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Collective-Distributive Interpretations in Bilingual Spanish-English-Speaking Children

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Abstract

Developmental semantic research in child Italian, Spanish, and English has shown that children's knowledge of distributive interpretations does not appear adult-like until 10 or 11 years of age. Further, children's knowledge of distributive interpretations predicts their knowledge of collective interpretations. Lexical development, in these studies, predicts both their distributive and collective interpretations, while development of the inhibition component of executive function predicts children's collective interpretations, but not their distributive interpretations. In this project, we test Spanish distributive and collective interpretations in a sample of bilingual Spanish-English-speaking 1st graders and an age-

matched sample of monolingual Spanish-speaking children in Mexico. We find that the bilingual children have significantly greater inhibition scores than the monolingual children. The monolingual children, in contrast, have greater lexical scores than the bilinguals. Further results show that the monolinguals have more adult-like distributive and collective interpretations than do the bilinguals and that lexical scores are predictive of distributive- collective interpretations in the combined sample, while inhibition is not. We conclude that lexicon plays a greater role in collective implicature interpretations than does inhibition.

Keywords: distributive, collective, scalar implicature, bilingual, pragmatics, semantics.

1. Introduction

This paper investigates the roles of lexicon and inhibitory control in the acquisition of collective and distributive readings between bilingual Spanish-English and monolingual Spanish-speaking children. Dotlačil (2010) has proposed a pragmatic, collective-distributive scale, anchored by the unambiguous, distributive entailment *cada* 'each', followed by the more ambiguous, less-informative quantifiers *unos* 'some' and *los* 'the'. Gricean pragmatic reasoning, then, leads to a calculation where distributive 'each' confers a collective reading upon 'some' and 'the' by way of an informativeness implicature. Developmental data consistent with this hypothesis was presented for child Italian, in a study in which collective interpretations of definite NPs were predicted by interpretations of distributive NPs modified by *ciascun* 'each' (Pagliarini, Fiorin and Dotlačil 2012).

Further work with monolingual child populations, in both Spanish and English, has shown that children's developing collective and distributive interpretations are not only correlated with one another, but also predicted by their lexical development. This same work found that collective but not distributive interpretations are predicted by inhibitory executive function (Padilla-Reyes, Grinstead and Nieves-Rivera 2016; Grinstead et al. 2018; and Grinstead, Padilla-Reyes and Nieves-Rivera 2021). While investigations among bilingual populations concerning collective and distributive interpretations are lacking, evidence from scalar implicature generation and Gricean conversational maxims has shown that both bilingual and monolingual children demonstrate similar patterns of interpretation (Syrett et al. 2017a/b) and that executive function and/or lexicon may play a role in these patterns (Siegal, Iozzi and Surian 2009; Antoniou and Katsos 2017).

Lexical development and executive function are widely studied areas in bilingualism research. It has been shown, though not without debate, that bilingual children possess greater inhibitory control abilities than their monolingual counterparts (e.g. Bialystok, Craik, and Luk 2012; Paap, Johnson and Sawi 2015). Additional, albeit controversial, research has shown that bilingual children may follow a slower lexical developmental trajectory compared to monolingual children (Ben-Zeev 1977; Pearson, Fernandez and Oller 1993; Bialystok et al. 2010; Bialystok and Luk 2012; De Houwer, Bornstein, Putnick 2014).

Given these putative patterns in monolingual vs. bilingual lexical and executive function development, and the fact that both domains appear to play a role in implicature generation in monolinguals, we are in a position to ask which of these abilities could matter more for the development of collective implicature interpretations, in general. If lexicon is more predictive, and monolinguals are indeed more advanced than bilinguals in their

single- language-lexicons, then we might expect monolinguals to develop adult-like collective interpretations more quickly than bilinguals. To the contrary, if inhibition matters more for implicature generation than does lexicon, and if bilinguals indeed develop greater inhibitory ability than do monolinguals, then we might expect that their collective interpretations would be more adult-like more quickly than monolinguals. In either case, we can further understand the potential role that executive function and/or lexicon play in collective implicature generation overall and further our understanding of the development of monolingual vs. multilingual cognition.

2. Linguistic Phenomenon and Background

2.1. Linguistic Phenomenon

In this paper, we focus on the interpretation of distributive determiner phrases (DP) with the quantifier *cada* 'each' and collective quantificational DPs with the indefinite determiner *unos* 'some'. Sentences (1) and (2) exemplify these contexts.

(1) Each minion planted a tree.

(2) Some minions planted a tree.

The first example yields a distributive interpretation, wherein individual minions are paired with individual trees for planting. The second example is primarily collective, however it can be taken to have either a collective or a distributive meaning. The collective reading in (2) is derived if a group of minions planted a single tree in a joint action. In the case that the minions acted individually, paired with individual trees, then a distributive reading can be derived. Adults have been found to categorically accept sentences such as (2) as collective under most circumstances, but may interpret it distributively, if the predicate associated with the subject and the pragmatic context are different (Frazier, Patch, Rayner 1999; Kaup, Kelter, Habel 2002; Pagliarini et al. 2012; de Koster, Spenader, Hendriks 2017;). Dotlačil (2010) posits that subjects with 'each' in (1) are the most informative with respect to distributivity, therefore, all things being equal, sentences with subjects as in (2) are less likely to take a distributive reading, in line with Grice's maxim of quantity. This claim gives way to the Pragmatic Scale Hypothesis (Dotlačil 2010; Pagliarini et al. 2012; Padilla-Reyes 2018) that places plural determiners on collective-distributive scale according to their informativeness. Dotlačil (2010) and subsequently Padilla-Reyes (2018) order plural quantifiers in order from distributive (*cada* 'each') to collective (*los* 'the'), as in (3).

(3) *cada* 'each' > *todos* 'all' > *unos* 'some'

Plural quantifiers *unos* 'some' can be ambiguous as far as a collective-distributive reading (see above with (2)), but *cada* 'each' is not. The latter's collective reading anchors the scale of informativeness through its entailment meaning. The collective interpretation of *unos* 'some', in contrast, is derived via scalar implicature, due to it being less informative (Horn 1972, 1989; Dotlačil 2010; Padilla-Reyes 2018). This is exemplified using the 'in fact' test in (4-5) where a *unos* 'some' phrase is cancelled by *cada* 'each', but not in reverse, generating the implicature (Grice 1975; Grinstead et al. 2021).

(4) Some minions planted a tree, in fact each minion planted a tree.

(5) #Each minion planted a tree, in fact some minions planted a tree.

2.2 The Acquisition of Collective-Distributive Interpretations

Research in collective and distributive interpretations has shown that children learn to reject collective interpretations in distributive contexts only after they have learned to reject distributive interpretations in collective contexts. This is consistent with the hypothesis that the collective draws the relative strength of its meaning from the relative strength of the distributive meaning (de Koster et al. 2020; Grinstead et al. 2021). In the following section we review studies that have examined the emergence of collective and distributive interpretations in child language development. These studies include age, verb-type, and general cognition as contributing factors to achieving adult-like interpretations across several languages.

Early research on the development of collective-distributive relationships in several languages has shown that adult-like interpretations of *each* as distributive emerge later in childhood than do interpretations of other quantifiers (Hanlon 1986; Brooks and Braine 1996; Brooks et al. 1998; Syrett and Musolino 2013), sometimes as late as ten or eleven years of age. Pagliarini et al. (2012) used a picture-based Truth-value Judgement Task (TVJT) to test children (ages 4-13) and adult's interpretation of collective and distributive noun phrases (NP) in Italian, (as in (6) and (7) in Pagliarini et al. 2012):

(6)	Ciascuna	bambina	costruisce	un	castello	di	sabbia.
	each	girl	build.3.SG.PRS	a	castle	of	sand
	'Each girl is building a sand castle.'						

(7)	Le	bambine	costruiscono	un	pupazzo	di	neve.
	the	girl	build.3.SG.PRS	a	puppet	of	snow
	'The girls are building a snowman.'						

The authors found that the acquisition of distributive *each* was predictive of the acquisition of collective interpretations with definite, plural DPs, consistent with recent work from de Koster et al. (2020). More specifically, they found that children begin to reject sentences with distributive *ciascun* quantifier subjects in collective contexts at around age six. Most innovatively, Pagliarini et al. (2012) showed that at this same age, children began to reject collective DP subject sentences in distributive contexts, in a significantly correlated way with their rejection of distributive sentences in collective contexts. Puzzlingly in this work, adults accepted collective interpretations of definite DP sentences in distributive contexts about 50% of the time. Thus, they did not show categorical collective interpretations of definite DP subject sentences, a point to which we return below.

Verb-type also plays a role in the acquisition of collective and distributive readings in childhood, given that there can be ambiguity as to how an event is interpreted, depending on the action and the quantifier or determiner used (see (2) above). De Koster et al. (2020) investigated how Dutch-speaking children and Dutch- and English-speaking adults interpret dependent or independent actions in distributive and collective scenarios. Dependent verbs (*lift, carry, hold, pull*) and independent verbs (*pet, brush, comb, wash*) were paired with *each* and *the* in both collective and distributive contexts in a TVJT. They found that when *each* was paired with a collective scenario in Dutch, it was accepted more with independent verbs. This was the case among both children and adults, in both Dutch and English. The authors conclude that verb-type reinforces the distributive quality of *each*,

as an independent verb could cause *each* to distribute over a series of events, not objects, which influences the impact of the distributive marking. Additionally, children were slower in implicature calculation compared with adults in the study, considering their higher acceptance rates of collective *the* paired with distributive contexts, following Pagliarini et al. (2012) and Syrett and Musolino (2013).

The connection between collective-distributive implicature generation and cognition has also been a subject of investigation. De Koster, Spenader and Hendriks (2018) tested collective and distributive interpretations in Dutch among children (ages 4-11) and adults via a sentence-picture verification task, as in (8) and (9) (examples from de Koster et al. 2018).

(8) De jongens wassen een boot.
the boy.PL wash.PL a boat.SG
'The boys are washing a boat.'

(9) Elke jongen wast een boot.
each boy.SG wash.SG a boat.SG
'Each boy is washing a boat.'

Additionally, they used a word span task to examine the connection between working memory and implicature generation. They found that by age 7, children can access an adult-like understanding of the distributive interpretation of *each.* In the same age group, they found children only marginally rejected *the* with distributive readings, though this rejection increased as children aged. Memory scores were found to significantly relate to children's rejection of *the* distributive readings; the greater the memory score, the more the child calculated the implicature needed to reject these readings.

Most recently, de Koster, Hendriks and Spenader (2021) explore the implicature-cognition relationship and the preference for distributive readings by children. They tested an adult population on their interpretation of collective and distributive contexts in conjunction with working memory (WM) to explore child-like implicature generation and memory load in Dutch. Participants were asked to complete a dual-task experiment that included a sentence-picture verification and digit-span task taken together. The sentence-picture verification task tested *each* and *the* across both collective and distributive scenarios in Dutch. The researchers found a significant effect for loading participant's WM resources and the interpretation of the collective-distributive contexts. Specifically, there was an effect for distributive interpretations with the unmarked definite determiner *the*, where implicature calculation is needed (Dotlačil 2010).

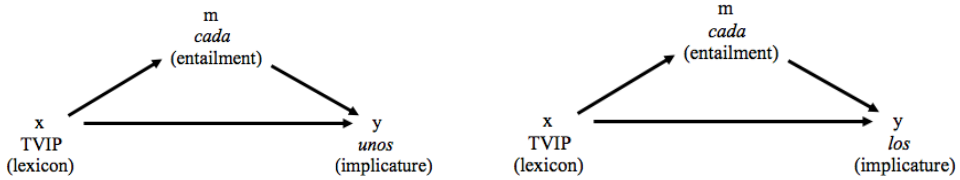
2.3 Categorical Collective Judgments and the Predictive Relationship of Lexicon and Executive Function in Collective-Distributive Interpretations

A mystery in Pagliarini et al. (2012) was why adult Italian speakers had 50-50 acceptance of definite DP sentences, marked with the plural definite determiners *i* and *le*, in distributive contexts. Similar results are reported for adult Dutch in de Koster et al. (2017). These findings were curious inasmuch as the English and Spanish versions of these sentences appear intuitively to produce categorically collective interpretations, which should have been rejected categorically in distributive contexts. Padilla-Reyes et al. (2016) and Grinstead et al. (2021) showed in adult Spanish that these judgments were indeed categorical. Follow-up work in monolingual English (Oates 2017) showed that adult English-speakers also have categorical judgments of sentences with definite DP subjects as collective. Thus, the contingency between collective and distributive interpretations in

development persists, but with categorical judgments of definite DP subject sentences as collective. The difference in findings across studies may be methodological, in that the 50-50 adult judgments resulted from a picture-based TVJT, while the 90% collective adult judgments resulted from stop-motion video-based TVJT. There may be some dimension of attention and memory that is engaged in video vs. static picture scenarios that is relevant for pragmatic calculation that is not entirely clear.[1]

If the Pragmatic Scale Hypothesis is correct, then it is the developing strength of meaning of the distributive entailment in *cada* 'each' that drives children's abilities to draw the pragmatic inference that underlies the scalar implicature associated with the quantified DPs that end up being interpreted as collective. In Grinstead et al. (2021), this was shown with two mediation analyses, exemplified in the following figure.

[1] See, along these lines, Pratt et al. (2019) for the visual working memory differences between consecutive and simultaneous action.**Figure 1.** Mediation Models



Source: Grinstead et al. (2021, pp.14-15)

Lexicon, in both models, is predictive of both distributive *cada* 'each' and collective *unos* 'some' and *los* 'the' judgments. However, with *cada* 'each' in the mediation model, a significant amount of the predictive power of lexicon on the collective is removed, which is to say that there is a significant mediation effect, following Preacher and Hayes (2008), with percentages mediated of 71% and 66%, respectively, for the two models. This means that lexicon plays an indirect role in determining the meaning of the collective, by virtue of primarily determining the strength of the distributive entailment driving the informativeness calculation, as the Pragmatic Scale Hypothesis proposes.

Beyond lexicon, and the relation among quantifiers, there is the question of how the ambiguity of interpretation of the plural quantifiers such as *los* 'the' and *unos* 'some' gets resolved. The domain of inquiry addressing ambiguity resolution has been natural language processing, which takes executive function abilities to be core language processing abilities (e.g. MacDonald, Pearlmutter and Seidenberg 1994; Trueswell and Tanenhaus 1994; Boland and Cutler 1996; see Novick, Trueswell and Thompson- Schill 2005 for review). From this perspective, we might expect that one of the three main executive function abilities hypothesized by Miyake et al. (2000) to be relevant to disambiguating between collective and distributive interpretations of the plural quantifiers, in particular pragmatic contexts. Grinstead et al. (2018) indeed show that scores on the Flanker Task measure of inhibition are predictive of children's judgments of collective sentences presented in distributive contexts, but not of their judgments of distributive sentences presented in collective contexts. This is sensible if we assume that inhibition is necessary for disambiguation of *los* 'the' and *unos* 'some', but unnecessary for the interpretation of *cada* 'each' which has less and less ambiguity as children age.

In sum, there is evidence that lexical abilities are predictive, albeit indirectly, of children's collective implicature interpretations of *unos* 'some' DP subjects and there is evidence that the inhibition component of executive function is similarly predictive of collective implicature interpretations as well. While lexicon also appears to be predictive

of distributive entailments, inhibition does not, consistent with the Pragmatic Scale Hypothesis.

2.4 Implicature Generation in Bilingual Populations

While there is a lack of research concerning collective and distributive interpretations in bilingual populations, insight can be gained from previous work in Quantity Scales and scalar implicature generation. Like the pragmatic scale that accounts for the distribution of collective and distributive readings, the Quantity Scale accounts for quantifiers associated with quantity information, starting with maximally informative 'all', followed by less informative 'some' and 'few'. Similar to 'each', 'all' anchors the scale of informativeness and derives its meaning through entailment. A scalar implicature can be derived through 'some' due to it being less informative, similar to 'the' (Horn 1972; 1989). 'Some' is cancelable with an 'in fact' statement as well, where the reverse with 'all' is not considered felicitous, as in (10).

(10) a. I ate *some* cookies. In fact I ate *all* of them.
b. #I ate *all* of the cookies. In fact, I ate *some* cookies.

The Spanish plural quantifier *algunos* 'some' encodes for this scalar implicature (as opposed to *unos* 'some' (see Gutiérrez-Rexach 2001; 2010 for full review)) and *todos* 'all' anchors the scale through entailment.

Research with *todos* 'all' and *algunos* 'some' lends insight into scalar implicature generation in general. Syrett et al. (2017a) tested both bilingual Spanish and English-speaking children, Spanish monolingual children, and adult Spanish-English Heritage Speakers (HS) on their interpretation of the scalar implicature associated with *algunos* 'some'. The first experiment was a TVJT that tested the participant's interpretation of *algunos* 'some' or *todos* 'all'. They found that HS adults categorically rejected *todos* 'all' in the 'some but not all' subset condition and rejected *algunos* 'some' in the 'all' whole set condition. The monolingual Spanish- speaking children and the bilingual children demonstrated comparable rates of acceptance; both groups used *algunos* 'some' in the felicitous 'subset' condition and the infelicitous 'whole set' condition comparably. The authors note that the monolingual children had similar adult-like interpretations, compared to the bilingual children who did not. Bilingual children and HS adults were given a follow-up task with additional conversational, pragmatic context needed for cooperative principles to apply in implicature generation. They found that both adult and child participants rejected quantifier use in infelicitous conditions. The authors concluded that increased conversational context helped participants calculate the scalar implicature, thus demonstrating their sensitivity to scalar relationships in quantifier use.

The connection between executive control and implicature generation has been investigated in bilingual children. Siegal et al. (2009) tested Slovenian-Italian bilingual children's interpretations of Grice's conversational maxims, but not implicature calculation. Here, the authors found a correlation between their superior performance and inhibitory control compared to the monolingual participants. Antoniou and Katsos (2017) tested implicature generation and inhibitory executive function in both multilingual (Cypriot Greek, Standard Modern Greek, and English) and bilectal (Cypriot Greek and Standard Modern Greek) child populations. The authors did not find a correlation between executive control and implicature generation but that the populations calculated implicatures comparably.

Importantly, they note that implicature generation relies on high pragmatic-communicative competence, which is inevitably tied to lexical understanding and not necessarily executive

control. Following the authors' reasoning, implicature generation may be less available to bilingual children if they are experiencing lexical delays in one or both of their languages (Antoniou and Katsos 2017).

2.5 Cognition, Lexicon, and Bilingualism

General cognition plays a role in implicature calculation and lexical development influences a speaker's ability to assign 'each' to distributive contexts and 'some' to collective ones. Cognitive function is a widely researched area of interest in bilingual language development and it has been claimed that being bilingual promotes enhanced executive function abilities. Research in lexical development among bilingual populations has cited a difference in overall outcomes, compared to monolingual counterparts as well, however with the more widely held belief that bilingual individuals may experience an overall lag in lexical development, or command smaller vocabulary sizes overall.

While highly researched, both claims are not without their controversy. In a large review of studies dealing with bilingualism and cognitive function, Bialystok et al. (2012) conclude that the purported 'advantage' of bilingualism is not the result of a single component of executive function. It is the overall conjunction of efforts, including the monitoring of context, speaker, environmental cues, and the inhibition of the unused language, that place a bilingual speaker at an advantage over their monolingual counterpart (Bialystok et al. 2012:10). Paap et al. (2015) argue that there is an overall lack of replicability in studies that claim bilingual speakers to possess a cognitive advantage. Importantly they note that variables such as socio-economic status (SES), cultural differences, and immigrant status are confounded or not accounted for and that there is an overall lack of correlation as to what exactly holds an advantage for bilingual speakers (Paap et al. 2015).

More recently, Giovannoli et al. (2020) conducted a systematic review of over 53 studies on bilingualism and executive function in childhood. The research included in the review had to include one bilingual group and monolingual group in its population, at least one measure of executive function, and the age of participants needed to be between five and seventeen years of age (Giovannoli et al. 2020:4). The authors reported on interactions between bilingualism and the following: attention, visual working memory (WM), verbal WM, inhibition, shifting, and multiple executive functions. The advantage of bilingualism appeared with studies on inhibitory control, specifically utilizing the Sky Search task, the Flanker task, the Dimensional Change Card Sort task, and the Trail Making test. In line with those results, Czapka et al. (2020) found pairwise matching of participants to make a difference in the overall outcomes of their study on the bilingual advantage, specifically with an interference inhibition task (e.g. the Flanker). Their 169 monolingual and multilingual participant pool was matched on age, gender, intelligence, SES, and lexicon size. They found the multilingual group to outperform their monolingual group in their response timing in the interference inhibition task used (see Czapka et al. 2020). In summary, while it may be difficult to pin down the exact variable that substantiates a bilingual advantage, the impact of task type, as well as consistency in participant comparison do help to reduce confusion and even promote an argument in favor of a cognitive bilingual advantage.

The link between bilingualism and lexical development has been widely studied. Early work in bilingual lexical and cognitive development by Ben Zeev (1977) found comparatively lower receptive English vocabulary sizes among bilinguals with relatively more advanced cognitive processing skills, compared to the monolingual population in the

study. Pearson et al. (1993) argued against the notion of an initial lag in bilingual receptive and productive language, as long as both languages of the speaker was assessed.
Bialystok et al. (2010) found distinctive differences between bilingual and monolingual receptive vocabulary scores in English among a broad age of children (ranging three to ten years of age) in a study of 1,789 children. Overall bilingual speakers had a smaller receptive vocabulary size compared to monolinguals. Importantly this was connected to vocabulary related to the home. The authors note that total receptive vocabulary for bilingual speakers could be much greater overall if both languages of the speaker were taken into account. More recently, work with young children growing up bilingual in the US has found differences in receptive vocabulary size between bilingual and monolingual children (Hoff et al. 2014). This was dependent on the languages spoken by parents (whether they both spoke Spanish, or a mix of Spanish and English) and helped determine relative vocabulary size in either language spoken by the bilingual child. Thordardottir (2011) found that community language environment was another important predictor in determining bilingual vocabulary size, compared to monolingual speakers. Specifically, "favorable bilingual environments" (e.g., French and English in Montreal) supported similar receptive vocabulary among bilingual and monolingual children.In summary, collective and distributive interpretations are a relatively late acquisition, at ten or eleven years of age in monolingual studies. Further, consistent with the Pragmatic Scale Hypothesis, both lexical development and inhibition have been shown to be predictive of children's collective interpretations. Lexicon, and not inhibition, has been shown to be predictive of distributive interpretations. Finally, there is substantial evidence that bilingual children have greater inhibition abilities, as measured by the Flanker Task, than do monolingual children, with age and SES controlled. Lexical abilities, in contrast, seem to be stronger in monolingual children than they do in the single-language lexicons of bilingual children of the same ages.

3. Research Questions

Given these considerations, we are led to the following predictions: if lexicon is more important to implicature generation than inhibition, monolinguals should generate more implicatures than bilinguals. To the contrary, if inhibition is more important than lexicon for implicature generation, then bilinguals should generate more implicatures than monolinguals. These predictions lead to the following research questions:

1. Can we replicate the bilingual advantage finding for inhibition in our sample?
2. Can we replicate the monolingual lexical advantage in our sample?
3. Does one group generate more implicatures than the other?
4. Does lexicon or inhibition or both predict implicatures?

4. Methods

4.1 Participants

We tested a bilingual, typically-developing sample of child English-Spanish-speakers in the US Midwest (n = 11, mean age = 96 months [8 years-old], age range = 84-112 months, SD = 8.9 months), whose parents were from different parts of Mexico, and an age-matched monolingual, typically-developing sample of child Spanish-speakers in Mexico City (n = 11, mean age = 96 months [8 years-old], age range – 84-98 months, SD = 5.3 months). Children were not matched on maternal level of education and the bilingual sample's values

(mean years of education = 9, SD = 4.43) were significantly lower (t(20) = 3.490, p = .002) than those of the monolingual sample (mean years of education = 14.73, SD = 3.16). Our background questionnaire also established that children were typically-developing and that our monolingual children were monolingual, which we defined as not having a person living in the home speaking to them or around them in another language. Children in the monolingual sample were exposed to English language music and some English classes, though in the Spanish-predominant context of Mexico City.

4.2 Procedures

Our children were all given a Truth Value Judgment Task to measure collective-distributive interpretations, a computerized version of the Flanker Task (Eriksen and Eriksen 1974) of inhibition, implemented in the PsychoPy platform by the EXAMINER Project (Kramer et al. 2014) and the Mexican Spanish version of the Peabody receptive lexical measure (el Test de Vocabulario en Imágnes Peabody (TVIP) – Dunn, Lugo, Padilla and Dunn 1986). All parents of the children in the bilingual sample were also given the Alberta Language Environment

Questionnaire (ALEQ – Paradis 2011) to determine the percentage of Spanish vs. English usage, among language-experience variables.

4.2.1 Truth Value Judgment Task

We follow the original design of Crain and McKee (1985), which includes a narrated story, which is acted out visually in front of the participants with plastic figurines that are moved in conjunction with the progression of short scenarios illustrating collective or distributive actions. Our variant of the original Truth Value Judgement Task presents the action with a recorded stop-motion video, for reliability of presentation across participants. We use the 'Minion' characters from the movie *Despicable Me* who perform a telic action on either 1 object, as a group (the collective condition; n=12 items), or individually and simultaneously on 1 object each (the distributive condition; n=12 items), as illustrated by the following screen shots (Figures 2 and 3). Half of the items in the collective condition occurred with a distributive *cada* 'each' sentence and other half occurred with a collective *unos* 'some' sentence. The same was done with the distributive condition.

Figure 2. Image of the Last Scene of a Distributive Scenario, in Which Each of Three Minions Pushes Its Own Rock

Source: Grinstead et al. 2021: 50

Figure 3. Image of the Last Scene of a Collective Scenario, in Which All Three Minions Push a Single Rock

Source: Grinstead et al. 2021:50

Following Crain and McKee (1985), there is always an obstacle for the Minions to overcome in order to perform the action, and there are multiple imaginable ways to achieve this result. This is plausible dissent, and it is argued to create a genuine question as to whether the scenario-final sentence that the children are asked to accept, or reject is appropriate. There is also a moment in the narration of each scenario in which an explicit question is asked as to how the Minions will do whatever it is that they are going to do. This question structures the discourse such that the scenario-final statement is a plausible answer to the Question Under Discussion (Roberts 2003) underlying the experimental discourse, following Gualmini et al. (2008). Here is an example of one of our scenarios:

(11) 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.'

Example (11) sets the stage for the Question Under Discussion to be explicitly stated. Once the participant has been oriented to the action by 11, the Minions move forward towards their goal of moving a rock. When the Minions get to the barn, the narrator produces the following utterance:

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

Example (12) expresses the explicit Question Under Discussion, "How will they do it?". The answer to this question is genuinely not known, which makes it plausible. Note that this is different from 'school behavior' type questions, which ask for known answers. The use of such pragmatically infelicitous questions has led children to give semantic-pragmatic results that do not align with the goals researchers have set for themselves (see Gualmini et al. 2008).

To make it clear that there are multiple possible ways to move the rocks being considered, the Minions huddle together to discuss their plan, in light of the fact that more than one rock has appeared. In the collective scenarios, the narrator states that there are rocks [plural] that must be moved and then later, with a tone of surprise, notes that there is only one. This creates a problem to be solved by the Minions and allows plausible dissent. After conferring, the minions either push one rock each, distributively, as in Figure 2, or push one rock together, collectively, as in Figure 3.

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

(13) 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 or reject 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. The experiment is presented using the SuperLab software (Cedrus Corporation) and children answer by pushing a happy face covering the 'c' key on a laptop keyboard for acceptance or a sad face covering the 'm' key of the keyboard. Experimental sentences, such as (13), always included either the distributive *cada* 'each' in the subject position or the collective *unos* 'some' in subject position, paired with the same predicates, which previous work has established to be equally acceptable by adult native speakers of Spanish as distributive vs. collective, as a function of the quantifier used.[1]

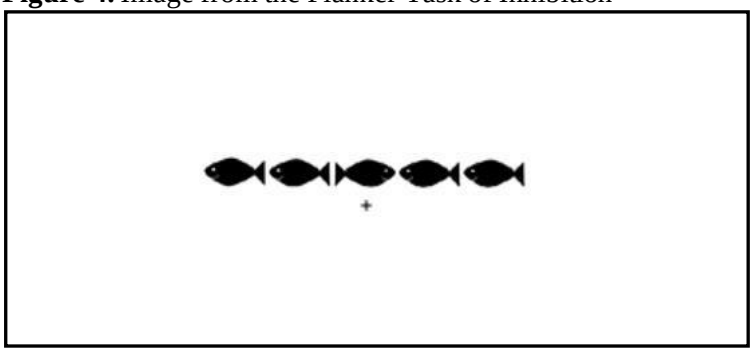
In addition to the experimental items, children were given four warm-up and twelve filler items that used either *todos* 'all' or *ningún* 'none' quantifiers in the subject position. There were six items of each kind, which were paired with videos depicting pragmatic contexts, half of which were true for *todos* 'all' and half of which were true for *ningún* 'none.' The predicates were *abrir la puerta* 'open the door', *encontrar el cerdo* 'find the pig' and *subir la piedra* 'climb the rock'. Participants had to answer at least ten of these twelve items correctly to be statistically above chance. Two of the bilingual children and none of the monolingual children were removed from the sample for failing filler items.

4.2.2 Flanker

The Flanker Task of inhibition is presented to participants as images of a horizontal line of 'fish' drawings, in which there is a central fish, above a plus sign, which is surrounded ('flanked') by additional fish, which are either all oriented in the same left-right direction as the central fish, or in the opposite direction, as illustrated in Figure 4.

[2] In previous work (Grinstead et al. 2021) we use both the plural definite determiner *los*/*las* 'the' as well as the plural indefinite *unos*/*unas* 'some.' They are highly correlated with one another and both of them are predicted by interpretations of *cada* 'each' in collective contexts. Here we worked with only the *unos* 'some' items in the name of making the experiment shorter.

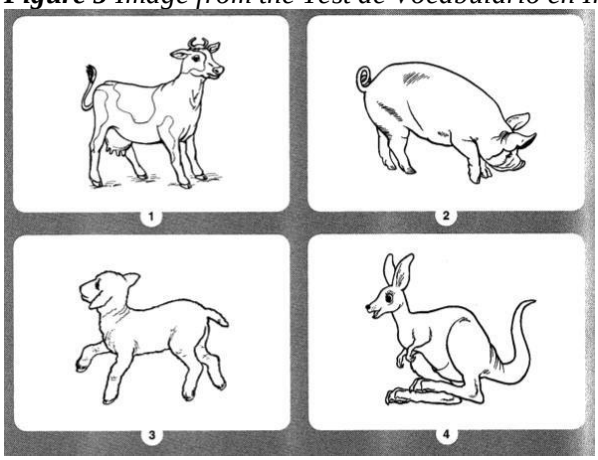
Figure 4. Image from the Flanker Task of Inhibition



Children must indicate by pushing the right or left arrow keys the direction that the central fish is oriented, and they must ignore the surrounding fish to do so. They are instructed to do this as fast as they can. The program records accuracy and reaction time. The score is a regression coefficient of accuracy by reaction time in incongruent trials, thus incorporating both elements.

4.2.3 Test de Vocabulario en Imágenes Peabody 'Peabody Picture Vocabulary Test'
In this Spanish-language version of the Peabody Picture Vocabulary Test, children are given a word and asked to choose the picture, presented together with three distractor pictures on a single card, that corresponds to the word they heard, as in Figure 5.

Figure 5 *Image from the Test de Vocabulario en Imágenes Peabody*



In an image such as the one in Figure 5, children would be asked to show the investigator the pig, which the child can do by pointing to it. Children name vocabulary items until a ceiling for the child is reached and that number of items constitutes the child's TVIP raw score, which we use in our models.

5. Results

5.1 Descriptive Statistics
In Table 1, we give the descriptive statistics corresponding to the scores of the monolingual and bilingual participants in our sample. A sample of twenty adult monolingual Mexican Spanish- speakers and three adult bilingual Spanish-English-speakers in the US gave 100%

categorical rejection judgments of *cada* 'each' in collective contexts and of *unos* 'some' in distributive contexts in pilot work.

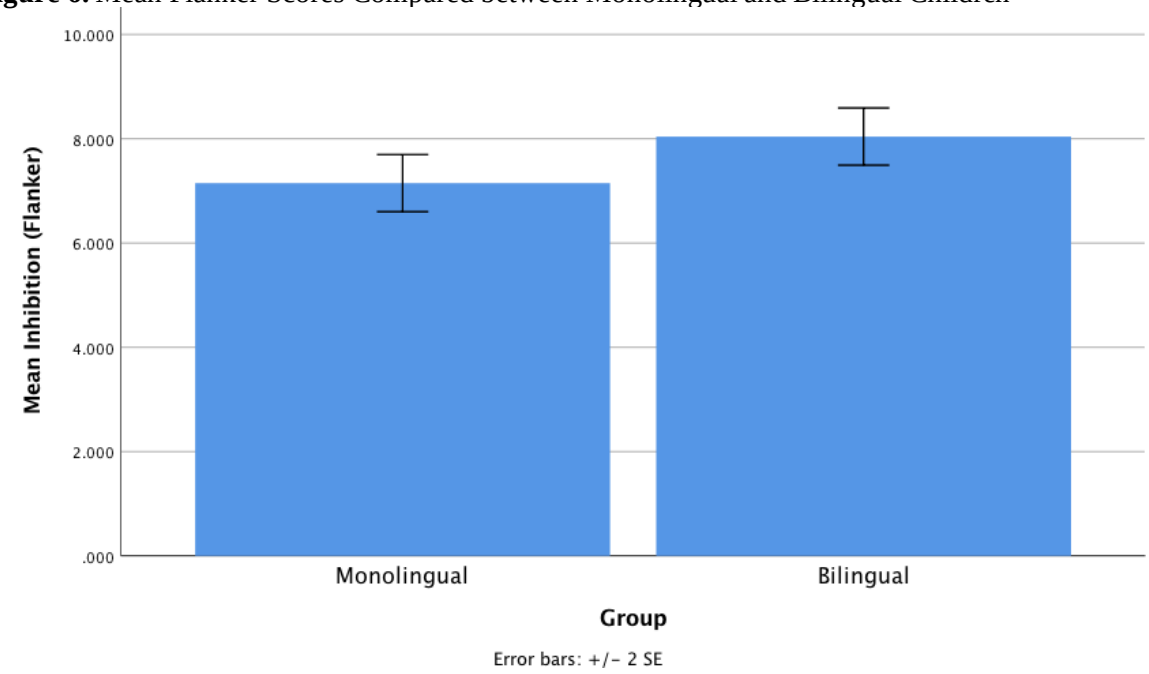
Table 1. Descriptive Statistics, Means and Standard Deviations from Study Measures

	cada 'each' Collective	*unos* 'some' Distributive	Flanker	TVIP	Spanish Richness Score from ALEQ
Bilingual	2.45 (2.38)	3.91 (1.30)	8.04 (.91)	51.91 (8.63)	.30 (.15)
Monolingual	.27 (.47)	1.64 (1.21)	7.15 (.91)	85.82 (8.49)	--

5.2 Inferential Statistics

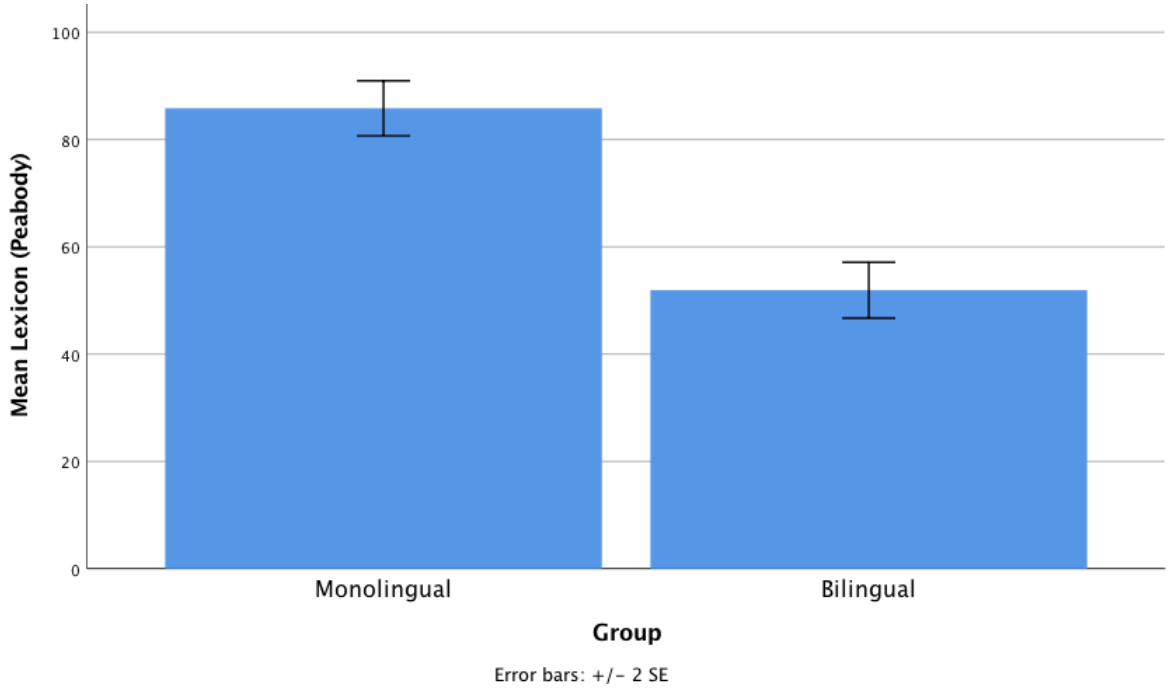
For our first comparison, we test mean inhibition scores, as measured by the Flanker test. In Figure 6, bilingual children appear to have greater Flanker scores than do monolinguals, which is confirmed by an independent samples t-test ($t(20) = -2.300$, $p = .032$). The effect size of this significant difference, expressed as a partial eta squared value, is .209, at .590 observed power.

Figure 6. Mean Flanker Scores Compared between Monolingual and Bilingual Children



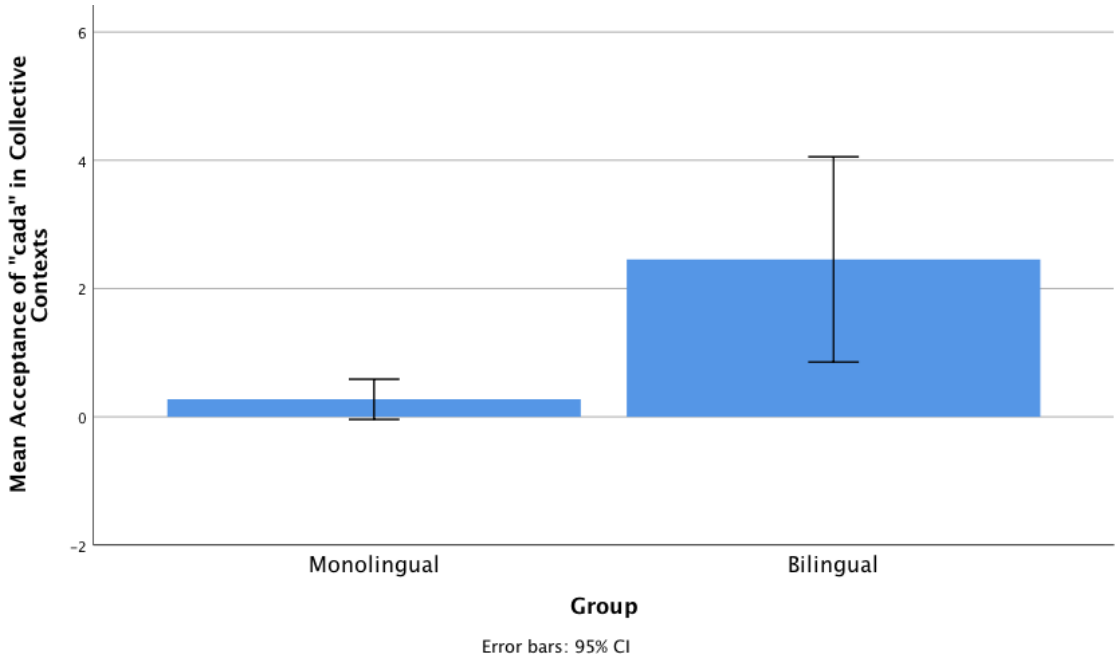
For our second comparison, we test lexical development scores, as measured by the TVIP. In Figure 7, monolingual children appear to have greater TVIP scores than do bilinguals, which is confirmed by an independent samples t-test ($t(20) = 9.287$, $p < .001$). The effect size of this significant difference, expressed as a partial eta squared value, is .812, at 1.0 observed power.

Figure 7. Mean TVIP Scores Compared between Monolingual and Bilingual Children



For our third comparison, we test interpretations of *cada* 'each' in collective (incongruent) contexts, as measured by our Truth Value Judgment Task. In Figure 8, monolinguals appear to accept such sentence-context pairings less than bilingual children do, which is confirmed by an independent samples t-test ($t(20) = -2.981$, $p = .007$). The effect size of this significant difference, expressed as a partial eta squared value, is .308, at .809 power.

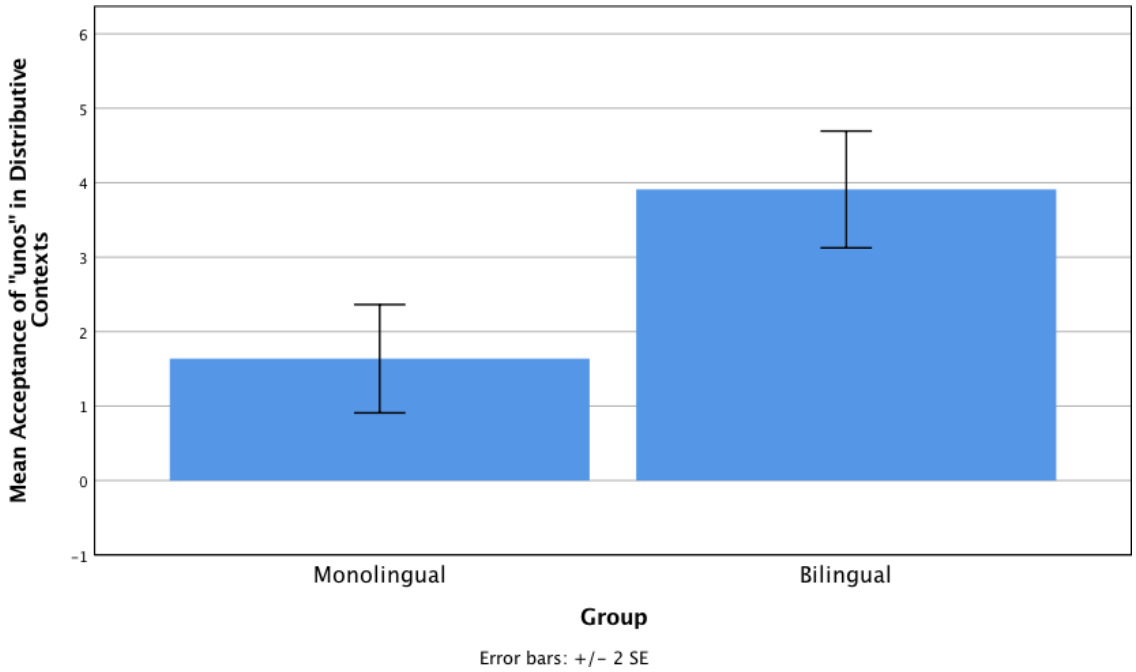
Figure 8. Mean Acceptance of *cada* 'each' Distributive Sentences in Collective Contexts



For our final comparison, we test interpretations of *unos* 'some' in distributive (incongruent) contexts, as measured by our Truth Value Judgment Task. In Figure 9, monolinguals, again, appear to accept such sentence-context pairs less than bilingual

children do, which is confirmed by an independent samples t-test ($t(20) = -4.250$, $p < .001$). The effect size of this significant difference, expressed as a partial eta squared value, is .475, at .981 power.

Figure 9. Mean Acceptance of *Unos* 'Some' Collective Sentences in Distributive Contexts



As to predictive relationships, we find that inhibition, is not significantly predictive of implicature generation (acceptance of *unos* 'some' in distributive contexts), by linear regression ($B = -.392$, $SE = .469$, $p = .413$, $r^2 = .034$). In contrast, lexicon is significantly, negatively predictive of implicature generation ($B = -.059$, $SE = .014$, $p = .001$, $r^2 = .457$), meaning that for every one-unit increase in TVIP scores, children accept *unos* 'some' in distributive contexts .06 fewer times. This relationship, and the relative bilingual vs. monolingual positions in it, are represented in Figure 10.

Figure 10. The Predictive Relationship of Lexical Development on *unos* 'some' Collective Implicature Generation in Bilingual and Monolingual Children

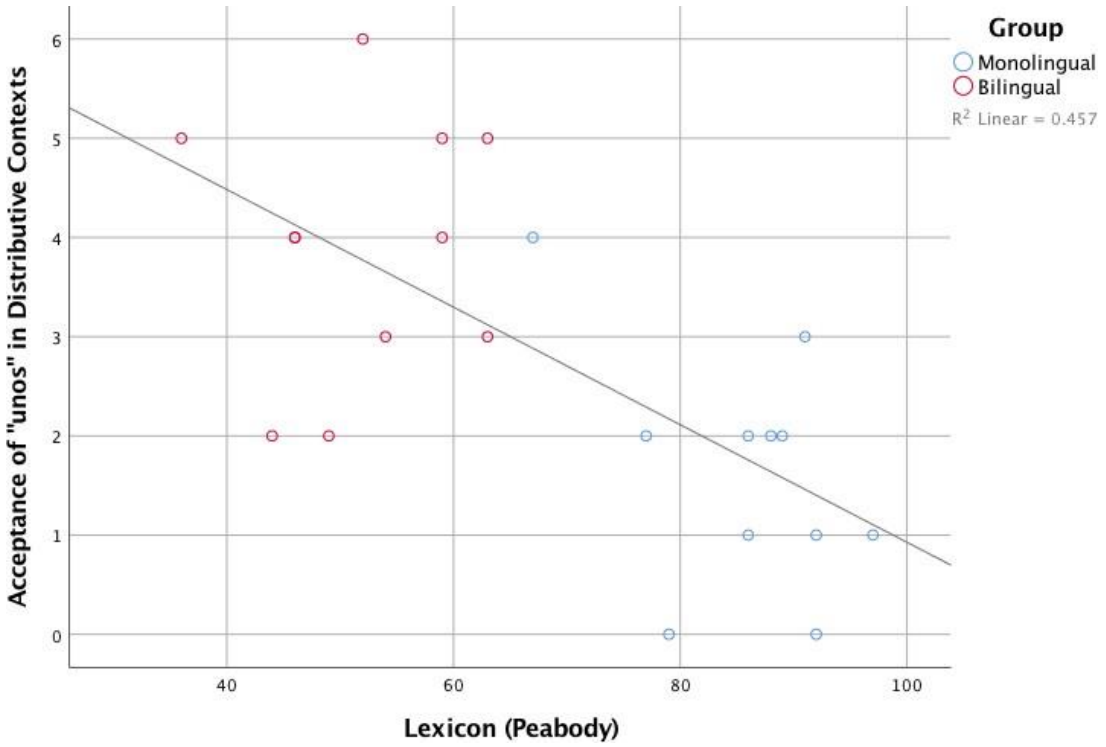
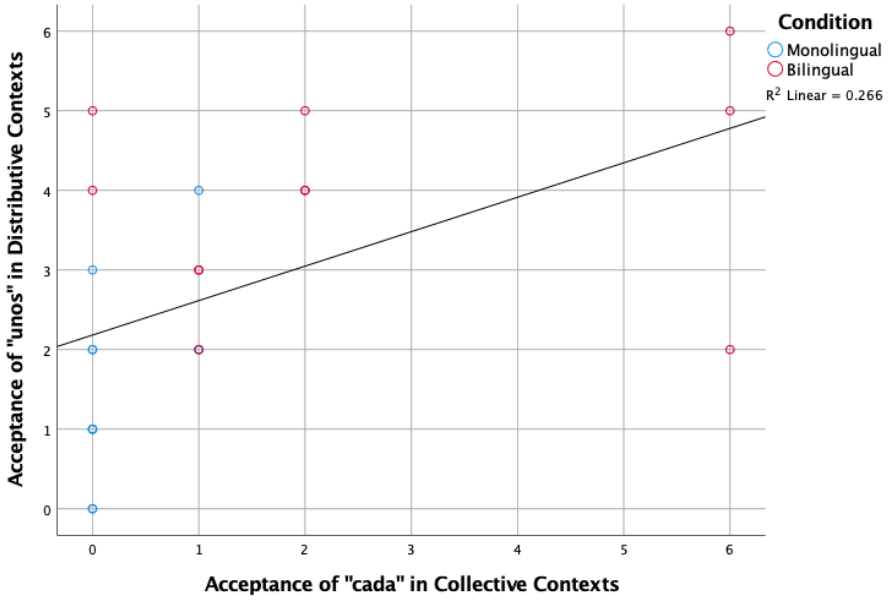


Figure 11 illustrates the significant positive predictive relationship of the acceptance of *cada* 'each' in collective contexts on the acceptance of *unos* 'some' in distributive contexts (B = .433, SE = .161, p = .014, r^2 = .266), meaning that for every one-unit increase in acceptance of *cada* 'each' in collective contexts, children accept *unos* 'some' in distributive contexts .43 more times.

Figure 11. The Predictive Relationship of Acceptance of *cada* 'each' in Collective Contexts on the Acceptance of *unos* 'some' in Collective Contexts, in Bilingual and Monolingual Children



6. Discussion and Conclusion

Returning to our research questions, we see that in our age-matched sample of children, in which the bilingual children had a significantly lower maternal level of education than did the monolingual children, we nonetheless replicated the finding that the bilingual children had greater inhibition ability, using the Flanker Task. Consistent with a major stream in the literature, we also replicated the finding that monolingual children had greater lexical development than did the bilingual children in Spanish (Ben Zeev 1977; Pearson et al. 1993; Bialystok et al. 2010; Thordardottir 2011; Hoff et al. 2014). Answering our third question, we see that monolingual children generated significantly more implicatures (accepted collective sentences in distributive contexts significantly less) than did bilinguals. They also accepted distributives significantly less in collective contexts than did the bilinguals, suggesting greater strength in their distributive entailment associated with *cada* 'each' consistent with the Pragmatic Scale Hypothesis. Finally, lexicon was significantly predictive of implicature generation in the combined monolingual and bilingual sample, while inhibition was not. What this appears to mean for the generation of collective implicatures, perhaps in general, and not just in children, is that lexicon is more important than inhibition. This is particularly notable given the role that inhibition has been documented to play in lexical development itself, as well as in settling on one of the possible interpretations of sentences that have multiple interpretations.

6.1 The Pragmatic Scale Hypothesis and the Lexical Refraction Hypothesis

At the theoretical level, then, we see that the Pragmatic Scale Hypothesis of Dotlačil (2010) and Padilla-Reyes (2018) is again confirmed in this study. Figure (11) illustrates the same linked relationship between the growth of distributive entailments and collective implicatures that we have seen in previous studies in developing monolingual populations in Spanish, Italian and Dutch. The relationship, again documented here, between lexicon, distributive entailment and collective implicature interpretations is further explicated in the bilingual-monolingual comparison by showing us something about the relative roles of inhibition and lexicon in implicature generation that is consistent with past findings, even though the bilingual population has different relative lexicon-inhibition abilities than do monolingual children. Though the bilingual population had significantly higher inhibition scores than did the monolingual population, their implicature generation scores were still significantly lower than those of the monolingual population. It seems, rather, that the significantly larger lexical scores of the monolingual population were more relevant to, and significantly predictive of, collective implicature interpretation.

In recent work on the Quantity Implicature, along these same lines, Grinstead, Kirk, Pratt and Arrieta-Zamudio (to appear) show that lexicon plays such a critical role in generating the 'some, but not all' conversational implicature, that children can be successfully identified as 'implicature-generators' 88% (44 of 50) of the time vs. 'non-implicature-generators' 100% (11 of 11) of the time, using a linear discriminant function analysis, using four distinct lexical measures to form the function. Given that the Pragmatic Scale to which Dotlačil referred constitutes a semantic structure within the lexicon, it seems clear that the development of this structure, and its implicated inter-quantifier relationships inside the lexicon, proceeds in parallel with overall lexical development.

Why, though, should the lexicon be so strongly predictive of the entailment interpretation of the distributive *cada* 'each' quantifier? In Grinstead et al. (2021), Grinstead et al. (2022) and Grinstead et al. (under submission), it is proposed that quantifiers, as lexical items, refract the non-species-specific number ability, referred to as the Approximate

Number System (ANS), through the lexicon in the form of natural language quantifiers and other number-related morphemes. This is referred to as the Lexical Refraction Hypothesis. These quantifiers take non-discrete ANS representations of magnitude and make them quantal and discrete. In existential quantifiers, such as *algunos* or *unos* 'some', this meaning is 'more than exactly one', which imposes a discrete, lower bound on the quantity expressed. In the distributive quantifier *cada* 'each,' quantification is universal, but also discrete and distributive, with an additional syntactic feature added to the lexical item, which requires that if the item occurs in the subject position, all predication in which that item participates as an argument must be distributive. This distributivity is only visible when a direct object forms part of the predicate (e.g., contrast 'Each child laughed.' with 'Each child ate a sandwich.'). The complexity implied by the presence of this syntactic feature may be an influential factor in the relatively slow development of children's distributive and collective interpretations, as suggested by the fact that an independent measure of syntax is predictive of distributive interpretations in Grinstead et al. (under submission). As quantifiers are added to the lexicon, through development, and more clearly understood through repeated exposure, their meanings become clearer to children. An analogy could be with color terms in the sense that children's interpretations of 'light blue' might change and become more specific when the term 'turquoise' is added to their lexicons. In Spanish, furthermore, nouns, verbs, adjectives, determiners, pronouns – most words, in fact – must have a number specification of some kind. This could mean that the addition of new lexical items in any of these grammatical categories could aid in the development of children's interpretations of quantifiers and of the semantic structures, such as pragmatic scales, that they form part of in the lexicon. It is in this sense that overall lexical development could plausibly contribute to quantifier interpretation, in general, and to collective implicature interpretations, specifically.

6.2 Limitations

Clearly, we would like to have run this experiment with a larger population, but the pandemic halted our progress. Nonetheless, we have been careful to include measures of both effect size and statistical power to make it clear that in our sample, the differences are quite robust. To be clear, the lexical difference between the groups is stark, while the inhibition difference is less so. This is consistent with existing literature and likely explains why the Bilingual Advantage claim is controversial. We have substantial confidence that the clear results we are reporting could be replicated in other language pairs, with similar measurement.

6.3 Future Directions

In recent preliminary work (Fogel 2020), we have seen that other measures of inhibition are predictive of collective-distributive interpretations. In particular, the Continuous Performance Task was predictive in a small sample of English speakers of different dialects of English. This study used the Diagnostic Evaluation of Language Variation Screener (DELV) to classify children into Mainstream American English (MAE) and Variation from MAE categories and found that the children in the Variation categories generated fewer implicatures. Though there was no direct measure of lexicon in this project, it seems likely that multi-dialectal children might have smaller single-dialect lexicons than their mono-dialectal age matches. Though the two dialect groups in this case did not show a 'Bidialectal Advantage' on any of the three inhibition measures (Flanker, Continuous Performance and Anti-Saccades), they neither showed a disadvantage. Similarly, working with the same set of children, Baghbanian (2021) showed that there was no difference in measures of numerical knowledge (Number Line Estimation, Panamath, Number Sets Task) across dialect groups.

Thinking more carefully about how different bilingual and bidialectal children are from one another and how cognitive systems interact and develop in distinct learning situations such as these is part of our group's future research plan. Further, we aspire to model many of these dimensions of cognition simultaneously in one statistical model, perhaps using structural equation modeling. Until then, we take it that lexicon, and the aspects of cognition that drive its growth, are very important dimension of the knowledge underlying pragmatic implicature interpretations.

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