Learning the logic in language: Acquiring the meanings of *all, every* and *each*

Natural languages contain a vocabulary of words that specify semantic relations between the elements in a sentence, like the universal quantifiers *all, each* and *every.* Although the relations specified by these words are all universal (i.e., they specify the 'for all' relation) they differ on other dimensions, such as distributivity. *Each* necessarily specifies a distributive relation: the predicate must separately apply to each individual member of the quantified set. The distributivity of *every* is weaker, while *all* can be used when the predicate applies to the quantified set collectively (e.g., Roberts, 1987; Tunstall, 1998). Previous studies on the acquisition of universal quantifiers often assumed that children treat them as universal from the outset, and only become sensitive to differences in distributivity later in development (see Syrett, 2019, for overview). However, it is also possible that the universality of *each* and *all* have different sources. In particular, the universal force of *each* might be a byproduct of its distributivity – of applying the predicate to each individual until none are left (see also, Knowlton, et al., 2022). In that case, children might not understand *each* as universal until whenever they also understand it as distributive. We tested these alternatives by directly comparing children's understanding of the universality of different quantifiers. Do children acquire the universality of different quantifiers at different points in development or all at once?

In Experiment 1, children (3-7 years old, *n* = 110) were shown five toy fruits and an Elmo puppet. They were asked *Can you give Elmo {each/every/all/some/a/dax} (of the) fruit?*, with *dax* serving as a baseline for how children respond when they don't know the quantifier's meaning. Results from a mixed-effect model revealed that older children were more likely to give a universal response (i.e., the maximal number of items) when prompted with any of the universal quantifiers (*all*, *each*, *every*) than younger children (which was not the case for *dax*). This suggests that the universality of these quantifiers is acquired gradually in development. However, the analysis also revealed differences between quantifiers: Averaged across ages, children were more likely to interpret *all* and *every* as universal than *each*, and even among 7-year-olds, *each* was only interpreted universally in about 75% of trials (Fig. 1).

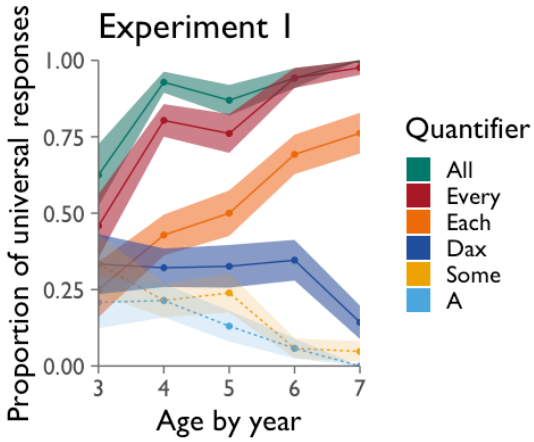

Fig. 1 Proportion of trials in which the maximal number of items were given in Experiment 1, split up per age (plotted in years) and quantifier. The shaded area represents the standard error. The quantifiers *some* and *a* are plotted for completeness, but not included in our analyses.

In Experiment 2, we focused on *each* specifically. Children (4-7 years old, *n* = 78) watched an animation of Cookie Monster taking a bite out of zero, two, or three out of three cookies. They were then asked *Did Cookie Monster bite each/the/two/dax (of the) cookies?* In our main analyses, again conducted with mixed-effect models, we tested whether children differentiated *each* from *dax*. When Cookie Monster bit two of the three cookies, the correct response would be to say

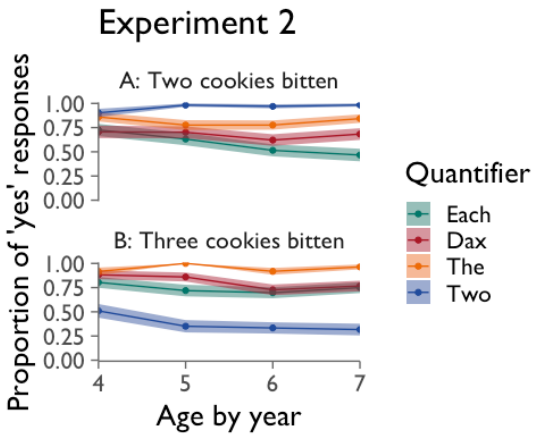

Fig. 2 Proportion of 'yes' responses, split up by event outcome, quantifier, and age.

'no' to the question of whether he bit *each of the cookies*. However, our analyses revealed that children were just as likely to say 'no' to the questions with *each* as to those with *dax*, and even the oldest children only provided correct 'no' responses for *each* on 50% of trials when two cookies were bitten (Fig 2a). When Cookie Monster bit three of the three cookies, the correct response would be to say 'yes' to the questions with *each*. Again, our analyses revealed that children were just as likely to say 'yes' to the questions with *each* as to those with *dax*, and even the oldest children responded with 'yes' to the questions with *each* in only about 75% of trials (Fig 2b). These findings reinforce the conclusion that children do not interpret *each* as universal until late in development.

In our ongoing Experiment 3, we are testing whether the late acquisition of *each* as a universal persists across sentences that might encourage a more distributive interpretation. Children (3-6 years old, *n* = 66 so far) are presented with three toy fish and a pile of toy fruits, and asked *Can you give {each/every/all/some/a/dax} (of the) fish fruit?*. In this experiment, a distributive interpretation may be more accessible than in the previous experiments because the questions can be answered by pairing fish and fruit one-to-one. We have not conducted inferential statistics due to ongoing data collection, but preliminary results (Fig. 3) show 4- and 5-year-olds already predominantly giving universal responses when prompted with *each*, and 6-year-olds nearing ceiling. We're currently investigating whether this pattern holds in a truth-value judgement task (Experiment 4). These observations suggest that constructions which encourage a distributive interpretation of *each* may thereby create a universal interpretation, via a one-to-one mapping between quantified individuals and predicates (e.g., fish and fruit).

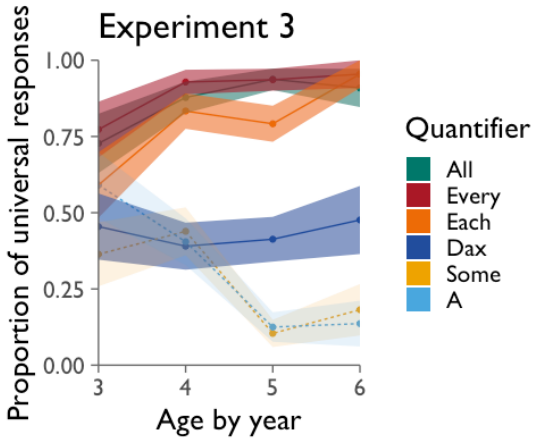

Fig. 3 Proportion of universal responses in Experiment 3, split up per age (in years) and quantifier. The shaded area represents the standard error. The quantifiers *some* and *a* are plotted for completeness, but not included in our analyses.

Our findings reveal that children learn that *all* and *every* are universal quantifiers before they learn that *each* is, at least in contexts in which each is not also clearly distributive. This suggests that different universal quantifiers are learned in a dissociable manner, possibly due to differences in the underlying cause of their universal force. In particular, children may understand that *each* has universal force only once they understand it as distributive.

References

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