Competence and Performance in Distributive/Collective Interpretations of Quantifiers in Child English and Spanish

A Senior Honors Thesis

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by

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Abstract

Crosslinguistically, children who are otherwise linguistically mature tend to assign a collective interpretation to quantifiers that are typically construed as distributive (*each/cada*) by adults; similarly, in distributive contexts, children accept quantifiers that adults interpret as collective (*some/unos, the/los*). The Pragmatic Scale Hypothesis proposes that collective and distributive meanings sit on a pragmatic scale, anchored by *each/cada*, which represents the distributive extreme of the scale with meaning derived through entailment. In contrast, *some/unos* and *the/los* derive meaning through a conversational, scalar implicature that is generated by virtue of the weaker informativeness of these quantifiers, relative to the stronger informativeness of *each/cada*. From this hypothesis come the following predictions: 1) Lexical development should predict children's abilities to reject distributive *each/cada* in collective contexts, as we expect such entailments to develop in tandem with denotative content in the lexicon. 2) Lexical development may also be predictive of children's abilities to reject collective *some/unos* and *the/los* in distributive contexts, as their meaning is indirectly inferred from the pragmatic scale, anchored by *each/cada*. 3) If scalar implicatures result from inferences drawn using non-linguistic cognitive performance abilities, then such abilities may be predictive of the ability to reject a quantifier in an incongruent context. We recruited 60 typically-developing 7 and 8 year-olds in Ohio and Puerto Rico. 31 were monolingual Spanish-speakers (mean age=95.25 months, SD=7.43) and 29 were monolingual English-speakers (mean age=95.38 months, SD=7.65). Children were given a video-recorded Truth-Value Judgment Task to measure their interpretations, as well as standardized tests of vocabulary, inhibition, working memory, and attention. Results confirmed predictions and support the Pragmatic Scale Hypothesis.

Table of Contents

Introduction

Across languages, children who are otherwise linguistically mature tend to assign a collective interpretation to sentences that contain quantifiers and are typically construed as distributive by adults (e.g. “Each minion pushed a rock.”); similarly, children accept collective sentences (e.g. “Some minions pushed a rock.”) in distributive contexts. Current accounts of this finding have attempted, with limited success, to explain it by focusing on language competence, but they have not been able to account for the entire phenomenon. In this study on English and Spanish, I explore the relevance of performance variables, including working memory and executive function, using a video-based Truth Value Judgment Task, a standardized lexical development test, and a battery of executive function measures.

Literature Review

Description of the Phenomenon

Brooks and Braine (1996)

The study conducted by Brooks and Braine in 1996 exemplifies the pattern of quantifier comprehension in child language that we will explore here. It included three picture selection experiments to measure children’s comprehension of the universal quantifiers *all* and *each*, and how they utilize these quantifiers to decide on distributive or collective interpretations of the pictures. As it was a cross-sectional study of 4-10 year olds, the researchers were able to examine the development of syntactic and semantic abilities as a function of age. The first experiment focused on participants’ abilities to restrict the modifier to the appropriate noun phrase by having them select subject-exhaustive or object-exhaustive picture representations of collective or distributive scenarios. Children of all ages selected the correct pictures for sentences with *all*, but

performed poorly on *each* sentences until the ages 9 and 10. Results indicate that children were able to restrict the modifier *all* to the correct noun phrase, but not *each*.

The second experiment was similar in that children were asked to select the picture best described by the sentence they heard, but it employed both active and passive sentence structures in order to determine if syntactic positioning influenced children's interpretation of universal quantifiers. In fact, it does, as passive sentences were more likely to be interpreted collectively. However, this influence remained constant across age groups, while the proportion of correct responses based on the quantifiers themselves increased accordingly with age, as in the first experiment. These results suggest that children use both lexical and syntactic information to interpret quantifiers, but the sensitivity to syntactic position does not show the same delay in development. The following table is a summary of data from the active sentences in the second experiment, presented herein because it clearly demonstrates change in acceptability of the pairings of quantifier with interpretation type over time. In addition, these data show how children across the cross-sectional sample move from a non-adult-like set of interpretations to an adult-like state, roughly in tandem.

	Quantifier			
	All		Each	
Age	Collective (%)	Distributive (%)	Collective (%)	Distributive (%)
4 years	54.4	45.6	37.8	62.2
5 years	56.7	43.3	44.2	55.8
6 years	69.2	30.8	26.7	73.3
7 years	75.6	24.4	24.4	75.6
8 years	71.1	28.9	1.1	98.9
9 years	72.2	27.8	6.7	93.3
Adult	83.3	16.7	0.8	99.2

Table 1. English-speaking children's evolving evaluation of quantifiers in collective and distributive contexts (compiled from Brooks & Braine 1996, Table 3, p. 250).

In the third experiment, Brooks and Braine added an exhaustive component to the collective versus distributive picture selection task, with the goal of investigating children's propensity toward a child-particular phenomenon, known as quantifier spreading. For sentences with *all* or *each*, children generally refrained from selecting the exhaustive depiction, which demonstrates that they were paying attention to the quantifiers and that quantifier spreading was not as prevalent as was hypothesized. Altogether, these three experiments showed that children interpret quantifiers with syntactic and lexical information, and that inappropriate quantifier spreading is relatively infrequent. For the purposes of this thesis, the critical observation is that children only begin to approach adult-like rates of rejection of collective interpretations with *each* as they reach 8 or 9 years old.

Brooks and Braine et al. (1998)

Two years after their initial study, in 1998, Brooks and Braine partnered with Jia and de Graca Dias, researchers who had native languages other than English, in order to determine if children's behavior regarding quantifiers was consistent cross-linguistically. The task was similar: Children heard sentences containing collective and distributive quantifiers and were asked to select the best fitting picture from three choices (in contrast with the two picture selection task of Brooks and Braine 1996), which represented collective, distributive, and exhaustive situations. Half of the sentences used copulae and a preposition to express a locative meaning (e.g. *Each flower is in a vase*.), while the other half used transitive action verbs (accomplishment predicates, in the sense of Vendler 1967), such as *Each man is building a boat*. They did three rounds of the experiment, each focusing on a different language: Mandarin Chinese, Brazilian Portuguese, and American English. In Chinese, the children were consistently accurate across age groups in selecting collective interpretations when they heard the collective sentence and distributive interpretations when they heard the unambiguously distributive sentence. However, within the language, it is more common to encounter distributive sentences that contain both a collective quantifier and a distributive quantifier. Adults typically weigh the distributive quantifier above the collective and interpret these sentences as distributive, but children do not behave like adults in this respect until the age of 9.

In Portuguese, children again showed no difficulty in interpreting the collective sentences correctly. Sentences containing the distributive quantifier were more consistently interpreted correctly if they were presented in the locative context, whereas those using action verbs were interpreted as collective by the younger participants. The English experiment differed from the Brooks and Braine 1996 study by alternating the use of the indefinite article *a* with the numeral

one, as these items are homophonous in both Mandarin and Portuguese, and could therefore lead to a bias toward collective interpretations. As such, the English data was needed for comparison.

Results were similar to those found in the former two languages; that is, children grasped the collective nature of *all* much earlier than they grasped the distributive nature of *each*. Additionally, the presence of *one* exerted a collective influence, as expected. The authors concluded that children are clearly aware of the collective and distributive nature of events, which are then gradually associated with linguistic cues as lexical development progresses. The lexical development hypothesis is the first attempt at explaining the phenomenon first described in Brooks and Braine 1996 and observed again in this 1998 study.

As an aside, it is clear that different types of predicates have an effect on quantifier interpretation; native English intuition rules that *each* may be collective or distributive in the locative context, as in "Each flower is in a vase," whereas such fluidity is not present in an action context like "Each man carried a box." Although predicate type is a potential variable to consider within this issue, it will not be manipulated in the present study.

Developmental Semantic Accounts

Musolino (2009)

Musolino broadened the quantifier development discussion from universal quantifiers to numerically quantified expressions (NQEs) in his 2009 study, which presents NQEs in sentences such as "Three boys are holding two balloons." Sentences involving two NQEs may be interpreted in up to four ways. For example, "Three boys are holding two balloons" may mean there are either two or six balloons in the situation, and an individual boy may have his hands on any number of balloons between one and six. Musolino then introduces the familiar universal

quantifier *each*, such that the sentence becomes "Three boys are holding each balloon," which may be interpreted in similar manners as the former sentence. These possibilities are related to subject-wide scope, object-wide scope, each/all interpretation, and cumulative interpretation.

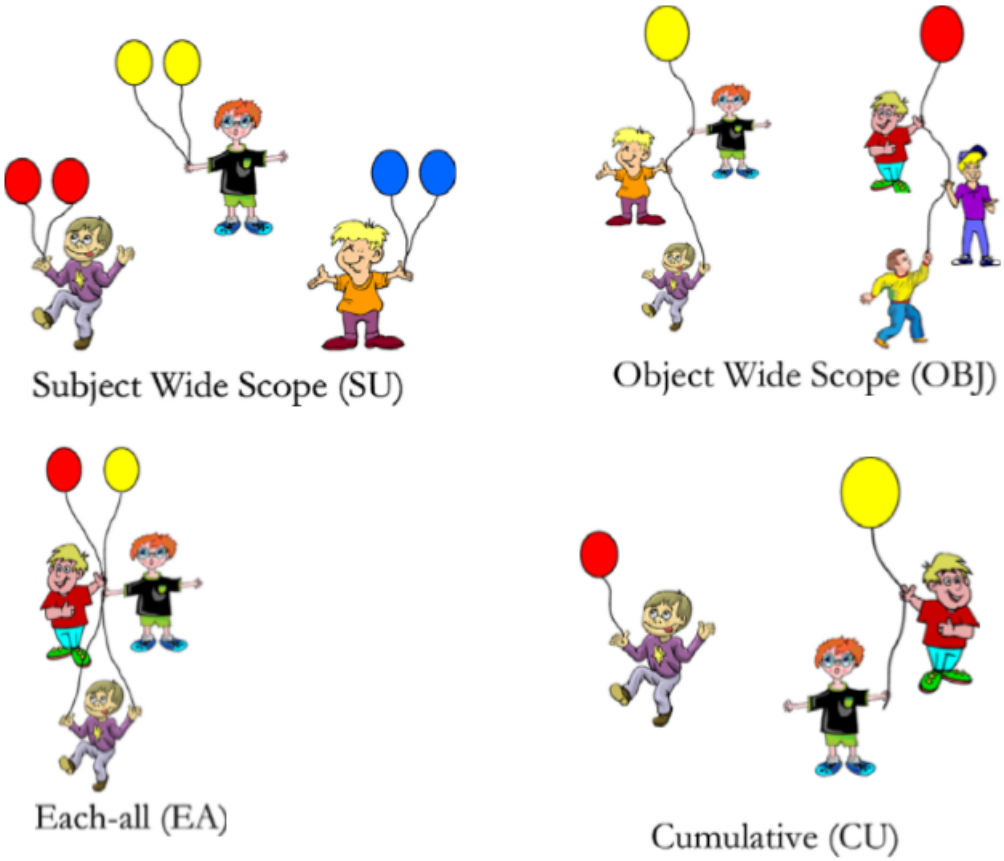

Figure 1. Experimental configurations for participants to select from. (Musolino, 2009, p.31-32)

Musolino thoroughly describes the relevant semantic theory of scope and logical analysis, making predictions along the way about how quantifiers influence interpretation. Then he introduces a Truth Value Judgment Task experiment to test both children and adults on their respective levels of acceptance of the various interpretations according to the quantifiers involved. The experiment utilizes short animated videos with quantifier-laden narration, following the pattern of the aforementioned balloon sentences, which the participants may deem correct or incorrect. The results of the study follow the predictions closely: Children behave like

adults in the *two N* situation, but not in the *each N* situation. They have the subject-wide interpretation of six balloons being present in the situation despite the number two appearing in the sentence, which demonstrates that they recognize the existence and properties of scope. In the *each N* condition, kids accepted the subject-wide and cumulative interpretations at much higher rates than adults, a discrepancy that forms a relevant data set for the present discussion. In terms of scope, the basis of adult interpretation of *each* is that *each* takes wide scope over other quantifiers. The question remains, if children understand scope, as shown by their adult-like preference for subject-wide scope in the double NQE sentence, why do they not grasp the wide scope of *each*? One answer is that it is related to the effects where children have difficulty accepting the universal quantifiers *all* or *every* in non-exhaustive contexts, as seen in previous research. The most relevant pieces of the study for our purposes are the control items that included sentences with *each* in subject position, presented in collective contexts, to ensure that children could reject sentences with multiple quantifiers:

1. Each boy is holding a balloon.
2. Each boy has an ice cream cone.

Adults accepted these sentences only 23.4% of the time, while children accepted them 85.1% of the time, consistent with the generalization that children lack a distributive restriction on the quantifier *each*. As a whole, this study adds to the pattern of children not fully grasping the properties of universal quantifiers until much later than expected, and makes a new contribution to the discussion with the explanation of scope.

Syrett and Musolino (2013)

Syrett and Musolino continued to build upon the foundation laid by Brooks and Braine, examining the development of collective and distributive interpretations of ambiguous numerical

expressions, such as “Two boys pushed a car.” Criticizing the forced-choice methods of Brooks & Braine (1996), they proposed the idea that children may be able to access both interpretations and simply have different preferences than adults. In order to test this theory, Syrett and Musolino conducted a series of experiments in which children heard a sentence and were asked to decide which picture it best represented, rather than accepting or rejecting a sentence in conjunction with one picture. In experiment 2, which presented subjects with sentences such as the one mentioned above, adults strongly preferred the collective interpretation, while children preferred the distributive. The sentences were made passive in experiment 3, which resulted in adults maintaining their collective interpretation and children increasing the rate of their collective interpretation. The word *together* was added to the active sentences in experiment 4, with the aim of amplifying the collective interpretation. Children selected the collective picture far more often than they had in experiment 2. These results clearly demonstrate that children understand both possible interpretations; it isn’t the case that they are unaware of the distinction between collective and distributive. Instead, they have access to both interpretations, but have different preferences than adults. These preferences are malleable; modifiers such as *together* and *each*, as well as passivization, can help to disambiguate sentences with numerical expressions. These results are not unrelated to the present hypothesis, in that Syrett and Musolino’s “preferences” may be a function of developing executive function.

Pagliarini et al. (2012)

The pattern of delayed quantifier development is present throughout the studies reviewed above, each one proposing potential explanations. Pagliarini et al. (2012) explored a new avenue, adding to the discussion the theory that collectivity and distributivity exist on a pragmatic scale, as proposed in Dotlačil (2010). Under this view, a conversational implicature would be generated

when the plural definite *i* (the) is used in Italian. Their view is that *i* is ambiguous between collective and distributive interpretations, but that the existence of *each* on the pragmatic scale makes use of *i* to convey a distributive interpretations infelicitous, by virtue of the availability of a more informative term. The opposite is not true since there is no quantifier expression that specifies collectivity in the lexically entailed way *each* specifies distributivity. *Together*, the closest equivalent, is an adverb, and therefore is not an equivalent quantificational expression, as it applies to events and not individuals. The authors conducted a modified truth value judgment task experiment, using static pictures, with Italian speakers, using the Italian quantifiers *ciascun* and *i*, which translate to *each* and *the (plural)* respectively. The results mirrored those of previous studies; that is, children accepted both quantifiers in both collective and distributive contexts, while adults discriminated between the two. As illustrated in the following table from Pagliarini et al. (2012, p. 394, Table 2), adults do not demonstrate a categorical interpretation of sentences with a plural definite article in subject position, but rather come to have a chance (50%) interpretation.

Table 2

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

Table 2. Proportion of Acceptance of Cond. A - ciascun *(each) In Distributive Contexts, Cond. B* - ciascun *(each) In Collective Contexts, Cond. C* - i *(plural definite) In Distributive Contexts, Cond. B* - i *(plural definite) In Collective Contexts*

Intriguingly, they found a statistical correlation between two of the conditions: acceptance of collective with *ciascun* and acceptance of distributive with *i*. As children acquire a more adult-like understanding of the distributive quantifier and reject the collective interpretation, they also begin to reject the distributive interpretation of the definite plural. As the concept of scalar implicature would suggest, children are learning the meaning of *ciascun*, and simultaneously learning that it would be used if its meaning was intended, therefore its absence indicates the default collective interpretation.

Padilla-Reyes, Grinstead, Nieves-Rivera & González-Bonilla (2015)

Fuelled by Pagliarini's hypothesis about a scalar implicature causing the delay in quantifier development (2012), researchers Padilla-Reyes, Grinstead, Nieves-Rivera, and Gonzalez-Bonilla conducted an experiment in Spanish to further examine adult collective and distributive interpretations, the relationship between lexical growth and children's propensity toward adult-like interpretations, and the possibility of an underlying scalar implicature uniting the development of the two interpretations. The experiment consists of a Truth Value Judgment Task within a video medium, featuring 36 experimental scenarios depicting collective and distributive actions, as well as 12 filler scenarios depicting "one" or "none" of the agents performing an action. The experimental items tested three quantifiers, *cada (each), unos (some), and los (plural the*), and six distinct predicates. An example sentence is "Unos minions empujaron una piedra" ("some minions pushed a rock"); the two scenes that accompany this particular sentence are included in Figure 2. They found that adults have categorical interpretations of the scenarios, overwhelmingly accepting *cada* for distributive scenarios and *unos* and *los* for collective scenarios, unlike Pagliarini's Italian-speaking adults. When running the task with children, the Test de Vocabulario en Imágenes Peabody, a standardized vocabulary

measure, was added. The younger children in the sample performed at chance level, but demonstrated a clear progression toward the categorical nature of adult interpretation. Also, the statistical calculations show that lexical development does appear to contribute to the advent of adult-like behavior, which had not been shown before. Additionally, and perhaps most importantly, Pagliarini's observation of a correlation between the levels of acceptability the distributive quantifier (*cada* in this case) in collective contexts and rejection of the collective quantifiers (*unos* and *los*) in distributive contexts was upheld. The data showing a connection between collective interpretations and distributive interpretations of these quantifiers, given in Table 3, lends support to the notion that the two are linked in a scalar implicature.

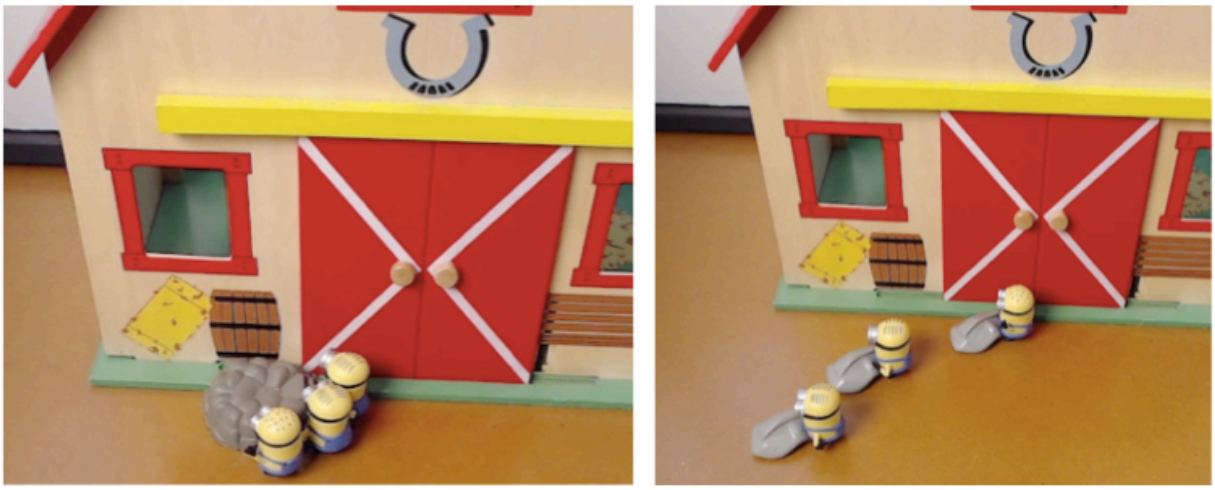

Figure 2. Respective collective and distributive scenarios corresponding to the predicate "… empujaron una piedra" (pushed a rock).

Groups	Los-Collective	Los-Distributive	Cada-Collective	Cada-Distributive	Unos-Collective	Unos-Distributive
5YO	%100	**%96**	**%72**	%100	%100	**%96**
6YO	%98	**%76**	**%66**	%99	%100	**%79**
7YO	%98	**%58**	**%58**	%96	%93	**%67**
8YO	%96	**%37**	**%24**	%94	%96	**%42**
9YO	%100	**%25**	**%32**	%96	%100	**%19**
10YO	%97	**%22**	**%19**	%100	%97	**%25**

Table 3. Proportion of Acceptance of Quantifiers In Distributive and Collective Contexts

Executive Function and Language

Miyake et al. (2000)

Because executive function is defined broadly across various analyses and publications, with an inconsistent combination of factors ranging from inhibition to planning, Miyake et al. (2000) conducted an investigation in search for a better model of overall executive function and in search of the relatively basic cognitive abilities that comprise it. They tested three such functions: attention/set shifting, updating and monitoring of working memory representations, and inhibition of pre-potent responses. The approach was twofold in that they asked both to what extent these are distinguishable executive functions and to what extent they are related in their contributions to an overall "executive function" measure. In order to answer these questions, they set up an experiment using the latent variables and factor analysis structure shown in Figure 3. 137 undergrads completed these 9 tasks, plus 5 that are commonly used to measure complex

executive function. According to the data, Miyake et al. states that "even though they are clearly distinguishable, the three latent variables share some underlying commonality. Thus, the three target executive functions show signs of both unity and diversity" (p 24). This demonstrates that they are reliable measures of independent executive function abilities, yet they also contribute collectively to the umbrella of executive function. Following the model set forth in Miyake et al.'s analysis, the executive function measures used in the current study include set shifting, working memory, and inhibition.

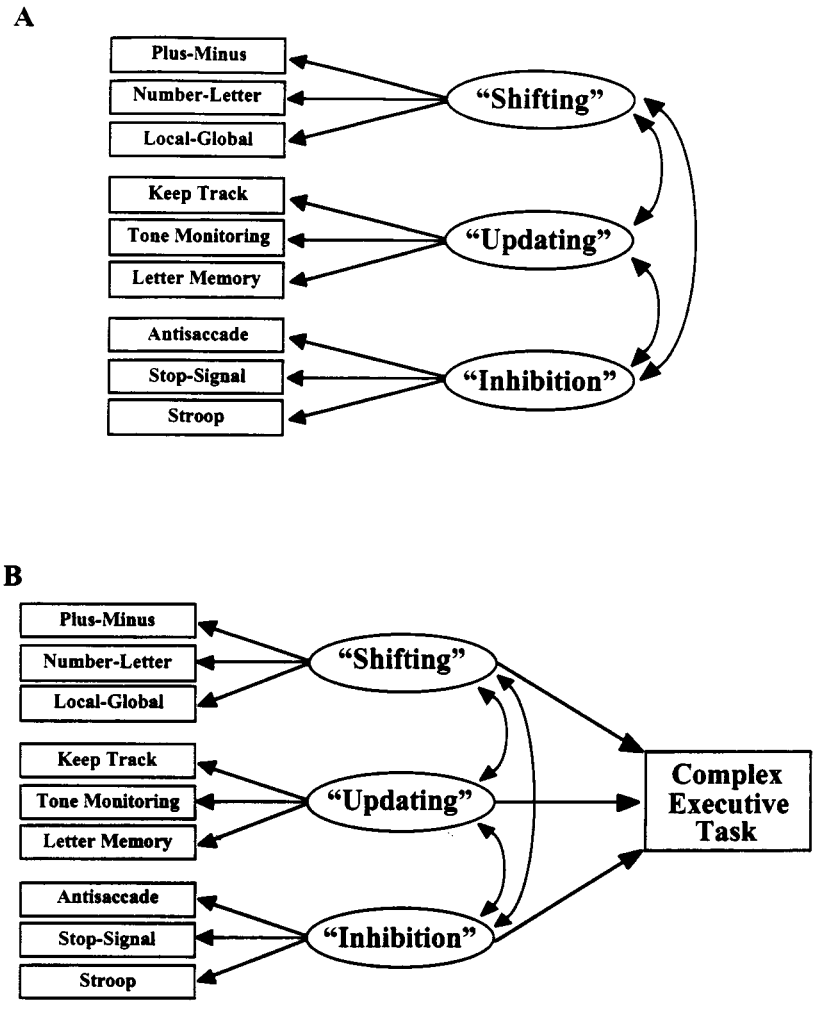

Figure 3. Factor analysis/latent variable/structural equation modeling flowchart. Miyake et al. (2000) page 12.

Miyake et al.'s (2000) three factor model seems to be widely cited in the developmental psychological and linguistic literature. We will follow Miyake et al. and use measures from the EXAMINER battery, as they seem possible to use with children and do not seem to be too language- or culture-specific.

Kapa & Colombo (2014)

Bringing together the summaries and analyses of several previous studies on children and quantifiers is the hypothesis that the questions asked within these studies ought to be examined in terms of children's developing executive function and working memory. Having suggested that executive function and working memory might be part of the solution to these puzzles, it is essential that we now support this possibility by turning to the already-established relationship between executive function and language processing.

According to Kapa and Colombo (2014), executive function is a collection of higher order cognitive skills, including inhibitory control, cognitive flexibility, attention shifting, and attentional monitoring, which work together to regulate behavior, thoughts, and attention (237). In their 2014 study, they examined the relationship between bilingualism and higher levels of executive function by teaching monolingual adults and preschool children an artificial language and performing a battery of cognitive tests. These tests included digit span, visual Simon task, attention network test, and Wisconsin Card Sorting Task for adults and Dimensional Change Card Sort for children. Language proficiency was measured by six tests of expressive and receptive knowledge related to vocabulary, sentence construction, and grammaticality judgment.

For adult learners, the only significant EF predictor of language-learning ability was ANT, or inhibition. For children, the significant EF predictor was the DCCS task, or attention shifting.

Overall, the results showed that learners with higher EF skills had greater success in learning the artificial language. This shows that the established correlation between bilingualism and high EF may be bidirectional; that is, linguistic proficiency has an influence on cognitive ability, but cognitive ability also has an influence on linguistic proficiency. Although we are not interested in bilingualism, this information is still quite relevant. The primary takeaway for us is that executive function can influence language development as a whole, despite it being a general cognitive ability rather than a language-specific ability. This knowledge is vital for the present study, in which it is hypothesized that executive function has an effect on the semantic and syntactic processing in one's native language.

Janssens et al. (2014)

Just as Kapa and Colombo (2014) described the link between executive function and language processing, previous research has also been done on the relationship between scalar implicature processing and working memory in children. Janssens et al. (2014) performed a series of experiments with 3, 5, and 7 year old Dutch children in order to determine the exact nature of this relationship. The working memory tests involved in the study included the Digit Span Forward, Digit Span Backward, and Corsi Block Span tests. In addition, they studied the effects of task type on pragmatic implicature by asking each child to complete a TVJT and an Action-Based Task (ABT), which required children to process and respond to sentences such as "Some marbles are (not) in the boxes" and "I would like some boxes (not) to contain a marble,"

respectively. In the latter task, children must perform an action to add or remove marbles to make the statement true. As expected, the older children responded more pragmatically than the younger children. In experiment 1, 3 year olds produced pragmatic responses approximately half the time, whereas five year olds produced pragmatic responses approximately 80% of the time. In experiment 3, the 7 year olds produced pragmatic responses even more often, at over 90% of the time. There was a clear effect of the type of task: ABT is easier than TVJT in that it provokes more correct responses, but not necessarily more pragmatic responses. There was no significant effect of WM, except on unambiguous control sentences in experiment 2. This information is in opposition to our hypothesis, but there is reason to believe that our results will be different. The documented WM effect in adults is quite small, and the sample size in this study is also rather small. As such, there may not be enough variation in the data to make the effect visible. With the 3 year olds performing at a chance level, it is unlikely that differences in working memory capacity among the 3 year olds would be significant. For these reasons, it will be important and interesting to see how nearly doubling the sample size and expanding the age range might assist in finding an effect of working memory capacity on pragmatic implicature.

Research Questions

1. Does adult English behave like Spanish with respect to collective-distributive interpretations of the quantifiers *some*, *the,* and *each*?
2. Do executive function measures predict developing collective-distributive interpretations in English and Spanish?
3. What relative role do lexicon, working memory, set-shifting and inhibition play in explaining children's collective-distributive interpretations?

Experiment 1 – Adult English

Having shown that Spanish-speaking adults interpret quantifiers in a clear, categorical manner, we set out to determine if English-speaking adults behave similarly. Knowing what adult behavior looks like allows us to compare child behavior and track progress toward adult behavior. This experiment is meant to answer research question 1: Does adult English behave like Spanish with respect to collective-distributive interpretations of the quantifiers *some*, *the,* and *each*? Do executive function measures predict developing collective-distributive interpretations in English? The phonetic variant of *some* we will be using is *sm* (as in e.g. Milsark 1974), as it seems to have similar properties to *unos* in Spanish.

Methodology

Participants

22 monolingual English-speaking adults from the undergraduate population of OSU make up the sample for this experiment. The sample included 7 females and 15 males, ranging in age from 18 to 23 years, with a mean of 19.8 years and standard deviation of 1.14 years.

Procedures

Participants were asked to fill out a questionnaire about their biographical information and language development. In order to be included in the sample, participants had to meet the following criteria:

- Not be exposed to a language other than English, except in language classes in school;
- have no concerns of speech, hearing, or language problems;
- have no family history of speech, hearing, or language problems.

Next, participants were given a subset of non-linguistic cognitive measures called EXAMINER, focusing on executive function. Participants took three tests from the battery, including the Flanker task to measure inhibition, set shifting to measure attention, and dot counting to measure non-verbal working memory. The tests are presented on a computer screen and take approximately thirty minutes to complete in total.

Finally, adult participants took the experimental linguistic measure of collective-distributive knowledge, which is a variation on Padilla-Reyes' (2016) video recorded Truth Value Judgment Task. Participants watch a compilation of short stop-motion videos, each depicting a group of three minion characters performing actions either together (collectively) or individually (distributively). The videos are accompanied by a prerecorded narration in a female voice. The narration is identical to that of Padilla-Reyes' work, simply translated into English, as in the following example.

1. Example English Scenario, Based On Padilla-Reyes (2016)

> "The minions are working on the farm and they have to catch a goose. There's more than one; how are they gonna do it? … I know how they did it. Some minions caught a goose."

The quantifier is manipulated among the videos such that *some* is exchanged for *each* or *the* in an equal distribution. These videos make up the stimuli for the Truth Value Judgment Task (TVJT); participants are asked to judge whether the narration was correct for each video. Clips were arranged into three different orders, which were administered at random to the participants. There were no significant differences arising from the order of presentation ($p > .05$). Each order begins with four practice clips that do not contain quantifiers to accustom participants to the

nature of the task, then 36 experimental items, and 12 filler items, which also lack plural quantifiers, and consequently do not allow distributive/collective interpretations in the adult language. The purpose of the filler items is to ensure that participants are paying attention. Example sentences include:

2. Example Experimental and Filler Sentences

Experimental – Each minion carried a bag.

Filler – One minion could open a door.

Participants had to perform above chance level on the filler items, meaning 10 or more correct responses out of 12, in order to be included in the sample.

Results

Questionnaire questions and results

Of the 22 adults who participated in the experiment, 9 reported that they have some exposure to a language other than English, including Chinese, Korean, Latin, Arabic, French, American Sign Language, and Hebrew. Of these, 7 are enrolled in foreign language classes at Ohio State, which meet multiple times a week, and 2 have families at home that speak another language. However, all 9 of these participants are native speakers of English. 4 adults out of the group of 22 reported a history of speech-language concerns, all 4 consisting of minor speech-sound delays in preschool or elementary school.

EXAMINER tasks

	Flanker score	Flanker incongruent mean	Flanker total mean	Dot counting	Shift score	Shift mean RT
Mean	9.256 (0.372)	0.634 (0.089)	0.577 (0.144)	19.05 (3.818)	8.828 (0.644)	0.654 (0.191)

Table 4. Adult English-speakers' mean EXAMINER scores and standard deviations.

The mean Flanker score – that is, combined accuracy and reaction time score out of 10 – for the adults was 9.256, with a standard deviation of 0.372. The mean reaction time for the incongruent trials of the Flanker task was 0.634 seconds, with a standard deviation of 0.089 seconds. The overall mean reaction time for the Flanker task was 0.577 seconds, with a standard deviation of 0.144 seconds. The mean dot counting score was 19.05 out of a possible 27, with a standard deviation of 3.818. The mean Shift score – again, combined accuracy and reaction time score out of 10 – was 8.828, with a standard deviation of 0.644. The mean reaction time for the Shift task was 0.654 seconds, with a standard deviation of 0.191 seconds.

English TVJT experiment

	Collective context	Distributive context
Each	0.038	0.962
Some	0.917	0.159
The	0.985	0.152

Table 5. Adult English speakers' acceptance of quantifiers in collective and distributive contexts.

Adults accepted sentences containing *each* in the collective context at a rate of 3.8%, while they accepted *each* in the distributive context at a rate of 96.2%. They accepted *some* in

the collective context at a rate of 91.7%, while they accepted *some* in the distributive context at a rate of 15.9%. They accepted *the* in the collective context at a rate of 98.5%, while they accepted *the* in the distributive context at a rate of 15.2%.

Discussion

As anticipated, adults overwhelmingly reject *each* in collective contexts and *some* and *the* in distributive contexts. This can be clearly visualized in Figure 4.

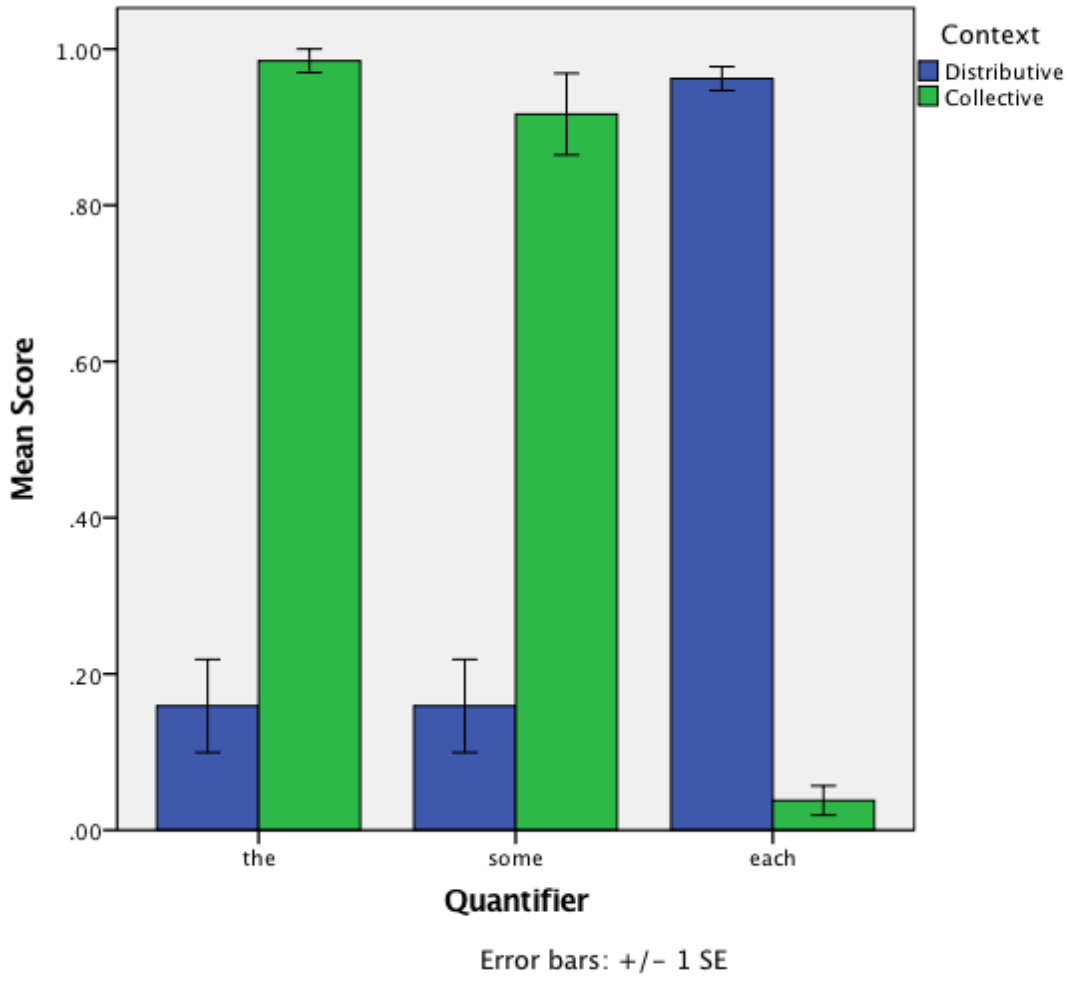

Figure 4. Mean acceptance rates of quantifiers in distributive and collective contexts in adult English.

The most notable outcome here is that English looks quite similar to Spanish in terms of the categorical nature of the judgments, even in a small sample of adults. These data also provide a baseline for the developmental trajectory we expect to see in children's interpretations, helping to define what a "correct" response for a child might be. When investigating correlations between executive function measures and quantifier interpretations, we found that there was not enough variance to observe any predictive relationships.

Experiment 2 – Child Spanish Collective-Distributive Interpretations and Executive Function

This experiment was designed to explore research question 2: Do executive function measures predict developing collective-distributive interpretations in Spanish? The experiment will enable the identification of the unique contributions of lexical development and executive function and working memory development as a means of understanding their relative contributions to the development of children's interpretations of quantifiers in collective and distributive contexts. Padilla-Reyes' data regarding Spanish-speaking children's quantifier interpretations show a pattern of children progressing from chance level to the acquisition of adult-like behavior. We anticipate the same pattern, with additional information about the possible cognitive mechanisms driving this progression.

Methodology

Participants

31 monolingual Spanish-speaking Puerto Rican children comprise the sample for Experiment 2. They were located through and tested at four different summer day camps in the

San Juan metropolitan area. They range in age from 83 to 107 months, with a mean of 95.25 months and a standard deviation of 7.43 months.

Procedures

As part of the process of gaining parental consent for their child's participation, parents were asked to fill out a questionnaire about their child's biographical information and language development. In order to be included in the sample, children had to meet the following criteria:

- Not be exposed to a language other than Spanish, except English in music, on tv, and in language classes in school;
- have no concerns of speech, hearing, or language problems, by parental report;
- have no family history of speech, hearing, or language problems, by parental report.

To measure the contribution of lexical development to children's interpretations, as in Padilla-Reyes et al (2016), children were asked to take a standardized vocabulary test – the Test de Vocabulario en Imágenes Peabody (TVIP). The child must select the correct picture, out of four choices, to match the word uttered by the tester. For purposes of accurate pronunciation, it was administered only by native Spanish speakers, who were two research assistants recruited from the University of Puerto Rico. The standardized scores used in this experiment were those normed for Puerto Rican Spanish.

Like the adult sample from Experiment 1, the child participants in Experiment 2 also took the three tests from the EXAMINER battery. The version used in this experiment contains instructions in Spanish and minor visual enhancements to engage children, such as fish figures instead of arrows.

Finally, the participants underwent Padilla-Reyes' (2016) video recorded Truth Value Judgment Task in order to test collective and distributive interpretations. As these children are Spanish-speakers, the original Spanish narration was used, such as in the following example scenario:

3. "Los minions están trabajando en la finca y tienen que atrapar un ganso. Hay más de uno. ¿Cómo lo harán? … Ya sé cómo lo hicieron. Unos minions atraparon un ganso."

The quantifier is manipulated among the videos such that *unos* is exchanged for *cada* or *los* in an equal distribution. As in Experiment 1, each video contains four practice clips that do not contain quantifiers to accustom participants to the nature of the task, then 36 experimental items, and 12 filler items, which also lack plural quantifiers, and consequently do not allow distributive/collective interpretations in the adult language. The purpose of using non-distributional quantifiers was to establish that children could 1) do our task reliably and 2) handle quantifier interpretations in general. Example sentences include:

4. Experimental – Cada minion cargó una bolsa.

   Filler – Un minion pudo abrir una puerta.

Participants had to perform above chance level on the filler items, meaning 10 or more correct responses out of 12, in order to be included in the sample.

Results

Questionnaire questions and results

13 out of the 31 (42%) parents of the participants completed the questionnaire. All 13 of the parents reported that their child was regularly exposed to English, as would be expected due

to school classes, but did not identify them as bilingual. No other language exposure was reported. 4 children had suffered from ear infections, but no other speech, language, or hearing development concerns were reported. Maternal education level ranged from 6 to 20 years, with a mean of 16.273 years and a standard deviation of 4.077 years, excluding two data points due to one lack of response and one parent who misunderstood the question and answered that their child had one year of education.

TVIP - Lexical development test

	Mean (standard deviation)
7 year olds	111.470 (14.392)
8 year olds	115.071 (15.269)
Combined 7 and 8 year olds	112.192 (14.827)

Table 6. Child Spanish-speakers' standard TVIP scores

On the TVIP test, 7 year old children had a mean standardized score of 111.470, with a standard deviation of 14.392. 8 year olds had a mean standardized score of 115.071, with a standard deviation of 15.269. The mean score of the group overall was 112.192, with a standard deviation of 14.827.

	Flanker score	Flanker incongruent mean	Flanker total mean	Dot counting	Shift score	Shift mean RT
7 year olds	6.802 (1.160)	1.546 (0.414)	1.484 (0.440)	7.722 (3.893)	5.073 (0.849)	1.695 (0.398)
8 year olds	7.218 (1.549)	1.236 (0.287)	1.132 (0.245)	8.846 (3.555)	6.611 (0.563)	1.241 (0.338)
Combined	6.603 (2.563)	1.183 (1.228)	1.315 (0.389)	8.467 (3.702)	5.909 (0.959)	1.555 (0.461)

Table 7. Child Spanish-speakers' mean EXAMINER scores and standard deviations.

The mean Flanker score – that is, combined accuracy and reaction time score out of 10 – for the 7 and 8 year olds combined was 6.603, with a standard deviation of 2.563. The mean reaction time for the incongruent trials of the Flanker task was 1.183 seconds, with a standard deviation of 1.228 seconds. The overall mean reaction time for the Flanker task was 1.315 seconds, with a standard deviation of 0.389 seconds. The mean dot counting score was 8.467 out of a possible 27, with a standard deviation of 3.702. The mean Shift score – again, combined accuracy and reaction time score out of 10 – was 5.909, with a standard deviation of 0.959. The mean reaction time for the Shift task was 1.555 seconds, with a standard deviation of 0.461 seconds. Across all measures, 7 year olds had lower accuracy and longer reaction times than 8 year olds, as expected.

Spanish TVJT experiment

	Cada		*Unos*		*Los*	
	Collective	Distributive	Collective	Distributive	Collective	Distributive
7 year olds	.559 (.433)	.912 (.205)	.951 (.098)	.529 (.430)	.980 (.081)	.480 (.448)
8 year olds	.393 (.396)	.964 (.097)	.917 (.109)	.333 (.376)	.952 (.121)	.381 (.400)
Combined	.484 (.418)	.935 (.165)	.935 (.103)	.441 (.412)	.968 (.100)	.435 (.423)

Table 8. Child Spanish speakers' acceptance of quantifiers in collective and distributive contexts.

Spanish-speaking children (combined 7 and 8 year old groups) accepted sentences containing *cada* in the collective context at a rate of 48.4% (standard deviation = 41.8%), while they accepted *cada* in the distributive context at a rate of 93.5% (standard deviation = 16.5%). They accepted *unos* in the collective context at a rate of 93.5% (standard deviation = 10.3%), while they accepted *unos* in the distributive context at a rate of 44.1% (standard deviation = 41.2%). They accepted *los* in the collective context at a rate of 96.8% (standard deviation = 10.0%), while they accepted *los* in the distributive context at a rate of 43.5% (standard deviation = 42.3%).

Discussion

These data confirm the results from Padilla-Reyes et al. (2016), in that Spanish-speaking children tend to accept collective and distributive quantifiers in the opposite contexts at much higher rates than adults do, as seen in Figure 5.

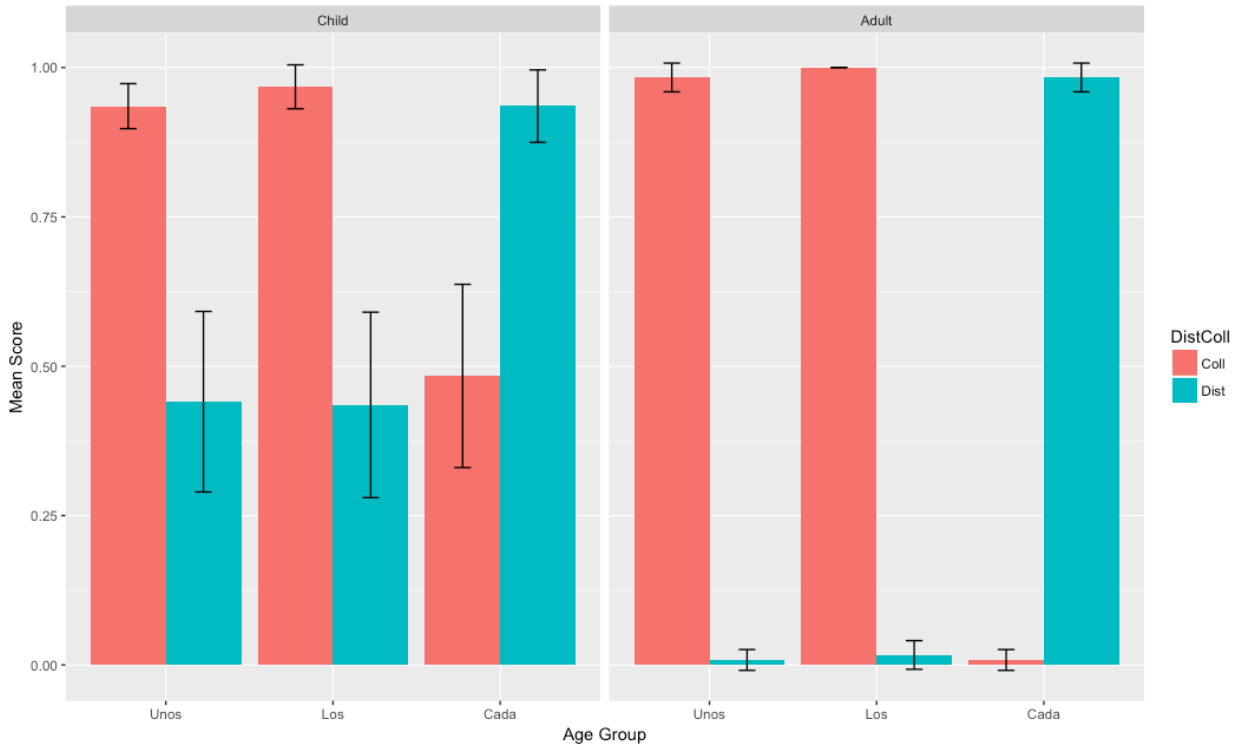

Figure 5. Comparison of mean acceptance rates of quantifiers in collective and distributive contexts in child and adult Spanish.

Additionally, there are strong correlations between the acceptance levels of *unos* in distributive contexts, *los* in distributive contexts, and *cada* in collective contexts, shown below in Table 9.

	Unos Dist	*Los* Dist	*Cada* Col
Unos Dist Pearson Correlation	1	.923	.721
Los Dist Pearson Correlation	.923	1	.664
Cada Col Pearson Correlation	.721	.664	1

Table 9. Correlations among child Spanish acceptance of quantifiers in incongruent contexts; all $p<.001$

The correlations remain strong when age is partialled out, as seen in Table 10.

	Unos Dist	*Los* Dist	*Cada* Col
Unos Dist Pearson Correlation	1.000	.918	.687
Los Dist Pearson Correlation	.918	1.000	.632
Cada Col Pearson Correlation	.687	.632	1.000

Table 10. Correlations among child Spanish acceptance of quantifiers in incongruent contexts, controlling for age; all p <.001

Even with age and vocabulary (raw TVIP score) partialled out, Table 11 shows that there are still strong correlations between these acceptance levels.

	Unos Dist	*Los* Dist	*Cada* Col
Unos Dist Correlation	1.000	.892	.568
Los Dist Correlation	.892	1.000	.512
Cada Col Correlation	.568	.512	1.000

Table 11. Correlations among child Spanish acceptance of quantifiers in incongruent contexts, controlling for age and lexical development; all p < .005

We find a strong association among the three quantifiers. They develop in a linked fashion, which Padilla-Reyes et al. argue is indicative of the pragmatic scale of collectivity and distributivity developing, following Dotlačil (2010). There is an inconsistent association of executive function measures with quantifier interpretation, but our sample size is small. These executive function measures are addressed again in the Global Discussion with the addition of the English-speaking children sample.

Experiment 3 – Child English Collective-Distributive Interpretations and Executive Function

The data from Experiment 2 complement those gathered by Padilla-Reyes et al. (2016), but the results from Experiment 3 extend further to determine whether the same phenomenon and explanation can be observed in child English, which is addressed by research question 2: Do executive function measures predict developing collective-distributive interpretations in English? As in experiment 2, the aim of this experiment is to identify the unique contributions of lexical development and executive function and working memory development as a means of understanding their relative contributions to the growth of children's interpretations of quantifiers.

Methodology

Participants

29 monolingual English-speaking children from three after-school programs near the OSU Columbus campus make up the sample for this experiment. Several of the children have parents who work in academia at OSU, and therefore have extremely high maternal levels of education. The participants range in age from 84 to 107 months, with a mean of 95.37 months and a standard deviation of 7.74 months.

Procedures

Just as in Experiment 2, parents were asked to fill out a questionnaire about their child's biographical information and language development. In order to be included in the sample, children had to meet the following criteria:

- Not be exposed to a language other than English, except in language classes in school, by parental report;
- have no concerns of speech, hearing, or language problems, by parental report;
- have no family history of speech, hearing, or language problems, by parental report.

In order to measure lexical development, children completed the Peabody Picture Vocabulary (PPVT), which is the English equivalent of the TVIP used in Experiment 2.

English-speaking children also participated in the EXAMINER battery of executive function and cognitive ability tests, presented in English with the child-focused imagery described in Experiment 2.

Finally, the children participate in the linguistic interpretation test, which is the English translation of Padilla-Reyes' (2016) video recorded Truth Value Judgment Task, described in Experiment 1.

Results

Questionnaire questions and results

24 out of the 29 (83%) parents of the participants completed the questionnaire. 3 of the parents reported that their child was regularly exposed to a language other than English, but did not identify them as bilingual. 2 parents reported that their children had delayed speech (at 2 years old), and 17 parents reported that their children had suffered from ear infections, but no other speech, language, or hearing development concerns were reported. Maternal education level ranged from 16 to 20 years, with a mean of 17.2 years and a standard deviation of 1.4 years, excluding six data points due to lack of response to the question.

PPVT – Lexical development test

	Mean (standard deviation)
7 year olds	119.294 (13.322)
8 year olds	113.75 (12.166)
Combined 7 and 8 year olds	117 (12.934)

Table 12. Child English-speakers' PPVT scores.

On the PPVT test, 7 year old children had a mean standardized score of 119.294, with a standard deviation of 13.322. 8 year olds had a mean standardized score of 113.75, with a standard deviation of 12.166. The mean score of the group overall was 117.000, with a standard deviation of 12.934.

EXAMINER tasks

	Flanker score	Flanker incongruent mean	Flanker total mean	Dot counting	Shift score	Shift mean RT
7 year olds	7.334 (1.061)	1.313 (0.436)	1.267 (0.420)	10.118 (4.299)	6.253 (0.843)	1.468 (0.447)
8 year olds	8.256 (0.541)	0.901 (0.176)	0.892 (0.170)	9.833 (4.970)	6.765 (0.657)	1.157 (0.298)
Combined 7 and 8 year olds	7.715 (0.986)	1.143 (0.384)	1.112 (0.384)	10.000 (4.504)	6.465 (0.801)	1.339 (0.416)

Table 13. Child English-speakers' mean EXAMINER scores and standard deviations.

The mean Flanker score – that is, combined accuracy and reaction time score out of 10 – for the 7 and 8 year olds combined was 7.715, with a standard deviation of 0.986. The mean reaction time for the incongruent trials of the Flanker task was 1.143 seconds, with a standard deviation of 0.384 seconds. The overall mean reaction time for the Flanker task was 1.112 seconds, with a standard deviation of 0.384 seconds. The mean dot counting score was 10.000 out of a possible 27, with a standard deviation of 4.504. The mean Shift score – again, combined accuracy and reaction time score out of 10 – was 6.465, with a standard deviation of 0.801. The mean reaction time for the Shift task was 1.339 seconds, with a standard deviation of 0.416 seconds. Across all measures except for dot counting, 7 year olds had lower accuracy and longer reaction times than 8 year olds, as expected.

English TVJT experiment

	Each		*Some*		*The*	
	Collective	Distributive	Collective	Distributive	Collective	Distributive
7 year olds	.235 (.382)	.912 (.086)	.931 (.205)	.304 (.335)	.971 (.066)	.323 (.341)
8 year olds	.264 (.379)	.930 (.112)	.861 (.223)	.305 (.388)	.931 (.132)	.361 (.413)
Combined	.247 (.374)	.919 (.096)	.902 (.211)	.304 (.351)	.954 (.099)	.339 (.366)

Table 14. Child English speakers' acceptance of quantifiers in collective and distributive contexts.

English-speaking children (combined 7 and 8 year old groups) accepted sentences containing *each* in the collective context at a rate of 24.7% (standard deviation = 37.4%), while they accepted *each* in the distributive context at a rate of 91.9% (standard deviation = 9.6%). They accepted *some* in the collective context at a rate of 90.2% (standard deviation = 21.1%), while they accepted *some* in the distributive context at a rate of 30.4% (standard deviation =

35.1%). They accepted *the* in the collective context at a rate of 95.4% (standard deviation = 9.9%), while they accepted *the* in the distributive context at a rate of 33.9% (standard deviation = 36.6%).

Discussion

The results are extremely similar to those from Experiment 2: Child interpretations are far less categorical than those of their adult counterparts, as seen in Figure 6.

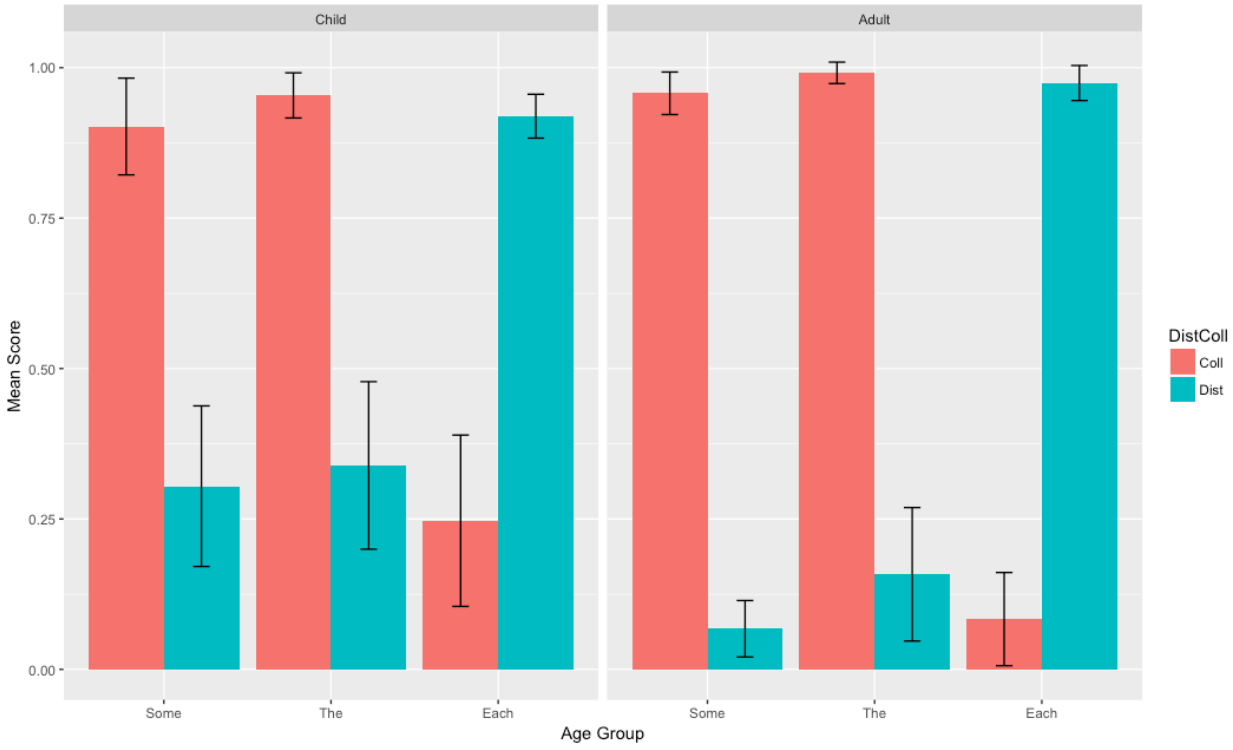

Figure 6. Comparison of mean acceptance rates of quantifiers in collective and distributive contexts in child and adult English.

As in child Spanish, we find a strong association among the three quantifiers, along with the same pattern of linked development that follows the Padilla-Reyes et al. (2016) and Dotlačil (2010) arguments regarding a pragmatic scale of collectivity and distributivity.

	Some Dist	*The* Dist	*Each* Col
Some Dist Pearson Correlation	1	.910	.789
The Dist Pearson Correlation	.910	1	.761
Each Col Pearson Correlation	.789	.761	1

Table 15. Correlations among child English acceptance of quantifiers in incongruent contexts; all p<.001

The correlations remain strong when age is partialled out.

	Some Dist	*The* Dist	*Each* Col
Some Dist Pearson Correlation	1.000	.912	.783
The Dist Pearson Correlation	.912	1.000	.756
Each Col Pearson Correlation	.783	.756	1.000

Table 16. Correlations among child English acceptance of quantifiers in incongruent contexts, controlling for age; all p<.001

Even with age and vocabulary (raw PPVT score) partialled out, there are still strong correlations between these acceptance levels.

	Some Dist	*The* Dist	*Each* Col
Some Dist Correlation	1.000	.903	.746
The Dist Correlation	.903	1.000	.729
Each Col Correlation	.746	.729	1.000

Table 17. Correlations among child English acceptance of quantifiers in incongruent contexts, controlling for age and lexical development; all p<.001

Again, we see inconsistent associations of executive function measures with quantifier interpretation, but due to the small sample size, these questions will be addressed in the broader context of both samples of children.

Global Discussion

Stepping back to assess both child-focused experiments, we can begin to answer research question 3: What relative role do lexicon, working memory, attention, and inhibition play in explaining children's collective-distributive interpretations?

In order to best answer this question, it will be beneficial to consider the data as one set of children, rather than two separate sets based on language. Before we are able to commence data analysis of the children overall, we demonstrate that they are sufficiently similar to merit combination into one group: Overall, adult English and Spanish appear very similar. In our small adult samples, there were slightly more categorical answers in Spanish than in English. English and Spanish 7 and 8 year-olds were only statistically different from one another in *cada/each* in collective contexts. The other five quantifier/context pairings were not significantly different from one another. In both languages, PPVT/TVIP predicted *cada*/*each* acceptance, as well as the other quantifier/context pairings. Therefore, we are comfortable combining both child populations in order to analyze them as a set of 60.

First, in Figure 7 we compare quantifier interpretation only across age group – children against adults. As a whole, children are more accepting of these three quantifiers in both collective and distributive contexts than adults are, regardless of language.

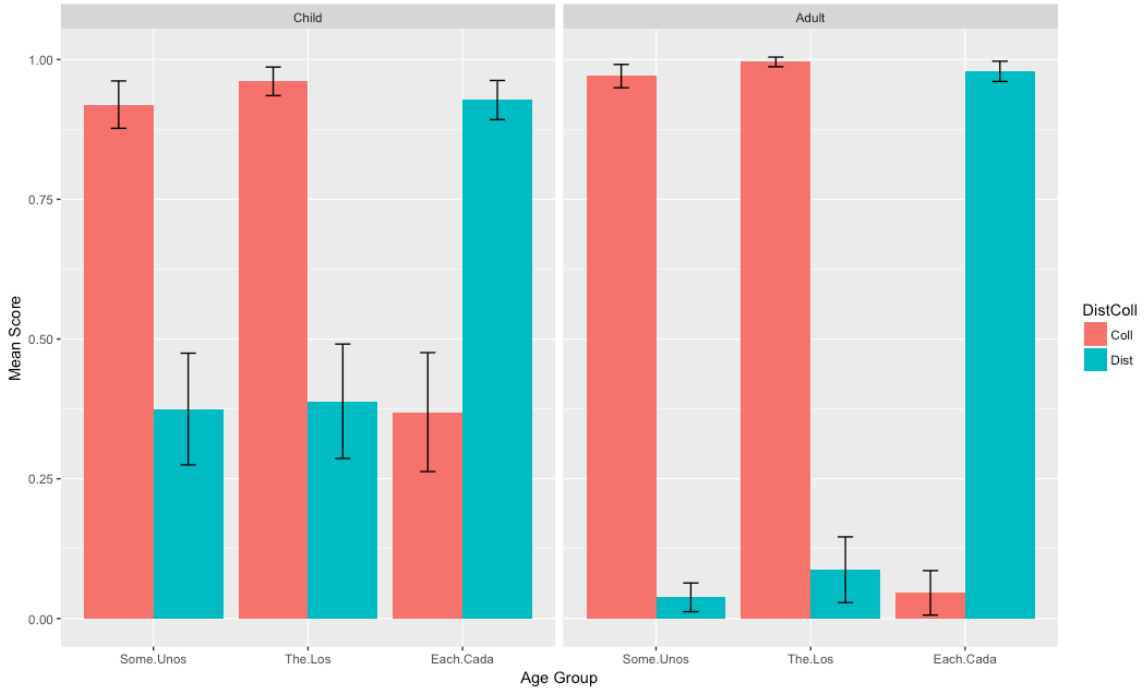

Figure 7. Age comparison of quantifier judgments for both English- and Spanish-speaking samples combined

Next, in Figures 8 and 9 we look within age groups and across languages to see how English-speaking children's interpretations differ from Spanish-speaking children's interpretations, and how English- and Spanish-speaking adults differ, as well.

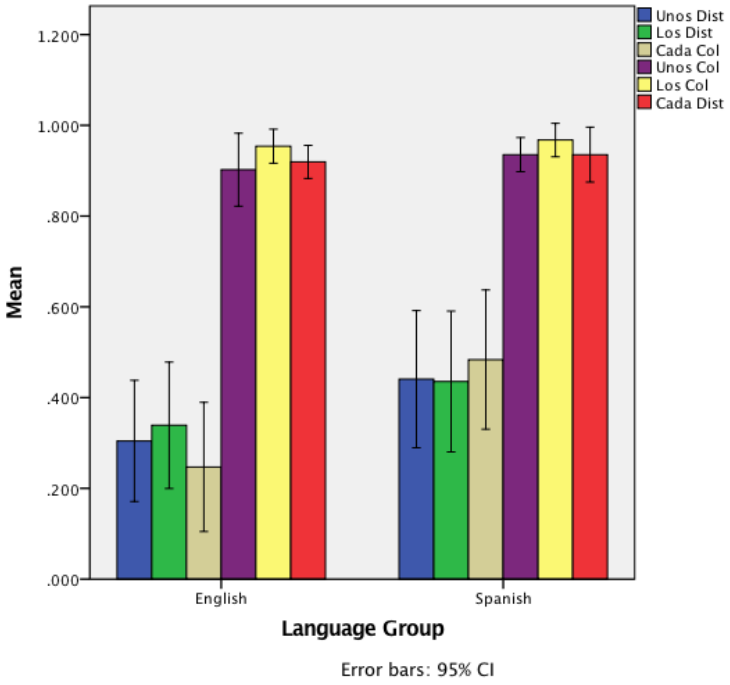

Figure 8. Child judgments, separated by language spoken.

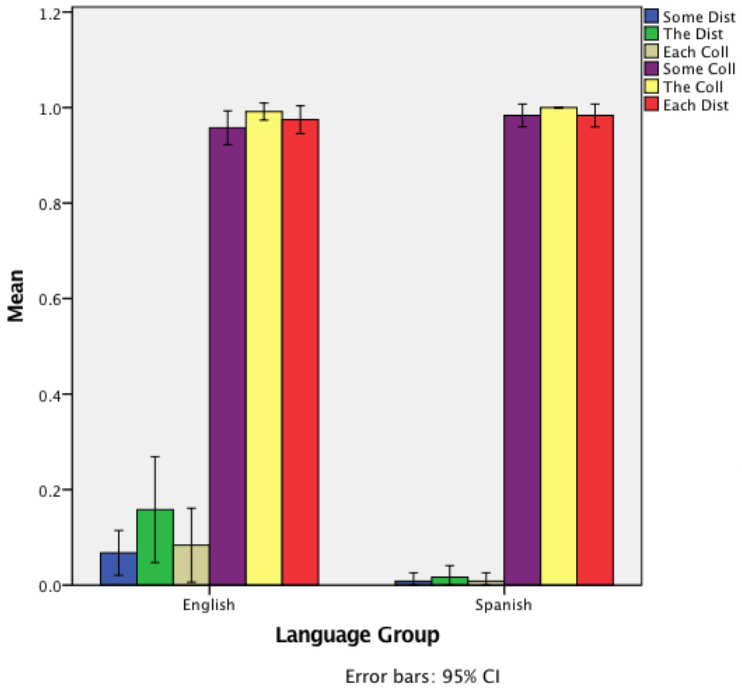

Figure 9. Adult judgments, separated by language spoken.

From these two figures, we can see that Spanish-speaking adults tend to have more strictly categorical judgments than English-speaking adults, but the reverse is true of the children.

After demonstrating the categorical nature of adult judgments and comparing child judgments, we then turn to the true question under discussion. We conducted a linear regression analysis to observe the relationships between these quantifier judgments and the executive function measures, specifically the rejection of the quantifiers in their respective inappropriate contexts. The data are log-transformed, using (log[1+ x]), in order to normalize them and eliminate zero values. One extreme outlier in the model was removed, as determined by Mahalanobis Distance. Therefore, n=59. There are three separate models, each featuring one of three dependent variables: Rejection of *cada/each* in collective, rejection of *unos/some* in distributive, and rejection of *los/the* in distributive. There are seven dependent variables, including PPVT/TVIP standardized score, Flanker score, Flanker incongruent mean reaction

time, Flanker total mean reaction time, Dot counting score, Shift score, and Shift mean reaction time.

Cada/Each *in Collective*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	9.699	2.110		4.596	.000
	tPPVTstandard	-.993	.292	-.422	-3.405	.001
	tFlanker	-.371	.598	-.182	-.621	.538
	tDot	.018	.091	.027	.199	.843
	tShiftScore	-1.539	.549	-.714	-2.800	.007
	tFlIncongMean	.369	.987	.241	.374	.710
	tFlTotalMean	-.682	1.074	-.434	-.635	.528
	tShiftMeanRT	-.821	.421	-.537	-1.952	.057

a. Dependent Variable: tCadaColl

Figure 10. Linear regression analysis of acceptance of each/cada in collective contexts with lexical and executive function development.

Here we see that lexical development (as measured by PPVT standardized score) is a strong significant predictor of the ability to reject *cada/each* in collective, with p = .001 and r^2=0.178. Attention, as measured by ShiftScore (combined accuracy and reaction time score), is also a strong significant predictor, with p = .007 and r^2=0.51. The reaction time component of the attention task, ShiftMeanRT, is borderline significant on its own, as well, with p = .057 and r^2=0.288.

Unos/Some *in Distributive*

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.519	2.004		4.250	.000
	tPPVTstandard	-1.107	.277	-.502	-3.995	.000
	tFlanker	-.508	.568	-.266	-.894	.376
	tDot	.107	.087	.165	1.226	.226
	tShiftScore	-.834	.522	-.413	-1.599	.116
	tFlIncongMean	.134	.937	.093	.143	.887
	tFlTotalMean	-.277	1.020	-.188	-.271	.787
	tShiftMeanRT	-.467	.400	-.326	-1.169	.248

a. Dependent Variable: tUnosDist

Figure 11. Linear regression analysis of acceptance of each/cada in collective contexts with lexical and executive function development.

Again, we see that lexical development (PPVT standardized score) is a significant predictor of the ability to reject *unos/some* in distributive, with $p < .001$ and $r^2=0.252$. However, attention is not a significant predictor for this relationship, nor is any other executive function measure.

Los/The *in Distributive*

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.346	2.183		3.365	.002
	tPPVTstandard	-1.084	.302	-.471	-3.592	.001
	tFlanker	-.781	.619	-.391	-1.262	.213
	tDot	.085	.095	.127	.900	.373
	tShiftScore	-.087	.568	-.041	-.154	.878
	tFlIncongMean	-.251	1.021	-.167	-.246	.807
	tFlTotalMean	.094	1.111	.061	.084	.933
	tShiftMeanRT	-.180	.435	-.120	-.412	.682

a. Dependent Variable: tLosDist

Figure 12. Linear regression analysis of acceptance of each/cada in collective contexts with lexical and executive function development.

Similarly, we see that lexical development (as measured by PPVT standardized score) is a strong significant predictor of the ability to reject *los/the* in distributive, with p = .001 and r^2=0.222. However, like *unos/some*, attention is not a significant predictor for this relationship, nor is any other executive function measure.

These results reaffirm the claim made by Padilla-Reyes et al. (2016) that lexical development is a significant predictor of quantifier interpretation ability. However, it is interesting to see that working memory and inhibition have no significant effect, especially in light of the work done by Kapa and Colombo (2014) that did find relationships between a variety of executive function measures and language processing. The attention measure, on the other hand, is a significant predictor in the *cada/each* in collective case. This is the ability to switch one's attention between two scenarios or interpretations.

The correlations described above are further summarized in Figure #, constructed using the r^2 values for the significant, or near significant, predictors of rejecting each quantifier in incongruent contexts as proportions of variance accounted for.

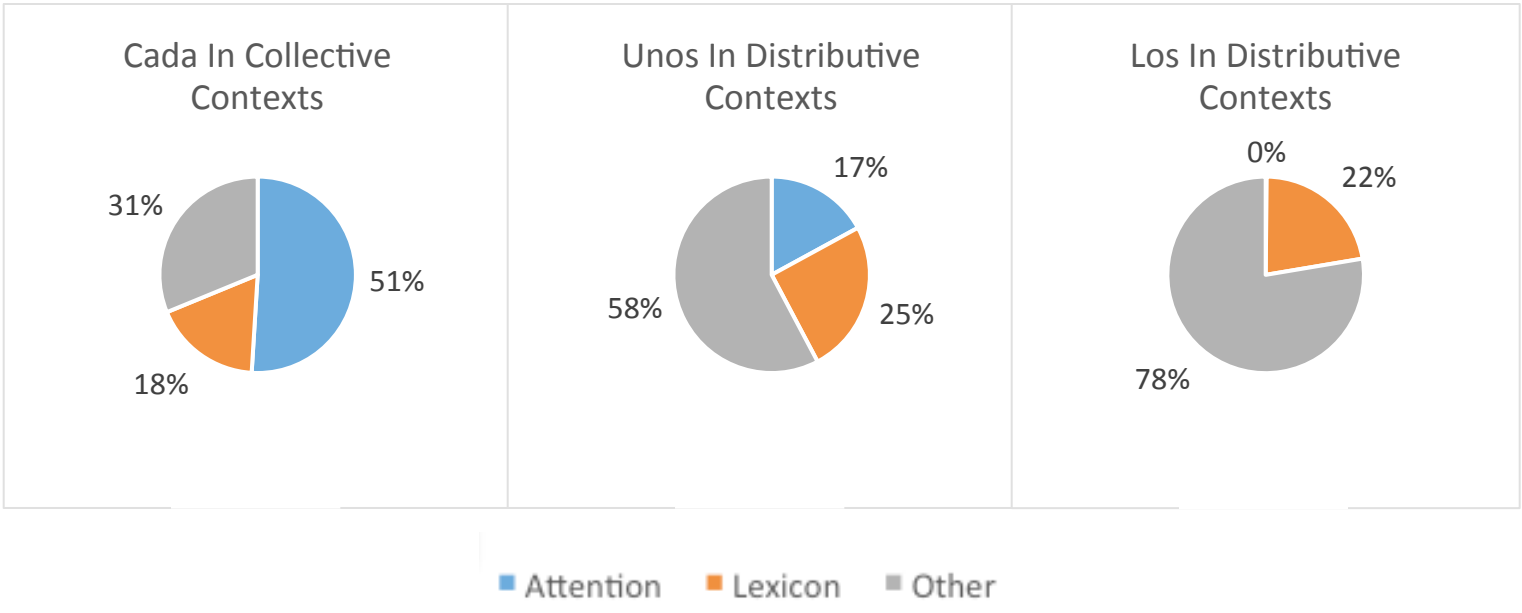

Figure 13. Proportions of variance accounted for by attention and lexicon in the ability to reject quantifiers in incongruent contexts.

It is worth noting that attention does in fact make up 0.17% of the variance for *los/the* in distributive, as opposed to the flat zero shown in the chart. For all three quantifiers, lexical ability represents approximately the same amount of variance, allowing for the clear, stark distinction between the percentages accounted for by attention. For *cada/each*, attention makes up 51%; for *unos/some*, only 17%, and for *los/the*, less than 1%. We turn now to an explanation of why this may be the case.

One potential cause is that it may require attention to toggle between numeral and bound variable interpretations of 'a rock/una piedra' in object position. English *a* and Spanish *una* can be interpreted either as numeral quantifiers with a cardinality of 1 or as indefinite quantifiers. In typically distributive sentences like "Each minion pushed a rock," adults interpret *a/una* as an indefinite quantifier and a bound variable, so it takes on the same quantity value as the amount of minions in the scenario. In typically collective sentences like "Some minions pushed a rock," adults interpret *a/una* as a numeral quantifier, meaning they expect one rock in the scenario. Distinguishing between the usages of these two possible interpretations may be more difficult for child language learners.

If this is true, we might expect the correlation to be stronger in Spanish, where *una* is morphologically identical to the count routine numeral *una/uno*, while *a* in English does contrast morphologically with the count routine numeral *one*. In fact, the entire correlation seems to be driven by the Spanish data: In Table 18, we see a significant correlation between rejection of *cada* in collective contexts in Spanish (CadaCollS) and the Spanish-speaking children's shift scores (ShiftS), with $p = .023$ and $r^2=.178$. The English equivalent pairing, however, is not significant, with $p = .597$.

Correlations

Correlations

		EachCollE	CadaCollS	ShiftE	ShiftS
EachCollE	Pearson Correlation	1	.265	-.102	-.269
	Sig. (2-tailed)		.164	.597	.166
	N	29	29	29	28
CadaCollS	Pearson Correlation	.265	1	-.281	-.422*
	Sig. (2-tailed)	.164		.139	.023
	N	29	30	29	29
ShiftE	Pearson Correlation	-.102	-.281	1	.358
	Sig. (2-tailed)	.597	.139		.061
	N	29	29	29	28
ShiftS	Pearson Correlation	-.269	-.422*	.358	1
	Sig. (2-tailed)	.166	.023	.061	
	N	28	29	28	29

*. Correlation is significant at the 0.05 level (2-tailed).

Table 18. Correlations among child rejection of each/cada *in collective contexts and shift score, separated by language spoken.*

This explanation is supported by Mateu and Hyams (2015), who examined the discrepancy between the development of numerals and the indefinite quantifier *un* in child Spanish. On two tasks designed to determine numerical knowledge, child Spanish-speakers performed at a level approximately one year delayed with respect to child English-speakers. They grasp the exact meaning of numbers 2 and above a year later than child English-speaker (4;4 vs. 3;3). They claim that this delay is due to the "conflicting morphosyntactic cues" and resulting ambiguity between the numeral and quantifier (Mateu & Hyams, 2015, p. 7).

With this evidence in mind, we hypothesize that when the children hear a collective quantifier (*unos/some, los/the*) and the indefinite/numeral in object position (*a/una*), but are confronted with a distributive scenario that has, for example, three rocks in it, they are faced with this interpretation decision of numeral or bound variable, but the numeral is weighted so heavily

that the bound variable option is rejected immediately. However, when they hear a distributive quantifier (*each/cada*) in subject position and the indefinite/numeral in object position (*a/una*), but are confronted with a collective scenario that has one rock in it, child English-speakers quickly reject the numeral interpretation of *a* that matches the collective visual scenario, knowing that only the indefinite, pluractional interpretation matches the *each* quantifier. This rejection is supported by the existence of the numeral *one*, as a distinct and more informative number word, in their lexicon. Child Spanish-speakers take longer to reject the interpretation of *una* as a numeral, because it is the most informative way to express both the numeral and the indefinite quantifier.

This is consistent with counting development studies in other languages. Child speakers of Japanese and Chinese face similar ambiguities and thus tend to exhibit slower counting development, in contrast to faster counting development in child learners of Egyptian Arabic, which has singular, dual, trial, and plural morphology. (Barner et al. 2009; Li, LeCorre, Shui, Jia & Carey 2003; Sarnecka, Kamenskaya, Yamana, Ogura, and Yudovina 2007; Almoammer et al. 2013).

Conclusion

Both adult Spanish and English have categorical distributive and collective interpretations associated with *each/cada*, *some/unos* and *the/los*, while 7 and 8 year old child speakers of these languages do not exhibit such categorical interpretations. Children's ability to reject these quantifiers in incongruent contexts develops in a linked manner in both English and Spanish, as the Pragmatic Scale Hypothesis would predict (Dotlačil 2010). Lexical development

is a strong predictor of this ability, but the executive function measures of working memory and inhibition do not appear to be related. Attention shifting does predict rejection of *cada/each* in collective contexts, but not other quantifier/context pairings. We propose that this is due to the lexical difference between Spanish and English indefinite quantifiers *a/one* and *una*. The identical morphology of the numeral and quantifier *una* creates more ambiguity for child Spanish-speakers than *a/one* do for child English speakers interpreting pluractional sentences, requiring Spanish speakers to pay greater attention in order to make correct interpretations. This hypothesis is an opportunity for further research in this area. Additionally, a large portion of the variance associated with the interpretation data is as yet unaccounted for by any known skill or quality, thus providing a wide avenue for future research in this area.

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Appendices

Language Background – Adult Controls

First Name & Surname_____

Date of Birth_____

1. Hearing

Do you have hearing problems? Yes No I don't know.

Have you recently had ear infections? Yes No I don't know.

2. Language

Does you hear any language other than Spanish English on a regular basis?
Yes No

If so, what language is it and how frequently?_____

Has anyone ever expressed concern about your speech or language? Yes No

If so, what are they? _____

Do you have a history of problems with speech or language? Yes No

Has your speech or language ever been formally assessed? Yes No

If so, when and what for?_____

Is there a history of speech or language delays or problems in your family? Yes No

If so, what kind?_____

What is the relationship of the person(s) with the problem(s) to you?_____

Language Development

Basic Information

First Name and Surnames of the child:_____ Date of Birth: _____

First Name and Surnames of the parent/guardian (mother or father)_____

Total Number of Years in School:_____

First Name and Surnames of the parent/guardian (mother or father)_____

Total Number of Years in School:_____

Development

1. Did anything unusual occur with the pregnancy or birth?

If so, what was it?_____

Child's birth weight: _____

Were there problems after birth?_____

2. At what age did your child first reach these milestones?

Sat alone_____ Stood alone_____

First words_____ Combined words_____

Potty trained_____ Walked alone_____

3. Do you have any concerns about your child's development? Yes No

If so, what?_____

_____

4. Hearing

Does your child have hearing problems? Yes No I don't know.

Has your child had ear infections? Yes No I don't know.

5. Language

Does your child hear any language other than Spanish on a regular basis? Yes No

If so, what language is it and how frequently?_____

Do you have any concerns about the development of your child's speech or language? Yes No

If so, what are they? _____

Does your child have a history of problems with speech or language? Yes No

Has your child's speech or language ever been formally assessed? Yes No

If so, when and what for?_____

Is there a history of speech or language delays or problems in your family? Yes No

If so, what kind?_____

What is the relationship of the person(s) with the problem(s) to your child?_____

Semantic and Pragmatic Development in Children

Participant's Code

			Order A		
#	Sent. Type	C/I	Context: C/D/N	Sentences	Response
1	Warm-up	C	one	One minion could move a horse.	
2	Warm-Up	I	one	No minion could move a horse.	
3	Warm-up	I	none	One minion could move a horse.	
4	Warm-up	C	none	No minion could move a horse.	
5	Exp	C	collective	The minions caught a goose.	
6	Exp	C	collective	Some minions trapped a rooster.	
7	Filler	I	none	One minion could open the door.	
8	Exp	I	collective	Each minion planted a tree.	
9	Exp	C	distributive	Each minion moved a rock.	
10	Exp	I	distributive	The minions carried a bag.	
11	Filler	C	one	One minion could find a pig.	
12	Filler	I	one	No minion could climb a rock.	
13	Exp	I	distributive	Some minions found a goose.	
14	Filler	C	none	No minion could climb a rock.	
15	Exp	I	distributive	Some minions planted a tree.	
16	Exp	C	distributive	Each minion carried a bag.	
17	Exp	I	distributive	The minions planted a tree.	
18	Exp	C	distributive	Each minion found a goose.	
19	Exp	I	distributive	Some minions trapped a rooster.	
20	Exp	C	collective	Some minions moved a rock.	
21	Exp	I	collective	Each minion carried a bag.	
22	Filler	I	none	One minion could climb a rock.	
23	Exp	I	distributive	Some minions caught a goose.	
24	Exp	C	distributive	Each minion trapped a rooster.	
25	Exp	C	collective	The minions found a goose.	
26	Exp	I	collective	Each minion moved a rock.	
27	Exp	I	collective	Each minion found a goose.	

28	Exp	C	collective	The minions carried a bag.	
29	Exp	I	collective	Each minion caught a goose.	
30	Exp	I	distributive	The minions found a goose.	
31	Filler	C	one	One minion could climb a rock.	
32	Exp	C	collective	The minions planted a tree.	
33	Filler	C	one	One minion could open the door.	
34	Exp	I	distributive	The minions caught a goose.	
35	Exp	C	collective	Some minions carried a bag.	
36	Filler	C	none	No minion could open the door.	
37	Exp	I	distributive	Some minions carried a bag.	
38	Exp	I	distributive	Some minions moved a rock.	
39	Exp	C	distributive	Each minion caught a goose.	
40	Exp	I	distributive	The minions trapped a rooster.	
41	Exp	C	collective	Some minions caught a goose.	
42	Exp	C	collective	The minions moved a rock.	
43	Filler	C	none	No minion could find a pig.	
44	Exp	C	collective	Some minions planted a tree.	
45	Exp	I	distributive	The minions moved a rock.	
46	Filler	I	one	No minion could open the door.	
47	Exp	C	collective	Some minions found a goose.	
48	Exp	C	collective	The minions trapped a rooster.	
49	Filler	I	none	One minion could find a pig.	
50	Exp	I	collective	Each minion trapped a rooster.	
51	Filler	I	one	No minion could find a pig.	
52	Exp	C	distributive	Each minion planted a tree.	

Semantic and Pragmatic Development in Children

Participant's Code

			Order A		
#	Sent. Type	C/I	Context: C/D/N	Sentences	Respuesta
1	Warm-up	C	un	Un minion pudo sacar un caballo.	
2	Warm-Up	I	un	Ningún minion pudo sacar un caballo.	
3	Warm-up	I	ningún	Un minion pudo sacar un caballo.	
4	Warm-up	C	ningún	Ningún minion pudo sacar un caballo.	
5	Exp	C	colectivo	Los minions atraparon un ganso.	
6	Exp	C	colectivo	Unos minions llevaron un gallo.	
7	Filler	I	ningún	Un minion pudo abrir una puerta.	
8	Exp	I	colectivo	Cada minion sembró un arbol.	
9	Exp	C	distributivo	Cada minion movió una piedra.	
10	Exp	I	distributivo	Los minions cargaron una bolsa.	
11	Filler	C	un	Un minion pudo encontrar un cerdo.	
12	Filler	I	un	Ningún minion pudo subirse a una piedra.	
13	Exp	I	distributivo	Unos minions encontraron un ganso.	
14	Filler	C	ningún	Ningún minion pudo subirse a una piedra.	
15	Exp	I	distributivo	Unos minions sembraron un arbol.	
16	Exp	C	distributivo	Cada minion cargó una bolsa.	
17	Exp	I	distributivo	Los minions sembraron un arbol.	
18	Exp	C	distributivo	Cada minion encontró un ganso.	
19	Exp	I	distributivo	Unos minions llevaron un gallo.	
20	Exp	C	colectivo	Unos minions movieron una piedra.	
21	Exp	I	colectivo	Cada minion cargo una bolsa.	
22	Filler	I	ningún	Un minion pudo subirse a una piedra.	
23	Exp	I	distributivo	Unos minions atraparon un ganso.	
24	Exp	C	distributivo	Cada minion llevó un gallo.	
25	Exp	C	colectivo	Los minions encontraron un ganso.	
26	Exp	I	colectivo	Cada minion movió una piedra.	
27	Exp	I	colectivo	Cada minion encontró un ganso.	

28	Exp	C	colectivo	Los minions cargaron una bolsa.	
29	Exp	I	colectivo	Cada minion atrapó un ganso.	
30	Exp	I	distributivo	Los minions encontraron un ganso.	
31	Filler	C	un	Un minion pudo subirse a una piedra.	
32	Exp	C	colectivo	Los minions sembraron un arbol.	
33	Filler	C	un	Un minion pudo abrir una puerta.	
34	Exp	I	distributivo	Los minions atraparon un ganso.	
35	Exp	C	colectivo	Unos minions cargaron una bolsa.	
36	Filler	C	ningún	Ningún minion pudo abrir una puerta.	
37	Exp	I	distributivo	Unos minions cargaron una bolsa.	
38	Exp	I	distributivo	Unos minions movieron una piedra.	
39	Exp	C	distributivo	Cada minion atrapó un ganso.	
40	Exp	I	distributivo	Los minions llevaron un gallo.	
41	Exp	C	colectivo	Unos minions atraparon un ganso.	
42	Exp	C	colectivo	Los minions movieron una piedra.	
43	Filler	C	ningún	Ningún minion pudo encontrar un cerdo.	
44	Exp	C	colectivo	Unos minions sembraron un arbol.	
45	Exp	I	distributivo	Los minions movieron una piedra.	
46	Filler	I	un	Ningún minion pudo abrir una puerta.	
47	Exp	C	colectivo	Unos minions encontraron un ganso.	
48	Exp	C	colectivo	Los minions llevaron un gallo.	
49	Filler	I	ningún	Un minion pudo encontrar un cerdo.	
50	Exp	I	colectivo	Cada minion llevó un gallo.	
51	Filler	I	un	Ningún minion pudo encontrar un cerdo.	
52	Exp	C	distributivo	Cada minion sembró un arbol.	

DOT COUNTING SCORE SHEET

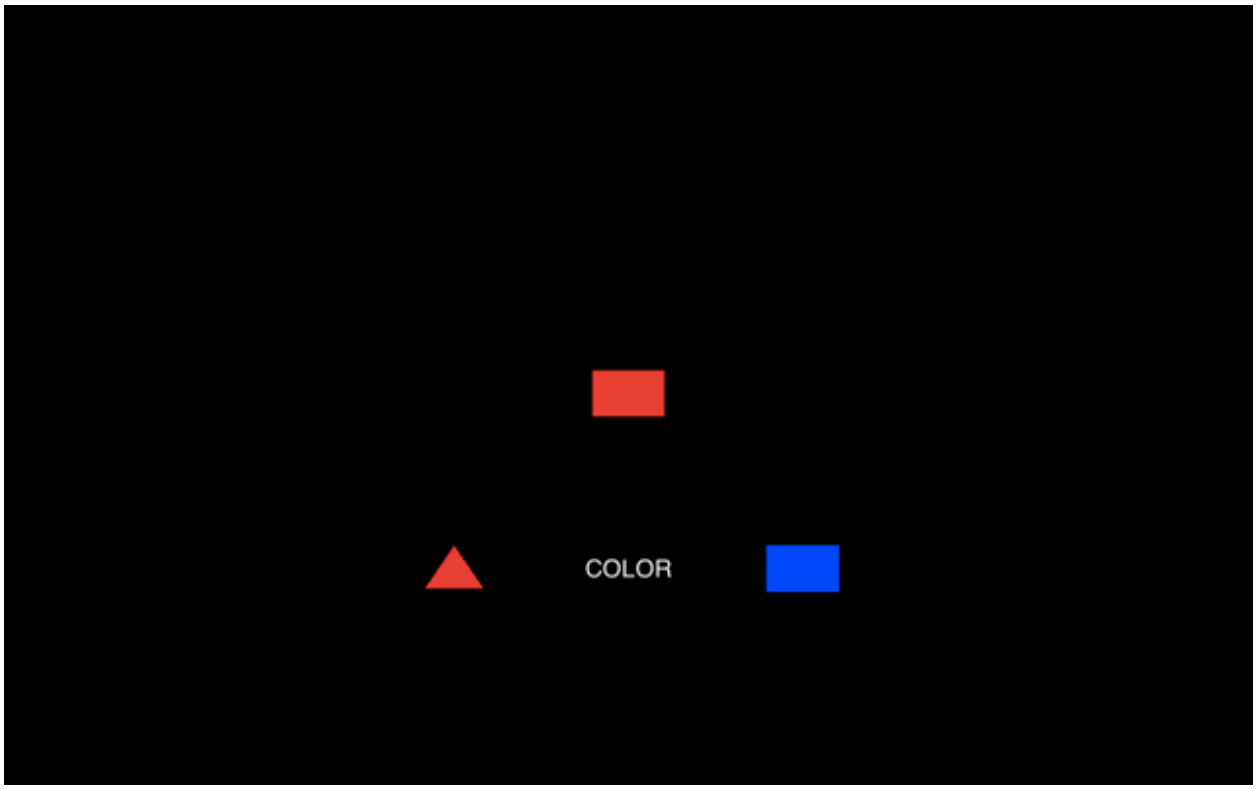
ADMINISTRATION:
Record the numbers the participant counts out loud from each display in the Response *column. The actual number of dots on each screen is provided below. At the end of the trial record the numbers the participant recalls in the* Recall *column. Administer all trials.*

SCORING:
Give 1 point for each correct digit recalled in each trial. Give 1 point if the number given as a response is not correct, but the number recalled is the same number. Record total in Correct *column. Add Correct values and record total at bottom of page (See Manual for complete scoring instructions).*

Practice: a. ____ (5) b. ____ ____ (4, 7) c. ____ ____ ____ (6, 2, 4)

Response:	Recall:	# Correct
1. ___ ___ (3, 8)	1. ___ ___	= _____
2. ___ ___ ___ (3, 9, 5)	2. ___ ___ ___	= _____
3. ___ ___ ___ ___ (5, 9, 3, 6)	3. ___ ___ ___ ___	= _____
4. ___ ___ ___ ___ ___ (3, 7, 6, 5, 8)	4. ___ ___ ___ ___ ___	= _____
5. ___ ___ ___ ___ ___ ___ (3, 5, 6, 9, 4, 7)	5. ___ ___ ___ ___ ___ ___	= _____
6. ___ ___ ___ ___ ___ ___ ___ (9, 3, 7, 8, 5, 6, 4)	6. ___ ___ ___ ___ ___ ___ ___	= _____
	TOTAL (Add values in column together for Trials 1 thru 6)	= _____ / 27

Dot counting image example (How many blue dots?)



Shift image example (Which of the two shapes on the bottom match the color [or shape] of the top shape?)

Flanker image example (Which direction is the center fish going?)