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Acquisition of Negation and Quantification: Insights From Adult Production and Comprehension

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Abstract

Inspired by adult models of language production and comprehension, we investigate whether children's nonadult interpretation of ambiguous negative quantified sentences reflects their sensitivity to distributional patterns of language use. Studies 1 and 2 show that ambiguous negative quantified sentences of the sort typically used in acquisition studies are strongly avoided in adult production and are judged as poor alternatives by adults. Corpus Studies 3 and 4 show that children and adults overwhelmingly use quantifiers and negation in ways that promote one interpretation of these ambiguous quantified sentences over others. We argue that these patterns guide children's ambiguity resolution processes and explain children's interpretations of ambiguous quantified sentences. The origin of distributional patterns in adult production processes is discussed.

1. INTRODUCTION

Imagine that you are told the following story:

> This story features a dragon and four giant slices of pizza. When he got home, the dragon was very hungry. He found four giant slices of pizza, which looked very yummy. He ate the first slice of pizza, then he ate the second one but was barely able to finish it. The dragon said that the two remaining slices looked good, but he was too full by then and could not have another bite to eat.

Suppose further that you are asked to say something about what happened in the story. There are many things you could say, some of which are shown here:

(1) The dragon only ate two slices of pizza.

(2) The dragon ate two of the slices (of pizza).

(3) The dragon did not eat two slices of pizza.

(4) The dragon did not eat two of the slices (of pizza).

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All of these statements are true with respect to this short story, but for native speakers of English, (3) seems a notably worse choice than the others to describe the story's events. Interestingly, statements such as (3) are frequently paired with stories such as the one above in investigations of children's abilities to comprehend negative quantified statements (e.g., Lidz and Musolino (2002)). This choice might seem unwise in the face of the observation that (3) is a very awkward characterization of the events in the story. However, psycholinguistic research has a long history of presenting idiosyncratic materials to both adults and children to assess comprehension processes—researchers have used filtered speech, compressed speech, complicated syntactic ambiguities, scrambled sentences, rampantly ungrammatical sentences, and many other types of language that children and adults rarely if ever encounter. In these cases, the choice of unusual language materials is motivated by the belief that performance on this particular type of language input will be informative about some underlying representations or processes in a way that more simple or typical language stimuli will not. This strategy has proved itself repeatedly throughout adult and child psycholinguistics, but in every case in which a particular set of materials and procedures yields a pattern of performance, researchers must ask whether the obtained results are really indicative of the participants' representations or processes or whether something about the odd materials or task demands has led to a misleading outcome in the experiment (see, e.g., Crain et al. (1996) and Gualmini (2004)).

In this article, we scrutinize the materials and tasks that have been employed in studies of children's acquisition of negative quantifier sentences. We place our analysis in the context of related issues in adult language comprehension and production both to ground these analyses in related empirical data and to make some broader points about how constraint satisfaction processes could be guiding children's comprehension of complex sentences. We begin with a summary of comprehension of ambiguous quantified statements in the acquisition literature and then review some key concepts within what has come to be called constraint-based sentence comprehension in the adult psycholinguistics literature.

1.1. Children's Interpretation of Negative Quantified Statements

There is an extensive literature in children's interpretation of quantifiers. Much of the debate initially concentrated on children's nonadult interpretations of affirmative statements like *Every farmer is feeding a donkey* (cf. Brooks and Braine (1996), Bucci (1978), Crain et al. (1996), Drozd (2001), Drozd and van Loosbroek (1999), Freeman, Sinha, and Stedmon (1982), Geurts (2003), Inhelder and Piaget (1964), Philip (1995), Smith (1979; 1980)). More recently, however, young children have also been shown to differ from adults in their preferred interpretations of ambiguous negative quantified statements. Musolino, Crain, and Thornton (2000) and Lidz and Musolino (2002) reported that in sentences such as (5) and (6), children preferred to assign the scope interpretation that derives from the overt syntactic c-command relations of the sentence (the isomorphic interpretation). Following standard linguistic approaches, these authors distinguished between overt syntactic scope—that dictated by the surface c-command relations of the syntactic structure—and semantic scope. Semantic scope relations are often assumed to obtain at a different level of representation such as Logical Form (LF) via movement rules involving the fronting of quantifier

expressions. At this level, semantic scope relations can differ from those in the overt syntactic structure.

Consider the two possible interpretations of (5). In the interpretation exemplified in (5a), the *every-not* interpretation, every duck is such that it did not cross the river (i.e., none of them crossed). This is the isomorphic interpretation, because the semantic scope indicated by the order of the quantifier and negation in the logical translation is similar to that of the surface syntactic structure. In the alternative scope relation, the *not-every* interpretation, the sentence means that not all of the ducks crossed, as exemplified in (5b), where negation has scope over the quantifier in the semantic translation, thus effectively undoing the overt syntactic scope.

(5) Every duck didn't cross the river.

a. $\forall x[\text{duck}(x) \rightarrow \neg\text{cross}(x, \text{the-river})]]$ (= none of the ducks crossed)

b. $\neg\forall x[\text{duck}(x) \rightarrow \text{cross}(x, \text{the-river})]]$ (= not all the ducks crossed)

(6) The dragon didn't eat two slices of pizza.

a. $\neg\exists_2 x\ [\text{slice}(x) \& \text{ate}(\text{the-dragon}, x)]$ (= the dragon didn't eat any two slices)

b. $\exists_2 x\ [\text{slice}(x) \& \neg\text{ate}(\text{the-dragon}, x)]$ (= there are two slices the dragon didn't eat)

Musolino et al. (2000) pointed out that in a story-context in which (5b) was true (e.g., only some ducks had crossed a river), children preferred to assign the interpretation in (5a), thus behaving unlike adults in considering (5) inaccurate. In cases like (6), children also have a preference for the isomorphic interpretation in (6a), in which negation precedes the quantifier as in the overt syntactic relations, meaning that it is not the case that the dragon ate any two slices of pizza. Thus, in a story context in which the nonisomorphic interpretation in (6b) is true, as in the initial example of this article, children reject the statement as a correct description of what happened in the story, thus behaving unlike adults.

Two kinds of explanations have been proposed to account for children's isomorphic responses. In Universal Grammar (UG) approaches, children's responses are attributed to a stage of acquisition predetermined by UG. For example, to explain isomorphic responses, Musolino et al. (2000) argued that children undergo a stage of development determined by UG in which their grammar allows only the isomorphic interpretation because there is parametric variation that needs to be set on the basis of experience. Languages like Chinese permit only the isomorphic interpretation. If the two possible interpretations are available from the outset, Musolino et al. argued, Chinese speakers would not have negative evidence to realize that the *not-all* or *not-every* interpretation, which is entailed by the isomorphic *none* interpretation, is incorrect.

In a different approach, Musolino and Lidz (2003; in press) also proposed pragmatic and/or performance factors to explain children's interpretations. They suggested that children's fragile pragmatic abilities and less sensitivity to pragmatic factors are the source of their inability to access nonisomorphic interpretations. They argued that, for example, in *Every*

duck didn't cross the river, a Gricean implicature is required to access the nonisomorphic interpretation (see Levinson (1983) for Grice's cooperation principles): If the speaker meant that none of the ducks crossed the river, then he or she would have said so (this would be a better way to convey this information), therefore he must mean that not all the ducks crossed the river. Although failure to perform Gricean inferences does not explain the case of cardinal quantifier *two* (quantity inferences are generated in both isomorphic and nonisomorphic readings with cardinal quantifiers), the pragmatic view was further supported by other findings showing that under certain circumstances, children can in fact access nonisomorphic interpretations. For example, the use of a partitive construction in (6) as in *The dragon didn't eat two of the slices of pizza*, or the addition of a preceding affirmative statement in (5) as in Every horse jumped over the log but every horse didn't jump over the fence, significantly increased children's performance (Musolino and Gualmini (2004), Musolino and Lidz (2003); see also Gualmini (2004) for nonisomorphic interpretations of the quantifier *some*).

In this article, we pursue an experience-based processing approach. We relate children's failures to adopt some interpretations of scope ambiguous sentences to specific observations about adult production patterns and comprehenders' (including children's) use of probabilistic constraints to resolve ambiguities. Along similar lines to Brooks and Braine's (1996) approach, we argue that children, like adults, are sensitive to the distributional patterns of language use, including use of negation, quantified expressions, and their pairings with specific situations, and that children's experience of such patterns shapes their comprehension of scope ambiguous sentences.[1] This experience-based view finds support in the fact that the mapping from quantifier word to a particular meaning must be learned from experience, because languages differ in the number and type of quantifier expressions they contain. Spanish, for example, has only two words (*todo, cada*) to express the English meanings of *every, each, all, everyone, everything, everybody*. Other distributional patterns (or cues) such as the quantifiers' plural or singular morphology or their syntactic positions must guide comprehenders in accessing one or another interpretation (see Brooks, Jia, Braine, and da Graca Dias (1998)). Our approach investigates in detail the properties of these mappings from form to meaning and explores the potential effects of distributional patterns of language use on children's interpretation of quantifier statements.

We argue that speakers' spontaneous use of quantifier expressions gives rise to distributional patterns of use in which certain quantified expressions are more often paired with certain situations (interpretations) than others. For example, a speaker would be highly unlikely to produce sentences such as *The dragon didn't eat two slices of pizza* or *Every duck didn't cross the river* with a nonisomorphic interpretation in contexts like those of the experimental stories and would choose some other description instead. As a result, children often do not

[1]Anecdotal evidence for such sensitivity can be seen in the following grammaticality judgment, spontaneously produced by a child and recorded by the authors. The child's comment was about the speech of another child (Netzer) who was not a native speaker of English.

Ethan (5;4): Netzer says “I have many LEGOS,” but really it should be “I have a lot of LEGOS.”

This judgment about the relative acceptability of the quantifiers *many* versus *a lot of* reflects a distinction between two highly similar utterances that are both generally acceptable but where one quantified expression, in the child's American English dialect, is a slightly better match to the situation in which someone claims possession of a large collection of tiny plastic toys. The child's judgment appears to reflect extreme sensitivity to the situation–quantifier pairings that have previously occurred in the input.

access nonisomorphic interpretations in experiments using these expressions, because they have not had sufficient language experience in which the quantifiers were paired with such interpretations. Instead, they access the interpretation that happens to be consistent with the most frequent patterns in their input and the most frequent interpretations of the structures at hand. This experience-based view has a number of parallels in adult language comprehension and ambiguity resolution, to which we turn next.

1.2. The Constraint Satisfaction Approach to Ambiguity Resolution

One of the truisms of adult language comprehension is that the frequency of elements in the input is a big player. An obvious example is that words that are encountered more often are both comprehended more rapidly and uttered more quickly by language users. Frequency also exerts a major influence in interpretation of ambiguities, both at the lexical level, such as recovering the noun versus verb meaning of *bark*, and at the syntactic level, in which more common interpretations of syntactic ambiguities are preferred to rarer ones, at least in the absence of context (MacDonald (1994), Rayner and Duffy (1986), Simpson (1984), Trueswell, Tanenhaus, and Kello (1993)). The constraint satisfaction (or constraint-based) approach to sentence processing (MacDonald, Pearlmutter, and Seidenberg (1994), Tanenhaus and Trueswell (1995), Trueswell, Tanenhaus, and Garnsey (1994)) has provided abundant evidence for the claim that the interaction of multiple probabilistic constraints, ultimately stemming from past experience, determines the semantic and syntactic analyses that are entertained as the sentence unfolds. Alternative interpretations of an ambiguity are partially “activated” during comprehension on the basis of the unfolding evidence, and the frequency of the alternatives modulates the relative activation strengths of the alternatives. One interpretation eventually gains sufficient activation to be adopted, and so the ambiguity resolution process can be seen as one in which distributional patterns of words, phrase types, word co-occurrences, word-situation co-occurrences, and many others, contribute to the relative weight of alternatives during comprehension. This approach bears some resemblance to Bates and MacWhinney's (1987) Competition Model, which holds that children learn to interpret linguistic cues through experience and competitions between these cues accounts for children's performance. One key difference between constraint-based accounts and the Competition Model is that the constraint-based accounts have emphasized how sentence interpretations change in real time (“on-line”) as more of the sentence is perceived.

One example of the influence of distributional patterns on adult on-line comprehension of ambiguous structures is the case of attachment ambiguities such as that in (7). In such cases, the final prepositional phrase (PP) can be syntactically attached to the noun phrase (NP) *the man* or to the verb *watch*, resulting in two different interpretations.

(7) The child was watching the man with the binoculars.

(8) The apache shot the cowboy with the leather vest.

Many studies have dealt with this ambiguity (e.g., Britt (1994), Rayner, Carlson, and Frazier (1983), Spivey-Knowlton and Sedivy (1995), Taraban and McClelland (1988)) and showed that unexpected attachments such as that in (8) take longer to read. Several distributional factors affect the attachment preferences in these cases, in particular, the lexical properties

of the verbs (action vs. perception verbs) and the definiteness of the object NP. These factors can interact so that the strength of a particular factor in favor of an interpretation can compete and be overridden by the others (Spivey-Knowlton and Sedivy (1995)). For example, PPs in sentences with perceptual verbs tend to be interpreted as NP-attached modifiers in corpora and comprehension studies measuring reading times (e.g., the salesman glanced at a customer with ripped jeans). However, when a definite phrase is used instead of an indefinite (e.g., *the customer*), comprehenders tend to assume that the denotation of this phrase is presupposed in the context (i.e., that there is a customer the salesman is glancing at), preempting the need for any identifying prepositional NP modification. Comprehenders therefore reverse their preferences, quickly activating a verb-phrase (VP) attached interpretation instead. Thus, distributional patterns associated with the verb (verb preferences) and the use of definite phrases (presuppositional contexts) rapidly influence interpretation and interact during on-line comprehension, modulating the activation strength of an interpretation over another when the PP is encountered.

Similar attachment ambiguities have also been investigated with children. When presented with a situation in which there are two apples—one on a napkin, one on the table—and a box, children tend to interpret sentences such as *put the apple on the napkin in the box* as meaning that an apple should be put on the napkin (Snedeker and Trueswell (2004), Trueswell, Sekerina, Hill, and Logrip (1999)). The ambiguous PP is thus attached to the verb rather than the NP *the apple*. Adults, in contrast, understand that the apple to be manipulated and put in the box is the one on the napkin, an effect fairly well understood in adult comprehension (Altmann and Steedman (1988), Crain and Steedman (1985), Ni, Crain, and Shankweiler (1996)). Children's failure to take this referential contrastive context into account in on-line processing (as evidenced by their eye movements and subsequent actions) is interpreted to indicate that young children initially tend to strongly rely on the lexical distributional bias of verbs like *put* (most often followed by a location) rather than the situational context, indicating a potential developmental trend (Snedeker and Trueswell (2004)).

These examples illustrate in both young children and adults the importance of distributional patterns in the input in processing ambiguities. Sensitivity to such statistical information leads comprehenders to activate on-line one interpretation or another (whether correct or incorrect) on the basis of the unfolding evidence. The role of these distributional patterns in ambiguity resolution raises two related questions. One of these is what computational mechanisms are involved in on-line comprehension. A number of symbolic and connectionist computational architectures have been proposed to deal with this question, and we do not discuss these alternatives here (but see Christiansen and Charter (2001), McRae, Spivey-Knowlton, and Tanenhaus (1998), Rumelhart and McClelland (1986), Tabor, Juliano, and Tanenhaus (1997), Tabor and Tanenhaus (2001), Tsang (1993)). Our focus is largely on a related question relevant to the present work: why particular distributional patterns exist in the first place—that is, why languages have particular distributional characteristics. This question has received less attention in psycholinguistics (though see Hawkins (2004) and Wasow (2002) for hypotheses relevant to grammar and processing), but our own work has begun to address this point. Our approach is called the Production–

Distribution–Comprehension (PDC) framework because it attempts to link properties of the language production system to particular syntactic choices made during utterance production to particular distributional patterns in the input comprehenders receive and finally to comprehension behavior that is modulated by these distributional patterns. The PDC account essentially argues that structure choices in production, at least some of which are determined by production-specific mechanisms, create distributional patterns in the language to which comprehenders are sensitive. Comprehension processes and interpretation preferences can thus be traced to distributional patterns in language use, as the constraint satisfaction approach has shown, but critically, these distributional patterns are derived from the architectural components of the *production* system and the production mechanisms affecting speakers.

An examination of what is known about language production mechanisms can suggest how production demands give rise to distributional patterns of language use. Substantial work in this area has shown that language production is *incremental*, meaning that an utterance is typically not fully planned before a speaker begins articulating the first part of it (see Ferreira and Swets (2002) for review). Thus production is typically a complex process of uttering one part of a sentence while planning upcoming material. During planning, choice of word order and syntactic structure is strongly constrained by the *accessibility* of words and phrases (e.g., Bock (1982; 1986; 1987), Bock and Irwin (1980), Bock and Loebell (1990), Bock and Warren (1985)). Accessibility itself stems from a variety of semantic and articulatory factors, but it can be understood in this context as the degree to which a word or phrase is ready for articulation in the utterance—some elements, by virtue of being long, rare, hard to articulate, and so on, may require more planning and retrieval time than others. Given the incremental nature of production, fluency is maximized by uttering more accessible portions of an utterance early, leaving additional time to plan less accessible components. Our claim is that these repeated production-driven choices yield distributional patterns in the language that ultimately shape comprehension processes.

An illustrative example of how the PDC approach accounts for interpretation phenomena can be seen in the interpretation of ambiguous verb modification (the approach for this ambiguity was initially described in MacDonald (1999)). Example (9a) shows a fully ambiguous structure, in which *yesterday* can be attached to the nearby verb *left* (*local modification*) or to the main verb *said* (*distant modification*). (9b) and (9c) show examples in which the tense disambiguates this ambiguous structure in favor of local or distant modification.

(9)

a. *Verb Modification Ambiguity:* John said that Bill left yesterday.

b. *Local Modification:* John will say that Bill left yesterday.

c. *Distant Modification:* John will say that Bill left tomorrow.

Adult English speakers have an extremely strong preference for local modification, as in (9a). Many researchers have assumed that this preference emerges from a general operating principle of the syntactic parsing mechanism to prefer the most local modification, which has been formalized in principles such as Right Association (Kimball (1973)), Late Closure (Frazier (1987)), and Recency (Gibson, Pearlmutter, Canseco-Gonzalez, and Hickok

(1996)). These principles capture the fact that any new incoming constituent is preferentially attached to the syntactic constituent being built (the most recent syntactic node), as opposed to a node higher up in the syntactic structure. The PDC account, by contrast, argues that these interpretation biases emerge from sensitivity to distributional information, and those distributional patterns emerged from constraints on production. When there are options for ordering phrases in English, choice of phrase order is strongly governed by the phrase length, such that the short phrase tends to be uttered first (Hawkins (1994), Ross (1967), Stallings, MacDonald, and O'Seaghdha (1998), Wasow (1997a; 1997b)). This effect can be interpreted in terms of the relative accessibility of the phrases, such that on average, shorter phrases tend to require less planning and be ready for articulation sooner than long ones (de Smedt (1994), Stallings et al. (1998)).

Given this production constraint, producers will tend to produce utterances in which short phrases precede long ones, creating particular distributional patterns in the language. Moreover, exceptions to this phrase ordering should tend to appear for a reason, for example, if the generally dispreferred long–short order is necessary to convey a particular meaning. This is the case in example (10a), where that John had left precedes a short (italicized) phrase, *yesterday*,[2] but is the only option for conveying the *left-yesterday* meaning. The need to convey the appropriate meaning pressures the speaker to violate the standard short–long order. Because the *said-yesterday* meaning is typically conveyed with the more easily produced short–long order in structures such as (10b,c), the violation of such tendency in structures such as (10a) is a strong cue that a different interpretation in the long–short order is meant, namely, the *left-yesterday* interpretation.

(10)

a. Bill said that John had left *yesterday*. (Long–*short* order)

b. Bill said *yesterday* that John had left. (*Short*–long order)

c. *Yesterday*, Bill said that John had left. (*Short*–long order)

Production constraints such as message pressures or ease of planning in short–long phrase orders therefore create a distributional pattern in the language in which a particular order is overwhelmingly associated with a particular meaning. Comprehenders are then sensitive to such patterns, preferring the more frequent interpretation of a given order. On this view, there is no need to postulate a local modification parsing principle (Frazier (1987), Gibson et al. (1996), Kimball (1973)) to account for interpretation preferences in this construction. Local modification preferences simply reflect the well-attested sensitivity of comprehenders to distributional patterns, which have their origin in the word order choices stemming from accessibility-based production planning.

This general approach has potential applications to acquisition research, in that it is also possible that children's interpretation preferences, which have previously been taken to reflect basic properties of the child's acquisition of the grammar, can instead be traced to the child's sensitivity to distributional properties of the input, which themselves reflect the architecture of the (largely adult) production system. On this view, children's performance with quantifier scope ambiguities should stem from their sensitivity to distributional patterns

[2]The notion of phrase here is clearly not a traditional syntactic one, but it is one that reflects units of planning in language production.

in their input, which in turn result from adults' production preferences. Investigating a claim of this sort has several steps, including identifying what the distributional patterns are, testing hypotheses about how production processes give rise to these patterns, and determining the extent to which the distributional patterns predict children's comprehension performance. Such an investigation spans several subfields of psycholinguistics, and we cannot accomplish it all within a single article. We begin, however, by establishing certain key distributional properties of quantifier usage, which can then guide research on both potential comprehension consequences and production underpinnings.

2. ADULT STUDIES

2.1. Production Study 1: What Adults Say

In this experiment, we investigated the kinds of expressions that adults spontaneously use to describe the stories that children are tested with in many studies of quantifier scope interpretation. These data can thus provide indirect information of the kinds of quantifier statements children and adults are likely to encounter in situations analogous to these stories.

We followed the overall format of the stories told to children in several acquisition studies (e.g., Crain et al. (1996), Lidz and Musolino (2002), Musolino et al. (2000)). In these experiments, children were told stories and then a puppet described what happened. Children were then asked to indicate whether the puppet was correct. We developed pictures to illustrate the stories rather than acting them out. We asked adults to read the stories and then produce a statement describing the gist of the story (so that the adult was effectively playing the role of the puppet). We analyzed the adults' descriptions according to several variables such as the type of statement preferred (negative or positive), the type of noun phrases used, and the number of times they use a quantifier expression.

2.1.1. Materials—We took the four cardinal quantifier stories directly from Lidz and Musolino's (2002) appendix. Version A describes a situation in which, for example, a girl playing hide-and-seek with her friends finds only two out of four friends, thus making the *two-not* nonisomorphic interpretation true, that is, the interpretation in which *The girl did not find two friends* is taken to mean that there are two friends that the girl did not find (this is the story version corresponding to the example at beginning of this article). In Version B, the story describes the girl finding one out of two friends, thus making the alternative *not-two* interpretation true, that is, the interpretation in which the girl did not find two friends but just one. *Two-not* and *not-two* indicate the relative order of the quantifier and negation in each of the logical translations of (6).

Four universal quantifier stories were constructed roughly following an informal example given in Musolino et al. (2000), although the actual stories were not reproduced. In the case of the story about ducks, Version A describes a set of ducklings trying to cross a river, with some of them succeeding. In this version, the nonisomorphic *not-every* interpretation of *Every duck did not cross the river* is true, that is, not every duck crossed. Version B of this story describes the set of ducks trying but failing to cross out of fear. In this version, the *every-not* isomorphic interpretation of the quantifier statement is true, that is, one in which for every duck, it is true that it did not cross.

For all stories, color pictures were developed using clip art software. Two pictures were made for each story, one illustrating the events conveyed in Version A and the other illustrating Version B. Examples of pictures and stories for the two sets of items are given in Table 1.

2.1.2. Procedure—Participants were 37 undergraduate psychology students at University of Wisconsin–Madison who logged into a Web site to participate in the experiment. The instructions indicated that they would read a series of illustrated stories and that, after reading each story, they would provide a summary description of what happened in it. They were explicitly told to use one sentence to describe the story, rather than a sequence of them, and to use the pictures as memory aids. Accompanying pictures helped them to keep in mind the main events of the stories. Full instructions are reproduced in the Appendix. Each participant saw only one version of each story, and story versions were counterbalanced across participants, such that each participant saw two cardinal quantifier stories with the intended *two-not* interpretation, two cardinal quantifier stories with the *not-two* isomorphic interpretation, two universal quantifier stories with the *not-every* interpretation, and two with the intended *every-not* isomorphic interpretation. The order of stories was random.

2.1.3. Results

2.1.3.1. Cardinal quantifier set: Of the 148 observations (74 each for the A and B versions), 13 statements were excluded from the analyses because they did not refer to the events of the story and were most likely based on the picture alone (e.g., The dragon is full, The dragon wants the pizza on its right). For the remaining observations, we computed the percentage of statement type provided and the type of NP used to refer to the direct object of the relevant quantifier sentence. Statements were classified as *negative* if the produced sentence contained explicit negation such as *did not* or *could not*, or it implied a negative statement (e.g., *X [failed/was too full/too scared] to do Y*). Moreover, a statement was classified as contrastive if it contained a partitive NP such as *two of the friends* and/or contained the contrastive particle *only*. In either of these cases, the statement implies the existence of a contrastive set of individuals that has not participated in the event, as exemplified below (see Gennari, Meroni, and Crain (2004), Rooth (1992; 1996)):

(11) The girl found (didn't find) two of the friends. ⇒ There are other friends that the girl did not find (found).

(12) The girl only found two friends. ⇒ There is at least one friend she did not find.

The results are summarized in Table 2, using the hide-and-seek story to exemplify the typical structures used.

2.1.3.1.1. Positive, negative and contrastive statements: Across both versions of the stories, participants used positive statements about 70% of the time and contrastive statements over 60% of the time (including positive or negative contrastive statements). Thus participants preferred to report events that did happen in the story, rather than those that did not happen, and preferred to highlight the presence of a contrastive set, which clearly identifies the subset of individuals talked about. These statements clearly contrast with the negative statements used in Lidz and Musolino's (2002) study.

2.1.3.1.2. Referring expressions: Participants' NPs referring to the direct object of the verbs (e.g., the children found, the slices eaten) tended to be more specific than the indefinite phrases (e.g., *two friends*) used in acquisition experiments. Participants used definite descriptions such as *the first friend, the remaining friends* 15% and 46% of the time in the *two-not* and *not-two* version of the story respectively (collapsing across affirmative and negative statements). This difference across versions may be related to the cardinality of the sets in each story: When only two friends were involved, *the girl only found the first friend* was common. In contrast, when only two friends out of four were found, there were more indefinite references such as *two of the friends* and, therefore, fewer phrases such as *the remaining friends*.

The use of indefinite partitive phrases such as *two of the friends* was common (48% and 22% of the time in each version of the story, respectively, across both statement types), rather than simply using *two friends*. These uses constituted the majority of cases for the negative statements. Such partitive phrases indicate that the elements of the story (friends, slices, etc.) are taken from a larger set of people or objects. In other words, the partitive construction splits the set of friends into those found and those not-found (see Diesing (1992)), which then, unlike *two friends*, unambiguously indicates which two individuals are being referred to. Taking these findings together, in all statements but most notably in negative ones, speakers tended to provide information that either identifies the story characters (*the first friend*) or identifies the relevant subset of the contextually given set (*two of the friends*).

2.1.3.2. Universal quantifier set: Table 3 presents the results for the universal quantifier stories, using the duck story as an example. Of the 148 observations, 22 items were excluded because they did not refer to the events of the story (e.g., *The ducks are on the shore*).

2.1.3.2.1. Quantifier expressions: Participants never used the word *every* in their statements. In the *not-every* version in which only some ducks crossed the river, participants preferred to refer to the ducks with expressions such as *not all the ducks* or *some of the ducks*. In the *every-not* version, in which a negative universal statement was called for, participants tended to refer to the ducks with expressions such as *all the ducks, none of the ducks*, or simply *the duck*s. The absence of *every* from the participants' descriptive statements may be due to the fact that the story and the picture represented an unidentified number of ducks, referred to as a group. The quantifier *all*, which usually refers to collections, may have thus been preferred over *every*.

2.1.3.2.2. Referring expressions: The choice of referential expressions to refer to critical entities (e.g., the ducks) varied with the version of the story. In the *not-every* version, in which some ducks crossed, the preferred referential phrase was *some of the ducks* (83% across negative and positive statements). In contrast, in the *every-not* version, in which no duck crossed, the preferred referential phrase (about 72% across all statement types) was *the ducks*. This indicates that participants tended to circumscribe the referential domain of the NP when a subset of ducks was referred to, whereas a definite plural phrase was preferred when referring to the entire set of ducks.

2.1.3.2.3. Negative statements: The percentage of negative statements also varied across the two versions of the story. In the *not-every* interpretation, participants preferred to use a negative statement only 22% of the time, compared to 100% in the *every-not* version. Moreover, in this version, participants preferred to use VP negation (e.g., *none, did not, could not*) in only 35% of the cases, whereas in 65% of the cases, participants preferred to mention or imply the events that actually occurred such as the attempt or intention to cross (the ducks were afraid to cross, failed to cross, were unable to cross, etc.).

2.1.4. Discussion—The results of the production experiment suggest that adults in these contexts rarely used the statements presented to children in Lidz and Musolino's (2002) study and similar experiments with universal quantifiers. The overall format of the statements preferred (positive and contrastive statements); the referential expressions used to refer to sets and subsets of individuals; and, critically, the virtual absence of nonisomorphic uses of negative statements with references such as *two friends* or *all (the) ducks* clearly contrast with those used in children's experiments. Structure–meaning pairings like those in acquisition studies are therefore unlikely to occur in children's language experience.

One possible objection that arises from this experiment is that pictures with crossed-out objects like that exemplified in Table 1 for the dragon story are not equivalent to act-out stories with objects in full view, as in children's studies. Although methodological differences can always be a source of contrasting results, we think that the impact of this feature on our results is minimal. First, there was only one story with crossed-out objects (the dragon-eating-pizza story), precisely because in this story some slices of pizza disappeared. In the hide-and-seek story, for example, also exemplified in Table 1, the characters were all in partial view. Second, adults were instructed to summarize the events of the story and not to describe the pictures (see the instructions of the Appendix), as their responses themselves clearly indicate. Thus, it is unlikely that the use of pictures and/or crossed-out objects in one item significantly influenced the results of our experiment.

2.2. Study 2: What Adults Think About Quantifier Statements

In this study, we investigated the effect of speakers' linguistic experience with quantifier sentences on their perception of such sentences. In particular, we asked whether adult native English speakers consider the negative quantifier statements used in children's experiments to be natural descriptions of what happened in the experimental stories. The fact that participants in Study 1 did not spontaneously produce a particular structure does not mean that these structures are necessarily unnatural or less acceptable. Thus, to establish the degree of acceptability of these statements, we simply asked participants to rate the naturalness of the statements in the context of the stories.

2.2.1. Materials—We use the same stories as in Study 1 for both cardinal and universal quantification. Participants were provided with the target statement (the ambiguous quantificational statements similar to those in child experiments) and several alternative descriptions. Tables 4 and 5 provide examples of the children's targets and the alternatives that we created for the cardinal quantifier set and the universal quantifier set of items, respectively.

2.2.2. Procedure—The same 37 participants who provided the descriptions of the stories in Study 1 performed this ratings study immediately after their participation in Study 1. In the rating section, they read each story. After the story, there were four statements describing the story events, including the target (the sentence with the form used in acquisition studies) and three alternatives. Participants were instructed to rate in a scale from 1 to 7 how good and natural the descriptions of the story events were.

2.2.3. Results—The mean rating for each alternative description and the target statement was calculated. These means computed across items are reported in Tables 4 and 5. For the cardinally quantified statements, the ratings of the three alternatives in the *two-not* versions of the stories were reliably higher than the ratings for the target in an analysis across participants, $t(36) = 9.37$, $p < .0001$. Across participants, the mean rating for the alternatives was 5.44 and for the target was 3.33. The three alternatives of the *not-two* story versions received a mean rating of 4.80 across participants, whereas the target received a mean rating of 2.58. The contrast between these groups of ratings was also reliable, $t(36) = 10.37$, $p < .0001$.[3] For the *not-every* story, the mean rating for the alternatives was 5.07, whereas the target received a rating of 2.66, a significant difference, $t(36) = 9.74$, $p < .0001$. For the *every-not* story, the same result obtained, with the alternative ratings (5.73) being higher than the target rating (3.35), $t(36) = 10.34$, $p < .0001$.

2.2.4. Discussion—The rating data complement the results of Study 1. Not only did participants avoid statements containing negation and nonisomorphic scope relations in the production experiment, but they also found such statements to be less natural and acceptable relative to potential alternatives in the two interpretations. Although we constructed the alternative statements on the bases of our intuitions, they were remarkably similar to the statements participants produced in Study 1. The presence of contrastive focus (*only*), partitive NPs (*two/some/none of the N*), or negative NPs (*not all ducks*) were judged more acceptable than the indefinite *two friends/every duck* occurring with VP negation.

Overall, the results of Studies 1 and 2 suggest that adults' experience with quantifiers, negation, and referential expressions does not promote the spontaneous production of ambiguous negative quantified statements or the perception of their being natural and acceptable. Adults' behavior is likely to generalize to child-directed speech and shape children's linguistic experience. This suggests therefore, that children are not exposed to the structure–meaning pairings in the experimental context intended in laboratory experiments and that their difficulty with these statements may stem from the lack of relevant experience. The next set of studies is designed to examine what kinds of quantification are in the child's input and thus addresses the question of what sorts of information the child might be likely to know.

[3]Note that the two target statement ratings are not directly comparable against each other because each were evaluated relative to alternatives that themselves varied in their ratings, and so higher ratings in one target relative to another can simply mean that the alternatives of each group differed (if the alternatives are rated as 5 but the target is perceived as worse, it may receive a rating of 4, but if the alternatives are rated 4, the target may receive an even lower rating, say, 3).

3. CHILD STUDIES

In the next two studies, we investigated in detail the distributional patterns that characterize quantifier use in child language and child-directed speech. One goal of this investigation was to establish why children prefer isomorphic interpretations of quantifiers and negation, given that adults did not produce or accept scope ambiguous sentences with any interpretation in Studies 1 and 2. We hypothesized that children would interpret scope ambiguous sentences in ways that are consistent with their previous experience, in the same way that adult interpretations of ambiguities have been shown to reflect the distributional patterns in the language. In this view, children would access only one of the interpretations of these sentences because the preferred interpretation is supported by children's experience of negation and quantifier expressions in similar contexts, whereas the inaccessible interpretation is not.

3.1. Study 3: What Children Hear and Say With Quantifier Expressions

In this study, we investigated the use of quantifiers in child-directed speech and child speech by examining two databases in CHILDES (MacWhinney and Snow (1985)). One set of 32 children was from the Wells database. Fifteen of these children were between 1½ and 5 years old, and the remaining 17 were between 1½ and 4 years old. This database contains files or sessions collected at different points in time for a given child (9–10 files per child). The second set was a selection of 10 children between the ages of 4 and 6 from the Warren database (the age range typical in many quantification studies). Both databases include mostly spontaneous utterances of children and adults engaged in unstructured play and conversation. We considered only the utterances of the adult mother speaker and the target child of the file and excluded other occasionally present adult or child speakers such as aunts or siblings. The total of utterances considered was 64,547, of which 36,743 (57%) were child utterances, and the remaining utterances were mother speech. We carried out several analyses on these data.

3.1.1. Overall Use of Quantifier Words—We computed the total raw number of times that the quantifier words every, all, each, two, everything, everybody, everyone, and *none* occurred in the set examined. Their frequencies are reported in Table 6. Overall, there were few occurrences containing quantifiers, less than 3% of the total number of utterances for both mother and child speech. Among the quantifiers, *all* was by far the most frequently used by both mothers and children, followed by the cardinal *two*. By contrast, *every*-words and *each* were relatively rare, together comprising less than 3% of all the quantifier words examined.

3.1.2. Uses of *Every*—Except for one example that we discuss later, all examples of *every* occurred in nonnegative environments. Nine out of 17 uses of *every* in the databases referred to periods or instances of events rather than to individuals (e.g., Elspeth (4;1): *you can put this on me every time I have soup*; Mother: *every time Mummy clears up you make a mess*). Such cases tend to correlate with wide-scope interpretations in which *every* is interpreted as quantifying over events (Kamp and Reyle (1993), Parsons (1990)). *We go to school every day* roughly means that for every day, there is a different event of going to

school. Moreover, both child and mother tended to qualify the set to which *every* applies, for example, with a relative clause (*every time that*) or a partitive phrase (e.g., *every one of you is blurred*), as did the adults in our production experiment. Of the remaining cases, *every* occurred in sentential object position (Loise, 5;1: we checked every channel and it was not on any channel) but did not occur with other quantifiers or negation, so that its scope was not ambiguous. It is possible that children glean additional knowledge about the use of *every* from hearing the words *everyone, everybody*, and *everything*, in that they may interpret these forms as two-word quantified NPs. These words together occurred as frequently as *every* did in the database. Although they have a different stress pattern than quantified expressions of the form *every N*, it is not clear when children would fully appreciate this distinction. These three words strongly tend to take wide scope over other quantified expressions (e.g., did everybody at school make a drawing?, I gave one to everybody), and so experience with these words could contribute to the child's interpretation of *every* as preferentially taking wide scope.

To determine more conclusively what uses of *every* are more common in adult speech, we conducted some auxiliary studies using written corpora. We randomly extracted 100 occurrences of *every* sentences from the British National Corpus (http://www.natcorp.ox.ac.uk; Leech (1992)) and 100 occurrences from the Brown corpus (Kučera and Francis (1967)). Except for seven examples we discuss later, all sentences were affirmative (nonnegative) sentences. We classified these sentences in three groups according to whether *every* received a wide-scope interpretation, a narrow-scope interpretation, or the scope could not be established. The wide-scope interpretation could only be determined for cases in which *every* co-occurred with an indefinite, a bound pronominal reference or other quantifiers. Examples in (13) exemplify this interpretation, which can roughly be paraphrased as *every X interacts with a different Y* rather than as *there is a Y and every X interacts with the same Y* (the alternative scope relation). Of the total cases, 25% had this sort of wide-scope interpretation. In most of these cases, *every* occurred in subject position, with few exceptions. Only three cases seemed to have clear narrow-scope interpretations relative to indefinites, as in (14). Interestingly, in 46% of the total cases, *every* quantified over time, a use that was equally frequent in the adult speech of the CHILDES databases. In such examples illustrated in (15), *every* tends to have wide scope with respect to events, as indicated earlier. Including these cases, the proportion of wide-scope interpretations of *every* was 71%. The remaining 30% of cases were unambiguous *every* sentences or cases in which a scope relation could not be determined, as exemplified in (16).

(13) **a.** Every room has at least one large bird of prey on its perch.

b. Every ship has a ledger to herself.

(14) **a.** Every bottle produced was taken through each stage of a complex operation by hand.

b. Every one of us might naturally make such a statement.

(15) **a.** McGovern met the train every day with his trolley to pick up the papers.

b. We'd get together for an hour or so every day.

(16) **a.** He said he would dance every dance with me if only I would stay.

b. In a past era of Hollywood, Penn would have been dumped by every studio in town.

This corpus analysis thus supports the general tendency in the mothers' speech regarding the use of *every* in nonnegative statements: The wide-scope interpretation was preferred when *every* was in subject position or quantified over time. This finding is consistent with the experimental results in Kurtzman and MacDonald (1993), in which adults preferentially assigned wide-scope interpretation to *every* in subject position.

3.1.3. Uses of *Two*—As Table 6 indicates, the quantifier *two* occurred frequently in child and mother speech. Unlike *every*, this quantifier appears in child language as early as 1½ to 2 years of age and its use stays constant over time. A random selection of examples from 4- and 6-year-olds indicated that children used *two* in the context of counting objects and pictures (47% of the time), in contexts in which they were asked *how-many*-type questions, or children reported how many things they had or had done (I found two worms, I got two pence, I played two games). In some of these cases, they reported something about a subset of a set (e.g., *I ate two of them*). The parents' uses were similarly distributed, except for the instances of counting. It is thus apparent that the quantifier *two* often refers to a precise number of things (*two friends*) or, if necessary, two things out of a larger set.

3.1.4. Discussion—These data reveal distributional properties of quantifier expressions present in the child input. *Two* is from an early age frequently used when counting or reporting quantities. *Every*, in contrast, is rare but is often paired with wide-scope distributive interpretations in affirmative sentences. Both these observations point to preferences for isomorphic interpretations of scope ambiguous sentences. *The girl didn't find two friends* requires an interpretation in which *two friends* means *any two friends* in the *not-two* interpretation, as opposed to two specific or previously mentioned friends. The reduced availability of this interpretation in children's minds may contribute to their difficulty with this interpretation. In *Every duck didn't cross the river*, the quantifier *every* is more likely to have scope over negation so that the verb phrase *didn't cross* applies to each individual independently, as the left-to-right semantic composition of the sentence would predict. This is consistent with linguistic analyses of these quantifiers (Ioup (1975), Szabolsci (1997)) and with child experimental evidence regarding *every* and *each*: Both quantifiers receive wide-scope distributive interpretation in subject position (Brooks and Braine (1996), Drozd (2001), Philip (1995)).

3.2. Study 4: How Children and Adults Use Negation

In this study, we investigated how children and adults use negation to understand how statements such as *The girl didn't find two friends* and *Every duck didn't cross the river* would be preferentially interpreted. Negation is a complex phenomenon in natural languages because it admits various interpretations depending on the sentential and discourse context. Whereas unambiguous sentences containing no quantifiers are analyzed as sentential negation in the semantic representation as in (18) (Horn (1989)), a simple sentence such as

(17) could in principle receive at least two semantic interpretations exemplified in (17a) and (17b):

(17) The little boy is not eating a carrot.

a. ∃x [carrot(x) & ¬[ate(the-boy, x)]] (There is a carrot and the boy isn't eating it)

b. ¬∃x [carrot(x) & ate(the-boy, x)]] (There is no carrot that the boy is eating)

(18) John does not smoke. = ¬[smoke(john)]

In the semantic translation of (17a), negation has semantic scope over the verb negating the boy's eating, whereas the existence of the carrot is not negated. This interpretation often requires a context in which the carrot is presupposed or given. In (17b), in contrast, negation has scope over the entire interpretation of the sentence, thus negating the existence of a carrot and the eating. Although logical sentential negation is widely assumed as the translation corresponding to VP surface negation, this analysis does not necessarily entail that negation normally takes scope over quantificational subjects. *One student did not come to the party* does not mean that there is no student who came to the party. Rather, it means that there is one student who did not come. This is more apparent in cases in which negation occurs with definite descriptions, which are also often translated with an existential logical quantifier. A sentence like (17) with definite phrases in subject and object position (e.g., *The boy is not eating the carrot*) cannot mean that there is no boy or carrot. The sentence instead presupposes the existence of both the boy and the carrot and is not ambiguous: It is true if it is not the case that the boy is eating the carrot. Whereas linguists and logicians have proposed alternative analyses of negation that better reflect its overt syntactic position (Gamut (1991), Kamp and Reyle (1993), Parsons (1990)), we continue to refer to semantic sentential negation as corresponding to VP overt negation but make no claim that such negation necessarily entails scope over the denotation of subject NPs.

3.2.1. Procedure—We again used both the Wells and Warren databases but restricted our analyses to the sessions of children between 4 and 6 years of age, which is the typical age of acquisition studies with quantifiers. In these sessions, there were 6,058 child utterances, 464 of which contained negation. There were 8,823 adult utterances (including mothers' and other occasionally present adults), 695 of which included negation. Sentences with negation constituted about 8% of the total utterances. To help identify the semantic scope of negation, we started by coding by hand the syntactic frames in which the negation occurred. A negative expression was defined as an expression containing *not* or a *not*-contraction (*haven't, don't, didn't, doesn't, hasn't*). Then we examined the cases in which the syntactic structure was not transparent as to the semantic scope.

3.2.2. Results—Of the total of child negations, 13% were occurrences of tag questions (e.g., *they look horrible, don't they?*), and 4% were other kinds of questions (e.g., *why don't you get …?*). There were also 8% of imperative uses (*don't do that*) and 11% of phrasal negation occurring in nonsentential fragments (*not that, not in there*). Thus, about 35% of child negations occurred in nonaffirmative or non-sentential contexts. This proportion was

higher in the parent child-directed speech (51%), which contained more imperatives and questions in general.

These nonaffirmative and nonsentential uses give some indication of how negation is used in child-directed speech and child language. Imperatives such as *don't take any more blues* (said of LEGO pieces by Iris (4;8)) and phrasal negations such as *not all* (e.g., as an answer to *Are those the valuable ones?*) are cases in which negation has semantic scope over the sentence or the constituent in question. Tag questions can be seen as cases in which negation has syntactic scope over the VP and semantic scope over the entire sentence, given that *do* support is widely assumed to stand for VPs (Jacobson (1999)). Intuitively, the question *don't you?* in *You have to stand on something, don't you?* stands for *don't you have to stand on something?*, which asks for the truth of the affirmative sentence *you have to stand on something*. Thus, in most of these cases negation semantically applies either to the immediately contiguous constituent or to the entire sentence or event.

For the next analysis, we concentrated on full sentential uses of negation. Table 7 reports the percentage of cases in each syntactic frame calculated over the total number of full sentences (i.e., cases of NP-neg-VP). These were 300 cases for children and 338 for adults. Because there were few cases of plural subject NPs (most of which were pronouns such as *they*, *we*), the table reports only the morphological number of the object NP.

Table 7 indicates a relatively high percentage of negative sentences with VP-ellipsis and intransitive VPs (grouped together in the frame *NP-neg-V*) and with adverbial and adjectival VPs. As argued by Jacobson (1999), VP-ellipsis is interpreted by picking up a salient VP in the context, as in conversations such as the following. Mother: *I haven't never seen any chicks*/Jason (5;0): *I haven't either*. In such cases, as with intransitive verbs, the sentences are logically interpreted as sentential negation (e.g., it is not the case that I have seen any chicks). Similarly, for adverbial and adjectival VPs, the only possible thing to negate is the corresponding state (e.g., *It is not hot* means it is not the case that it is hot), amounting to logical sentential negation. Thus, these cases are most likely cases in which the syntactic and semantic scopes of negation are consistent: Surface VP negation is interpreted as negation of the entire sentence.

3.2.2.1. Indefinites in object position: Table 7 also indicates that most transitive verbs occur with singular NPs in object position, in both child and adult speech. We inspected some cases of indefinites and quantifiers referring to sets because such references are critical to determine the relative scope of negation and are analogous to the cardinal quantifiers used in children's experiments. Examples are shown in Table 8. In both adult and child speech, indefinite phrases in object position seemed to be included within the syntactic and semantic scope of negation. Many of these phrases were introduced by *any*, a negative polarity item that requires a semantic negative environment. Examples such as *They do not have any names* and *We've not got shoes on, I didn't see any* mean that it is not the case that the sentential subject satisfies the property denoted by the VP (logical sentential scope). Other quantifiers occurring after negation were also included in the scope of negation (*you are not having four*). *You haven't got none left* is an interesting case of double negation also found in parental speech in which the direct object is clearly under the scope of negation. These are

thus cases in which the syntactic scope is isomorphic with the semantic scope. Interestingly, when parents and children refer to a subset of a given set, they use partitives (*any of those, one of these*).

3.2.2.2. *Every* and negation: In the CHILDES databases we examined, there was no instance of *every* in subject position occurring with negation (the relevant position to understand the statements of acquisition studies). The only instance was in an adverbial modification (*You can't have the magic sponge every time*). The adult corpus analyses reported earlier yielded only seven cases of *every* occurring with negation. In none of these cases, however, did *every* occur in subject position. Rather, this quantifier occurred in adverbial phrases or embedded positions in the sentence and tended to take narrow scope with respect to negation (e.g., You cannot keep your eye on children every minute of the day; We don't agree with each other on every dot and comma; We need not expect to find such ideas in every piece of literature). Thus, in these cases, *every* has the scope that is isomorphic with its overt position relative to negation.

3.2.3. Summary and Discussion—Taking all the data of this study together, they suggest that children are frequently exposed to surface phrasal and VP negation, in which negation has semantic scope over syntactically dominated constituents, particularly indefinite objects referring to sets. This frequent pairing of sentence form and interpretation may compel children to interpret negation in a manner that is isomorphic with the syntactic structure of the sentence. Thus, *The girl didn't find two friends* would receive an interpretation consistent with logical sentential negation in which negation has scope over the indefinite reference *two*. To this distributional pattern, one can add the previously noted tendency to use the cardinal quantifier *two* as referring to two specific things, as opposed to *any* two things, and the tendency to use partitives when a subset of a set is meant. Such pairings of form and interpretation frequent in the child's environment would strongly favor and cue the activation of the isomorphic interpretation for the sentence.

The distributional pattern we have identified is consistent with the literature on children's negation (Boysson-Bardies (1977), Kim (1985), Morris (2003)). Boys-son-Bardies reported that when faced with sentences such as example (17), children interpreted the sentences as containing sentential negation, that is, they often considered that there was no carrot that the boy was eating. Similarly, in early child language (before 4 years of age), children tend to use negation as denying the existence or properties of immediately following constituents as in *no truck, no pocket* (Bellugi (1967), Bloom (1970), Drozd (2002)). Like the phrasal negation in our data, these are cases in which negation has semantic scope over the phrase it precedes.

It is more difficult to establish a clear distributional pattern for *every* cases and negation. This quantifier does not occur with negation in our corpus studies in subject position (nor did the quantifier *all*). This fact may be related in part to our observations in the production and acceptability studies. The use of *every* (or *all*) in this position with negation to convey an *every-not* interpretation is not very appropriate because other expressions such as *none* or plural references to individuals (e.g., *the ducks*) better convey such interpretations. *Every duck did not cross the river* in this interpretation is essentially preempted by the existence of

more acceptable forms. Nevertheless, as pointed out in the previous study, the use of *every* in affirmative sentences in subject position does tend to have wider scope over other quantifiers. Moreover, when *every* occurs in postverbal positions with negation, it has narrow scope relative to negation. Both these observations favor an isomorphic interpretation for this quantifier. Overall, whether quantifiers occur in subject or object positions, they tend to be interpreted relative to negation or other quantifiers as having semantic scope isomorphic with syntactic scope.

4. GENERAL DISCUSSION

In this article, we have attempted to link children's interpretations of ambiguous quantified sentences to their experiences with quantified expressions. Children, like adult comprehenders, are sensitive to the distributional patterns in the input, including the frequency of use of individual quantifiers, the frequency of word and phrase orders including the placement of negation in the sentence, and utterance–situation pairings, and this distributional information guides ambiguity resolution. Studies 1 and 2 investigated the pairings between situations—the stories often used in quantifier acquisition studies—and utterances. We showed that adults strongly avoided structures of the sort that are typically presented to children, and when asked to judge the appropriateness of these utterances, adults rated the ones from the child studies as significantly poorer than alternative utterances. These data suggest that children are likely to have little or no experience with utterance–situation pairings of the sort exemplified in the child studies.

Studies 3 and 4 then investigated what sorts of experience children do have with quantifiers and negation. Here we found that child- and adult-directed utterances overwhelmingly use quantifiers and negation in ways that are consistent with isomorphic interpretations. For example, the majority of children's and parents' negative statements involve semantically negating the constituents under the syntactic scope of negation, particularly the direct object of the sentence. In this position, if references to a subset of sets are made, both children and adults consistently use partitives. Similarly, the quantifier *every* is rare in child-directed speech, its occurrence in subject position with sentential negation is rare in adult written corpora, and its use in subject position is associated with wide-scope interpretations relative to other quantifiers in nonnegated sentences. This contrasted with the use of the quantifier *two*, which appears early and occurs frequently in child and adult speech in counting situations and to indicate references to a specific set of two, rather than subsets of individuals.

Given these distributional properties in the child's input, let us turn to the situation confronting the child in the acquisition studies. Consider how a child might behave given the story in which a subset of ducks crossed the river and others did not. The puppet in the experiment produces the utterance *Every duck didn't cross the river*, and the child must indicate whether this is an accurate statement about the story. What resources does the child have to interpret this utterance? We know that children have extensive experience with isomorphic interpretations of negation and have very little experience with *every* in subject position; what little experience they do have promotes a wide-scope interpretation. We also know that adults in our studies literally never used *every* or *all* and negation to describe a

split-set type of situation. All of these aspects of the child's previous experience bias the child to adopt an interpretation of this utterance in which none of the ducks crossed the river. In other words, although the sentence is technically ambiguous, structures of this sort have overwhelmingly been linked to the isomorphic interpretation in the child's experience in such situations, and children have little experience with nonisomorphic uses of the quantifier to refer to those situations. Likewise, children's overwhelming experience with indefinite object NPs such as *two friends* to refer to sets of individuals within the scope of negation, but little experience with such phrases to refer to a subset of a set outside the scope of negation, strongly biases them to prefer an isomorphic interpretation. These frequency asymmetries provide strong constraints on the interpretation of the sentence and determine which interpretations the child will activate during the course of processing.

This experience-based view makes a strong link between processes in adult ambiguity resolution and sentence interpretation in the child. The distributional patterns in the child's input strongly promote one interpretation of the ambiguous quantified sentences over others. In the same way that we claimed that it is not necessary to build anything special into the adult parsing mechanism to account for interpretation preferences in the VP-modification ambiguity, we suggest that the child's interpretation preferences in the quantifier studies need not reflect properties of UG or lack of grammatical and pragmatic competence. Instead, they reflect ambiguity resolution processes in which interpretations are activated as a function of their prior frequency in the input. We pursue implications of the constraint satisfaction approach below but first address some questions for extending this constraint-based approach into the PDC account that we have advocated.

4.1. Toward the PDC Account

Along the lines of the constraint satisfaction approach, we have indicated how the distributional patterns we have uncovered in this work play a role in ambiguity resolution processes in comprehension. Such patterns and processes are part of the *distribution* and *comprehension* components of the PDC account of children's scope interpretation that concern how distributional patterns affect interpretation of quantified expressions via a constraint-based comprehension system. The PDC approach, however, goes beyond the constraint satisfaction approach in arguing that distributional patterns derive from aspects of the language production mechanism that encourage speakers to produce certain expressions over others. In the VP-modification ambiguity discussed in the introduction, for example, the PDC approach accounted for adults' interpretation preferences as a function of the distributional patterns derived from the tendency to produce short adverb phrases before long ones. The production component of this approach thus requires an explanation of how the language production system (and possibly other constraints affecting the speaker) gives rise to distributional patterns. In our other PDC-based work (e.g., Gennari and MacDonald (2004)), we have investigated the production component with tightly controlled production experiments in the lab and have observed the effects of distributional regularities on comprehension with reaction-time studies that manipulate materials to coincide or conflict with production preferences. Such investigations are well beyond the scope of this article, but in the next section we offer some preliminary speculations concerning the production origin of the distributional patterns we have documented.

4.1.1. Origin of Distributional Patterns—Recall that speakers in our production study preferred to use partitives (e.g., *some of the ducks*, *two of the friends*) to refer to the relevant (set of) characters or provided contrastive information using *only*. Similar trends were observed in our corpus studies. We can describe these preferences in Gricean terms: Adults tend to choose constructions and referential expressions that are more informative than the less acceptable ones found in the child experiments, thus resulting in unambiguous negative statements such as *The girl didn't find two of the friends* or *Some of the ducks didn't cross*. However, a more processing-based account of these preferences is also available by considering the operation of the production system.

Speakers rarely use *every*, *all*, or bare indefinites such as *two friends* when the utterance situation involves a subset of all characters introduced. The choice of partitives over these expressions can be seen as the natural consequence of lexical selection mechanisms in production. Most accounts of language production posit that word choices emerge from competition between alternatives as a function of their match with the conceptual representation underlying the utterance (called the *message*) and the word's frequency (e.g., Bock and Levelt (1994), Levelt, Roelofs, and Meyer (1999)). Given that the stories clearly indicate that only a portion of the entities participate in an event (e.g., some of the ducks cross, some of the friends were found), the conceptual representation will tend to map more strongly onto partitive terms than to *every*, *all*, or bare indefinites. Thus these expressions will lose the competition during lexical selection and will not be selected for the utterance.

This production-based account of distributional preferences can also be extended to the overall low number of negated expressions in both the corpora and our production study. At any given moment, there are essentially an infinite number of events that do not happen and thus an infinite number of negative statements that might be said (e.g., *it isn't snowing*). But people tend to describe events and states that do happen and avoid infinite negated statements that could be truthfully uttered. This avoidance has been often interpreted in pragmatic terms as indicating that negation requires a contrastive conversational background that contains the expectation of an opposite statement (Gualmini (2004), Horn (1989), Musolino and Lidz (in press), Wason (1965)), but potential production-based explanations are also available.

As observed in the introduction, choices of what to utter and the syntactic structure in which to utter it are guided by the accessibility of concepts, words, and phrases during planning. Those concepts, words, and phrases that have the highest levels of activation (are most accessible) tend to get uttered first, and others are uttered later or not at all. From this production perspective, it can be argued that nonevents are not typically uttered because the discourse environment did not sufficiently activate the associated concepts relative to other competing alternatives. For example, in the stories in which two of four friends or only some of the ducks were engaged in an event, it is possible that the story contexts make the events that did happen in the stories relatively more accessible than those that did not happen or that the split-set situation makes contrastive particles like *only* more accessible (see our discussion of *only* in Study 1). These activated concepts may promote the use of affirmative descriptions implying contrastive events over bare negative ones (the girl (only) found two of the friends, some of the ducks crossed). The events that did not happen may be less

activated in the semantic representations of those who hear the story, and as a result, few people would produce an utterance describing only those events.

Another potential contributing factor in the production of affirmative versus negative statements is the production choices that have already been made up to that point in the sentence. Planning of multiple components of utterances is incremental so that factors that affect the choice of particular quantifiers during lexical selection may then constrain the choice to use negation. For example, if lexical selection favored reference to the subset of individuals who did engage in, say, the crossing event (as opposed to those who didn't), this choice would constrain the sentence to end up being affirmative (*(only) some of the ducks crossed*). In general, if sufficient activation of relevant concepts, contrasts, sets of individuals, and so on, is required to drive the production system to produce a negated utterance, then the general lack of negated sentences describing the stories, as well as their relatively low frequency in the corpora, may reflect the low activation of these elements relative to others in the utterance contexts.

These observations about accessibility and lexical selection processes represent early tentative steps in grounding speakers' choices of negation and quantification in the operation of independently motivated production mechanisms. This type of production-based account is not inconsistent with a Gricean characterization of the behavior but is rather at a different level of the process, focusing on how specific words and structures will become activated as a speaker plans an utterance. In some situations, as in the VP-modification examples in (9) and (10), the explanation at the production planning level provides an explanation for behavior that is not offered by Gricean maxims. It remains to be seen whether the production-based account will be similarly informative here.

4.2. Challenges for a Constraint Satisfaction Approach

A constraint-based account of quantifier scope interpretation in children is clearly in its early stages, and a number of issues must be further specified. Space constraints here have prevented a detailed description of the adult language comprehension and production work that underlies our account. Constraint satisfaction approaches of adult ambiguity resolution have been applied to a large number of syntactic ambiguities, although with varying degrees of specification of exactly what probabilistic constraints guide ambiguity resolution, at what point in the ambiguity they begin to have their effect, and how various potentially converging or conflicting constraints are weighed against one another (for examples of this level of detail, see McRae et al. (1998) and Tabor et al. (1997)). Clearly we have not matched this level of specificity here, and this remains a point for future research.

A second critical question for this approach, and of course any approach, is how to account for developmental change. Specifically for the quantifier sentences discussed here, we must explain why adults perform reasonably well when children fail in the puppet studies, even when adults do not like the choice of description or would prefer to give the isomorphic interpretation. Phrased in terms of ambiguity resolution, the question becomes why adult comprehenders can often gain access to the low-frequency and generally disfavored interpretation of the quantifier ambiguities, even though they prefer alternate interpretations, whereas the children cannot. A similar question has been addressed in the adult parsing

literature, namely, why some adults are better at using often subtle contextual constraints that might favor a rare interpretation of ambiguity, whereas other people consistently misinterpret the ambiguous sentence in favor of a high-frequency interpretation, even in context.

There is no universally agreed-upon account of individual differences in adult ambiguity resolution; some accounts have suggested that individual differences in working memory yield different abilities to handle syntactic ambiguity (Just and Carpenter (1992)), and other accounts have argued that these individual differences can be traced to differences in experience (MacDonald and Christiansen (2002), Pearlmutter and MacDonald (1995)). Constraint-based comprehension accounts are in principle neutral with respect to the issue of biological developmental changes such as increases in working memory, but they make some very interesting predictions about the role of experience in activating low-frequency interpretations of ambiguities that are relevant here. Frequency-based activation is assumed to be nonlinear, yielding an S-shaped activation function in which additional experience has little effect on activation levels for extremely rare interpretations and overwhelmingly frequent interpretations but a much larger effect on activation levels in a broad middle frequency range (McClelland (1987) provides a useful discussion, though this general point does not depend on using the distributed system he advocates).

The computational details are beyond the scope of this article, but there are two important outcomes of this type of system. First, the effect of experience changes over time: Activation of a rare interpretation will be virtually nonexistent the first few times it has been encountered, but it will be a much more viable alternative after it has been encountered, say 100 times, even if it may take years to have that many occurrences of this rare alternative, and even if the ratio of the rare versus more frequent interpretations of an ambiguity remains the same over the time period. Second, the effect of experience is larger for moderately rare interpretations than for very common ones (see MacDonald and Christiansen (2002) for a detailed illustration of these points for common vs. rare kinds of relative clauses). Thus the prediction from constraint satisfaction accounts of ambiguity resolution is that people with more experience (e.g., adults vs. children) will show relatively little differences in their ability to recover high-frequency interpretations of an ambiguity but will show substantial differences in their ability to activate low-frequency interpretations. This is the pattern reported for adults and children in the quantifier studies (Lidz and Musolino (2002), Musolino et al. (2000)), and similar results are found for older vs. younger children in interpretation of PP-modification ambiguities in various discourse contexts (Hurewitz, Brown-Schmidt, and Thorpe (2000), Trueswell et al. (1999)), in adults with varying degrees of comprehension skill (Pearlmutter and MacDonald (1995)) and in constraint satisfaction networks (MacDonald and Christiansen (2002)).

Of course language interpretation, and cognitive development more generally, are enormously complicated processes, and both biological change (such as increasing memory or attentional capacities) and experience are likely to have complex effects. We have emphasized experience with alternative syntactic interpretations above, but adults also have greater experience in a number of other potentially useful domains that can help them to access low-frequency interpretations. For example, adults have more experience with lexical

ambiguities (e.g., the use of *every*) and vastly more experience with communicative situations in general, particularly those in which multiple properties of the utterance situation need to be taken into account. Such experience could plausibly be useful in quantifier studies in trying to figure out what the puppet could possibly have meant and make adults better able to contemplate alternatives or attend to aspects of the utterance situation.

4.3. Implications for Theories of Acquisition

Our approach is partially consistent with that of Crain and colleagues (Crain and Thornton (1998), Crain et al. (1996), Meroni, Gualmini, and Crain (in press), and Musolino and Lidz (in press)), who argued that children's exquisite sensitivity to pragmatic factors is crucial in accounting for their behavior, but our point is more broad: Children are extremely sensitive to many distributional properties of their environment, which subsume considerations about pragmatic felicity and referential success. Unlike Crain et al.'s (1996) proposal, however, our approach does not imply that when those felicities and input regularities are violated, children make performance errors; instead they process the sentence as they would in any other situation, activating the interpretation derived from the distributional information available to them from previous experience.

Our approach also contrasts with current UG approaches to scope ambiguities in that it does not assume that children have adult knowledge of quantifier scope (Crain et al. (1996)) or that children's nonadult performance indicates parametric variations in UG prespecified stages of acquisition or that children's (incorrect) performance is governed by principles of UG (Musolino et al. (2000), Philip (1995)). These claims assign a limited role to linguistic experience, which needs only guide the setting of one or another prespecified stage of acquisition. In our approach, linguistic experience itself determines the interpretations available to the child. Although universal concepts may constrain the acquisition of quantifier words, the exact pairing of a quantifier word and a meaning should be language specific. The number and type of quantifier words vary cross-linguistically, but the number of interpretations to be expressed is presumably constant across languages. The preferential interpretation of a quantifier like *all* in a given language and the way it differs from the preferential interpretations of other existing quantifiers like *each* and *every* emerge from language use. Such interpretations ultimately depend on the whole range of quantifier words available in the language and the grammatical means used in the language to signal a particular interpretation (such as morphology and syntactic position). Linguistic experience is therefore critical for the child to learn the necessary word–interpretation pairings.

Our approach also does not make any claims as to the content of possible biological constraints for lack of enough evidence in this respect. Claims of parametric variation may not withstand detailed scrutiny because the interpretations that are available in a given language may depend on the domain of quantificational lexical choices and their uses, which are specific to the language. For example, the Gricean inferences that are available for English *Every N not VP* to obtain the nonisomorphic interpretation may not arise in a different language if this language does not have alternative more appropriate ways of conveying the English isomorphic interpretation or if the lexical meaning of the quantifier

requires wide-scope interpretations like English *each* does. Moreover, previous stage-of-acquisition claims have already been shown not to be empirically adequate (Crain et al. (1996), Musolino and Gualmini (2004)) as children in proper pragmatic circumstances do in fact access adultlike interpretations. It is therefore very difficult to evaluate the validity of such claims until further investigation of various pragmatic experimental conditions and quantifiers' uses in other languages is carried out.

Our approach also contrasts with recent proposals that children's nonadult performance with quantifier words indicates fragile pragmatic knowledge or abilities (Musolino and Lidz (in press), Noveck (2001), Papafragou and Musolino (2003)) or with proposals arguing for children's distinctive strategies to determine the domain of quantification (Drozd (2001), Drozd and van Loosbroek (1999), Geurts (2003)). Although in principle consistent with this view, we have shifted the focus of the explanation from pragmatic abilities or strategies to experience-based factors such as children's sensitivity to pragmatic infelicities and distributional patterns of language use. The reason why children and adults differ in performance is because their experience differs in significant respects and differentially constrains their interpretations in the face of rare inappropriate statements. In our view, children do not lack pragmatic abilities and need not apply nonadult interpretational strategies; they simply have not had the proper experience to learn that certain interpretations are possible in certain contexts.

Our approach, however, is neutral with respect to proposals claiming that children possess limited computational or processing abilities. In several accounts, adults and children are thought to differ in computational resources, in working-memory capacity (e.g., Adams and Gathercole (2000), Reinhart (2004)), or in their ability to overcome initial misanalysis (Trueswell et al. (1999)). Our data so far do not speak against or in favor of such limitations in processing resources. It is possible that children's inability to entertain various alternative interpretations can be linked to working-memory limitations. However, children's ability to access nonisomorphic interpretations in certain circumstances—for example, when the ambiguous statements are preceded by an affirmative contrastive sentence (Musolino and Lidz (in press))—suggests that, rather than having processing limitations, children are less sensitive to and experienced with the rare sentential and contextual cues that indicate the intended interpretation to the adult in some acquisition experiments.

4.4. Concluding Remarks

In this work, we have shown that many scope studies in acquisition have used ambiguous negated sentences with interpretations that adults avoid in production and judge as poor matches to the discourse contexts. We have also shown that child and adult corpora rarely contain such interpretations and the uses of referential expressions and negation that characterize them. We thus argued that many of the phenomena that researchers would like to attribute to properties of UG or to grammatical and pragmatic competence are in fact due to comprehenders' sensitivities to distributional properties in their linguistic experience. Children's nonadult performance with ambiguous sentences reflected ambiguity resolution processes in which interpretations are activated as a function of distributional properties of their input, which strengthened the pairing of one interpretation with the experimental

context but disfavored the alternative one. Inspired by the adult constraint satisfaction and PDC accounts, the approach emphasized the role of properties of the child input and of children's experience in understanding how children use and interpret quantifiers. Although advocates of constraint-based accounts in adult ambiguity resolution have gone farther and argued that constraint-based approaches provide better accounts of precise patterns of ambiguity resolution than modular parsing alternatives (see MacDonald et al. (1994), McRae et al. (1998), Trueswell et al. (1994), Trueswell et al. (1993)), it remains to be seen whether a more fine-grained investigation of children's quantifier scope interpretations would yield a similar argument in the domain of language acquisition.

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APPENDIX

Instructions Used in Production Study 1

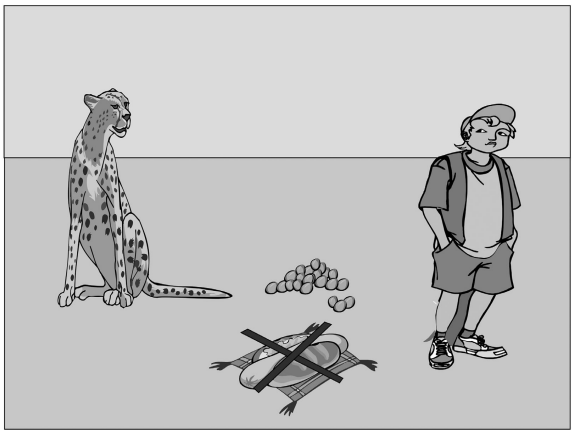
In the following section you will read a few stories. These stories were written for children, so they are very simple. Each story is accompanied by a supporting picture and a request for you to tell us something about the story. The pictures are meant to help you remember what happened in the story.

Your task is to describe the events of the story that we ask you about with ONE SINGLE SENTENCE and ONE VERB. This will require some attention on your part because the stories contain a sequence of events, and you cannot describe them all. Thus, your sentence must summarize the events of the story that we ask you about. The supporting pictures will provide you with the relevant information to be described.

Here is an example story:

> In this story, a hungry cheetah asked his human friend, a boy, to cook him dinner. The boy made dinner and served him a hotdog and some peas. The cheetah complained about the peas because he did not like them, and said that he would not eat them. He ate the hotdog and thought it was yummy.

Now, we will ask you something like this: Tell us about what the cheetah ate.



Your task is to describe those events of the story in which the cheetah ate something with a single sentence. For example, you can say something like The cheetah did not eat the peas, The cheetah did not eat all the food, The cheetah left the peas, The cheetah only ate the hot-dog, etc.

Here is another example a bit more complex:

> This story features a group of children, a few boys and a girl, playing hide and seek. The boys hid in the woods and the girl turned her head to count. After counting to ten, the girl started to look for her friends. First she looked behind a tree but, to her amazement, there was a snake there. Then she looked behind another tree and she found a snake there too. She got very scared. There were too many snakes in the woods.

We will ask you something like this: Tell us about what the girl found.

Now, you should describe with a single sentence what happened to the girl when she looked for her friends. You could say anything that in your opinion provides a good description of these events. For example, you could say The girl did not find the boys, The girl did not find any of the boys, The girl only found two snakes.

There are several things to notice about these examples:

(a) The picture reminds you of the characters and objects of the stories, including the ones that have disappeared from the story. For example, in the first story, the cheetah and his friend are in the picture, and the hot-dog is crossed out because it has been eaten. It also reminds you of the basic content of the story to support your description.

(b) Because you are constrained in the amount of information you have to provide, there is no room for you to describe the sequence of events of the story (for instance, in the second story example, details of how the girl first found a snake and then found a second one). You can safely ignore these details in your summary statement and concentrate on the gist of the events represented in the picture. YOU SHOULD PROVIDE A SUMMARIZING STATEMENT USING ONE VERB AND A FEW WORDS. The verb will refer to the events we ask you about (for example, eating and finding above). You CANNOT say things like The girl tried to find the boys but she could not do it. You CANNOT use words such as *and* or *but*, which essentially allow you to string several sentences together. You have to find a way to use fewer words as in the examples above.

(c) There is no correct or incorrect way to describe the story, and there are many possible things one can say. You must say what you think is the most natural way to succinctly describe the story events requested. This is precisely what we are interested in finding out.

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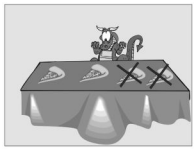
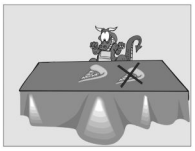
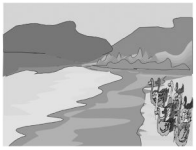
TABLE 1

Example of Stimulus Items for Studies 1 and 2

Version A	***Version B***
Cardinal Quantifier Set	
This story features a dragon and four giant slices of pizza. When he got home, the dragon was very hungry. He found four giant slices of pizza, which looked very yummy. He ate the first slice of pizza, then he ate the second one but was barely able to finish it. The dragon said that the two remaining slices looked good, but he was too full by then and could not have another bite to eat.	This story features a dragon and two giant slices of pizza. When he got home, the dragon was very hungry. He found two giant slices of pizza, which look very yummy. He ate the first slice of pizza but was barely able to finish it. The dragon said that the remaining slice looked good, but he was too full by then and could not have another bite to eat.
	
Please, tell us about the dragon eating	Please, tell us about the dragon eating
In this story, a girl was playing hide and seek with four of her friends. The girl counted to 100 and then started looking for her friends. She looked behind a tree, and found one of her friends. She then looked behind a rock, and found another of her friends. She then looked all over the woods to find the other two guys, but she could not find them.	In this story, a girl was playing hide and seek with two of her friends. The girl counted to 100 and then started looking for her friends. She looked behind a tree, and found one of her friends. She then looked all over the woods to find the other child, but she could not find him.
	
Please, tell us about the girl finding her friends	Please, tell us about the girl finding her friends
Universal Quantifier Set	
This story features a group of little ducks. They were all happily feeding in the grass by the river. Suddenly, one of them spotted a beautiful green field on the other side of the river. It looked yummy! Quickly, one of the ducks jumped onto the water and crossed the river. It was difficult. The current was very strong and the ducky was still too young to be skilled at swimming. He made it though. Then, another duck tried and crossed. A bunch of them also tried and succeeded. However, some ducks felt that it was too dangerous to cross. They remembered their mothers' recommendations and decided to be cautious.	This story features a group of little ducks. They were all happily feeding in the grass by the river. Suddenly, one of them spotted a beautiful green field on the other side of the river. It looked yummy! Quickly, one of the ducks jumped onto the water and tried to cross the river. It was difficult. The current was very strong and the ducky was still too young to be skilled at swimming. He could not make it. Then, another duck tried and made it to the middle of the current, but he got scared and came back to the shore. A bunch of them also tried and failed.
	
Please, tell us about the crossing of the river	Please, tell us about the crossing of the river
This story features a group of children. The children went to the zoo. They were all excited because they wanted to touch the giraffe. The teacher has told them many things about this giraffe. When they got to where the giraffe was, one child slowly approached the giraffe and touched it. He was so happy! Then, another approached and touched it. And then, another, and another and another. Some children however were afraid because the giraffe was so big and threatening. They then decided not to touch it.	This story features a group of children. The children went to the zoo. They were all excited because they wanted to touch the giraffe. The teacher had told them many things about this giraffe. When they got to where the giraffe was, one child slowly approached the giraffe but it looked so threatening that he was afraid to touch it. Then, another child approached but was also afraid. One by one the children tried but were afraid to touch it. How disappointing!

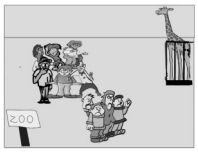
Version A	*Version B*
	
Please, tell us about the children touching the giraffe	Please, tell us about the children touching the giraffe

TABLE 2

Results From Production Study 1—Cardinal Quantifier Set

Story Events	Interpretation	Positive Examples	%	Negative Examples	%
Girl finds two of four friends	Two-not-interpretation	She (only) found two friends	19	She didn't (failed to) find the remaining friends	08
		She only found the first and second friend	12	She didn't find all/two of the friends	14
		She found two of the friends	34	Other	05
		Other	08		
		Total	73	Total	27
Girl finds one of two friends	Not-two-interpretation	She (only) found one friend	20	She didn't (failed to) find the second friend	20
		She found the first friend	26	She didn't (failed to) find all the friends	03
		She (only) found one of the friends	22	She didn't (failed to) find the friends	06
		Total	68	Total	29

Lang Acquis. Author manuscript; available in PMC 2014 June 10.

TABLE 3

Results From Production Study 1—Universal Quantifier Set

Story Events	Interpretation	Positive Statements	%	Negative Statements	%
Some of the ducks crossed the river	Not-every-interpretation	The ducks crossed	15	Some of the ducks didn't cross	22
		Not all ducks crossed	02		
		Some of the ducks crossed	61		
		Total	78	Total	22
None of the ducks crossed the river	Every-not-interpretation	Implied negation	43	All the ducks didn't cross	02
		(e.g., The ducks/all the ducks failed, tried, were afraid to cross)		The ducks didn't/were unable to None of the ducks crossed	32
					17
				Other	06
		Total	43	Total	57

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TABLE 4

Example Statements and Mean Ratings From Study 2—Cardinal Quantifier Set of Items

Events in Each Story Version	Example Statement	Example Type	M
Girl finds two of four friends	The girl didn't find two friends	Two-not-scope	4.09
	The girl only found two friends	Alternative 1	5.22
	The girl only found two of the friends	Alternative 2	5.44
	The girl found two of the friends	Alternative 3	5.32
Girl finds one of two friends	The girl didn't find two friends	Not-two-scope	2.60
	Only one friend was found	Alternative 1	4.64
	The girl only found one of the friends	Alternative 2	5.51
	The girl didn't find one of the friends	Alternative 3	4.15

Note. Ambiguous target items are listed first in each story version.

TABLE 5

Example Statements and Mean Ratings From Study 2—Universal Quantifier Set of Items

Events in Each Story Version	Example Statement	Example Type	M
Some of the ducks crossed the river	Every duck didn't cross the river	Not-every-scope	3.29
	Not all the ducks crossed	Alternative 1	5.40
	Only some of the ducks crossed	Alternative 2	5.85
	Some of the ducks crossed	Alternative 3	6.07
None of the ducks crossed the river	Every duck didn't cross the river	Every-not-scope	2.59
	Nobody crossed	Alternative 1	4.20
	None of the ducks crossed	Alternative 2	5.32
	The ducks didn't cross	Alternative 3	5.38

Note. Ambiguous target items are listed first in each story version.

TABLE 6

Total Number of Quantifier Expressions From Study 3

	Utterances	all	every	everything	everybody	everyone	each	two	none
Total	64,547	1,005	17	15	8	2	21	568	5
Adult	27,804	427	14	11	3	1	11	206	2
Child	36,743	578	3	4	5	1	10	362	3

TABLE 7

Percentage of Syntactic Frames Calculated From the Total of Full Negative Sentences in Study 4

	Syntactic Frames	% of Cases	Examples
Child	NP-neg-V	38	I'm not playing/I didn't/I am not
	NP-neg-V-adj/adv	16	It's not hot/it's not there/I didn't go outside
	NP-neg-V-NPpl	7	I don't like those ladies
	NP-neg-V-NPsg	25	I don't want a snake/they don't have cable
	NP-neg-V-S	13	I don't think I like the whistle
Input	NP-neg-V	26	You're not/I don't know/You didn't
	NP-neg-V-adj/adv	21	That's not pale/I'm not sure/it's not on
	NP-neg-V-NPpl	5	A frog does not have whiskers
	NP-neg-V-NPsg	30	I didn't see your picture/I'm not playing that
	NP-neg-V-S	18	I don't know where the book is

Note. *NP* = noun phrase; *neg* = negation; *V* = verb; *adj/adv* = adjective or adverb; *pl* = plural; *sg* = singular; *S* = sentence.

TABLE 8

Examples of Negation With Indefinite References to Sets and Individuals by Children and Adults in Study 4

Speaker	Utterances	Child and Age
	Adults' Examples	
Father:	What's your favorite game down there?	
Child:	Pac+Man	
Father:	And what else? That's not *all* you play.	David, 5; 10
Father:	He doesn't have any horns (said of Rudolf)	Ben, 5;0
Child:	Have you have you [?] earrings in.	
Mother:	No.	
Mother:	I haven't got no earrings in.	Jason, 5;0
Grandmother:	You're a greedy boy. Four dinners. Four.	
Grandmother:	You aren't going to have four today Jason [=! vocative].	Jason, 5;0
Child:	I've won.	
Grandmother:	I know she got three and you got two and you didn't get any next and I haven't get none. I haven't get none.	Gavin, 4;9
Mother:	You don't remember that?	
Child:	No.	
Mother:	Bobo doesn't climb trees, does he?	Mary, 4; 6
Visitor:	I told him, don't do me anything. I will have something later (for lunch)	
Child:	But now?	
Visitor:	Yes but I wasn't going to have any.	Gavin, 4;9
	Children's Examples	
Child:	He has lots of rocks around the yard, I'll show you.	
Mother:	Are those the shiny ones, the valuable ones?	
Mother:	In his yard?	
Child:	Not all.	Bill, 6;2
Mother:	You haven't got any shoes on.	
Child:	We've not got shoes on.	Gerald, 4;9
Father:	What kind of bird did you see outside before?	
Child:	I didn't see any.	Beth, 4;9
Father:	How many are there?	
Child:	Umm, ten.	
Father:	How does that song go that names all the names?	
Child:	They didn't have any names.	Beth, 4;9
Mother:	Let's count them.	
Child:	One two three + …(…)	
Child:	Four five [=! laughs] no!	
Child:	We didn't count it all yet	Jmarkey, 5;3
Mother:	The globe, the earths you mean the earth that you saw the United States and Africa and did you see Iceland?	
Child:	I didn't see any of those, I just saw the earth, Pluto, and Mars.	Susan, 6;1
Child:	All your money has gone now.	
Child:	You haven't got none left. You haven't got none left.	Elspeth, 5;0

Speaker	Utterances	Child and Age
Father:	What kind of bird do you want, did you see outside before?	
Child:	I didn't see any.	Ben, 5;0
Child:	You haven't got one of these tanks have you?	
Child:	Only a motor bike and side car.	Jack, 4;9
Father:	Well, tell me about this picture over here.	
Child:	I don't know anything about it.	Susan, 6;1
Child:	And don't forget it. Cause I'm not having ballet lessons.	
Child:	Never again in my life.	
Father:	Angela takes ballet lessons.	
Child:	Not anymore.	Sandra, 6;2