

## Research Article

# Predicting Scalar Implicature Interpretations From Lexical Knowledge

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## ABSTRACT

**Purpose:** We measure typically developing monolingual child Spanish speakers' lexical development with a range of standard expressive and receptive tests. We also measure their comprehension of sentences with the existential quantifier *algunos* "some" to determine their abilities to generate "some, but not all" scalar implicatures or pragmatically enriched quantifier interpretations. We then determine the degree to which lexical development predicts implicature interpretations.

**Method:** We fit regression models with lexical measures as predictor variables and implicature interpretations as the outcome variable. We then divide the child sample into implicature generators (50/61) and implicature nongenerators (11/61) and test the usefulness of the four lexical measures in a linear discriminant function analysis to separate children into these two categories.

**Results:** Results show significant correlations between each lexical measure and the outcome variable and, in a regression, that three of four lexical measures account for unique variance. Furthermore, the linear discriminant function analysis separates children into implicature nongenerators with 100% accuracy (11/11) and implicature generators with 88% accuracy (44/50).

**Conclusions:** The Quantity Scale, or set of quantity-expressing determiners, proposed by Horn and Grice, develops as a function of the links among its quantifiers. We speculate that children's lexicons refract approximate number system representations in language- and morpheme-specific ways. These quantified noun phrases (NPs) are then merged into sentences interpreted pragmatically with conversationally computed implicatures, using higher order reasoning.

Existing research into children's lexical development addresses the relationship of overall lexical development to the development of semantic structures in the lexicon, which typically include color, size, and category of the objects denoted by lexical items (e.g., Alt et al., 2004; Alt & Plante, 2006; Kersten & Smith, 2002; McGregor et al., 2002; Sheng & McGregor, 2010). Very little work, in contrast, addresses the relationship of overall lexical development to the development of the semantically structured class of quantity-related determiners, including {all, each, every, most, many, some, few...}, referred to by Grice (1975) as the Quantity Scale. In the work of Grice (1975) and Horn (1989), it is argued that the relation among the

determiners on the Quantity Scale is managed in particular conversational contexts to determine which is most appropriate. For example, if a child eats all of the cookies on a plate, it is true that that child ate "all the cookies." It is also true, strictly speaking, that the child ate "some cookies." This is true in the same (sometimes hard-to-understand) sense that if a child has eaten five cookies, that child has also eaten three cookies. If "some" is logically true when a child has eaten five of five cookies on a plate, then why are not "some" and "all" equally useful quantifiers in this context? Grice and Horn argue that to be most cooperative, following Grice's concept of a cooperative conversational participant and his Maxim of Quantity of information, a cooperative speaker-hearer makes a pragmatic calculation that using "some" in the context in which a child has eaten five of five cookies would be underinformative and uncooperative in the

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conversational context. They argue that this is so on the basis that “some” in this context would be likely to be interpreted to mean “some, but not all,” which would not match the context. This “some, but not all” interpretation is what they refer to as a conversational implicature, and it constitutes a negation of the stronger determiners on the Quantity Scale, including “all.” Conversational implicatures are argued to constitute a different semantic ontological category from presuppositions, entailments, and others, in that their meaning is computed in conversational contexts and is thus susceptible to being canceled in a way that others are not. To illustrate this less immutable nature of the meaning of “some,” take the following “in fact” test comparisons of the entailment associated with the quantifier “each” and the conversational implicature associated with the quantifier “some.”

- (1) Some students came to my office. In fact, each student came to my office.
- (2) #Each student came to my office. In fact, some students came to my office.

The cancelable conversational implicature associated with the quantifier “some” in the first sentence in Example 1 can be canceled by the stronger entailment associated with “each” in the second sentence in Example 1. In contrast, the entailment of “each” in the first sentence of Example 2 cannot be canceled by the implicature of “some” in the second sentence in Example 2, resulting in the sentence’s semantic anomaly, indicated by the “#” symbol.

While the literature on studies of language disorders has been concerned with the relationships of quantity and quality of lexical items in children’s language development, a parallel literature has addressed the development of children’s ability to compute conversational implicatures, without connecting these interpretations to the quality or quantity of lexical items in children’s lexicons. Although there is developmental research on more than one pragmatic scale in the lexicon (e.g., the work on collective–distributive interpretations in the work of Brooks & Braine, 1996, Padilla-Reyes, 2018, Pagliarini et al., 2012, *inter alia*), most of this research has been concerned with the development of the “some, but not all” conversational implicature meaning associated with existential quantifiers, across an array of languages (Chierchia et al., 1998; Guasti et al., 2005; Huang & Snedeker, 2018; Katsos & Bishop, 2011; K. Miller et al., 2005; Papafragou & Musolino, 2003; Pouscoulous et al., 2007), with little attention being given to the relationship between these developing interpretations and children’s developing lexicons. This is somewhat surprising, given the amount of research on lexical development and given that the original thinking about conversational implicatures viewed them as stemming from semantic structures within the lexicon, which Grice (Grice, 1975) identified as Pragmatic Scales.

In what follows, we explore the relationship between general lexical development in monolingual Spanish and the development of the conversational implicature associated with the quantifier *algunos* (“some”). As a conceptually prior step, we will describe our hypothesis for how quantity words, such as the natural language quantifiers studied by Grice and Horn, come to have their denotative meanings. That is, quantifiers are lexical items that express a kind of numerical knowledge. We hypothesize that the non–species-specific Approximate Number System (ANS) is the conceptually most likely source of this knowledge and that the human language lexicon refracts ANS representations into specific quantifier and other number morpheme interpretations. Following our sketch of this hypothesis and our statement of our assumptions as to how conversational implicatures develop in children, we test the degree to which different lexical measures associate with children’s abilities to generate conversational implicature interpretations. If general lexical development associates with the development of conversational implicature development, then it may be possible to pick out children who are able to categorically generate conversational implicatures using a linear discriminant function composed of lexical measures.

## ***Algunos* and Domain Restriction**

The Lexical Refraction Hypothesis proposed in the work of Grinstead et al. (2021) holds that the natural language lexicon makes use of the non–species-specific quantity ability referred to as the ANS to represent various instantiations of number. Each morpheme that represents numerical information has its own language-particular and morpheme-particular properties. Cardinal number quantifiers express exact numerical quantities that differ as a function of  $n + 1$  or  $n - 1$  from their nearest whole number neighbor. Plural morphemes represent the “more than exactly 1” concept and may attach to a wide variety of grammatical categories in Spanish, including nouns, verbs, adjectives, and determiners. *Algunos* is a plural, indefinite, intersective, and existential quantifier in Spanish (Gutiérrez-Rexach, 2001, 2010; Martí, 2008; Palma, 2007) that can be loosely translated as *some* in English. Following von Stechow (1994) and Roberts (1995), we assume that, as with *some* in English, *algunos* in a determiner phrase (DP)<sup>1</sup> may pick out a plural number of

<sup>1</sup>The Determiner Phrase Hypothesis, first proposed by Abney (1987), holds that noun phrases (NPs) are structural complements of determiners, which seems particularly well supported by acquisition research, given the role that determiners appear to play in word learning and in the development of auditory working memory (e.g., Egido [1983], Bloom [2000] *inter alia*). We will assume this hypothesis, throughout.

indefinite exemplars of all members of the set of countable objects it modifies, as in (3), or it may be restricted by context to represent indefinite exemplars of a discourse-defined set of countable objects that are prominent in the Conversational Common Ground, as in (4).

- (3) Esta noche, algunos niños se acostarán sin comer.  
Tonight, some children will go to bed without eating.

The subject DP *algunos niños* in (4) can be made prominent in an experimental discourse when, for example, a video is played in which there are four children and three of them cross a street, and one of them does not. After having viewed such a scenario, the use of the DP *algunos niños* in the sentence in (4) to describe what has occurred is pragmatically felicitous. Some, but not all, of the children under consideration have crossed the street. This visual depiction of the event matches the scalar pragmatic implicature interpretation (Grice, 1975; Horn, 1989) that is conversationally computed, upon hearing this sentence in this context. In (3), in contrast, there is no restriction of the set of children to those observed and the listener is free to conclude that the children in *algunos niños* potentially refer to all the children in the world and, indeed, would also be true if a subgroup of all the children in the world went to bed hungry. Famously, it is logically true that if the entire group of all children in the world went to bed hungry, then some of them did.

- (4) Algunos niños cruzaron la calle.  
Some children crossed the street.

We become most poignantly aware of this pragmatic implicature meaning when it is used infelicitously, for example, in a visually depicted situation, such as the video from which the still image in Figure 1 is taken. In the video, all four of the four children under consideration cross the street and the sentence in (4) is uttered.

Summarizing, *algunos* has multiple possible interpretations, which may be more or less informative in a particular pragmatic context. The quantifier *algunos* is logically possible in a context such as the one depicted in Figure 1, because if all of the children crossed the street, then it is also the case that some of them did so. However, the fact that a more informative quantifier, *todos* (all), is available in the lexicon to describe the situation, with less ambiguity, makes the “some, but not all” conversational implicature use of *algunos* for such a scenario infelicitous.

## Lexical Refraction

Although the conventional view of children’s knowledge of pragmatic computations and their relationship to lexical development is important to consider, a potentially

**Figure 1.** Still image from a video in which four of four children have crossed a street.



deeper question is how natural language quantifiers come to be quantal in the first place. That is, how does natural language deploy what conceptually seems to be very related to a type of quantity sensitivity that nonhuman animals use, to express the different meanings that quantifiers convey? The Lexical Refraction Hypothesis (Grinstead et al., 2020, 2021) claims that (a) the natural language lexicon refracts nonexact representations of quantity through morphemes including the natural language quantifiers and number morphemes, including plural, dual, and trial markers, among others, and (b) the quantity-expressing lexical items are linked or structured in different ways in the lexicon into what Grice referred to as pragmatic scales. These would include not only the Quantity Scale, addressed here, but also possibly scales of collectivity–distributivity, following Dotlačil (2010) and Padilla-Reyes (2018). As new quantity-related morphemes are added to the lexicon and incorporated into their corresponding pragmatic scales, the denotative and implicated meanings of the other morphemes, associated with the new morphemes, becomes more precise. This sense of development could be likened to the semantic representation of the color term *light blue* after the color term *turquoise* is acquired.

The hypothesis that ANS feeds the natural language lexicon (Grinstead et al., 2021, 2022) stems from the observation that nonhuman animals appear to have the ANS ability (e.g., Agrillo et al., 2012; Gallistel, 1990), which implies that a sense of quantity may exist in the absence of human language. Furthermore, ANS, which undergoes its own developmental trajectory (e.g., Siegler & Opfer, 2003), appears to predict overall lexical development in child Spanish, at least as it has been measured in previous research (Grinstead et al., 2020, 2022; Nieves-Rivera & Grinstead 2019). Because it seems unlikely that

such an ability would evolve completely independently of everything else natural language does with quantity judgments, we assume that developing ANS ability in children feeds those aspects of lexical development that are sensitive to number. Being lexical items, however, each quantifier must be learned on an item-by-item basis, which, we believe, means that every time a new quantifier is added to the scale, the meanings of the others become more precise. Repeated exposure to the use of quantifiers is likely to make their meanings clearer. In this way, lexical refraction claims that the development from the outside of language, in the domain of number, drives more precise meanings of quantifiers, whereas the development inside the lexicon, among quantifiers and perhaps other number-related morphemes, also serves to make each quantifier's meaning more precise.

### Lexical Development and Pragmatic Implicature Interpretations

The literature on the development of pragmatic implicature interpretations associated with existential quantifiers that sit on the Quantity Scale generally shows that children initially struggle to interpret “some, but not all” scalar implicatures but eventually learn them. Children age 5;0 (years;months) through 7;0 appear to understand this interpretation of “some, but not all” in English, Spanish, and Italian (Guasti et al., 2005; Huang & Snedeker, 2009; K. Miller et al., 2005; Vargas-Tokuda et al., 2009). What changes make this possible? The role that development in the lexicon itself might play in this regard has not been given much attention in the existing developmental literature, but perhaps should, at least on the lexical refraction view of quantifier development.

Specifically, we hypothesize that because general lexical development includes so many words that require number to be expressed in Spanish (e.g., most nouns, verbs, adjectives and determiners), it is logical that ANS predicts overall lexical growth. We have referenced literature, above, that bears out this connection empirically. In turn, overall lexical growth should index children's interpretations of *algunos*, in relation *todos*, inasmuch as each of these elements' meanings in relation to all other numerically oriented lexical items should become clearer as a function of the addition of each new noun, verb, adjective, and determiner to their lexicons.

In terms of development, recently published work (Grinstead et al., 2022) reports that children do not pass through a prolonged developmental sequence of first, not generating implicatures at all and then very gradually increasing the degree to which they do so. Rather, in this sample, the details of which are presented below, a bimodal distribution of responder types is found. In this cross-sectional sample, most children are either mostly generating implicatures (e.g., 4 or 5 times out of 5) or mostly not generating implicatures (0 or 1 time out of 5). We will refer to them as “implicature-generators” and “implicature-non-generators,” respectively.

Theoretically, the pragmatic calculation that children must make in a given situation, with the lexical knowledge they have developed, is what produces their judgment of whether *algunos* has a “some, but not all” implicature interpretation. In our experiment, we attempt to discover how much of this theoretical judgment can be explained on the basis of lexical knowledge alone.

### Summary and Research Questions

Pragmatic implicature interpretations of the existential quantifier *algunos* depend on children grasping the pragmatics of choosing the domain from which the plural indefinite exemplars should be drawn (e.g., for *algunos niños*, all children vs. a set of children that is pragmatically prominent in the conversation). Nonlinguistic number or ANS provides approximate number information to the lexicon, which then refracts this information in language-specific, morpheme-specific ways to produce the number-expressing bound and free morphemes that populate the lexicon. Some of these free morphemes in Spanish constitute the Quantity Scale that includes *algunos*. This quantifier comes to have its pragmatic “some, but not all meaning” as a function of its relation to *todos* (all), and both of these quantifiers come to have more precise meanings for children as ANS becomes more adultlike and as other number-expressing morphemes are added to the lexicon. If this hypothesis is on the right track, we should see contingency between general lexical development and the development of “some, but not all” interpretations. This hypothesized contingency leads to the following research questions.

1. Does general lexical development, as measured by four independent measures of general Spanish lexical development, predict children's “some, but not all” interpretations of sentences with *algunos*?
2. Can these four independent measures of general lexical development form part of a linear discriminant function capable of distinguishing categorical “implicature-generators” vs. categorical “implicature-nongenerators”?

### Method

#### Participants

Parents or guardians signed a university institutional review board-approved informed consent document for children. Adult controls signed their own informed consent documents. A total of 82 monolingual, typically developing, Spanish-speaking children in Mexico City took the experiment (41 girls and 41 boys). Children were recruited in public and private day care centers and elementary



schools. Of these 82, 18 were excluded for not passing our filler items, described below, leaving 64 children whose data we consider. These 64 children ranged in age between 50 and 101 months, with a mean age of 77.8 months ( $SD = 15.2$ ). Adult participants ranged between 18 and 36 years of age ( $M = 26$  years). No adults were excluded for not passing filler items. The distribution of participants who passed filler items into age groups is given in Table 1.

## Procedure

Only one of the four lexical measures that forms the discriminant function used in this article, *Adivinanzas*, from the BELE *Batería de Evaluación de Lengua Española* (“Evaluation Battery of the Spanish Language”; BELE; Rangel et al., 1988) was used in the work of Grinstead et al. (2022). The Truth Value Judgment Task (TVJT), from which we construct our two dependent variable subgroups here (implicature-generators and implicature-nongenerators), was reported in the work of Grinstead et al. (2022).

## TVJT

Our dependent variable is the result of a TVJT, as proposed by Crain and McKee (1985). This measure was chosen because it allows for a rich pragmatic context to be presented to children, which is critical for measuring conversationally computed interpretations. Numerous aspects of experimental methodology have proven to be obstacles to measuring children’s knowledge of conversational implicatures. Because test sentences using generic predicates (e.g., Some giraffes have long necks. Yes or no? from the work of Noveck, 2001) can confound measurement of quantifier comprehension with children’s world knowledge, our TVJT uses eventive predicates that describe events depicted in a stop-motion, video-recorded scenario. Because consecutively carried out actions, as opposed to simultaneous carried out actions (Pratt et al., 2019), are more likely to yield implicature interpretations in children, for attention and memory-related reasons (see the work of Ricker & Cowan, 2014), our video depictions employ consecutive action. Furthermore, because an explicit Question Under Discussion has also been shown to help adults generate implicatures in Spanish (e.g., Pratt et al., 2018), we include one in our TVJT. Finally, our experimental scenarios culminate with sentences that have “covert partitives” in them, following de Hoop (1997), as in (5).

- (5) Algunos niños bajaron la resbaladilla.  
Some children went down the slide.

- (6) Algunos de los niños bajaron la resbaladilla.  
Some of the children went down the slide.

Covert partitive sentences are distinct from overt partitive sentences, such as (6), in that they lack a Uniqueness Presupposition, in the sense of Russell (1905). Following von Stechow (1994) and Roberts (1995), because of the lack of this presupposition, listeners must decide whether the referents of the indefinite are exemplars drawn from the set of all possible children, or whether they are drawn from a set of children that is prominent in the Conversational Common Ground. In (6), the Uniqueness Presupposition associated with the definite article *the* implies that no such decision must be made. The referents associated with the indefinite are presupposed to be familiar or specific to the listener. While it may also be interesting to study children’s interpretations of overt partitives, here, we will be studying whether children are able to generate scalar implicatures that are drawn after the children make the pragmatic decision as to which domain the indefinites are drawn from, using covert partitive constructions, as in (5).

Our primary outcome variable is children’s interpretations of sentences with *algunos* modifying a noun in subject position, presented in a video-recorded depiction of a context in which *algunos* is not felicitous, but rather *todos* (all) would be. The rationale for this choice is given in the original TVJT design of Crain and McKee (1985), which is that confirmation bias will orient children toward saying “yes” much more than “no.” Thus, if children are willing to say “no” to a sentence as a description of a scenario, which would require a scalar implicature interpretation, then it is highly likely that they feel confidence in that interpretation.

Our version of this task is video-recorded for reliability of presentation and is created using stop-motion video, following Padilla-Reyes et al. (2015), to make the scenario visually appealing to children. Following Crain and McKee (1985), we include the property of Plausible Dissent in our design to imply doubt as to whether the children in the videos can carry out a particular action, for example, going up a tall ladder to watch TV. This implied doubt sets the stage for a genuine question about whether an action occurred or not, as opposed to a “school question” in which obvious or known facts are queried to prompt repetition of something that is supposed to be known.

- (7) Los niños están en la casa y quieren subir a ver la tele, pero la escalera es muy alta.

**Table 1.** Age of participants.

Age	4-year-olds	5-year-olds	6-year-olds	7-year-olds	8-year-olds	Adults	Total
<i>n</i>	7	19	13	14	11	27	91

The children are at home and they want to go upstairs to watch TV, but the ladder is very tall.

After having commented on the height of the ladder, the narrator (a female speaker of the same dialect of Spanish as the children—Mexico City Spanish) states our explicit Question Under Discussion, following Gualmini et al. (2008):

- (8) ¿Quién va a subir a ver la tele?  
Who is going to go up to watch TV?

The children then climb the ladder (either all four of them or only three of four), as in Figure 2, and the female voice produces the experimental sentence, given in (9).

- (9) Ya sé. Algunos niños subieron la escalera.  
I know. Some children went up the ladder.

This statement is consistent with the implicature interpretation, which should be accepted when paired with the video in which only three of four children go up the ladder, but rejected when paired with the video in which all four children go up the ladder. There are five such sentences, each of which is paired with both a video scenario in which all four children carry out the action and a video scenario in which only three of four children carry out the action.

- (10) Algunos niños bajaron la resbaladilla.  
Some children went down the slide.  
(11) Algunos niños subieron la escalera.  
Some children went up the ladder.

**Figure 2.** Scene from a video depicting the third of four children consecutively climbing a ladder to watch television.



- (12) Algunos niños brincaron la cerca.  
Some children jumped over the fence.  
(13) Algunos niños cruzaron la calle.  
Some children crossed the street.  
(14) Algunos niños le dieron vuelta al autobús.  
Some children went around the bus.

To familiarize participants with the task, warm-up scenarios were presented in the same format with the same type of sentences and action, with the difference that the quantifiers *todos* (all) and *ningún* (none), as in (15) and (16), were used. The purpose of these items was to orient participants to the task and make clear the experimenter's expectations of the participants, without actually training participants on the critical items, which include *algunos*. In our pilot work, even our youngest children (4-year-olds) were able to give consistently correct judgments of *todos* and *ningún* statements.

- (15) Todos los niños pasaron el puente.  
All the children crossed the bridge.  
(16) Ningún niño pasó el puente.  
No child crossed the bridge.

Sentences 17 and 18, which are of this same type, were presented as filler items interspersed throughout the experimental items. They were each presented in both a context congruent with their truth conditions and in a context that was incongruent with their truth conditions, for example, Sentence 17 with a context in which all of the children got in the pool and also with a context in which not all of the children got in the pool.

- (17) Todos los niños se metieron en la alberca.  
All the children got in the pool.  
(18) Ningún niño se metió en la alberca.  
No child got in the pool.

Participants who did not answer all of these items correctly were removed from the sample. No adults were removed for this reason. Eighteen children were removed for this reason.

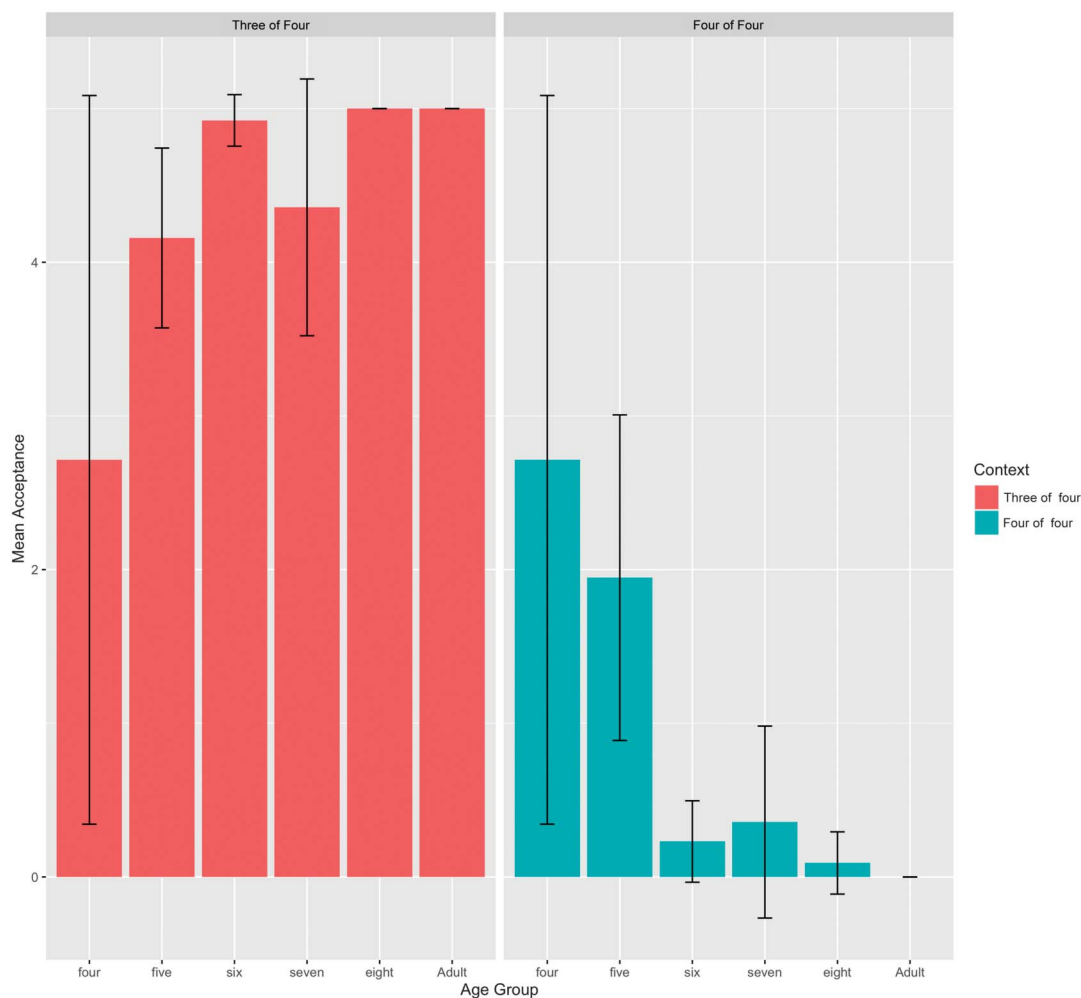
The scenarios were presented in randomized order using SuperLab 5 software (Cedrus Corporation) on 13" Macintosh MacBook Air laptop computers. Participants indicated acceptance of the final sentence by pushing the "c" key of the keyboard, which had a foam "smiley face" affixed to it, and conveyed rejection by pushing the "m" key of the keyboard, which had a foam "sad face" affixed to it. The audio of the experiments was transmitted through over-the-ear, noise-canceling headphones, which were plugged in to the computers. All audio files were recorded by a female native speaker of the same variant of Spanish spoken by the children (Mexico City Spanish).

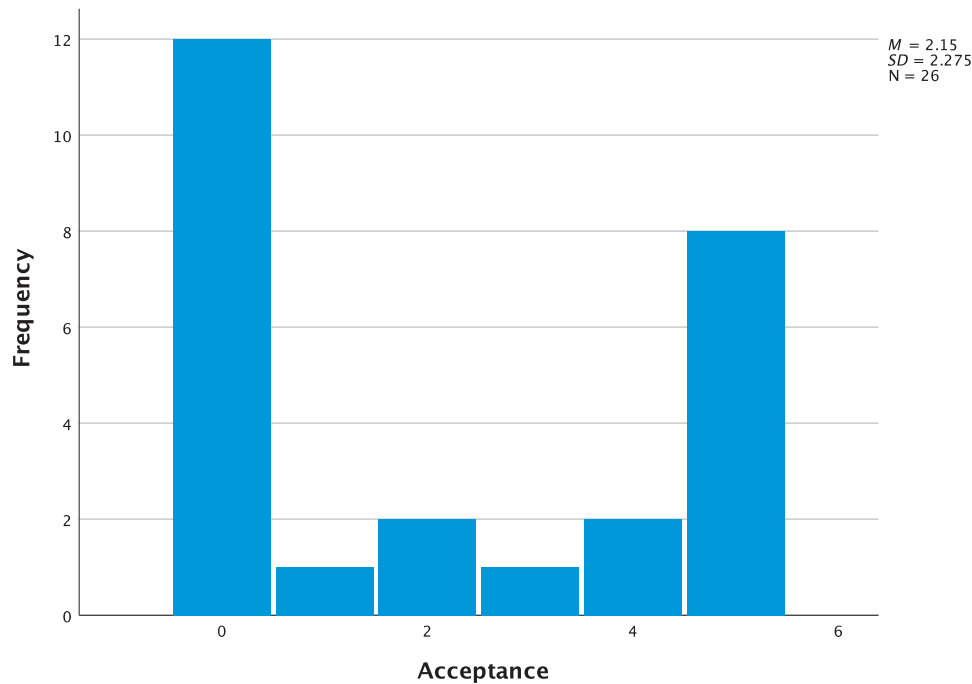
## Lexicon

In order to abstract away from the variance inherent in the distinct methodologies used in measuring children's lexical development, we used four different types of tasks, which we will use in our discriminant function analysis. The *Adivinanzas* ("Riddles") subtest of the BELE consists of a brief definition (the "riddle"), which is read aloud to the child, who then must guess the word to which the definition makes reference. The *Definiciones* ("Definitions") subtest of the BELE measures the ability of the child to define words. The *Test de Vocabulario en Imágenes Peabody* or TVIP (Dunn et al., 1986) is the Puerto Rico- and Mexico-standardized Spanish version of the Peabody Picture-Vocabulary Test (Dunn & Dunn, 2010). Finally, our last lexical measure, Number of Different Words (NDW), is expressive and is based on spontaneous production samples. NDW is a measure of lexical diversity

that counts the NDW roots in speech samples (J. Miller, 1991). For this study, the participating children were individually video-recorded while retelling the *Frog, Where Are You?* story (Mayer, 1969). The video recordings were then transcribed in CHAT format in line with CHILDES transcription conventions (MacWhinney, 2000). Four native Spanish speakers were trained on the conventions of transcribing children's narratives using CLAN, and after some practice, all four were able to achieve initial reliability of at least 90% exact agreement on a master transcript. The audio files were then transcribed iteratively: After a first pass, all the transcriptions were reviewed, and any discrepancies were resolved. Following Castilla-Earls et al. (2015), after the third pass, all audio files and transcriptions were reviewed by an independent transcriber. NDW was then calculated for each child by the CLAN programs of the CHILDES Project (MacWhinney, 2000). Testers were

**Figure 3.** Acceptance of *algunos* in implicature-consistent contexts (three out of four) and in implicature-inconsistent contexts (four out of four) from Grinstead et al. (2022, Figure 4, p. 18). Used with permission of SAGE Publications Ltd., from "Piecewise Structural Equation Modeling of the Quantity Implicature in Child Language," Grinstead et al., *Language and Speech*, 2022; permission conveyed through Copyright Clearance Center, Inc.



**Figure 4.** Histogram of acceptance of *algunos* in *todos* contexts by 4- and 5-year-olds, showing bimodal distribution.

initially trained on each measure and gave it multiple times under supervision of already proficient testers until they were similarly proficient with test application.

## Results

### Descriptive Statistics

First, we see that 6-, 7-, and 8-year-olds in our sample appear to generate implicatures categorically, as do adults, illustrated by the blue bars in Figure 3, in which lower bars (closer to 0) equal higher implicature generation. The mean acceptance values given in Figure 3 show that 4- and 5-year-old children accepting, as a group, *algunos* in *todos* contexts at chance (50%); however, there is in fact a bimodal

**Table 2.** Means and standard deviations for each of four lexical measures, for each of 5 years age bands.

Age band	TVIP	Definiciones	Adivinanzas	NDW
4	53.7 (11.3)	37.7 (12.2)	11.6 (5.3)	100.3 (20.0)
5	55.7 (13.8)	36.7 (9.3)	14.5 (5.9)	97.7 (16.3)
6	77.0 (10.4)	47.9 (8.2)	16.1 (3.8)	123.1 (12.2)
7	78.9 (10.8)	51.1 (7.2)	19.4 (3.5)	117.1 (14.6)
8	86.0 (8.4)	52.2 (10.2)	21.8 (2.9)	124.9 (21.6)

Note. TVIP = *Test de Vocabulario en Imágenes Peabody*; NDW = Number of Different Words.

distribution, illustrated in Figure 4. The largest group of these children (13/26) is adultlike and accepts *algunos* 0 or 1 time out of 5, whereas another substantial group (10/26) accepts it 4 or 5 times out of 5 and only a small group (3/26) in the middle accepts *algunos* 2 or 3 times out of 5, as illustrated in the following histogram. Table 2 gives the means and standard deviations for each age band, for each lexical measure.

### Inferential Statistics

Our first research question addresses the relationship between lexicon and implicature generation. We begin with a Pearson product-moment correlation of our four lexical variables and implicature generation reported in Table 3.

To determine the degree to which each lexical variable accounts for unique variance, given the high degree of correlation among our lexical measures, we perform a multiple regression. Because the distribution of the dependent variable is a count distribution, a Poisson multiple regression is appropriate. The regression coefficients, standard errors, and standardized coefficients (for maximum comparability among predictor variables) are given in Table 4. The likelihood ratio chi-square test ( $-65.14$ ) indicates that the full model is a significant improvement over a null (no predictors) model ( $p < .001$ ). Furthermore, we see that in addition to all four lexical measures correlating with implicature interpretations, three of the four measures (all but *Adivinanzas*) account for unique variance in implicature interpretations in the multiple regressions.



**Table 3.** Pearson product–moment correlation of study variables.

Variable	<i>Adivinanzas</i>	<i>Definiciones</i>	TVIP	NDW
Acceptance in implicature contexts	-.446***	-.568***	-.675***	-.423***
<i>Adivinanzas</i>		.479***	.622***	.390**
<i>Definiciones</i>			.621***	.353**
TVIP				.487***

Note. TVIP = *Test de Vocabulario en Imágenes Peabody*; NDW = Number of Different Words.

\*\* $p < .01$ . \*\*\* $p < .001$ .

Our second research question asks whether our lexical variables can effectively identify children as those who categorically generate implicature interpretations “generators” and those who do not “non–generators,” where generators accept zero or one scenarios of *algunos* in *todos* contexts and nongenerators accept four or five scenarios of *algunos* in *todos* contexts. In our sample of 64 children, 61 fit into one of these two categories, whereas two children accepted two scenarios and one child accepted three. Of the 61 remaining children, 11 would be classified as “nongenerators” and 50 would be classified as “generators.”

A statistical means of modeling the role that the lexical measures can play in categorizing children into implicature-generators and implicature-nongenerators is a linear discriminant function analysis. This is advantageous because we are able to put to use the unique variance contributed by three of the four distinct lexical measures (all but *Adivinanzas*), giving us a much more informed measure of lexicon, as a construct, than a single measure would. Fitting a linear discriminant function model with the four lexical measures to identify our two groups of children, we were able to classify implicature-generating children with 88% sensitivity (44/50) and implicature non-generating children with 100% specificity (11/11). The structure matrix for this analysis is given in Table 5.

## Discussion

With respect to our research questions, the first was whether lexical development, measured by four distinct measures of lexical development, would be predictive of

children’s pragmatic implicature interpretations of sentences using *algunos* in subject position. The answer to this question is affirmative. Each lexical measure correlated with implicature generation. Follow-up analysis showed that three of the four lexical measures were independently predictive of implicature generation, accounting for unique variance. Our second question asked whether these four measures could profitably form a linear discriminant function that would distinguish “implicature-generators” from “implicature-nongenerators.” Again, the answer was affirmative. Forty-four out of 50 (88%) of the implicature-generators were identifiable in this way, and 11 of 11 (100%) of the implicature-“nongenerators” were identifiable in this way. Thus, if we know children’s scores on these four measures in Spanish, we can say with a high degree of confidence whether or not they are going to be children who can draw a conversational implicature interpretation of an eventive sentence, with *algunos* in subject position.

Most previous work on children’s abilities to draw these inferences has paid little attention to modeling the specific subdomains of cognition that might be relevant to comprehension of sentences with conversational implicatures presented in pragmatically rich contexts. Providing this type of rich pragmatic context is one of the primary advantages of the TVJT, and this design feature is the reason we have used it here to measure children’s pragmatic knowledge. Because Grinstead et al. (2022) has shown that multiple dimensions of language and cognition are predictive of implicature interpretations, we wanted to know more about the lexical dimension. Specifically, because Grinstead et al. only used *Adivinanzas*, we wanted to confirm that this was

**Table 4.** Poisson multiple regression of acceptance of *algunos* in *todos* contexts.

Variable	Constant	<i>Adivinanzas</i>	<i>Definiciones</i>	TVIP	NDW
<i>Algunos</i> acceptance in implicature contexts	6.421 (.826) -.875	.027 (.027) .145	-.039** (.014) -.437	-.051*** (.009) -.872	-.021** (.008) -.415

Note. Coefficients (standard errors) and standardized coefficients. TVIP = *Test de Vocabulario en Imágenes Peabody*; NDW = Number of Different Words.

\*\* $p < .01$ . \*\*\* $p < .001$ .

**Table 5.** Structure matrix of lexical variables forming an implicature-generation discriminant function.

Measure	Correlation with function
TVIP	.937
Definiciones	.657
Adivinanzas	.500
NDW	.454

Note. TVIP = *Test de Vocabulario en Imágenes Peabody*; NDW = Number of Different Words.

not a measurement fluke associated with this one measure. In the results presented here, we have seen that in fact both highly ecological measures, such as NDW, as well as more high-task demand measures, such as TVIP, are predictive of implicatures. This suggests that it is the lexicon, and not a nonlexical task-specific aspect of cognition, that relates to implicature generation.

### Lexical Refraction

We do not believe that lexicon is the only determining factor in child or adult scalar implicature interpretations. A range of competence and performance abilities drawn from the larger linguistic and nonlinguistic cognitive system is required, as has been argued elsewhere (Grinstead et al., 2022), including syntax, inhibition, and the ANS. Among these variables, however, development in the lexicon plays a critical role. One of the most important and well-studied dimensions of semantic structure in the lexicon are pragmatic scales, including the Quantity Scale, addressed here. We take the possibility of identifying children as implicature-generators versus nongenerators with high degrees of accuracy to be indicative of how major a role the lexicon plays in creating the “some, but not all” interpretation.

### Limitations and Future Directions

We have used a set of lexical measures to identify children as implicature generators versus nongenerators. A distinct approach to finding the common variance among lexical measures that predict implicatures would be to work with latent variables. That is, a traditional structural equation model (e.g., Kline, 1998; Wolf et al., 2013) could be used with these multiple lexical measures to isolate the lexical variance common across our distinct measures, in a single variance-covariance matrix. Such an approach would require roughly 300 participants, 5 times the number who took our tests. In this way, we could abstract away from the different tasks demands that individual lexical measures require, including perhaps the inhibition dimension referred to above, among others. Future work of this type would allow us to get beyond specific task properties and allow us a clearer picture of the relationship among the distinct domains of cognition that allow pragmatic inferences to be drawn.

## Data Availability Statement

Data can be made available upon reasonable request.

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