A Collective-Distributive Pragmatic Scale and the Developing Lexicon

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The Ohio State University, Columbus, Ohio, USA

ABSTRACT

A locus of the difference in meaning between distributive and collective sentences can be the quantifiers that modify their subjects. A current theoretical account of distributive and collective sentences claims that sentences with quantifiers such as *the* in English, or *los* in Spanish, in subject position and an indefinite direct object, modified by *a* in English, or *una* in Spanish, are ambiguous as to whether they are distributive or collective, all things being equal. In contrast, the same sentences with *each/cada* in subject position are unambiguously distributive. This account claims that sentences with quantifiers such as *the/los* in subject position come to be interpreted collectively, and not distributively, because the distributive meaning could more informatively be constructed using the unambiguous *each/cada* quantifier. This is the same neo-Gricean reasoning that accounts for the Quantity Implicature that arises for *some*, given the informativeness of *all*. On this account, collective and distributive interpretations are intrinsically linked, which predicts that even children's non-adult-like collective and distributive interpretations should nonetheless be statistically associated, which we confirm in a sample of Puerto Rican Spanish-speaking children. We further propose that growth occurs both internal to lexical items, in terms of denotative content, as well as externally, within the lexicon in quantifier networks. Such networks have traditionally been expressed in formal semantics as pragmatic scales. We claim that the growth of both of these lexical dimensions are indexed by general lexical growth and show that a statistical association obtains between them in our sample.

Introduction

Neo-Gricean explanations of how natural language quantifiers such as *some* in English come to mean "some, but not all" in some situations, as opposed to "some, and possibly all" in other situations, stem from the relationship that *some* has to the quantifier *all* in the lexicon. Namely, it is true that if I eat *all* of the cookies on a plate, I have also eaten *some* of the cookies on that plate. Thus, the existence of *all* in my lexicon causes *some* to be more often interpreted to mean "some, but not all" because *all* is a more informative and less ambiguous way to convey the message that I have consumed the entirety of the cookies on the plate. It has been proposed (Dotlačil, 2010; Padilla-Reyes, 2018; Pagliarini et al., 2012) that a similar relationship exists between generalized quantifiers such as *the* and *some* and the distributive quantifier *each*. These quantifiers *the* and *some* are typically interpreted as collective, but may also be interpreted as distributive, while *each* unambiguously, and therefore more informatively, conveys a distributive interpretation. In this way, the presence of *each* in the lexicon drives *some*, as well as other plural quantifiers, to have a collective interpretation. It is argued that in the same way that the Quantity Scale includes quantifiers that convey quantity information {all, most, many,

some, few ... }, the Collective-Distributive Scale {each, every, the, some ... } includes quantifiers that convey information about how the plural entities quantified over are made available as distributive vs. collective arguments of predicates.

It is known that children across an array of languages initially struggle to generate scalar quantity implicatures, but manage to do so by 5 years-old or so. Studies of the Quantity Scale, associated with *some*, include Smith (1980), Chierchia et al. (1998), Noveck (2001), Papafragou and Musolino (2003), Feeney et al. (2004), Guasti et al. (2005), Miller et al. (2005), Pouscoulous et al. (2017), Vargas-Tokuda et al. (2009), Huang and Snedeker (2009, 2018), Katsos and Bishop (2011), and Pratt et al. (2018). Nonetheless, existing evidence suggests that distributive-collective interpretations take much longer, until children are roughly 10 years-old. In what follows, we consider what it means for the distributive and collective senses of lexical items such as *each, the* and *some* to grow and develop. This growth must occur internal to the lexical items themselves, as well as within the lexicon, as a network of lexical items that are linked into a pragmatic, lexical scale. This type of study is difficult to carry out with the "some, but not all" implicature associated with the Quantity Scale because children appear to learn, at least the quantity dimensions of, *all* substantially earlier than the quantity dimensions of *some*. This may occur as early as 3 or 4 years-old, at which point using a Truth-Value Judgment Task to test their knowledge is difficult. In contrast, the distributive meaning of *each* takes so much longer to develop, until roughly 10 years of age. For this reason, it is more practical and developmentally appropriate to use a Truth-Value Judgment Task to measure whether growth in children's understanding of distributive *each* in fact develops in tandem with their understanding of the collective interpretations of plural quantifiers such as *the* and *some*.

We propose that the development of children's understanding of scalar implicatures in part stems from growth internal to lexical items and in part from growth across the lexicon. Children likely come to have a clearer grasp of the meaning of individual quantifiers as their quantity knowledge grows. Further, lexical development must occur in their understanding of the relationships among the lexical items on the collective-distributive scale. Because so much of this growth appears to be lexical, we believe that it is plausible that a measure of general lexical development could index children's abilities to interpret collective and distributive sentences. To that end, we explore the implicature-lexicon connection.

The phenomenon & hypothesis

There is an established developmental cognitive and linguistic line of research that shows that children across an array of languages are delayed in their interpretations of distributive sentences (Brooks & Braine, 1996; Brooks et al., 1998; Hanlon, 1986; de Koster et al., 2017, 2018; Musolino, 2009; Pagliarini et al., 2012; Syrett & Musolino, 2013), such as the following, corresponding to the action depicted in Figure 1:

1. **Distributive Sentence** – Each minion pushed a rock.

In particular, children, unlike adults, are capable of interpreting such a distributive sentence to be an appropriate description of collective action situations, in which three minions simultaneously push a single rock, as in Figure 2.

Adults, in contrast, categorically interpret such distributive sentences to be appropriate for spatially distributive situations in which each of three minions is paired up with a single rock of their own.[1] Adults, after viewing a collective scenario, such as three minions pushing a single rock, will reject a distributive sentence such as 1 as a description of what they have just seen, while children seem to

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[1]There is an alternative version of distributivity, among others, which is temporal in nature. This type of situation would consist of multiple minions pushing a single rock, one after another (consecutively). We will not concern ourselves further with this here.
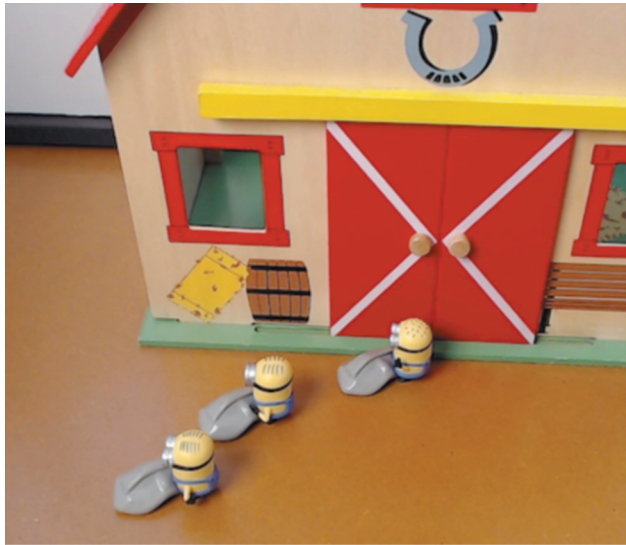
Figure 1. Image of the last scene of a distributive scenario, in which each of three minions pushes its own rock.

Figure 2. Image of the last scene of a collective scenario, in which all three minions push a single rock.

delay until they are 10 or 11 years-old in rejecting distributive sentences presented in such collective contexts at adult levels.

In what follows, we explore the hypothesis that the knowledge that underlies these judgments stems from a collective-distributive lexical scale, in the sense of Horn (1972, 1989)) and Grice (1975), as proposed by Dotlačil (2010), Pagliarini et al. (2012), and Padilla-Reyes (2018). On this hypothesis, the lexical scale is anchored by the distributive entailment of *each* in English (*cada* in Spanish), which relegates the remaining plural quantifiers to a state of collective-distributive ambiguity. This is resolved, usually in favor of the collective reading, by scalar pragmatic reasoning regarding the informativeness of the plural quantifier vis-à-vis distributivity, in relation to the distributive quantifier's entailment. This greater informativeness of *each/cada*, which we hypothesize exists implicitly in the lexicon, almost always over-rules the potential distributive meaning of the plural quantifiers (e.g., *some, the* in English or *unos, los* in Spanish), yielding their collective meanings. This proposal is

especially plausible if we find that there is a contingency between collective and distributive meanings across developmental stages. Pagliarini et al. (2012) in fact showed precisely this for a cross-sectional sample of elementary school-aged child Italian-speakers between interpretations of *each* (*ciascun* in Italian) and plural *the* (*i* and *le* in Italian). Though a revolutionary finding in some ways, an odd dimension of the project was that adults in the experiment interpreted the plural definite article quantifiers *i/le* to be collective only 50% of the time. That is, in situations represented in their experiments pictorially as distributive, e.g., three girls, each in their own picture, each building their own separate sandcastle, adults accepted sentences such as 2, 50% of the time.

2. **Collective Sentence** – The girls are building a sandcastle.

Our reading of this sentence is that its analog in English and Spanish, at least, should be categorically collective and should have been rejected by adults nearly 100% of the time. Thus, on the one hand, the correlation between increasing rejection of distributive sentences, such as 1, in collective contexts, and the rejection of collective sentences, such as 2, in distributive contexts, seems consistent with Dotlačil's, Pagliarini et al.'s and Padilla-Reyes's hypothesis that collective and distributive interpretations should develop together. However, on the other hand, we worry that such a correlation might be spurious, inasmuch as the adult interpretations reported do not match what we believe we will find in adult Spanish or English of parallel sentences. This 50% outcome in adults is also consistent with chance behavior, and could have resulted from the use of static pictures in place of visually acted-out scenarios in what Pagliarini et al. (2012) describe as a Truth Value Judgment Task (TVJT). The primary virtue of TVJT, at least according to its inventors (Crain & McKee, 1985), is the rich pragmatic context provided by visually acted-out scenarios, which can make the interpretations to be paired with sentences more clearly understood. We suspect that the putative link between the two types of interpretations could be more profitably tested by using a standard TVJT, with visually acted-out scenarios, and that the findings of a regression between the distributively entailed *each/cada* and the collectively implicated *the/los* (and perhaps also collective *some/unos*) would be most compelling if categorical (and not chance), adult-like behavior were interpretable from the experimental stimuli. Finally, we would like to explore whether, if these interpretations are indeed the product of scalar reasoning based on the relationship among plural quantifiers in the lexicon, standard measures of lexical development predict children's developing interpretations.

Syntactic scope and semantic ontology

A neo-Gricean account of collectivity and distributivity is possible because of the ambiguity available in sentences with two quantifiers, such as 2, above. In syntactically oriented generative linguistic accounts, this type of ambiguity has standardly been addressed in terms of quantifier scope and the syntactic operation of Quantifier Raising, by which quantified arguments move from a previous syntactic position, after having been expressed phonologically, which renders the phonological representations of distinctly intended sentences indistinguishable (e.g., Chomsky, 1995; May, 1985). Specifically, if the interpretation is collective, then it is said that the indefinite direct object has "wide scope" with respect to the quantifier in subject position (e.g., "There is a sandcastle such that the girls are building it"), and has moved above it syntactically. In contrast, if the interpretation is distributive, it is said that the indefinite object has "narrow scope" with respect to the quantifier in subject position (e.g., "For each girl, there is an individual sand castle, such that each girl built her own individual sand castle."), and has remained in the syntactic position corresponding to its phonological representation. While this works with ambiguous sentences such as 2, which are susceptible to a scope analysis, the non-ambiguity of the sentence in 1 renders such an analysis less informative.[2] That is, a noun phrase

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[2]For a review of work on the development of children's scopal interpretations, including Musolino's (1998) *Observation of Isomorphism*, see Lidz (2016).

that includes *each/cada* in subject position does not allow other quantified noun phrases in direct object position to "scope over" them. Thus, for adults, sentence 1 cannot have the collective interpretation: "There is one rock, such that all of the minions pushed it together." In this way, the distributive property of sentences with *each/cada* in subject position appears to inevitably reduce to lexical, idiosyncratic properties of the quantifiers themselves, which makes a regular, productive syntactic account less explanatory.

Within formal semantic theories, which are less concerned with implementing semantic representations syntactically, or mentally for that matter, there is a rich tradition of accounting for the distinct properties of collective and distributive sentences. Though a full exposition of the debate within this field of linguistics goes beyond what we can provide here, we can informally classify the distinct semantic theory types to account for the distributive-collective distinction into three groups: The Ambiguity Theory, originating in the work of Link (1983), and further developed by Roberts (1987), Landman (1989), and Gutierrez-Rexach (2001) and others; The Underspecification Theory, originating in the work of Schwarzschild (1996) and The Pragmatic Theory, originating in the work of Horn (1972), and further developed by Dotlačil (2010), Pagliarini et al. (2012), and Padilla-Reyes (2018).

The Ambiguity Theory recognizes that some expressions are compatible with collective and distributive readings, while others are not. The ambiguous expressions, on this account, are disambiguated in favor of an abstract distribution operator over the Verb Phrase (VP) and plural individuals. It further assumes that collectivity is the default property of predicates. A version of these theories captures non-default collectivity as the introduction of a group or plural individual subject (e.g., Gutierrez-Rexach, 2001). On the other hand, The Underspecification Theory (as in Schwarzschild, specifically) uses the concept of "covers" to individuate and partition sets to collapse the dichotomy between collectivity and distributivity, thereby using one ontological mechanism to explain both. Covers simulate the way we individuate sets of individuals by converting a set into a set of subsets of its own members. Finally, The Pragmatic Theory assumes that the unavailability of distributivity in some Determiner Phrases (DP), such as the subject of sentence 2, is due to pragmatic informativeness, evaluated on a scale of distributivity and collectivity on which all plural DPs participate. The informativeness evaluation dictates that if a speaker uses an expression x that has two meanings (d,c) and there is an expression y that conveys only (d), then by conversational principles (Grice, 1975; Horn, 1972) the hearer will understand that the speaker intended to convey c with expression x.

Because these theories are primarily proposed to be the most elegant and parsimonious theories of meaning possible, and not necessarily intended to be mentalist claims, it would not be entirely fair to attempt to use child data to adjudicate among them. Further, it is also not entirely clear where in linguistic data to situate the distributive operators of the type proposed by Link, which can occur in individual quantifiers, but also be a compositional property of predicates. Similarly, the covers of Schwarzschild do not lend themselves in obvious ways to identification as elements of the lexicon, morphology or syntax. For this reason, we will limit ourselves here to exploring the proposal among these accounts that appears most susceptible to empirical validation: The Pragmatic Account.

The Pragmatic Scale Hypothesis

Given that this distributive property of *each/cada* appears to be particular to them as lexical items, we ask what type of semantic object these quantifiers are, which is to say, where they fit in semantic ontology. To this end, Grice (1975) uses the "in fact" test to determine whether an expression carries a conversational, pragmatic implicature. If the meaning of a phrase can be canceled by following it with "in fact" and a different quantificational expression, then it is likely a conversational implicature because cancelability is one of this semantic object type's properties. If not, then it must be a stronger, non-cancelable expression type in semantic ontology, such as an entailment, presupposition, etc.

In the following example, we see that the collective interpretation of the sentence, with the definite article in subject position, can indeed be canceled and replaced with a distributive interpretation, using the "in fact" test, consistent with the claim that it is collective by conversational implicature.

3. The minions pushed a rock. In fact, each minion pushed a rock.

In contrast, the distributive interpretation of the following sentence cannot be canceled by the "in fact" test, suggesting that the distributive interpretation associated with the subject modified by *each* is of a different semantic type than the collective implicature associated with the subject modified by *the* in 3.

4. #Each minion pushed a rock. In fact, the minions pushed a rock.

In fact, the minions pushed a rock. We take the results of the "in fact" test to be consistent with *the/los* deriving its collective interpretation via conversational implicature and *each/cada* producing a distributive interpretation by distributive entailment. The fact that it is not cancelable and is thus not ambiguous in the way that 3 can be, allows the quantifier to be included in the set of quantifiers in the lexicon that convey collective-distributive information. Thinking of this group of quantifiers as a scale that ranges from most informatively distributive, as in *each/cada*, to slightly less unambiguously distributive as in *every/todo*, to quantifiers that are more fully ambiguous, and consequently are frequently interpreted as collective, such as *the/los* and *some/unos*, is consistent with the neo-Gricean vision of pragmatic scales (Horn, 1989).

A critical property of Dotlačil's, Pagliarini et al.'s and Padilla-Reyes's proposals is that by situating collectives and distributives on a single, pragmatic scale, they claim that the collective inference of *the/los* and *some/unos* should only be as strong as the distributive entailment is. This theoretical claim of an intrinsic connection between the two is unique among prominent semantic theories of collectivity-distributivity (e.g., Dowty, 1987; Link, 1983; Moltmann, 1997; Roberts, 1987; Schwarzschild, 1996; Winter, 2001). For developmental theories, this particular claim is consistent with the prediction that children's rate of collective implicature generation should be predictable from their rate of distributive entailment interpretation.

The developing lexicon and pragmatic scales

Though our discussion is necessarily somewhat speculative, there are linguistic elements that, conceptually, must develop in order for children's representation of a distributive quantifier's entailment to develop. If the Pragmatic Scale Hypothesis is correct, then this development should drive a concomitant development of collective conversational implicature interpretations. Growth internal to the distributive lexical item *each/cada* must include increased precision in understanding of the denotative content. The denotative content of quantifiers would necessarily have to include quantity knowledge. Quantity knowledge has been extensively studied in both human and non-human animals and perhaps the brightest line dividing what human and non-human animals can do with quantity knowledge is the human lexicon. Substantial evidence suggests that pre-linguistic infants can make quantity judgments akin to those made by non-human animals (e.g., Starkey & Cooper, 1980, inter alia). This type of non-species-specific quantity knowledge is conventionally referred to as the Approximate Number System (ANS). We have argued that it is the lexicon that refracts ANS quantity knowledge, through the natural language quantifiers of the numeral counting system to allow humans to count (Grinstead et al., 2020). Evidence consistent with this claim comes from Negen and Sarnecka (2012), who show that multiple measures of lexical development in child English indeed predict children's performance on the Give-a-Number task of Wynn (1992), which of course makes critical use of cardinal numbers, which are natural language quantifiers.

If the denotative content from ANS is refracted by cardinal numeral natural language quantifiers in the count routine, then we may conceive of the denotative content of distributive quantifiers as being similarly refracted, though with distinct, lexical item-particular properties. For numerals, exact cardinalities that are equidistant from n + 1 and n-1. In contrast, for distributives such as *each/ cada*, they must quantify universally over a set, the members of which are partitioned individually, or distributively for predication. While this seems a plausible way of thinking about how the lexical item-internal denotative content of a distributive quantifier comes to have meaning, there must also be lexical item-external properties, if the quantifier sits on pragmatic scale in the lexicon. Lexical item-externally, but still internal to the lexicon, quantifiers form networks that have traditionally been formalized as pragmatic scales (Grice, 1975; Horn, 1972). We can imagine that the links among quantifiers in these networks become stronger as children gain experience with contrastive uses of quantifiers that express related types of meaning. This contrast would appear to be logically important for drawing Gricean inferences regarding the informativeness of a quantifier, linked to other quantifiers on their scale. Growth in these two lexical dimensions – internal and external – could drive greater ease of inferencing especially by making the units over which the inference computation ranges more internally meaningful and externally contrastive.

For our purposes, we will conceive of the growth of the collective-distributive relationship as occurring between ANS and lexicon, and between lexicon and distributive-collective interpretations. However, for our current study, we will limit ourselves to the latter half of this relationship, between lexicon and distributive-collective relationships.

Collective interpretations of distributive sentences

In previous research, we see the same pattern, across languages, of distributive sentences not being interpreted in an exclusively distributive fashion until children are well into the elementary school years. Hanlon (1986), working with English-speaking children between 3;0 and 8;0, uses an act-out task with sentences such as *Put each letter in a box.* and *Give him each of the cookies.* and shows that of the quantifiers *some, none, any, other, either, all, every, each* and *another*, the quantifier to be used correctly the latest, in development terms, was *each*. Similarly, Brooks and Braine (1996) show in a series of experiments that *each* is a late development relative to the quantifiers *all* and *three*, and that active vs. passive voice is also a significant factor, active being most likely to support distributive interpretations of sentences with distributive subjects. In an interesting, and one of the only, cross-linguistic studies, Brooks et al. (1998) show the same pattern, but also show that predicate type matters, in that stative predicates (in the sense of Carlson, 1977) constructed by copula + prepositional phrase, as in 5, are more easily interpreted as distributive than are activity predicates (in the sense of Vendler, 1967), as in 6.

5. Each flower is in a vase.
6. Each man built a boat.

Further, they showed that in Mandarin and Portuguese children take longer to develop distributive interpretations. This could be because in these languages, the indefinite direct object must be represented by a numerical quantifier, unlike the English indefinite *a*, that is ambiguous with the cardinal numeral *one*, as with Portuguese *um* (e.g., Cardinal Numeral: ***um**, dois, très, quatro*; Indefinite Article: *Cada flor está em **um** vaso.*), in contrast to English *a* (Cardinal Numeral: **a/one, two, three, four*; Indefinite Article: *Each flower is in **a** vase.*). They add a condition in English with sentences such as 7, and show that English-speaking children are similarly less accurate in identifying these sentences as distributive when a cardinal number is used as the quantifier of the direct object.

7. Each man pushed <u>one</u> boat.

In a study with a distinct focus (the Isomorphism Effect), Musolino (2009) shows that children accept his distributive control sentences, as in 8, much more (85.1% vs. 23.4%) than do adults as characterizations of non-distributive images.

8. Each boy is holding a balloon.

Syrett and Musolino (2013) show in a series of experiments, including a sentence preference task, that preschool-aged children appear able to access distributive interpretations and that their preferences for one interpretation over the other can be influenced by active vs. passive voice and by adding further denotative content to the sentence, as in the sentence in 9, to which the addition of the word *together* increases the preference for a collective interpretation.

9. Two boys pushed the car (together).

Finally, Pagliarini et al. (2012) use a picture-based Truth Value Judgment Task with a large sample of Italian-speaking children and adults and show that children's rejection of distributive sentences such as 10 (Pagliarini et al., 2012, ex. 5) in collective contexts is predictive of children's rejection of collective sentences such as 11 (Pagliarini et al., 2012, ex. 6) in distributive contexts.

10. Ciascun bambino costruisce un pupazzo di neve.
    Each boy build.3Psing.PRES a puppet of snow
    '*Each boy is building a snowman.*'

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

Again, the unexpected outcomes of this intriguing study were that though adults categorically rejected the distributive sentences, such as 10, in collective contexts (91%), they were at chance in rejecting collective sentences, such as 11, in distributive contexts (50%). Nonetheless, children's rejection of these two sentence-context pairings were significantly correlated.

Summarizing, there is a pattern of results across an array of developmental studies showing that children are delayed to 8, 9 or even 10 years-old, in developing adult-like distributive interpretations of distributive sentences carrying a quantifier such as *each* in the position of agent, whether active or passive, and an indefinite noun phrase in theme position, whether active or passive. This finding seems to hold across at least English, Italian, Brazilian Portuguese and Mandarin and it appears to hold across predicate type and syntactic construction. The proposal that these two interpretations could be linked, by virtue of collective and distributive interpretations belonging to a common lexical scale in children's lexicons, is at least partially supported by Pagliarini et al.'s findings. However, the chance adult results call this statistical connection into question.

Research questions

Intrigued by the possibility that collective and distributive quantifiers could be lexically linked and that interpretations that depend critically upon these links could develop in tandem in children, we ask the following research questions:

1. Are collective sentences in distributive contexts categorically rejected by adult Spanish-speakers, as distributive sentences in collective contexts seem to be across languages?

2. Are children's interpretations of collective and distributive sentences developmentally linked, as predicted by the Pragmatic Scale Hypothesis?

3. Does a measure of general lexical development predict children's developing collective-distributive interpretations?

4. Does the impact of lexical development on *each/cada* significantly mediate the relationship between lexical development and the interpretations of *some/unos* and *the/los*?

Methods

Participants

We tested 88 monolingual Spanish-speaking children between the ages of 5;0 and 10;0 (mean = 7;9, SD = 17.36) and 20 Spanish-speaking adults (range = 17;8– 26;7, mean = 20;6, SD = 29.25). All adults were volunteers from a university in western Puerto Rico. The children were selected from daycare centers and summer camps in western Puerto Rico. All participants or their families signed a university institutional review board-approved informed consent document before beginning the study.

Participants were divided into seven groups:

- five year-olds (n = 8, range: 5;1–5;9, mean: 5;5, SD: 3.12)
- six year-olds (n = 19, range: 6;0–6;10, mean: 6;4, SD: 3.16)
- seven year-olds (n = 20, range: 7;0–7;8, mean: 7;4, SD: 3.30)
- eight year-olds (n = 15, range: 8;1–9;0, mean: 8;5, SD: 4.09)
- nine year-olds (n = 16, range: 9;0–9;8, mean: 9;4, SD: 3.50)
- ten year-olds (n = 8, range: 10;0–10;7, mean: 10;3, SD: 3.66)
- adults (n = 20, range: 17;8– 26;7, mean: 20;6, SD: 29.25)

We also administered a background questionnaire to the parents of our child sample, or to the participants themselves in our adult sample, to determine maternal level of education and the degree to which participants were monolingual Spanish-speakers and whether they were typically-developing. For most participants, the maternal level of education (measured in years, such that 12 years is high school and beyond that is higher education) was beyond high school (range = 6– 24, mean = 15.72, SD = 3.90). Only monolingual Spanish-speakers were included in the sample. Our criterion for determining whether participants were monolingual was whether there was anyone living in the house speaking to the child in a language other than Spanish. Two child participants were excluded for being multilingual and one child participant was excluded for having a history of speech-language problems.

Procedures

Children were given a standardized lexical measure, the Test de Vocabulario en Imágenes Peabody "The Peabody Picture Vocabulary Test" (Dunn et al., 1986), which was normed for Puerto Rico, and was only given to children. Our concern with having a normed test has more to do with having a test that uses culturally appropriate images and dialect-appropriate terms, and less for being able to use standard scores for our population. We work with raw scores in order to include age as an independent co-variate in our analyses. Both adult and child participants took our Truth Value Judgment Task (TVJT).

Our TVJT follows the original design of Crain and McKee (1985) and includes a narrated story. Our variant of this original design acts out the scenarios in video-recorded format on a laptop computer, made using stop-motion animation, with the goal of improving reliability of delivery, compared to a "live" acted-out TVJT. At the end of the scenario, the narrator's voice produces a sentence, the contextualized interpretation of which is our object of inquiry. Following Crain & McKee, each scenario includes a dimension of "plausible dissent," that is, a discourse structure that allows for an alternative outcome to be considered. In our case, there is always an obstacle to be overcome and the question is how the protagonists in the story (the Minions from the movie *Despicable Me*) are going to overcome it. Because there is always either 1 object or 3 objects to be acted upon to overcome the problem, there are multiple ways in which the Minions could decide to overcome their problem. This is plausible dissent. The fact that we ask explicitly how the Minions will overcome the obstacle further structures our discourse, following Gualmini et al. (2008), such that the narrator's scenario-final statement answers what Roberts (2003) refers to as the Question Under Discussion. The idea is that all conversational contributions must address some, usually implicit, Question Under Discussion, in order to be relevant. Here is an example of one of our scenarios.

12. Los minions están trabajando en la finca y tienen que mover una piedra.
    The minions are working on the farm and they have to move a rock.

The purpose of 12. is to set the stage for a soon to be stated explicit Question Under Discussion. Having set the stage, the Minions pursue their goal of moving a rock. Upon the Minions' arrival at the barn, the narrator produces the following sentence:

13. Hay más de una y se ven bastante livianas. ¿Cómo lo harán?
    There is more than one (rock) and they look pretty light. How will they do it?

13. thus includes the explicit Question Under Discussion, "How will they do it?". In this way, a question with a truly unknown (and therefore plausible) set of answers is asked. This contrasts with "school behavior" type questions, which ask children questions with obvious answers, which sometimes produces answers unrelated to the question that researchers seek to answer (Gualmini et al., 2008).

In order to make it prominent that the Minions think that there are multiple logically possible ways to move three rocks, we have the Minions move together in a huddle and confer to discuss what they are going to do, now that there is more than one rock. (To the contrary, in the collective scenarios, we say that they have to move rocks [plural] and then the narrator remarks on there being only one, again posing a problem to be solved by the Minions, and allowing degrees of freedom for plausible dissent.) After conferring, the minions either push one rock each, distributively, as in Figure 1; or push one rock together, collectively, as in Figure 2.

After the Minions complete their task, the narrator produces either a collective sentence or a distributive sentence, such as the following:

14. Ya sé cómo lo hicieron. Cada minion movió una piedra.
    I know how they did it. Each minion moved a rock.

After the final sentence is produced, the participant is then asked to either accept (*sí*) or reject (*no*) whether what they have heard is a correct representation of what they have seen. It is a forced choice task and *both* and *neither* answers were not permitted.

Stimuli

Participants were presented with 36 experimental scenarios, 12 filler scenarios and 4 warm-up scenarios. The purpose of the warm-up scenarios was to familiarize participants with the TVJT format. In particular, the warm-up items asked participants to accept or reject the utterance produced by the narrator's voice, as to whether the Minions in the movie they had just seen had managed to move a horse from in front of the door of a barn. In the warm-up items, feedback was given to participants if they did not appear to grasp the format. None was given thereafter. Only participants who scored above chance on the 12 fillers (significantly above chance = 10, 11 or 12 correct) were retained in the sample. All adult participants tested scored above chance on filler items and were included in the sample. Five children of the original 93 failed 3 or more filler items and were removed from the sample. Items were presented in one of three randomized orders. There was no significant difference in acceptance among the three orders ($p > .05$).

Of the 36 items, half (18) were presented in collective contexts and half were presented in distributive contexts. Each of 12 videos was presented with a scenario-final sentence containing a subject noun phrase quantified by either the plural definite determiner *los* (the), the plural existential quantifier *unos* (some) or the distributive universal quantifier *cada* (each), for a total of 36 videos, as illustrated in Table 1.

Every scenario-final sentence had a subject with one of the three quantifiers (*cada/unos/los*), followed by a verb, followed by an indefinite object, quantified by the singular indefinite determiner *una* or *un*, as in 15.

15. Cada Minion atrapó un gallo.
    Each Minion caught a rooster.

Predicates can be inherently collective or distributive, or ambiguous. To remove inherent distributive vs. collective predicate interpretations as a confound, we did our best to choose predicates that were ambiguous and equally easy to interpret either way. Half of our events were activity predicates and half were accomplishment predicates, in the sense of Vendler (1967). Activity and accomplishment predicates had similar results in Brooks and Braine (1996), while statives (e.g., Each flower is in a vase.) showed different behavior. We chose these activity and accomplishment predicates to have the most homogeneous results and to remove predicate type as an additional variable.

16. Atrapar un gallo.'To catch a rooster'.
17. Cargar una bolsa.'To carry a bag'.
18. Encontrar un ganso.'To find a goose'.
19. Llevar un gallo. 'To carry a rooster'.
20. Mover una piedra.'To move a rock'.
21. Sembrar un arbol.'To plant a tree'.

Table 1. Distribution of quantifiers by distributive-collective pragmatic context.

	Distributive	Collective
Unos	6	6
Los	6	6
Cada	6	6

Results

Descriptive statistics

First, we present in Table 2 the results of our lexical measure, the TVIP raw score, across the child sample, divided by age group.

Next, we present in Figure 3 our child and adult mean acceptance rates of each quantifier type, out of a possible 6, in each context. Cronbach's Alpha for the entire test is .91, which is considered high reliability. For the incongruent sub-scales, Alpha is also quite high: for *cada* in collective contexts = .91; for *los* in distributive contexts = .87; and for *unos* in distributive contexts = .88. For the congruent subscales, alpha is quite low, as one would expect, given the near 100% acceptance and consequent low degree of variance: for *cada* in distributive contexts = .16; for *los* in collective contexts = −.10; for *unos* in collective contexts = .61.

It is interesting to note in Figure 3 that among the incongruent quantifier-context pairs, *cada* appears more adult-like than does *los* (76% of children had less acceptance of *cada* in incongruent contexts than they did of *los*) or *unos* (82% of children had less acceptance of *cada* in incongruent contexts than they did of *unos*). Putting them together, more children accepted *cada* less than either *los* or *unos* or both (88%). Statistically, if *cada* was accepted less than or equal to the number of times that either *unos* or *los* or both was accepted, we categorized the child as a "1." If not, a 0. Then, we carried out a one-sample t-test to determine whether the distribution of children was different from chance, which would be .5. It was (t(87) = 10.576, $p < .001$), and in the expected direction.

Correlations

In Table 3, we see Pearson Product Moment Correlations of our variables. The three incongruent quantifier-context pairings are significantly associated. Perhaps more interestingly, the measure of lexical development only correlates with the incongruent pairs and not the congruent pairs, consistent with the claim that lexical development drives implicature generation, though this is perhaps not informative because of the low degree of variance. Similarly, Age does not correlate with congruent pairings because they are always accepted, lending very little variance to be entered into the calculation. Maternal level of education correlates with nothing and is not explored further in subsequent analyses.

Stepwise multiple linear regression

It could be argued that the following analyses should be run with an ordinal or count (e.g., Poisson) regression model, given the small number of items per dependent variable (7). We have run these analyses and the results are the same.[3] Given this fact, and the more intuitive interpretability of OLS regression coefficients, we will present the results of the linear regression.

Following the claim of the Pragmatic Scale Hypothesis that the presence of *each/cada* in the lexicon is what produces the collective interpretations of *unos/some* and *los/the*, in Table 4 we consider the predictive force of children's interpretations of *cada/each* in collective (incongruent) contexts on their interpretations of *unos/some* and *los/the* distributive (incongruent) contexts and the impact of adding

Table 2. TVIP raw score, with SD in parentheses, divided by age Group.

5 Year-olds (n = 8)	6 Year-olds (n = 17)	7 Year-olds (n = 20)	8 Year-olds (n = 13)	9 Year-olds (n = 12)	10 Year-olds (n = 6)
55.0 (15.3)	54.3 (15.9)	73.0 (8.4)	78.27 (10.2)	84.19 (10.0)	92.4 (8.6)

[3]We note also that our seven-point scale is near the 8-item threshold proposed by Rhemtulla et al. (2012) for treating a scale as continuous.
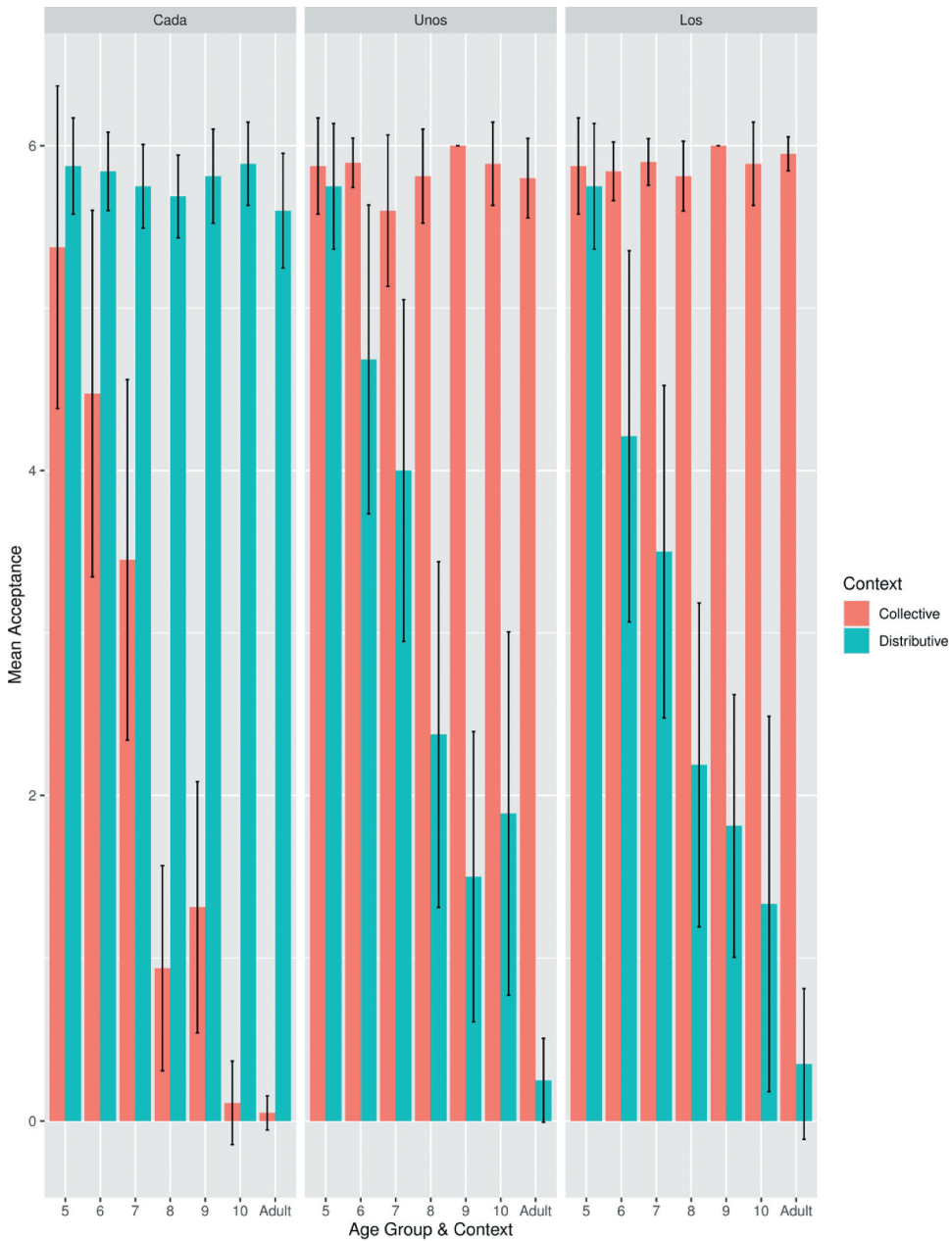
Figure 3. Child Spanish-speakers' acceptance of collective (*unos, los*) and distributive (*cada*) quantifiers in distributive and collective pragmatic contexts.

in the lexical measure (TVIP) and age in months into the model. We add a third analysis, showing the close connection between the two interpretations that are putatively derived via scalar implicature (*unos* and *los*). Note that the addition of lexicon (TVIP) and age dramatically reduces the beta value of the distributive *cada* on the collectives, but much less so of one collective (*unos*) on the other (*los*).

Table 3. Pearson product moment correlations of variables (*. correlation is significant at the 0.05 level, 2-tailed; **. Correlation is significant at the 0.01 level, 2-tailed).

	Cada Dist.	Los Coll.	Unos Coll.	Cada Coll.	Los Dist.	Unos Dist.	TVIP	Age	Mat. Ed.
Cada – Dist.	1								
p									
Los – Coll.	.369**	1							
p	<.001								
Unos – Coll.	.164	.271*	1						
p	.128	.011							
Cada – Coll.	.027	.038	−.074	1					
p	.800	.728	.495						
Los – Dist.	.226*	−.017	.030	.685**	1				
p	.034	.873	.783	<.001					
Unos – Dist.	.125	−.040	.079	.711**	.855**	1			
p	.246	.709	.462	<.001	<.001				
TVIP	.010	.059	.020	−.673**	−.566**	−.569**	1		
p	.929	.588	.852	<.001	<.001	<.001			
Age	−.051	.065	.072	−.675**	−.601**	−.622**	.730**	1	
p	.634	.545	.502	<.001	<.001	<.001	<.001		
Mat. Ed.	−.182	.107	.031	−.007	−.055	−.059	.060	−.077	1
p	.123	.366	.796	.953	.644	.620	.615	.520	

Table 4. Stepwise multiple linear regression showing effect of predictor *cada* in collective contexts on *unos* and *los* in distributive contexts, and of the predictor *unos* in distributive contexts on *los* in distributive contexts, with Lexicon and with age and Lexicon.

Predictor (x)	Outcome (y)	Alone	With Lexicon	With Age & Lexicon
cada	unos	B =.711, SE =.070, p <.001	B =.598, SE =.095, p <.001	B =.520, SE =.100, p <.001
cada	los	B =.685, SE =.072, p <.001	B =.559, SE =.096, p <.001	B =.487, SE =.102, p <.001
unos	los	B =.855, SE =.055, p <.001	B =.790, SE =.066, p <.001	B =.770, SE =.071, p <.001

Mediation analysis

An important question for our project involves how the growth in the lexical scale impacts the entailment of *cada*, which we conceive of as greater understanding of denotative content of the quantifier and as greater strength of connection in the links among the quantifiers on the lexical scale of collectivity and distributivity. By hypothesis, this entailment, in turn, affects the interpretation of the less informative, vis-à-vis distributivity, ambiguous quantifiers *unos* and *los*. Because the interpretation of *cada* theoretically plays a mediating role between the lexicon and the putatively implicated interpretations of *unos* and *los* on the Pragmatic Scale Hypothesis, we model this relationship as a mediation analysis, following Preacher and Hayes (2008).

Figure 4 schematizes a linear regression showing that (a) lexicon (TVIP) is predictive of acceptance of *cada* in (incongruent) collective contexts (B = .096, SE = .011, p < .001). Further, (b) in a multiple regression including TVIP, *cada* is predictive of acceptance of *unos* in (incongruent) distributive contexts (B = .555, SE = .093, p < .001). Following Preacher and Hayes (2008), the product of (a) x (b)
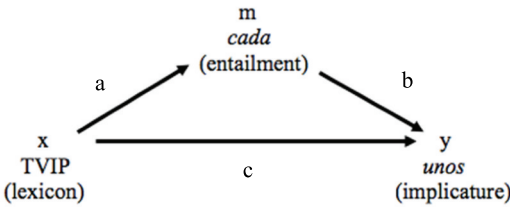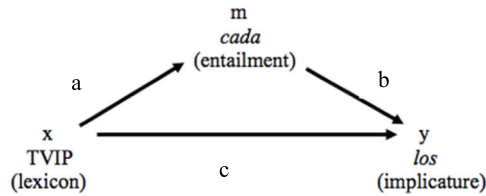

Figure 4. Mediation model with *unos*.

Figure 5. Mediation model with *los*.

(the Indirect Effect) is significant (B = .054, SE = .011, *p* < .001). Significance of the indirect effect was tested using a percentile bootstrap estimation approach with 5000 samples, implemented with the PROCESS macro Version 3 (Hayes, 2018). This indicates that after *cada*, the mediator, is controlled for, TVIP is no longer predictive of acceptance of *unos*. The percentage of the total effect accounted for by *cada* in collective contexts (Percent Mediated or P_m) is 71% and approximately 32% of the total variance in the interpretation of *unos* is accounted for by the predictors (r^2 = .324).

Similarly, for *los* in Figure 5, a linear regression shows that (a) lexicon (TVIP) is predictive of acceptance of *cada* in (incongruent) collective contexts (B = .096, SE = .011, *p* < .001). Further, (b) in a multiple regression including TVIP, *cada* is predictive of acceptance of *los* in (incongruent) distributive contexts (B = .512, SE = 0.095, *p* < .001). Again, the product of (a) x (b) (the Indirect Effect) is significant (B = .049, SE = .011, *p* < .001). Significance of the indirect effect was tested using a percentile bootstrap estimation approach with 5000 samples, implemented with the PROCESS macro. This indicates that after *cada*, the mediator, is controlled for, TVIP is no longer predictive of acceptance of *los*. The percentage of the total effect accounted for by *cada* in collective contexts (Percent Mediated or P_m) is 66% and approximately 32% of the total variance in the predictors is accounted for by the predictors (r^2 = .320).

From these Percent Mediated effect sizes, we can draw an intuitive sense of the role played by the distributive entailment of *cada* in the hypothetical informativeness calculation being made, in order to draw the pragmatic inference, or conversational implicature, that produces the collective interpretation.

Discussion

With respect to our first question, regarding adult Spanish-speaker judgments of collective sentences presented in distributive contexts, we find, in contrast to Pagliarini et al. (2012), that adults are entirely categorical, with greater than 90% rejection of collective quantifiers *unos* and *los* in distributive contexts, as illustrated in Figure 3, above. Further, they were similarly categorical in their rejection of the distributive quantifier *cada* in collective contexts. We suspect that this difference relates to the distinct methodologies employed.

For our second question, as to whether Pagliarini et al.'s finding of a developmental association of collective and distributive interpretations, we confirm Pagliarini et al.'s findings and the Pragmatic Scale Hypothesis that these interpretations could be linked via a pragmatic scale in the lexicon. We find, in fact, that this association persists independently of age and independently of our lexical measure, first in our stepwise linear regression and then in our mediation analysis models. We note that the connection between the interpretations of the two collective quantifiers that are hypothetically derived via implicature, *unos* and *los*, appears stronger than does the link between the distributive *cada*, theoretically derived via entailment, and the two collectives. This strength of association is consistent with these two lexical items having contributed to the interpretations of the sentences in which they occur in the same way, namely, by conversational implicature.

Our third question addressed the degree to which a standard measure of lexicon, the receptive Test de Vocabulario en Imágenes Peabody in this case, would be predictive of collective and distributive interpretations. The point of asking the question, of course, is that it only makes sense to speak of a pragmatic, lexical scale in the sense of Horn (1972) and Grice (1975) if the lexical entries that sit on a particular scale are somehow indexed in the lexicon as belonging to that scale. Certain lexical items, *some*, for instance, by the current hypothesis, participate in multiple scales, including the Quantity Scale and, given our current findings, the Collective-Distributive Scale. In Table 3, we saw that TVIP is statistically associated with both putatively implicature-driven collective interpretations: *unos* and *los*. To a first approximation, then, the answer is affirmative.

However, having established that TVIP is associated with the interpretations of collective *unos* and *los* in distributive contexts, we turn to testing the prediction of the Pragmatic Scale Hypothesis that the meaning of the distributive *cada* is sufficiently linked to the meaning of the collectives on the pragmatic scale to be predictive of them, independently of the lexicon. If true, this mediating effect would serve as a strong confirmation of the hypothesis. Indeed, we find that roughly two-thirds of the predictive power of the indirect effect of lexicon on collective interpretations is in fact driven by the effect of the lexicon on the mediating distributive *cada*. This finding is consistent with the claim that the informativeness of the distributive entailment drives a disambiguating function in children's lexicons to make the quantifiers increasingly less ambiguous, until they finally reach the adult state of being wholly categorical in their collective interpretations.

This type of mathematical illustration of a pragmatic informativeness relationship among quantifiers traditionally hypothesized to sit on a pragmatic scale is unique in the literature, to our knowledge. This kind of finding is not something we could have seen by simply considering adult data because adult interpretations are categorical and provide no variance for statistical modeling. However, given our cross-sectional semantic window, which simulates linguistic development, to see the ambiguity of *los* and *unos* we need only look at the 5 year-olds in our sample (Figure 3) who seem to be equally content with a collective or a distributive interpretation of these quantifiers. This variance, which in the end was found to be statistically linked, was the critical component for being able to test the hypothesis. We take this result to be strong empirical substantiation of the central claim of neo-Gricean pragmatics.

Lexical scales and conversational implicatures

Our results here are unique, in that we are able to see sufficient variance in the entailed quantifier on the Collective-Distributive Scale, *cada*, that we could pose mathematical questions about its relationship to interpretations of other quantifiers (*unos* and *los*) on the same scale. In children's Quantity Scale interpretations of the "some, but not all" interpretations of quantifiers such as *some* in English, or *algunos* in Spanish, this kind of question is difficult to ask. The entailed members of these scales, *all/ todos* and *none/ningún* are quickly acquired, and show no variance in children's interpretations by the age that their behavior can be measured using Truth-Value Judgment Tasks. Perhaps other techniques that allow for earlier measurement could be useful in this regard.[4] Thus, the fact that the Collective-Distributive Scale is late to develop in fact allows an opportunity to measure the interaction among entailed vs. implicated quantifier interpretations that is denied to us on the Quantity Scale. To take another case, the scale involving exact interpretations of cardinal numbers seems to be relatively undifferentiated, in the ontological sense, from one quantifier to the next, though the exact ontological quality of numerical quantifiers and their interpretations is still actively debated (e.g., Kennedy & Syrett, 2018; Papafragou & Musolino, 2003). The nature of ad-hoc and encyclopedic implicatures (Papafragou & Tantalou, 2004), as yet one more case to consider, is fundamentally different inasmuch as their implicational force is not drawn from a set of related quantifiers in the lexicon, but rather from the conceptual restrictions on the entities and actions to which they refer.

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[4]See, for example, Huang and Snedeker (2009, 2018)), inter alia, for work with younger children, using the Visual World Paradigm.

In contrast, our other current work does show differential relationships of general measures of lexical development, both receptive (TVIP) and expressive (the *Adivinanzas* or Riddles sub-test of the Batería de Evaluación de Lengua Española; Rangel et al., 1988), on children's interpretations of the Quantity Implicature (i.e. they are predictive – Grinstead et al., 2019), and upon exact interpretations of cardinal numerals (they are not predictive – Nieves-Rivera & Grinstead, 2019).

In current work, we explore other, linguistic, and non-linguistic variables and their relation to the very prolonged development of children's interpretations of collective-distributive interpretations. It is clear that this development depends not only upon lexical development. Further work will hopefully lend insight into the puzzle of why children take so long to develop what could be considered a fundamental cognitive and linguistic ability.

Disclosure statement

The authors have no conflicts of interest that could be perceived to have influenced their objectivity, relative to the study reported in this manuscript.

Data sharing

The data that support the findings of this study are available from the corresponding author (John Grinstead – grinstead.11@osu.edu) upon reasonable request.

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