisingly, there was also a significant effect of CONDITION D, albeit smaller (collective interpretation with definites; $z=2.4$, $p<.05$). Putting aside CONDITION D for a while, we thus see that our model predicts that the acceptance of Condition C (distributive readings with definites) depends on child's age and also his or her answers to Condition B. In other words, child's response to Condition B is a significant predictor over and beyond his or her age. This result supports our analysis.

Before concluding, we would like to comment on two things. The first is the effect of CONDITION D in our last model, which is surprising and not explained by our model. Here, we only want to suggest that these results should be handled with great care if one wishes to treat them as a real linguistic phenomenon. The problem is that in our data there are very few responses other than acceptance of all 6 items in Condition D. In fact, it appears that this condition is significant because out of 189 children we tested, three accepted Condition D only four times and two of them accepted Condition B two times, which seems to make the condition a good predictor. Excluding either of these two children leads to the drop in the z -value by half and a non-significant result. The situation is different with Condition C in which responses are much more spread and thus, no individual children have such a big effect on its role in predicting responses to Condition B.

The second issue we would like to comment on is the role of distributivity. Recall that at the beginning we have mentioned that we can distinguish two types of distributive readings: dependent and independent readings. Now, one might wonder: which reading of these two did we test?

The answer is that we always used dependent readings in the distributive conditions since the indefinite object varied with the subject. However, in the collective conditions some items might be classified as belonging to independent distributive readings rather than collective interpretations. At least the test items with the verbs *dipingere* 'paint' and *mangiare* 'eat' belong to these because these verbs normally require individuals as agents, not groups. For instance, the test item 'the boys are eating a pizza' in a picture with two boys eating one pizza is highlighting the distributive independent reading, not the collective reading. Since the test items appearing with 'eat' or 'paint' verbs did not show different patterns than other test items we provisionally conclude that it is not distributive readings that are rejected with definite plurals, rather, only dependent readings are. Similarly, *ciascun* 'each' not only requires the distributive reading but it specifically requires the distributive dependent reading (among adults and older

children). The same has been shown to hold for the adults' interpretation of *each*, see for instance Roeper et al. (2011). We leave exploration of this issue to the future research.

4. Conclusion

In this article we tested the hypothesis that the degraded status of the distributive reading of plural definite NPs is a case of conversational implicature: a definite plural NP such as *the boys* is not interpreted distributively because, if the speaker wanted to express a distributive interpretation, she would have used the unambiguous NP *each boy*. In our experiment we tested the following predictions: (i) in language development, the rejection of distributive readings with non-quantificational noun phrases follows the acquisition of 'each'; (ii) the level of acquisition of 'each' predicts whether subjects will reject distributive readings or not. The results of the experiment show that children learn to reject the collective reading of 'each' before they learn to reject the distributive reading of plural definite NPs. The results also show that children's acceptance of the collective reading of 'each' is a significant predictor of children's acceptance of the distributive reading of plural definite NPs. Therefore, the results support our hypothesis.

References

- Avrutin, Sergey and Thornton, Rosalind (1994). Distributivity and binding in child grammar, *Linguistic Inquiry*, vol. 25, no. 1, pp. 165–171.
- Brooks, Patricia J. and Braine, Martin D.S. (1996). What do children know about the universal quantifiers all and each?, *Cognition*, vol. 60, no. 3, pp. 235–268.
- Dotlačil, Jakub (2010). *Anaphora and Distributivity. A study of same, different, reciprocals and others*, Doctoral Dissertation, Utrecht Institute for Linguistics OTS, LOT Series.
- Ferenz, Krag and Prasada, Sandeep. (2001). Singular or plural? Children's knowledge of the factors that determine the appropriate form of count nouns. *Journal of Child Language*, vol. 29, pp. 49-70.
- Frazier, Lyn, Patch, Jeremy M. and Rayner, Keith (1999). Taking on semantic commitments, II: collective versus distributive readings, *Cognition*, vol. 70, pp. 87–104.
- Horn, Laurence (1989). *A Natural History of Negation*, Chicago, University of Chicago Press.
- Kaup, Barbara, Kelter, Stephanie and Habel, Christopher (2002). Representing referents of plural expressions and resolving plural anaphors, *Language and Cognitive Processes*, vol. 17, no. 4, pp. 405–450.
- Landman, Fred (1995). Plurality. In *The Handbook of Contemporary Semantic Theory*, ed. Shalom Lappin. London: Blackwell.
- Lønning, Jan Tore (1997). Plurals and Collectivity, in *Handbook of Logic and Language*, eds. Johan van Benthem and Alice ter Meulen, Amsterdam, Elsevier.
- Musolino, Julien (2009). The logical syntax of number words: Theory, acquisition a processing, *Cognition*, vol. 111, pp. 24-45.

- Roeper, Thomas, Pearson, Barbara Zurer and Grace, Margaret (2011). Quantifier spreading is not distributive. In BUCLD 35, ed. Nick Danis, Kate Mesh and Hyunsuk Sung, Somerville MA: Cascadilla Press, pp. 526-539.
- Syrett, Kristen and Musolino, Julien (submitted), Collectivity, distributivity, and the interpretation of numerical expressions in child and adult language. Ms. Rutgers University.