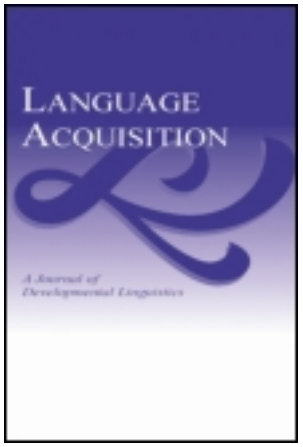

Language Acquisition
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hlac20

Collectivity, Distributivity, and the Interpretation of Plural Numerical Expressions in Child and Adult Language

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Published online: 23 Sep 2013.

To cite this article: Kristen Syrett & Julien Musolino (2013) Collectivity, Distributivity, and the Interpretation of Plural Numerical Expressions in Child and Adult Language, Language Acquisition, 20:4, 259-291, DOI: 10.1080/10489223.2013.828060

To link to this article: http://dx.doi.org/10.1080/10489223.2013.828060

Language Acquisition, 20: 259–291, 2013

ISSN: 1048-9223 print / 1532-7817 online
DOI: 10.1080/10489223.2013.828060

Routledge
Taylor & Francis Group

ARTICLE

Collectivity, Distributivity, and the Interpretation of Plural Numerical Expressions in Child and Adult Language

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Sentences containing plural numerical expressions (e.g., *two boys*) can give rise to two interpretations (collective and distributive), arising from the fact that their representation admits of a part–whole structure. We present the results of a series of experiments designed to explore children's understanding of this distinction and its implications for the acquisition of linguistic expressions with number words. We show that preschoolers access both interpretations, indicating that they have the requisite linguistic and conceptual machinery to generate the corresponding representations. Furthermore, they can shift their interpretation in response to structural and lexical manipulations. However, they are not fully adult-like: unlike adults, they are drawn to the distributive interpretation and are not yet fully aware of the lexical semantics of *each* and *together*, which should favor one or another interpretation. This research bridges a gap between a well-established body of work in cognitive psychology on the acquisition of number words and more recent work investigating children's knowledge of the syntactic and semantic properties of sentences featuring numerical expressions.

1. INTRODUCTION

The capacity to refer to *quantities* of individuals, and not be merely restricted to mention of *specific individuals*, represents a fundamental property of human language, lying at the heart of its expressive power. In English, for example, this can be achieved through a number of means, including, for example, the use of quantificational expressions (*every student)*, plurals (*the students)*, or numerical expressions (*two students*). Over the past several decades, theoreticians have developed formal tools to account for the linguistic behavior of such expressions, showing that the phenomena of quantification and plurality are complex and interrelated (see Link 1983, 1987,

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1991, among many others). For example, numerically quantified expressions (e.g., *two students*) can express plurality, enter into scopal interactions with other quantified expressions, and indicate the number of objects in a set.

In investigations of these expressions in the child language acquisition literature, however, researchers have focused almost exclusively on one particular property of such expressions: Gelman & Gallistel (1978)'s cardinal principle. This interest has led a range of researchers of linguistic and cognitive development to investigate how and when children come to know that the final tag in a count list represents the number of items in (or the *cardinality* of) a set (Barner & Bachrach 2010; Bloom & Wynn 1997; Gelman & Gallistel 1978; Fuson 1988; Gelman 1993; Gelman & Meck 1983; Carey 2004, 2009; Le Corre & Carey 2007; Le Corre, Van de Walle, Brannon, & Carey 2006; Mix 2009; Sarnecka & Carey 2008; Sarnecka et al. 2007; Syrett, Musolino, Gelman 2012; Wynn 1990, 1992, among others). Two of the central issues that have emerged from this line of work pertain to the conceptual roots of cardinality and the nature of the mechanism whereby children learn how cardinality is expressed by the verbal counting system. Thus, the goal has been to try to explain how children learn that a phrase such as *two boys* picks out a set of boys in the world with a cardinality of exactly two and what accounts for the errors children display in experimental tasks designed to tap into this knowledge. This issue, it turns out, has proven to be particularly vexing, and there is still no consensus on how young children acquire this core aspect of number word meaning and how the conceptual and linguistic systems are linked in the acquisition process.

Thus this line of work has focused on the notion of cardinality to study how numerically quantified expressions are acquired by children. Here, we take a different approach and use numerically quantified expressions to study how children acquire a fundamental semantic property shared by a range of plurality-denoting expressions. The semantic property in question is the ability of such expressions to give rise to two distinct readings: a collective and a distributive one. For example, in (1), the VP *push a car* can be predicated of the *group* of two boys denoted by the Noun Phrase in subject position (i.e., there is only one car and the two boys pushed it together). We refer to this as the *collective* reading.

(1) Two boys pushed a car.

Alternatively, *push a car* can be predicated of each *individual* boy in the set denoted by the Noun Phrase (in which case, each boy pushed a car). This is called the *distributive* reading. The crucial difference is that the VP predicate can either denote a property of the *set* or group or the individual *members* of the set. By signaling a property of the individuals, *push a car* must apply to each boy, which means that the indefinite object *a car* does not necessarily pick out exactly one car. Thus, the language learner needs to be able to represent the plurality denoted by the subject Noun Phrase, allowing for two levels at which the predicate can apply.

This basic distinction, left virtually unexplored in the developmental literature, has generated substantial discussion in the theoretical literature over the years, since an understanding of sentences with plurals depends on it (Gillon 1987, 1990; Lasersohn 1995; Link 1983, 1987, 1991; Roberts 1987; Scha 1981; Schwarzschild 1991, 1994, 1996; van der Does 1992, 1993). Moreover, certain recent accounts of number word interpretation have appealed to collective/distributive ambiguity to account for when the different senses of number word meaning surface (see Koenig 1991). Studying the acquisition of the collective/distributive distinction is thus an important first

step toward an approach integrating various aspects of the meaning of quantity-denoting expressions. Here, we use numerically quantified expression as a gateway to investigating children's developing understanding of the collective/distributive distinction. The results of our experimental investigation, in turn, offer the possibility of integrating the conceptual and linguistic aspects of the interpretation of numerical expressions and have the potential to shed light on the compositional meaning of these interpretations.

Our findings demonstrate that the ability to generate collective and distributive interpretations of sentences such as (1) is part of the semantic repertoire of children as young as 3 (Experiment 1). However, we also uncover intriguing differences in the preferences preschoolers and adults have for resolving the collective/distributive ambiguity: whereas adults strongly prefer the collective interpretation, preschoolers prefer the distributive one (Experiment 2). We focus on the way that judgment and preference tasks complement each other to uncover children's linguistic knowledge and point out that this pattern is in line with previous findings concerning the way in which preschoolers resolve a range of sentence-level ambiguities. A common conclusion within this line of work is that while preschoolers are in principle capable of accessing the full range of interpretations available to adults, the two age groups often display different interpretive preferences (Lidz & Musolino 2002; Miller & Schmitt 2004; Musolino 2011; Musolino & Lidz 2006; Musolino, Crain & Thornton 2000; Syrett & Lidz 2005, 2011). We further demonstrate that children's preferences are malleable in that they can shift their interpretation in response to both lexical and structural manipulations (Experiments 3 and 4)—specifically, the addition of certain modifiers and passivization. Finally, we discuss the implications of our findings for models of the acquisition of the conceptual and linguistic representation of number words and the acquisition of the abstract and complex linguistic properties of numerical expressions occurring in natural language. In doing so, we seek to bridge the gap between the literature on the acquisition of the basic conceptual meaning of number words and the emerging line of research on their more complex linguistic properties.

2. THEORETICAL BACKGROUND

Numerically quantified expressions such as *two boys* and sentences such as (1) in which they appear, repeated here, have played a central role in discussions of collectivity and distributivity in the semantics literature over the last few decades.[1]

(1) Two boys pushed a car.

As we described, such sentences have two readings: one in which the predicate is applied to each of the two individuals denoted by the subject (the distributive reading), and one in which the predicate is applied to the group as a whole (the collective reading). This sentence therefore says that there is a group of individuals composed of two boys and that either the group or each of the individuals in the group has the property of pushing the car. While it is widely accepted that

[1]We are restricting discussion to these two readings and not addressing others covered elsewhere in the semantics literature: cumulative, neutral, or pseudodistributive readings (see Gillon 1984, 1987, 1990; Link 1987; Lønning 1991; Scha 1981, 1991; van der Does 1992, 1993).

such sentences give rise to multiple interpretations, there is not a consensus on how precisely to account for the multiplicity of meanings. Debates have centered around questions about whether such sentences should be understood as ambiguous or merely as underspecified, whether the subject NP or the VP predicate should be implicated as the source of the ambiguity, and whether the numerical expression itself should be best represented as a *group*, a *sum*, or a *set*. In many ways, this ongoing debate about the formal account for the variety of interpretations serves to highlight the intricacies the language learner must master and the potential for misinterpretations or misrepresentations along the way.

Following analyses by Link (1983, 1987) and others more recently, we will assume that these sentences are truly ambiguous, and not merely underspecified, and that the source of the ambiguity in our target sentences is the VP predicate. Here, we adopt a default semantics approach in order to illustrate how two different interpretations may be generated. In a sentence such as (1), the plural subject NP *two boys* denotes a plurality of individuals. This plurality can be conceived of as the group itself, or as the collection of individuals, since it has an internal structure. Thus, to interpret the phrase *two boys*, a learner must know that it picks out a set of two entities *x*, each of which has the property of being a boy (*boy[x]*), and that these boys are united in the semantics. This union can be captured by an atomic join semilattice structure or set membership. For example, there may be closure under the sum function, creating an *individual sum* (i.e., {a⊕b}) out of the individuals *a* and *b*. The same can be said of the conjoined NPs (e.g., *Peter and Neal*). Importantly, whatever structure is obtained consists of atomic subparts (the individuals) and a whole (the individual sum, set, or group). Variations on implementation can be found in a wide range of works over the last few decades (Bartsch 1973; Bennett 1974; Gillon 1984, 1987, 1990; Higginbotham 1980; Jackendoff 1996; Landman 1989a, 1989b, 1996; Lasersohn 1989, 1990, 1995, 1998; Link 1983, 1987, 1991; Lønning 1989, 1991; Moltmann 1997; Peres 1998; Roberts 1987; Scha 1981, 1991; Schein 1993; Schwarzschild 1991, 1994, 1996; van den Berg 1994; van der Does 1992, 1993; Verkuyl 1998; Verkuyl & Does 1991; Winter 2002).

When such a plural expression appears in a sentence with an ambiguous predicate (or *mixed predicate* in Link's terms) such as *push a car*, the combination yields multiple interpretations, since the predicate can be applied to either each individual boy or to set of two boys. This predicate differs from exclusively distributive predicates, such as *be asleep, be left-handed, have blond hair, have brown eyes*, or *be tall*, or collective predicates, which require pluralities, such as *agree, come to a consensus, gather (around), meet, scatter, separate*, or *surround*. Mixed predicates can be VPs, such as *push a car*, or the others in our scenarios, or adjectival predicates, such as (*be*) *heavy*.[2]

When the predicate in our example sentence is applied to the individuals, the derived reading is the distributive one. The resulting interpretation is therefore that there are multiple "car pushing" events. When the predicate is applied to the group, however, a collective reading is derived, and the extension is an atomic joint "car pushing" event in which the boys collectively push the car. (This collective action does not necessarily entail collaboration among these individuals.) These differences are often captured by appealing to the presence and/or location of a Distributivity operator (^{D} or Distr) in the syntactic and/or semantic structure, the purpose of which is to function over individual entities or singletons (see Brisson 2003; Heim, Lasnik & May

[2]See Champollion (2011), Link (1987), Schwarzschild (1994, 2009), and Winter (2002) for further discussion.

1991; Lasersohn 1995, 1998; Link 1983, 1987; Schwarzschild 1996). However, nothing about our account or experimental findings hinges upon the D operator or its being involved in the computation of one reading and not the other. What matters for our purposes is that children have some way to represent the set captured by the expression *two boys* such that it has an internal structure and that they can apply the predicate to multiple levels (the set or sum and the individuals).

Ambiguous sentences with so-called mixed predicates can be disambiguated in favor of either a collective or distributive interpretation with the addition of certain lexical expressions, such as *each* and *together*, or manipulation of the syntactic structure. For example, while *each* is claimed to force a distributive interpretation, *together* is claimed to force a collective interpretation (see Bartsch 1973; Brisson 1998, 2003; Dowty 1986; Hoeksema 1983; Lasersohn 1990, 1995; McCawley 1968; Parsons 1980; Schwarzschild 1994, 1996; van der Does 1993; Verkuyl 1998).

This difference can be accounted for by appealing to the semantic representation of these items. Following Schwarzschild (1994; who follows others, most notably Link [1983]), we can think of *each* as a Distributivity operator with the following semantics.

(2) $\lambda P[\lambda x[\forall y((y \in x) \rightarrow P(y))]]$

This representation says that for every individual *y* that is a member of the plurality denoted by *x*, the predicate *P* holds of each of those individual members of the plurality. For example, for every boy in a plurality of two boys, the predicate "push a car" would hold true of each individual boy. By contrast, the semantics for *together* says that while a plurality or group has a property *P*, the individual members do not (necessarily), thereby yielding the collective interpretation.[3]

A passivized structure such as *A car was pushed by two boys* is claimed to favor the collective reading because it topicalizes and/or forces wide scope of the object (see Givon 1981; Keenan & Dryer 2007; Watanabe 2000). The context that makes this sentence true is therefore one in which one car is pushed by two boys simultaneously, and there is only one atomic pushing event. It may also be possible for this sentence to be true in a context in which there is one car, but each of the two boys takes turns pushing it. In such a context, there are multiple pushing events, so the interpretation that is generated is a distributive one, but one in which the object takes narrow scope relative to the subject. Interestingly, this kind of sentence highlights the fact that an account simply based on the relative scope of the subject and object with respect to each other cannot account for the ambiguity, since it is possible to get both a collective and a distributive interpretation when the object takes wide scope with respect to the subject. Scope may, however,

[3]Schwarzschild (1994) is mainly concerned with post-NP *together*, as in (i). There is a subtle difference in interpretation between this appearance of *together* and the postverbal one, which is of interest to us in this article.

(i) John and Adam together lifted the block.

In addition, there is the issue of ambiguity of *together*, discussed at length in Lasersohn (1995), which we have continued to investigate in subsequent experimental work with adults and children. Thus, this presentation is, we admit, an oversimplification of the semantics of *together*, but the predominant claim in the semantics literature that the presence of *together* should signal a collective reading remains the same. This issue will figure into our discussion of the results of Experiments 4 and 5, since the possible semantic accounts of postverbal *together* in a neo-Davidsonian event semantics may help to explain the difference in response patterns between children and adults. Space precludes us from discussing this issue at length in this article, so we leave the details of this particular lexical semantics acquisition problem—and the question of why there *together* is associated with such a strong collectivizing function, given its polysemy—for future work.

be an important factor in accounting for potential differences in interpretation between children and adults—a point that we return to later.

3. DEVELOPMENTAL BACKGROUND

Little attention has been paid to the collective/distributive distinction in the developmental literature. Two previous studies—one by Brooks & Braine (1996) and another by Musolino (2009)—are nevertheless relevant to our purposes. Beginning with the latter, Musolino (2009) was primarily concerned with the range of readings arising from the interaction of two numerically quantified expressions in so-called relational plural sentences such as (3).

(3) Three boys are holding two balloons.

This sentence could be true in multiple contexts. In one, each of three boys could be holding a different set of two balloons (resulting in six balloons total). This interpretation corresponds to a configuration in which the numerical expression in subject position takes wide scope over the numerical expression in object position (three boys > two balloons), and since the property *hold two balloons* is predicated of each of the individual boys, this interpretation is therefore a distributive one. In a second context, the three boys could be holding one set of two balloons together. This reading has been called the "each/all" reading (see Gil 1982; Scha 1981), and since the predicate *hold two balloons* applies to the group of three boys, this interpretation is therefore a collective one. Relevant to our aims, Musolino (2009) found that children as young as age 4 patterned like adults in accepting sentences such as (3) in contexts 1 and 2. Moreover, they rejected it in the third context corresponding to the object NP taking wide scope (two balloons > three boys), which is considered to be unavailable, for reasons that need not concern us here. From such results, one might infer that preschoolers must know something about the collective/distributive distinction. However, because of the very limited range of predicates used in the experiment—all of the sentences involved either the verb *hold* or *walk* (e.g., walk a dog)—and the use of two interacting numerical expressions, it is difficult to know how generalizable these results are. In addition, Musolino's work is silent on children's *preference* of certain interpretations, and how their preference compares with that of adults, so we lack a complete picture of the degree of continuity in language development in this area.

Brooks & Braine (1996; B&B), offered a more direct test of children's knowledge of the collective/distributive distinction. Although they focused on universal quantification, B&B included control items in their Experiment 2, which are relevant to our aims. In this condition, they tested children's interpretation of sentences such as the active sentence in (4) and its passive counterpart in (5), using a forced-choice paradigm.

(4) Three (actors) are (verb)ing an (object).

(5) An (object) is being (verb)ed by three (actors).

Participants were asked to select the image that best matched the sentence, given a choice between collective and distributive contexts. For example, for one item, participants saw a black-and-white drawing depicting three men building a boat together (a collective context), and in another, they saw an image with three men each building a separate boat (for a total of three

different boats; a distributive context). B&B found that 4-year-olds chose randomly between collective and distributive pictures for sentences such as (4), and that they were insensitive to the active versus passive manipulation captured by comparing (4) and (5). In fact, it was not until age 5 that the children in B&B's study started to display a preference for the collective interpretation of sentences such as (4)—a preference that their study showed became stronger through adulthood.

However, there are again reasons to think that we are far from having a complete picture of what children know about the collective/distributive distinction as it pertains to numerical expressions. First, the overarching goal of B&B's study was to investigate the acquisition of the universal quantifiers *each* and *all*—and not the interpretation of sentences containing numerical expressions. Insofar as these authors looked at plurals with number words, it was only as a control. In this experiment, participants heard sentences containing *each, all*, or *three*, and the active/passive distinction was also within subjects. It is possible, then, that there was bleeding across item types, and participants would have responded differently with a between-subjects design. An additional consequence of the within-subjects design was that to make the session a reasonable length, there had to be a limited number of items for each item type. From their description of their materials, we gather there were only three items for sentences such as those in which we are interested for the active version, and three for the passive version.

Finally, B&B's study was designed to assess children's *preference* of a collective or distributive context given a target sentence, rather than their ability to accept or reject an interpretation of a sentence given a possible context. This approach cannot tell us whether children, like adults, are able to access both interpretations of an ambiguous sentence; it can only tell us which interpretation they prefer. This observation, in turn, may lead one to erroneously conclude that children are able to generate only one of two possible interpretations. While a forced-choice method may reveal interesting information about children's representations (in fact, we make use of such methodology in the current work), the limitations of relying *exclusively* on a forced-choice paradigm to measure comprehension have been discussed in much detail in the developmental literature (e.g., Crain & Thornton 1998). Finally, the objects in B&B's collective context images were much larger than those in the distributive context. It is possible that the salience of the larger object pulled children's attention toward the collective context, thereby masking an otherwise distributive preference and making their responses appear chance-like.

The two studies reviewed so far present a somewhat conflicted picture of the acquisition of the collective/distributive distinction as it pertains to sentences with plural numerical expressions. On the one hand, Musolino's (2009) work suggests that children as young as 4 may be able to predicate of both groups and individuals when interpreting such sentences, but we are left knowing little about how general this knowledge is and what children's interpretive preferences are. On the other hand, B&B's study suggests that 4-year-olds are far from adult-like and may behave no better than chance, but the small number of items, the within-subject design, and the choice of images leave us wondering how much their findings tell us about the availability of collective and distributive interpretations in our sentences of interest. All of these points are combined with the fact that the difference in methodology between the two previous studies makes it difficult to compare results. Thus, we still lack an answer to the question about what young children know about the collective/distributive distinction that is central to linguistic knowledge of numerical expressions and plurals more generally. This study aims to fill this gap by both drawing from and

improving upon these previous studies and offering a deeper semantic dimension to the analysis of the target sentences and representational knowledge entailed by children's responses.

By 4 years of age, many children succeed in linguistic tasks designed to investigate knowledge of the more complex and flexible interpretations available to sentences containing numerical expressions (Barner & Bachrach 2010; Musolino 2004, 2009, 2011; Syrett & Schwarzschild 2009; Syrett 2010, 2013). By this age, many children have also exhibited mastery of the cardinal principle in counting-oriented tasks (see Le Corre & Carey 2007; Le Corre et al. 2006). If the collective/distributive distinction serves as a bridge between these core components of the meaning of numerical expressions,[4] we would then expect to find that knowledge of the collective/distributive distinction is in place by age 4, contra B&B. However, in order to test this prediction, we cannot rely on the sentences used by Musolino (2009), or the experimental design used by B&B, for reasons previously discussed. We must therefore devise new materials and a new task. This is what we now turn to in our first experiment.

4. EXPERIMENT 1: JUDGMENT TASK WITH AMBIGUOUS SENTENCES

The purpose of this task was to test the prediction previously discussed and determine whether children are able to access both the distributive and collective readings of sentences with a plurality expressed by a numerically quantified NP in the subject position of a sentence.

4.1. Method

4.1.1. Participants

Twenty children (10 boys, 10 girls) participated. Children were divided into two age groups: 10 "three-year-olds" (range: 3;4–4;3, mean: 3;9) and 10 "four-year-olds" (range: 4;5–5;4, mean: 4;10). Gender was evenly divided across the two groups. In all experiments, children were recruited from area preschools and tested in a quiet room on the premises. Children's performance was compared with 16 adult controls. The adult controls in all experiments reported here were undergraduates who received course credit for their participation.

4.1.2. Materials

Participants were shown a video consisting of a series of short events. Events were child-friendly activities such as pushing a toy car or building a tower from toy blocks, which were

[4]To be clear, the link that we have in mind here is not that the collective/distributive distinction is somehow involved in helping children become cardinality knowers. Rather, the idea is that once children know about the basic cardinality-denoting properties of numerically quantified expressions (whether or not they are full CP knowers and however such knowledge is acquired), the collective/distributive distinction is what allows them to go beyond the overt cardinality denoted by numerical expressions in cases like the ones we discussed. For example, we observed that our sentence in (1), *Two boys pushed a car*, is true in a context in which each of the two boys is pushing his own car. Such a context would involve two cars, and not just one, as is suggested by the presence of the indefinite *a car*. This is so precisely because of the rule-governed interaction between cardinality-denoting properties and the collective/distributive distinction—and more generally, the basic compositional nature of the semantics.

performed by one or two people. Events were filmed using a Sony HD Handycam. The original sound from the recording was removed so that during the experiment, participants could evaluate the visual stimuli paired with a test sentence. Auditory stimuli were recorded in a sound-attenuated recording booth in the Rutgers Phonetics laboratory by a female native speaker of American English, using child-directed speech prosody. They were later edited for length and intensity using Praat software (Boersma & Weenink 2010). Videos of the events were downloaded onto a Macbook. iMovie software was used to edit and manipulate the video segments and attach auditory stimuli.[5] An entire list of stimuli is included in Appendix A.[6]

Two versions of each event type were filmed. We refer to these versions as the *collective* and the *distributive* context, depending on which interpretation the event favored. In the *collective* context, the two participants performed the action together. In the *distributive* context, two participants performed the action side by side in parallel. For example, in the "push a car" event, two boys both sat at a table. In the collective context, there is a toy car positioned on the table in between the two boys. Each of the boys had a hand on the car, and they both pushed the car together. There was therefore one car-pushing event in the scene. In the distributive context, each boy pushed his own toy car, positioned on the table directly in front of him. There were therefore two car-pushing events in the scene. Screen shots of the final freeze-frames from the collective and distributive contexts for the "push a car" event are presented in Figure 1.

Each event lasted between 7 and 40 seconds. Distributive and collective context versions of the same event were approximately the same length. Test and control events were also comparable in length. An exclamation (e.g., *Look!, Let's see/watch what's happening!*) occurred at the beginning of each video segment to direct participants' attention to the event on screen. An occasional exclamation such *Wow!, Yay!*, or *Ooh!* punctuated the events to maintain participants attention. At the conclusion of each event, there was an 8-second freeze-frame of the final scene, during which we elicited participant judgments of our target sentences.

Two seconds into the freeze-frame, participants heard a sentence describing the event (e.g., *Two boys pushed a car*.) The same target sentence accompanied each of the two contexts for an event type. Participants were asked to respond "yes" or "no" in the space remaining in the freeze-frame. This was ample time for adults and generally enough time for children. If children needed more time to respond, the experimenter simply paused the video while the child answered and offered a justification. For both age groups, the entire experimental session took between 10 and 15 minutes.

There were six test-event types within the experimental session, each with a collective and distributive context version, for a total of 12 test items. Predicates in the test sentence were ambiguous (or ūmixed"), thereby lending the sentence to both collective and distributive interpretations. Context type was manipulated within subjects. The design was therefore

[5]The first author recorded and manipulated all auditory and visual stimuli.

[6]We also incorporated into our design a difference in the event type based on telicity and agent involvement (Dowty 1979; Vendler 1967; Verkuyl 1972). Some of the events (e.g., "push a car," "lift a block") could be considered activities with no endpoint to the event (i.e., atelic), while others could be considered accomplishments, with a clear telos or endpoint (e.g., "stack a set of rings," "draw a circle"). This difference becomes especially clear in the collective context: "push a car" can be predicated of each of the agents, because both boys helped to push the car, but "draw a circle" cannot, because each girl only drew half. Contrary to our expectations, this difference did not matter for acceptance rates in any of the experiments. In fact, we found no such difference among the items in our experiments or among individual children being influenced by aspect. We therefore collapse over items (and children) in our analyses.

FIGURE 1 Freeze frames of collective and distributive contexts for the test sentence *Two boys pushed a car*. Participants in the judgment tasks saw short videos of the events (color figure available online).

3 (age: 3-year-olds, 4-year-olds, adults) × 2 (context: collective vs. distributive), with age as a between-subjects factor and context as a within-subjects factor.

In addition to the 12 test events, there were 12 control events, similar in structure to the test events. The purpose of these events was to keep participants' attention, to ensure that they were paying attention to both the semantic content of the VP and the number of event participants, and to maintain a relative balance of *yes* and *no* responses within each condition. Six of the sentences accompanying the events were false because of the VP content, and two were false because of the numeral in the subject. For example, in one event a girl kicked a ball to a boy, who stopped it with his foot. The true statement was *A girl kicked a ball to a boy*. The false statements were rendered so by the underlined portion: *The girl blew up a balloon* or *Two girls kicked a ball to a boy*. A full list of auditory stimuli is included in Appendix A.

During the test session, test and control events were counterbalanced across two 12-item blocks. Each block contained the same number of control items and the same number of test items. Distributive and collective versions of the same event were separated into two different blocks and well spaced apart. Participants were randomly assigned to one of two experimental orders, created by reversing the order of events. The test session was preceded by a three-item training session, composed of two true utterance-video pairings and one false utterance-video pairing.

4.1.3. Procedure

Participants were told that they were going to be shown a series of short videos and that at the end of each video, a person on the computer was going to say what she thought happened. The experimenter explained that sometimes she was right, and sometimes she was wrong, and that the participants' job was to say when she was right or wrong, and (for children) explain why. Children delighted in this task.

Children were asked to respond directly to the experimenter (either the first author or a research assistant accompanying the first author), who recorded their verbal responses on a response sheet (either at the time or later while watching videotapes of the session). Adult participants were run one or two at a time in the laboratory at separate consoles. They recorded their answers by hand on a response sheet. Before participating, they were told that the tasks were designed for preschoolers, that we were using their responses as a comparison, and that they should therefore not over think the task because it seemed too easy.

We predicted that if participants allowed the predicate to hold of both the group and the individuals, they would accept the sentences in both the distributive and collective contexts. We further predicted that children might appeal to elements of the scene in their justifications. We had no reason to expect that perceptual elements of either context would be more salient than in the other, thereby biasing participants toward accepting sentences presented in that context. Nor did we have reason to believe that children's conceptual or semantic representations would lead them to favor or resist one interpretation over the other.

4.2. Results

Because responses to both types of control events were at ceiling, we leave those items aside and focus on the test items. The percentage of acceptance of the test sentence in each of the two target contexts, averaged over all test sentences and participants for each age group, is presented in Figure 2.

Given our 3 (age: between subjects) $\times$ 2 (context: within subjects) design and our categorical judgment data, we ran a mixed model logistic regression analysis, with participants and items as random effects. The results demonstrate that both children and adults were able to access both the collective and distributive interpretations of the target sentences. While there was a significant main effect of age ($p = .02$), there was no main effect of context ($p = .75$) and no interaction between age group and context ($p = .26$). We then performed multiple comparisons on the various age groups (all possibilities) to determine the source of the age effect. The only significant difference was between adults and 4-year-olds ($p = .01$). This difference stems from the fact that while 4-year-olds were near ceiling in their acceptance of the sentences in the distributive context, adults' acceptance rates were slightly suppressed. All acceptance rates were significantly above chance, and there was no effect of item or predicate.

It is important to note that while children in both age groups were inclined to accept the test sentence, no matter the context, this pattern does not simply reflect a *yes* bias. Recall that there were control items, which children were able to reject appropriately. Moreover, children offered clear justifications for their acceptances, a representative selection of which we present in Appendix B.

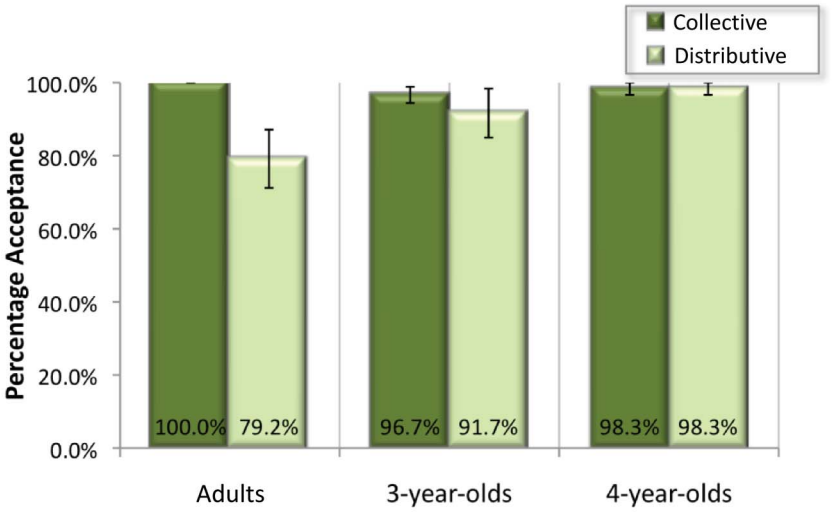


FIGURE 2 Percentage of acceptance of the target sentence (e.g., *Two boys pushed a car*) for three different age groups in two different experimental contexts (color figure available online).

4.3. Discussion

The results of Experiment 1 demonstrate that children as young as 3 years of age are able to access both the collective and distributive interpretations of sentences with plural numeral expressions in subject position, thereby confirming our prediction. We conclude from this set of findings that children—like adults—must be able to predicate of both the individuals and the plurality itself (whether conceived of as a group, sum, or set).

Recall that Musolino (2009) demonstrated that 4- and 5-year-olds accepted sentences such as (3) in a situation in which each of the three boys was holding two balloons (the "subject wide scope" reading) and a situation in which all of the boys held a group of two balloons together as group (the "collective" reading).

(3) Three boys are holding two balloons.

Setting aside the question of whether these readings are, in fact, derived via scopal interaction between the subject and object phrases, we can address a more fundamental question about the interaction between the predicate and the subject. Looking at a wider range of predicates and replacing the numeral in object position with a singular indefinite, we found in this study that children consistently allowed an ambiguous predicate to apply to either the entire group or to the individuals in the group.

Given children's ability to access both the collective and distributive interpretations in this experiment, adults' tendency to accept the test sentences more often in the collective context, and Brooks & Braine's (1996) earlier findings that a collective preference emerges in the course of development—combined with the line of literature we mentioned in the introduction in which

children have been shown to display different interpretive preferences from adults while still being shown to access the same range of interpretations—we decided to complement our judgment task with a preference task. The goals of this task were to assess children's preference for either the collective or distributive interpretation, replicate Brooks & Braine's results with adults, and compare the results from children and adults. We present this task in Experiment 2.

5. EXPERIMENT 2: PREFERENCE TASK WITH AMBIGUOUS SENTENCES

The purpose of this task was to assess participants' preference for either a collective or distributive interpretation, given ambiguous sentences that yield either interpretation.

5.1. Method

5.1.1. Participants

Twelve children (9 boys, 3 girls; range: 4;1–5;3, mean: 4;6) and 12 undergraduates participated.

5.1.2. Materials and Procedure

Visual stimuli were a set of nine pairs of images printed in color on 8.5" × 11" sheets of paper and laminated. The images were freeze-frames portraying a final (or penultimate) scene extracted from the distributive and collective test events in Experiment 1 (see Figure 1), with three additional events as indicated in Appendix A. Each pair of images juxtaposed a distributive and a collective context version of an event. Left-right position of the images was counterbalanced, and participants were randomly assigned to one of two orders. (There was no effect of order.)

The experimenter displayed each picture side by side, allowing children time to look at each image. The experimenter than asked, "Which is a better match when I say [test sentence]?" The experimenter repeated the sentence at least once while the child looked at the pictures. Children pointed to one or the other image to indicate their choice. The experimenter occasionally asked the child for a justification of his/her choice. This task was automated for adults. Left-right order of the contexts was counterbalanced, but the left was always labeled A and the right B; adults indicated their choice on a response sheet. The task took approximately 10 minutes for both age groups.

5.2. Results

The results are presented in Figure 3.

As the results demonstrate, adults overwhelmingly preferred the collective version of the event, as predicted (difference from chance: $p = .002$, Wilcoxon signed rank test). Eleven of the 12 adults displayed this preference. Only one adult did not display any preference, choosing between the contexts equally. Children differed from adults, slightly preferring the distributive version of the events more often (difference from chance: $p = .07$, Wilcoxon signed rank test). Eight children displayed this preference, two preferred the collective context, and two displayed

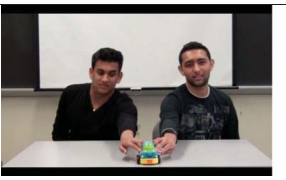
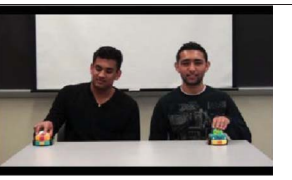
	Collective Context	Distributive Context
		
Adults	88.9% (.06)	11.1% (.06)
Children	31.5% (.07)	68.5% (.07)

FIGURE 3 Percentage of selection of collective or distributive context as the preferred match for the target sentence (e.g., *Two boys pushed a car*), standard error in parentheses (color figure available online).

no preference at all. Children and adults differed significantly from each other (Mann-Whitney, $U_A = 131.5$, $z = -3.41$, $p < .001$). Interestingly, despite the presence of the singular definite article in object position, children generally appealed to the fact that there were two objects in the scene when justifying their acceptance of the distributive context. (Examples of children's justifications are included in Appendix B.)

Given our results and those of Brooks & Braine (1996), we considered the possibility that the side-by-side presentation of two still images simply lends itself to a collective preference in adults. We therefore ran a second version of the automated preference task with adults in which adults viewed two images for each context: one in which the event was still in progress (i.e., a tower of blocks was in the process of being built by two boys), and the other in which the event was completed (i.e., there was a finished tower of blocks in front of two boys seated at a table). These scenes were viewed in succession. The order of the two contexts was counterbalanced throughout the experimental session, but the first was always labeled A and the second B. Adults indicated their choice on a response sheet. There were two experimental orders. The statement was displayed on a separate screen and played aloud simultaneously both before and after the video segments. We found the same pattern of results as in the original version, with a collective context preference emerging 77.8% of the time, and 10 of the 12 adults preferring this version ($p = .004$, Wilcoxon signed rank test).)

5.3. Discussion

In this experiment, we found that while adults robustly prefer the collective context as a match for the ambiguous target sentences, children display a slight preference in the opposite direction, leaning toward preference for the distributive context. Although we do not have an account for why this difference is present, we note that these results are consistent with at least two previous lines of research on the treatment of indefinites by adults and children in the same age range as those in the current study. First, previous research on the scope of indefinites in object position and their interaction with other scopal elements higher in the syntactic structure (e.g., negation,

quantificational subjects) has demonstrated that while children do allow such indefinites to take both narrow and wide scope relative to the other element, children generally resist the indefinite taking wide scope without certain pragmatic felicity conditions being satisifed and appear to prefer the indefinite taking narrow scope (see Gualmini 2003; Gualmini et al. 2008; Lidz & Musolino 2002; Miller & Schmitt 2004).

For example, children display a strong preference for the reading in which negation takes scope over the indefinite in object position in sentences such as (6) (i.e., in which the quantity of guys found is at issue) and need extra support to derive the reading in which there are two guys such that the detective did not find those two guys. Adults, however, access both readings easily.

(6) The detective didn't find some guys.

However, 4-year-olds robustly access the "wide scope" reading of the indefinite in (7), where the candle is a member of a discourse-salient set of candles on a cake (Miller & Schmitt 2004).

(7) Timothy didn't blow out a candle.

Thus, it may be that the scope of the indefinite is a factor leading children to prefer the distributive interpretation. Notice, however, that children were not restricted to this interpretation, as they also allowed the indefinite object to take wide scope with respect to the subject.[7]

To see how this reasoning applies to our test sentences and our results, notice that the only way for a sentence such as *Two boys pushed a car* to be true in a situation in which two boys each pushed a different car (our distributive context) is for the subject DP *two boys* to take wide scope over the indefinite object DP *a car*. This configuration yields the reading that there are two boys such that they each pushed a (different) car. If the indefinite object *a car* were to take wide scope with respect to the subject, we would get a situation in which there was only one car, which was pushed by each of the two boys. This is the scopal relation that holds for our collective context with one car-pushing event, but also for a situation in which the two boys take turns pushing the same car (resulting in two car-pushing events, each with the same car)—a context that we did not test here. Therefore, one way to interpret the distributive preference seen in children is that it is equivalent to a preference for assigning the subject wide scope over the object (or having the object maintain narrow scope).

Our results are also in line with findings from tasks involving indefinites in contexts in which scope is not relevant. For example, Barner, Chow & Yang (2009) have shown that when asked about a quantity of objects (e.g., "Is there a strawberry in the red circle?"), children as young as age two allow the indefinite description *a strawberry* to apply to a set that has more than one strawberry in it. By contrast, they treat *one strawberry* as referring to a set with only one strawberry in it. Thus the existence of (at least) one strawberry makes the proposition that there is *a strawberry* in the circle true. Adults in their task consistently interpreted *a strawberry* as referring to a singleton set. In related work, we have found that when asked to describe the collective and distributive contexts, adults are more likely to use a singular indefinite description to describe the collective context. By contrast, when describing the distributive context, they are more likely to

[7] Four- and 5-year-olds are also able to successfully access distributive (or bound variable) interpretations for sentences with quantificational subjects and bare nominals (e.g., *Everybody went home*; Pérez-Leroux & Roeper 1999), suggesting that it is not the presence of the indefinite that forces this reading.

use a plural object, and to occasionally add additional descriptors, such as *their own, each, different*, or *separately*. It is quite possible, then, that in the absence of anything explicitly indicating distributivity on the surface, adults opt for a collective interpretation of an otherwise semantically ambiguous sentence. The process of becoming adult-like in the interpretation of these sentences would involve developing an awareness of the surface-level cues disambiguating readings, such as the presence of a plural marker or additional modifiers whose lexical semantics favor or force one or the other reading—a point that motivates Experiments 4 and 5.

As we have seen, sentences containing a numerically quantified expression and an indefinite can give rise to a collective and a distributive reading. However, this is not always the case. Indeed, the availability of the collective/distributive ambiguity is mitigated by a number of factors, including lexical and structural ones. Having shown that children can access both readings when the relevant sentences are ambiguous, we now ask whether preschoolers are sensitive to some of the linguistic constraints regulating the availability of collective and distributive interpretations. This is an important step, because part of what it means to have adult-like knowledge of the collective/distributive distinction is to be able to assign the right reading(s) in the right contexts. In Experiment 3, we therefore investigated passive versions of our target sentences, which we hypothesized should favor a collective interpretation—a prediction that receives experimental support.

In Experiment 4, we investigated how participants would respond to sentences with an additional lexical item (*each, together*), which are argued to favor one of the two possible interpretations. Specifically, target sentences with *each* should only admit the distributive interpretation, while sentences with *together* should strongly favor the collective interpretation. We show that while children are adult-like in their judgment of the previous sentences, they are not like adults when these lexical items are involved. Thus, while the structural, grammatical constraints are active, children have yet to acquire (or deploy) the lexical semantics of these items when accessing the collective or distributive interpretation of these sentences.

6. EXPERIMENT 3: JUDGMENT TASK WITH PASSIVE SENTENCES

In this task we ask whether the structural manipulation of passivization will lead participants to prefer the collective context.

6.1. Method

6.1.1. Participants

Ten children (5 boys, 5 girls; range: 4;3–5;6, mean: 4;10) and 12 undergraduates participated.

6.1.2. Materials and Procedure

The materials and procedure were the same as in Experiment 1, with the exception of the test sentences. In place of the active sentences of Experiment 1, we used passive sentence such as the following, which are claimed to force a collective reading.

(8) A car was pushed by two boys.

For reasons outlined in the theoretical background, we predicted that participants who were guided by this syntactic information would accept the sentence in the collective context but would strongly resist accepting it in the distributive context.[8] Note that in these sentences, the type of event remains the same, and the NP referring to the agent of the event still denotes a plurality, although it occurs in a postverbal *by*-phrase and is therefore no longer in subject position.

6.2. Results

The results are presented in Figure 4. As predicted, adults consistently accepted the passive test sentences in the collective context but largely rejected them in the distributive context. Most children also followed this pattern, although the difference between acceptances in the two contexts was not as striking for children as it was for the adults. While 9 of the 10 children consistently accepted the test sentences in the collective context, one child consistently rejected them and appeared to be confused by the fact that the agent was displaced in the *by*-phrase. This child offered as a justification the fact that there were *two* agents in the event, not seeming to recognize that the passive sentences entailed just this. Excluding this child's responses from analysis would have resulted in an acceptance rate of 92.6% in the collective context.

We conducted a 2 (age: children vs. adults) × 2 (context: collective vs. distributive) mixed-model logistic regression on proportions of acceptances with participants and items as random effects. The analysis revealed a significant main effect of age ($p < .01$), a significant main effect of context ($p < .01$), and no interaction between age and context ($p = .99$).[9] As expected, adults accepted the target sentences in the collective context but rejected them in the distributive context (98.6% vs. 23.6% acceptance rates respectively, $p < .01$). This pattern was less pronounced, but still significant, in children (92.6% vs. 66.7%, $p < .05$).

In this experiment, though, we added a twist. Following the judgment task, we invited children to participate in an abbreviated preference task, targeting the items that were test items in the judgment task for them. We explained to the children that they were going to see pictures that looked like the videos they just saw, and that this time, we wanted to know which one of the pictures they preferred, given what we said. Children readily adapted to this task. We used

[8]Research on children's acquisition of the passive in English shows that children may experience difficulty when interpreting passives well beyond the preschool years. (See O'Grady [1997] and Guasti [2002] for a review.) However, the fact that our sentences were actional passives with a *by*-phrase, which are supposedly the easiest to comprehend, paired with research demonstrating that children as young as 3 years of age can both comprehend and produce passives (see Crain & Fodor 1993; Crain, Thornton & Murasugi 2009; Demuth 1989; Fox & Grodzinsky 1998; Pinker, Lebeaux & Loren 1987) made us confident that children could succeed in interpreting these sentences. The question distinguishing our work from this previous line of research is not whether children assign the correct roles to the agent and patient, but rather—as in Brooks & Braine (1996)—whether the passive sentence form can be used to disambiguate sentences that are otherwise ambiguous in the active voice.

[9]Some readers may be surprised to see a lack of interaction in this analysis, given the graphs in Figure 4. We therefore decided to follow up this analysis with a 2 × 2 repeated measures ANOVA. The ANOVA also yielded main effects of age ($p = .02$) and context ($p < .001$) but did show a significant interaction ($p = .05$). The pairing of a lack of any interaction in a mixed logit model with a significant interaction in an ANOVA is not unheard of and is discussed at some length in Jaeger (2008). Essentially, the interaction does not add significant information to the model and so comes out as insignificant in the mixed-model logistic regression.

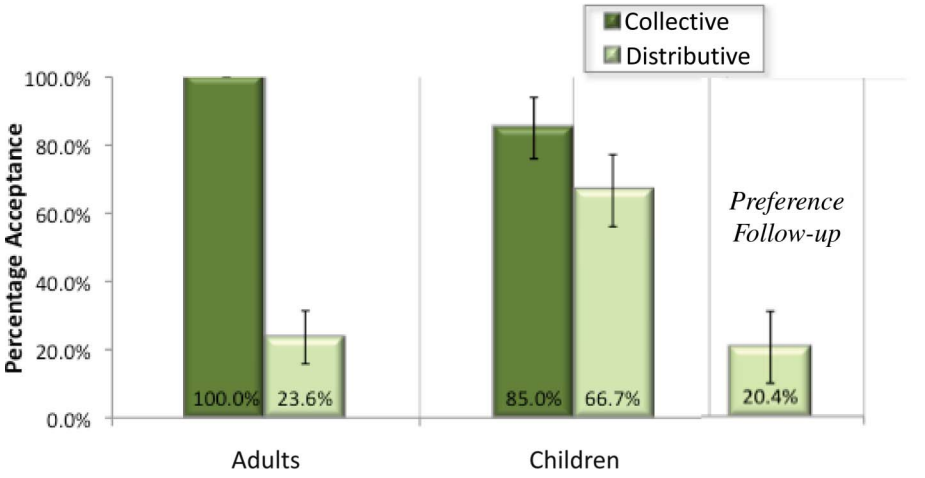


FIGURE 4 Percentage of acceptance of the target sentence (e.g., *A car was pushed by two boys*) for adults and children in the two experimental contexts (color figure available online).

their choice of image in this follow-up task to calculate the percentage of times they chose the distributive context. This value is reflected in the bar graph to the far right in Figure 4.

This time around, the difference is quite clear: given a passive sentence, children have a strong preference for choosing the *collective* context and resist allowing the passive sentence to hold true of the distributive context ($p = .05$, Wilcoxon signed rank test). Again, we note that our results diverge from B&B's. In their Experiment 2, 4-year-olds chose the collective context as the better match for the passive sentences only 53% of the time—no greater than chance. However, 4-year-olds in our task *did* appear to be sensitive to the difference between the active and passive versions of these sentences, as evidenced in their ability to use the unambiguous passive construction to distinguish between collective and distributive interpretations, as adults did. This sheds further light on the pattern of responses from Experiment 1: children are aware that there are limits on when such interpretations are licensed and when they are not. Examples of children's justifications from both the judgment and preference tasks are presented in Appendix B.

6.3. Discussion

This experiment examined a structural constraint on the availability of interpretations for our target sentences. We found that both children and adults recognized that the passive construction strongly favored the collective context. This knowledge, however, did not come to us directly from the judgment task. In the judgment task, children were still accepting the passive sentence in the distributive context more than 50% of the time, which did not square with adult responses. In the follow-up forced-choice task, though, the same children indicated a strong preference for the collective context over the distributive context for these same sentences. Thus, this experiment affords us the opportunity to make a comment on methodology: It is imperative to be flexible enough to revisit one's paradigm of choice in order to determine whether it adequately assesses

the knowledge that is of interest. Judgment and preference tasks can complement each other by providing information about the range of utterance interpretations made available by the grammar in context and the preference for (or lack thereof) one interpretation over another.

Whether or not children have a truly adult-like understanding of the passive, the results of Experiment 3 demonstrate that they do appear to recognize a strong correlation between the passive form and a situation that makes it true. More importantly for our objectives, we see that there are limits on whether either the collective or distributive interpretation is available to children, even as the type of event and the existence of an agentive plurality remains the same. Knowing that there are such limits based on structural manipulations, we asked whether children are aware of the constraints on collective and distributive interpretations induced by the presence of additional individual lexical items.

7. EXPERIMENT 4: JUDGMENT TASK WITH ADDITIONAL LEXICAL ITEMS

Given the findings from the previous task, the purpose of this task was to determine whether participants can recruit lexical semantic information provided by individual words to disambiguate the target sentence and assign either a collective or distributive interpretation, depending on the lexical item.

7.1. Method

7.1.1. Participants

Twenty children (11 boys, 9 girls, divided evenly across conditions) participated. Children were randomly assigned to an *each* condition (range: 4;4–5;3, mean: 4;9) or a *together* condition (range: 4;4–5;3, mean: 4;10). Twelve undergraduates at Rutgers University served as controls.

7.1.2. Materials and Procedure

The materials and procedure were the same as Experiments 1 and 3, with the exception of the test sentences. In the *each* condition, participants heard the subject plural numerical expression modified by *each*, as in (9). In the *together* condition, participants heard the sentence with the collectivizing adverbial *together* in postverbal position, as in (10).[10]

[10]We acknowledge that *each* and *together* appear in difference positions in these sentences and that there is therefore a difference in word order between these sentences. Since we are not investigating the time course of interpretation of these sentences (i.e., how children incrementally process these sentences), and we wanted to present these items in the most natural order (and the order in which they most likely appear in child-directed speech), we allowed this difference. We also do not think that moving *each* to a sentence-final position (i.e., *Two boys pushed a car each*), where it is highly marked, would improve children's response pattern. Whether putting *together* in a postsubject position (i.e., *Two boys together pushed a car*) would have an effect on children's interpretation of these sentences we do not know; this order seems rather marked to us, an intuition that is supported by a search of child-directed speech transcripts.

(9) Two boys each pushed a car.

(10) Two boys pushed a car together.

The experiment therefore had a 2 (age: 4-year-olds, adult) × 2 (context: distributive vs. collective; within-subject) × 2 (modifier: *each, together*) design, with context as a within-subject factor and the type of modifier as a between-subject factor.

Based on the semantic contribution of these lexical items to the interpretation of the target sentences, we made the following predictions. First, we predicted that participants would accept the *each* sentences in the distributive contexts and reject them in the collective contexts. Second, we predicted that participants would accept the *together* sentences in the collective contexts and reject them in the distributive contexts. However, given children's non-adult-like performance in previous experiments evaluating their interpretation of *each* (Brooks & Braine 1996; Brooks & Sekerina 2005–2006; Ferenz & Prasada 2001; Hanlon 1986; Musolino 2009), we had reason to expect that children's ability to recruit the lexical semantics of *each* to home in on a distributive interpretation might be diminished.

7.2. Results

Percentage of acceptance of the target events for each age group and condition is presented in Figure 5.

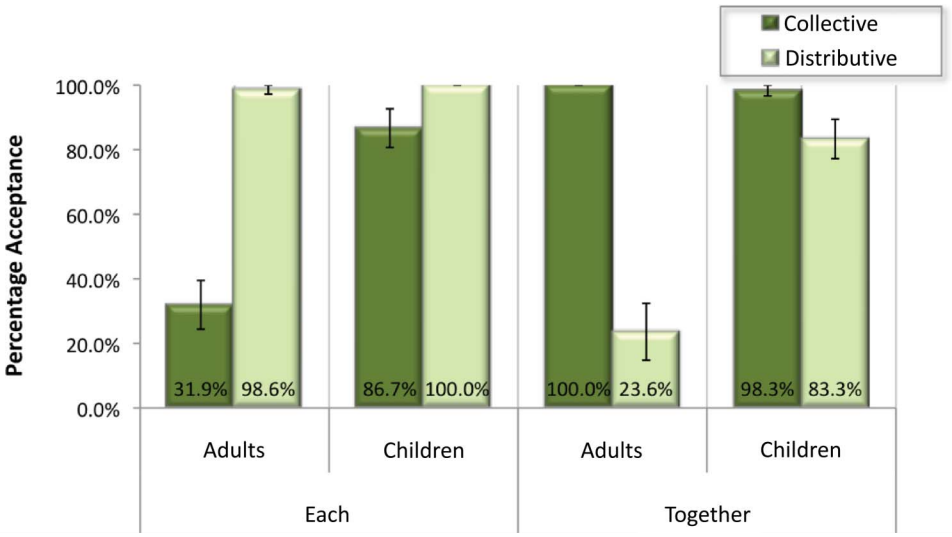


FIGURE 5 Percentage of acceptance of the target sentence (e.g., *Two boys* [*each*] *pushed a car* [*together*]) for adults and children in the two experimental contexts (color figure available online).

We conducted the same analysis as in the previous judgment task, using a 2 (age: child, adults) × 2 (context: collective, distributive) × 2 (modifier: *each, together*) mixed model logistic regression with subjects and items as random effects. The analysis revealed a significant main effect of age ($p < .01$), a significant main effect of context ($p < .05$), no effect of modifier, and no interactions (age × context, $p = .98$, age × modifier, $p = .99$, age × modifier × condition, $p = 0.99$). (See our earlier footnote regarding the lack of any significant interaction.) As predicted, adults were guided by the presence of the additional lexical item in their interpretation of these sentences, accepting the test sentences with *each* in the distributive context, but rejecting them in the collective context (98.6% vs. 31.9% acceptance rates respectively, $p < .01$). By contrast, they accepted the test sentences with a postverbal *together* in the collective context and rejected them in the distributive context (100% vs. 23.6% acceptance rates respectively, $p < .01$).

Children, however, did not display the same robust difference. In fact, they were prone to accepting the test sentence in both contexts, no matter what the modifier was. When children heard sentences containing *each*, they were not statistically more likely to accept them in the distributive than in the collective context (100% vs. 86.7%, $p = .99$). However, they were marginally more likely to accept the sentences with *together* in the collective context than in the distributive context (100% vs. 83.3%, $p = .057$). The standard deviation among the responses in the two conditions was comparable (.01 for both).

In both conditions, children provided justifications for their acceptances, a selection of which we present in Appendix B. These responses reflect the fact that children were able to appeal to elements of the context when providing their justifications and were not merely accepting the sentences blindly. In the *each* condition, children clearly recognized that the lexical item required the predicate in question to apply to each individual. However, as there was no telic/atelic distinction (as evidenced by children accepting these sentences for predicates such as "draw a circle" in the collective context), their interpretation of this requirement appears to have been more lax than the semantics would actually require. Indeed, it seems more as though children required that each individual participated in the event (e.g., *Two girls each participated in a "drawing a circle" event*). We think investigation of this interpretation would be a very interesting line for future research but do not pursue this issue here, and merely observe that children's interpretation of the *each* sentences is not the same as that of the adults.

7.3. Discussion

This pattern of results suggests that *each* and *together* clearly do not have the same interpretive force for children as they do for adults. However, the results also suggest that by age 4, children are on their way to becoming adult-like. It would be interesting to see how slightly older children interpret these same sentences, to determine the age at which children are adult-like in their acceptance patterns with such sentences. (Though we recognized that the ability to exhibit this knowledge is perhaps not a direct consequence of chronological age and may be the result of other knowledge acquired in the interim.) For now, it is sufficient to note that there is already a hint of this, but it is not yet fully there—at least as far as acceptance goes.

Given the divergence in Experiment 3 between results exhibited in acceptance rates in judgment tasks and preference patterns exhibited in a forced-choice tasks, we decided to pursue a similar approach to children's interpretations of the sentences with *together*. We reasoned that it

was possible that while children accepted sentences with *together* in both contexts, they could still be aware of the collectivizing force of this modifier and demonstrate a preference for it to apply to the collective context. We targeted *together* because of children's non-adult-like responses to sentences with *each* in a variety of other developmental studies (see previous), and because children's justifications in this experiment gave us the distinct impression that they knew more about these sentences than their response pattern let on.

8. EXPERIMENT 5: PREFERENCE TASK WITH *TOGETHER*

8.1. Method

8.1.1. Participants

Twelve children (6 boys, 6 girls; range: 3;9–4;10, mean: 4;5) participated.

8.1.2. Materials and Procedure

The materials and procedure were the same as the preference task reported as Experiment 2, with the exception of the test sentences. In place of the ambiguous sentences, children heard sentences with a postverbal *together* (e.g., *Two boys pushed a car together*).

8.2. Results

Results are presented in Figure 6.

Interestingly, despite children's acceptance of the *together* sentences in both contexts of the judgment task of Experiment 4, children appeared to be aware of the collectivizing force of *together* in the current preference task. Indeed, they were significantly more likely than chance to select the collective context as a better match for the target sentences and therefore more so than

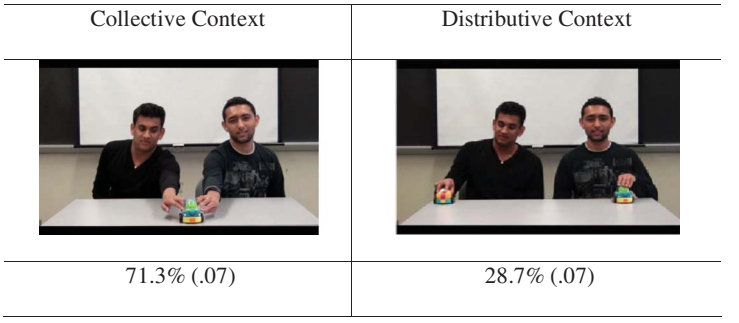


FIGURE 6 Percentage of children's selection of collective or distributive context as the preferred match for the target sentence (e.g., *Two boys pushed a car together*), standard error in parentheses (color figure available online).

the distributive context ($p = .05$, Wilcoxon signed rank test). Examples of children's justifications are included in Appendix B.

8.3. Discussion

The results of this experiment demonstrate that children are aware of the collectivizing role of the modifier *together*. Given a choice between a collective and distributive context, they strongly preferred the collective context as a match for sentences such as *Two boys pushed a car together*. This pattern lies in contrast to their responses in the previous preference task without *together* presented in Experiment 2, in which children marginally preferred the distributive context as a match for the ambiguous target sentences. Thus, the presence of *together* induces a shift from a slight distributive inclination to a collective preference. These results complement those of the previous judgment task by demonstrating that while children accept these same sentences in both the collective and distributive contexts, they are aware that one context (the collective one) is a better fit than the other. Thus, by complementing a judgment task (in which children may be inclined to accept more often than adults a highly dispreferred but semantically permissible interpretation of a potentially ambiguous sentence) with a preference task in which children are forced into a choice of contexts, we are able to witness the deployment of underlying constraints on interpretation.[11] Combining these results from the experiment with passives, we have direct evidence that structural and lexical manipulations of the original ambiguous target sentences can move children's responses around, as predicted by the syntax and semantics. Their ability to access interpretations is thus both flexible and constrained by the grammar and the lexicon.

9. GENERAL DISCUSSION

The set of experiments presented in this article sheds new light on young children's developing understanding of numerical expressions and pluralities in general. By moving away from the more traditional focus on the cardinality component of such expressions, we were able to highlight a fundamental aspect of their semantic representation—namely, their ability to give rise to sentence-level ambiguity when they compose with ambiguous VP predicates. This aspect of their meaning is a consequence of the fact that such expressions refer to pluralities, or collections of individuals, which allow for both the individual members and the group itself to be predicated of in natural language. The language learner must then not only be able to conceive of a group in this way but also recognize that language has a means for performing this function.

[11] A reviewer suggests that the preference task may raise the possibility that children's preferences become solidified over time and eventually become the more categorical judgments we observe in the adults. We prefer to think of the pattern of responses as we have described them above: By forcing children to choose between two contexts and not just accept or reject the sentences within a context, the preference task is able to bring to light constraints that are active and guide children's choice of the best-fitting context. Over time, children become more adult-like—in this case, specifically—by acquiring real-world knowledge and bolstering their lexical semantic knowledge, leading them to adjust the probability of a given interpretation in a context accordingly. Thus, although *together* is polysemous and can be felicitous in both distributive and collective contexts, the most prominent reading is a collective one. This reading is available to children, but it has not yet overshadowed the other readings for children as it has for adults. We discuss this particular point at some length in other research (see Syrett et al. 2011).

We have shown that preschoolers have the conceptual and linguistic wherewithal to access collective and distributive interpretations of ambiguous sentences with a plural numerical expression in subject position. Thus, a sentence such as *Two boys pushed a car* can mean that either the group of two boys performed the action together or that each boy has this property. We have demonstrated that young children have the means to derive both interpretations and that like adults, they are not restricted to either one. However, children diverge from adults in their preferences of these interpretations: while adults strongly prefer the collective interpretation of these ambiguous sentences, children are drawn toward the distributive interpretation. This finding, we mentioned, is consistent with previous work on the acquisition of scopally ambiguous sentences with indefinites and with children's and adults' interpretations of indefinite like *a car* more generally.

Like adults, 4-year-olds are sensitive to linguistic constraints, such as passivization, on predication of individuals and groups. Unlike adults, however, children do not display a robust difference in acceptance patterns with the addition of lexical modifiers such as *together* (a well-known collectivizer) and *each* (a well-known overt distributivity operator). However, children *do* appear to be sensitive to the collectivizing function of *together*, as evidenced in our preference task. Their acceptance of sentences with *together* in the distributive context may, then, reflect underlying knowledge of an alternate reading of *together*—one which appeals to synchronization of events and one which adults suppress for pragmatic reasons. We have pursued the precise reason for this pattern in separate, but related, research. Thus, while we are witnessing a transition toward a fully adult-like understanding of sentences with plural numerical expressions, a number of questions remain open regarding the role of number words in these expressions, the nature of the conceptual and linguistic representations that children possess that allow them to access both interpretations, and the way in which the conceptual and linguistic systems interact in the acquisition of collectivity and distributivity and natural language expressions of these concepts. Here we take some space to reflect on possible answers to these questions.

We have seen that the ability to access both the collective and distributive interpretation of our target sentences arises from the fact that the representation of the plurality and the corresponding linguistic expression admits of parts and wholes, thus allowing for the individuals and the group itself to be predicated of. One might then ask when this knowledge is first evidenced. One hypothesis is that it is a direct consequence of the ability to represent a set of objects and that the young child is waiting for language to be parasitic on this conceptual representation. Another hypothesis is that the ability to predicate of parts and wholes would be concomitant with or the direct result of the acquisition of certain aspects of the linguistic system. If we follow this reasoning, to which linguistic expressions should we attribute this function?

A strong candidate is plural morphology. Indeed, Carey (2009, 2011) has proposed that, "mastery of explicit linguistic singular/plural morphology plays a role in deploying this quantificational distinction in nonlinguistic representations of sets" (Carey 2011: 117). Under this account, language shapes the way in which we think about sets, but note that the claim here is that the role of the acquisition of plural morphology is to aid in the deployment of such a distinction—not to create it. Under either of these accounts, the representation of pluralities or sets results in multiple interpretations of the target sentences, because such representations permit the child to capture the requisite mereological structure for the linguistic ambiguity.

What is the role of number words in ambiguous sentences with plural numerical expressions? Under one view, there is nothing special about number words in these expressions. As plurals,

these expressions simply admit of collective and distributive interpretations when composed with the right sort of predicate, just as a coordinated NP in subject position such as *Peter and Neal* would. However, it may be no accident that example sentences with number words have figured so prominently in discussions of this topic in the semantics literature. One might argue that the presence of number words could highlight the collective reading, since they denote a property of a set. It is more likely, though, that by referring to the number of individual set members, they reinforce the idea that each individual has the property in question, thereby highlighting the distributive interpretation.

A question left open to future research is how children who produce plural morphology, but who are not yet number savvy, interpret the target sentences: Are they, like the children in our experiments, able to robustly access both interpretations, and do they also lean toward a preference for one of the two interpretations? Just how, then, might children represent set membership, and how do number words map on to this conceptual representation, if the cardinality component of number word meaning is lacking? One possibility comes to us from Carey (2004, 2009, 2011). A core aspect of her Quinian bootstrapping proposal of number word acquisition is that those children who are not yet CP knowers have the capacity to represent sets of individuals, which can form an atomic join semilattice. This "placeholder" allows for parallel object individuation and one-to-one correspondence, necessary components of quantificational representation, even as the cardinal principle is lacking. Thus, even without having acquired the entirety of the conceptual representation of number words, children might still be able to predicate of individuals and sets, since this precursor representation allows them to represent both parts (the individuals) and wholes (the set or group)—just what they need to be able to access the two interpretations in question.

Similarly, if nothing about accessing these interpretations hinges upon number word meaning, we would predict that if there is a stage during which children interpret *two* as a general plural marker (Clark & Nikitina 2009), children might still be able to derive these two readings, since they would still capture the fundamental aspects of plurality. However, there are limits to what a non-adult-like number word representation allows. If there is a stage during which children interpret an expression with *two* as picking out a "pair" of objects (see discussions in Shusterman, Gibson & Finder 2010), then children at this stage might only be able to access the collective reading. We leave the task of pinning down the precise contribution of number words for future researchers.

We have argued that probing the collective/distributive distinction allows us to move beyond the cardinality component of numerical expressions and explore the range of semantically permissible interpretations of the sentences in which they appear. This distinction may also allow us to move beyond "exact" cardinality in another way still. As we (and many others before us) have noted, number words give rise to readings beyond an "exact" one, namely "at least" and "at most" readings. Collectivity and distributivity may play a crucial role in the availability of these readings.

Take, for example, the set of sentences in (11) (examples [14] and [13] from Koenig [1991]). The proposition that Mary saw three men entails that she saw two men, since the set of two is contained in the set of three. A well-known property of numerals and other so-called *scalar* predicates is that they exhibit scale reversal effects under negation (Horn 1972, 1989). Thus, if Mary did not see three men, she cannot have seen four (a larger number on the scale).

(11) a. Mary saw three men. ⊩ Mary saw two men.
b. Mary didn't see three men. ⊩ Mary didn't see four men.

Relevant to the current research, Koenig (1991) observed that such entailment patterns appear to hold only for distributive interpretations. The sentence in (12), which has a collective interpretation, does not give rise to the same entailment pattern (Koenig [1991]'s [15']).

(12) Three boys together brought a sofa up the stairs.
⊭ Two boys together brought a sofa up the stairs

The difference between distributive and collective interpretations is also observed in the following examples, also from Koenig (1991) (his [16] and [17]), involving "upward compatability."

(13) a. Mary has three children, in fact four.
b. *Three boys together carried a sofa up the stairs, in fact four.

Under this account, it is in part *because* sentences containing number words can be assigned a collective or a distributive reading, depending on the linguistic environment in which the number word appears, that they can also give rise to "nonexact" interpretations. An interesting question for future research, then, is whether children who assign sentences containing numerically quantified expressions "nonexact" interpretations also know that there are limits on such interpretations, which are fundamentally linked to the collective/distributive distinction.

ACKNOWLEDGMENTS

We gratefully acknowledge funding provided by NIH grant HD-057699 and a postdoctoral fellowship from the Rutgers Center for Cognitive Science to K.S. and NSF grant BCS 0545067 to J.M. and contributions from the children and staff at Pennington Presbyterian Nursery School, Pine Grove Cooperative Nursery School, and the Douglass Psychology Child Study Center. Our undergraduate research assistants Hannah Baker and Ariana Kalkstein helped in the creation of stimuli and collecting data from participants. Without a talented troupe of undergraduates, there would have been no video stimuli for this and related research. For fruitful discussions on this topic we thank audiences at BUCLD 2010 and 2011, LSA 2011, Stanford University, the University of Maryland, Johns Hopkins University, and Roger Schwarzschild, Paul Pietroski, Justyna Grudzińska, and Jakub Dotlačil. Finally, we would like to thank John Grinstead and two anonymous reviewers for their helpful comments on earlier versions of this article.

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Submitted 26 November 2011
Final version accepted 8 October 2012

APPENDIX A

Judgment task events (test and control)

Target sentences for test events

(1) Two boys pushed a car.
(2) Two girls lifted a block.
(3) Two girls read a book.
(4) Two girls drew a circle.
(5) Two boys built a tower.
(6) Two girls stacked a set of rings.

Control events, with content substituted for false utterances

	Event	False (content)	False (number)
(7)	give a present to a girl (one boy)	n/a	two boys
(8)	kick a ball (one boy)	n/a	two boys
(9)	pet a duck (one girl)	feed a cat	n/a
(10)	kick a ball to a boy (one girl)	blow up a balloon	two girls
(11)	put a bow on a present (one boy)	open a box	n/a
(12)	complete a puzzle (2 girls)*	pet a duck, jump up and down	n/a
(13)	give a girl a balloon (2 boys)*	throw a ball, eat a piece of cake	n/a

Control events with an * were used in the preference tasks as test items, along with an additional "lace a card" event with two boys.

APPENDIX B

Justifications for acceptance of test sentences in both contexts in Experiment 1 (judgment task, ambiguous)

Collective context

(1) Two boys pushed one car! (child 43; age: 4;2; event type: "push a car")
(2) One car, not two! (child 63; age: 4;8; event type: "push a car")
(3) ONE circle! (child 63; age: 4;8; event type: "draw a circle")
(4) They drew a circle! (child 35; age: 3;5; event type: "draw a circle")
(5) Because they read it together. (child 45; age: 5;11; event type: "read a book")

Distributive context

(6) Because there was two boys, and they were pushing cars! (child 54; age: 4;9; event type: "push a car")
(7) Child: Yes, but there's two cars, too. (child 53; age: 4;11; event type: "push a car") Experimenter: So was she right?
Child: Yes, but there's two cars. So there's two boys and two cars.
(8) Because two blocks, and they were lifting it! (child 54; age: 4;9; event type: "lift a block")
(9) Because they both drawed a circle. (child 56; age: 4;7; event type: "draw a circle")
(10) Because they both did it! (child 58; age: 5;2; event type: "stack a set of rings")

Justifications for selection of distributive context in Experiment 2 (preference task, ambiguous)

(11) Because there was two cars. (child 89; age: 4;5; event type: "push a car")
(12) Because they each built one tower. (child 77; age: 4;3; event type: "build a tower")
(13) Because look—two circles! (child 89; age: 4;5; event type: "draw a circle")
(14) Because two circles! [Of collective context: Only one here!] (child 83; age: 5;3; event type: "draw a circle")
(15) Well, because they both made their own circle. (child 90; age: 4;9; event type: "draw a circle")

(16) Because they're reading . . . each of them are reading one book. (child 77; age: 4;3; event type: "read a book")

Justifications for rejection of test sentences in distributive context in Experiment 3 (judgment and preference tasks, passive)

(17) [corrected answer, after initially accepting sentence] Actually, that wasn't right, because she said only *one* car! (child 34; age: 5;1; event type: "draw a circle")
(18) Two girls drawed one circle on each . . . on one side of the board. (child 29; age: 5;3; event type: "draw a circle")
(19) Uh, I think it was *two* cars! (child 29; age: 5;3; event type: "push a car")
(20) It was two cars pushed by two boys, so it was a *no*! (child 26; age: 5;0; event type: "push a car")
(21) That's not really right, because two towers were built by two boys. (child 29; age: 5;3; event type: "build a tower")

Justifications for acceptance or rejection of test sentences in both contexts in Experiment 4 (judgment task, *each* and *together*)

each
Collective context

(22) They both did it. BOTH boys pushed a car! (child 36; age: 4;9; event type: "push a car, " acceptance)
(23) 'Cause they both did the same amount. (child 49; age: 4;9; event type: "build a tower," acceptance)
(24) Now those 2 are drawing a circle. They're drawing one circle. (child 42; age: 4;11; event type: "draw a circle," acceptance)
(25) Because there wasn't two cars! (child 38; age: 5;3; event type: "push a car," rejection)
(26) Two boys each pushed *one* car! (child 39; age: 4;11; event type: "push a car," rejection)
(27) They each put one together! (child 36; age: 4;9; event type: "stack a set of rings," rejection)

Distributive context

(28) They're building 'em by theirselves! They're building a house! (child 42; age: 4;11; event type: "build a tower," acceptance)
(29) Because they each built a tower. Because they have each same the triangle [pointing to triangle block on top of each boy's tower]. (child 38; age: 5;3; event type: "build a tower," acceptance)
(30) 'Cause they both did the same thing. (child 61; age: 4;9; event type: "stack a set of rings," acceptance)

together
Collective context

(31) They're reading together one book! (child 52; age: 5;0; event type: "read a book," acceptance)

(32) They're both doing the same book. (child 51; age: 5;0; event type: "read a book," acceptance)
(33) Yeah, but . . . They only draw one circle. (child 40; age: 4;4; event type: "draw a circle," acceptance)

Distributive context

(34) Because there's two cars on the table! (child 40; age: 4;4; event type: "push a car," acceptance)
(35) 'Cause they both made a circle! (child 64; age: 4;6; event type: "draw a circle," acceptance)
(36) Because they both stacked the rings. (child 64; age: 4;6; event type: "stack a set of rings," acceptance)
(37) They're both drawing one circle! They drew their own! (child 51; age: 5;0; event type: "draw a circle," rejection)
(38) 'Cause they pushed it at the same time, not together. (child 52; age: 5;0; event type: "push a car," rejection)
(39) They didn't pushed one together. They have two. (child 47; age: 4;5; event type: "x," rejection)

Justifications for selection of context in Experiment 5 (preference task with *together*)

Collective context

(40) Their hands are on the car. (child 4; age: 4;5; event type: "push a car")
(41) Because two boys, one tower. (child 22; age: 4;4; event type: "build a tower")
(42) They builded together and this [switching attention to distributive context] is because the two boys . . . um . . . builded the towers in this part, they builded by themselves. (child 25; age: 4;5; event type: "build a tower")
(43) They share it. [Of distributive context: They were playing with their own. (child 3; age: 4;7; event type: "lace a card")
(44) 'Cause there's one stack. (child 28; age: 4;7; event type: "stack a set of rings")

Distributive context

(45) They have two. 'Cause there's two! (child 9; age: 3;10; event type: "draw a circle")
(46) Because they have two. (child 1; age: 4;8; event type: "stack a set of rings")