Continuity in Linguistic Development: The Scope of Syntax and the Syntax of Scope

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Abstract

One of the core assumptions underlying generative models of language acquisition is that children's emerging linguistic systems ought to be explained in terms of the same abstract principles invoked in accounts of adult grammars (the Continuity Assumption). Recently, however, alternative views have emerged which directly challenge the Continuity Hypothesis (Tomasello, 2000). In this regard, we recently reported evidence suggesting that young learners of English and Kannada compute scope relations on the basis of the abstract relation of c-command (Lidz and Musolino, 2002). However, these results remain open to alternative interpretations and therefore, they may not require that young children possess abstract linguistic knowledge. In this article, we address these alternative explanations and, on the basis of novel experimentation, we demonstrate that none of them explains the full pattern of facts as well as an account based on the abstract principle of c-command. We therefore take these results to provide evidence in favor of the Continuity Assumption.

Key-words: language acquisition, continuity, quantification, c-command, Kannada

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1. Introduction

Modern linguistic theory rests on two fundamental ideas. The first is that linguistic knowledge is best characterized with formally precise models of mental grammar (Chomsky, 1957, 1965). Such models explain the human ability to produce an unbounded number of sentences using finite means and aim towards an understanding of the notion "possible human language". The second assumption, often referred to as the Innateness Hypothesis and generally taken to be a consequence of the first, is that human beings are biologically endowed with *a priori* linguistic knowledge. This innate linguistic knowledge is described by the theory of Universal Grammar (Chomsky, 1965, 1981, 1986, 1995), which serves as a restriction on the hypothesis space for language learners. A related idea associated with the generative enterprise is the Continuity Assumption (Pinker 1984, 1989, Crain, 1991). According to the Continuity Assumption, learners have access to the same (universal) set of abstract linguistic principles and representations that characterize the adult system. A direct consequence of the Continuity Assumption is that emerging linguistic systems can be described and explained in terms of the same abstract format used in accounts of the fully developed linguistic systems of adults. To quote Pinker " … in the absence of compelling evidence to the contrary, the child's grammatical rules should be drawn from the same basic rule types, and be composed of primitive symbols from the same class, as the grammatical rules attributed to adults in standard linguistic investigations." (1984: 7).

Recently, however, alternative views have emerged which directly challenge some of these core assumptions (Tomasello 2000; Elman et al., 1996; Seidenberg, 1997). In

particular, proponents of such accounts argue that (a) knowledge of language should not be equated with knowledge of a formal grammar (Seidenberg, 1997; Tomasello, 2000) and (b) that even if learners eventually arrive at abstract linguistic generalizations, they initially approach the task of language acquisition with virtually no abstract linguistic knowledge - contra the Continuity Assumption (Tomasello, 2000). To quote Tomasello "Other than the category of nominals, nascent language learners possess no other linguistic abstractions or forms of syntactic organization." (2000:214) and "Overall, children's limited creativity with their early language calls into question the practice of describing their underlying syntactic competence in terms of abstract and adult-like syntactic categories, schemas and grammars." (2000:211).

In this regard, we have recently reported empirical evidence in favor of a grammar-based, continuous model of language acquisition (Lidz and Musolino, 2002; Musolino and Lidz, submitted). The phenomenon of interest concerns young children's interpretations of ambiguous sentences containing quantified NPs and negation (Musolino, 1998; Musolino, Crain and Thornton, 2000; Lidz and Musolino, 2002; Musolino and Lidz, submitted). The main observation arising from this line of research is that children, unlike adults, display a strong preference for the interpretation of such sentences which corresponds to the surface syntactic position of the quantificational elements involved. This observation has been described under the label of 'isomorphism' (*ibid*). Crucially, however, Lidz and Musolino (2002), based on a series of cross-linguistic experiments, have shown that children's interpretive limitations are a consequence of an over-reliance on the surface *hierarchical* structure of the sentence.

More narrowly, children's scope preferences are determined by the surface c-command relations holding between these elements.

This finding illustrates that even when children differ from adults in their linguistic behavior, their errors are driven by abstract grammatical properties which are not directly encoded in the linguistic signal. Moreover, we see in these results a continuity of representation between children and adults even though we find a discontinuity in behavior. This conclusion runs counter to recent work, both inside and outside of generative linguistics, claiming that children do not have grammatical representations like those of adults (Tomasello 2000; Krämer 2000).

Given the importance of the ideas at stake, empirical evidence bearing on these two competing models of language acquisition should be treated with extreme caution and subjected to the highest level of scrutiny (Fisher, 2002). Echoing this cautionary note, Tomasello reminds us that "… it is just that: a hypothesis. Continuity cannot be simply assumed without systematic investigation of the type that is conventional across the behavioral and cognitive sciences." (2000:247). Tomasello further argues that "The continuity assumption cannot be justified "negatively", that is, by arguing that there must be continuity between child and adult linguistic competence since there is no way a child could get from concrete and item-based linguistic structures to the powerful abstractions that constitute adult linguistic competence." (2000:246).

In the present article, we propose to address Tomasello's concerns and show that "systematic investigation of the type that is conventional across the behavior and cognitive sciences" do lead to positive justifications of continuity. In order to address the first concern, we discuss a number of alternative explanations of the results presented in

Lidz and Musolino (2002), and, through novel experimentation, we demonstrate that none of these explains the full pattern of facts as well as our original syntactic account, based on the abstract principle of c-command. Consequently, we conclude that children do, in fact, possess the same kinds of linguistic representations as adults and that their non-adult behavior does not reflect an impoverished representational format. In doing so, we also address Tomasello's second concern by providing a positive demonstration of Continuity. That is, we show that the only viable explanation of children's linguistic behavior - in the case at hand - is one that crucially relies on the assumption that they possess abstract linguistic knowledge of the kind invoked in standard linguistic investigations.

The upshot of these deliberations is that the continuity assumption is more than "just a hypothesis" in dire need of empirical confirmation. It represents, in some cases, the best *explanation* we have. Using Tomasello's own reasoning, we submit that the continuity assumption cannot be abandoned "negatively", that is, on the basis of the fact that there may exist a restricted domain in which it appears to not hold (Fisher, 2002). Any serious attempt to remove continuity from the developmental equation should, at minimum, provide an alternative account of the existing facts taken to provide evidence in favor of continuity. Until this can be achieved, these facts, including the ones presented here, will remain a challenge for non-continuous models of language development.

The discussion is organized as follows. In section 2, we provide the theoretical foundations necessary to a proper understanding of the phenomena under consideration, namely quantificational interactions. Section 3 reviews the results of previous studies on

the acquisition of quantificational interactions, paying particular attention to a recent account of children's behavior in terms of the formal relation of c-command defined over abstract hierarchical representations (Lidz and Musolino, 2002). In section 4, we discuss recent objections to the c-command account and alternative accounts of Lidz and Musolino's findings. In section 5, we present new experimental results which directly test the predictions of the competing accounts discussed in section 4. In light of the new results presented in section 5, section 6 concludes that Lidz and Musolino's c-command account remains the best explanation of children's behavior.

2. Theoretical background

One of the fundamental facts about language that any linguistic theory must account for is that expressions are not always interpreted uniquely in their surface positions. This phenomenon of displacement is evident, for example, in interrogatives, relative clauses, and raising constructions.

(1) a. Which book did Kim write?

b. I liked the book that Kim wrote.

c. Kim seemed to dislike the ending.

In (1a), the expression *which book* is interpreted as the object of the verb *write* despite not occurring in the object position. In (1b), the expression *the book* is interpreted both as the object of *like* and as the object of *write* even though it occurs in only one position. Finally, in (1c) *Kim* is interpreted as the subject of the embedded clause even though it occurs in the matrix clause.

This phenomenon is also evident in ambiguous sentences involving multiple quantificational expressions, such as (2):

(2) Every author didn't like the review.

On one interpretation, illustrated in (3a), we interpret *every author* outside the scope of negation. On this interpretation, every author is such that she didn't like the review. In other words, no author liked it. On the other interpretation, illustrated in (3b), we interpret *every author* inside the scope of negation. On this interpretation, not every author liked the review, i.e. some authors did but others did not.

(3) a. $\forall x$ [author(x) $\rightarrow \neg$ like (x, the review)] (=none)

b. $\neg\forall x$ [author(x) $\rightarrow$ like (x, the review)] (=not all)

The latter reading illustrates the displacement phenomenon because the universal quantifier is interpreted inside the scope of negation semantically even though it is not in the surface syntactic scope of negation.

It is generally held that the semantic scope of a scope-bearing element is determined on the basis of its c-command domain. That is, a scope-bearing element takes scope over everything that it c-commands in the phrase structure, where c-command is defined as an algebraic relation holding between nodes in a syntactic tree (Reinhart 1976, Chomsky 1981):

(4) x c-commands y iff

i) the first branching node dominating x also dominates y

ii) x does not dominate y and y does not dominate x

The inverse scope reading of sentences like (2) (i.e., (3b)), is thus taken to be a consequence of the fact that at a stage of derivation distinct from surface structure, the subject occurs within the c-command domain of negation (McCloskey 1996). The argument proceeds from examples like (5) which illustrate that the scope of negation and adverbial elements is fixed at surface structure:

(5) a. Subjects don't always raise.

b. Subjects always don't raise.

Neither (5a) nor (5b) is ambiguous, leading to the conclusion that if anything interacts scopally with negation, it must be because it, and not negation, is moving. Thus, since a quantificational subject, which c-commands negation in the surface syntax, can take scope below negation, it must be because the subject occurs at some level of representation in a position below the surface position of negation. One variant of this idea is illustrated in (6), in which the expression *every author* occurs in two positions, the higher of which is phonologically interpreted (i.e., pronounced) and the lower of which is semantically interpreted.[1]

(6) a. Every author didn't like the review

b. $[_{IP}$ every author $[_{I'}$ didn't $[_{VP}$ ~~every author~~ $[_{V'}$ like the review]]]]

pronounce this copy ↑ ↑ interpret this copy

That is, while the subject must be pronounced in the higher of the two positions it occurs in, it can optionally be interpreted in the lower position, giving the interpretation (3b).

[1] The "strikethrough" notation is used for copies of a moved element that are unpronounced.

With quantificational objects, the system works in the opposite fashion. The object is obligatorily pronounced in the lower position but is optionally interpreted in a higher position:

(7) a. The author didn't like two reviews.

b. [$_{IP}$ the author [$_{I'}$ didn't [$_{VP}$ like two reviews]]]
pronounce this copy
interpret this copy

c. [$_{IP}$ ~~two reviews~~ [$_{IP}$ the author [$_{I'}$ didn't [$_{VP}$ like two reviews]]]
interpret this copy pronounce this copy

Accordingly, the sentence can either be interpreted to mean that it is not the case that the author liked two reviews, in which case negation takes scope over the object (i.e., 7b), or that there are two reviews that the authors didn't like, in which case the object now takes scope over negation (i.e. 7c). Here the object raises covertly to a position outside the scope of negation,[2] leading to the interpretation that there are two reviews that the author didn't like.

3. Psycholinguistic background

In order to investigate when and how children become aware of the complex mapping between syntax and semantics involved in quantificational interactions, Musolino, Crain and Thornton (2000) (based on Musolino, 1998) tested children and adults' interpretation

[2] For the purposes of this paper, the precise landing site of the raised QP is irrelevant. We also leave aside for the moment the possibility that indefinites take wide scope by a mechanism other than movement. (Fodor and Sag 1982, Reinhart 1997, Kratzer 1998). The crucial observation is simply that quantificational expressions can be interpreted in ways not directly signaled in the surface structure. We return to the issue of indefinites below.

of sentences like (8) and (9) using the Truth Value Judgment Task methodology (Crain and Thornton 1998).

(8) Every horse didn't jump over the fence.
  a. $\forall x$ [horse(x) $\rightarrow \neg$ jump (x, over the fence)] (none)
  b. $\neg\forall x$ [horse(x) $\rightarrow$ jump (x, over the fence)] (not all)

(9) The smurf didn't buy every orange.
  a. $\neg\forall x$ [orange(x) $\rightarrow$ buy (smurf, x)] (not all)

As we have seen, sentences like (8) are ambiguous between a "none" and a "not all" reading (8a and 8b, respectively). By contrast, (9) is unambiguous, allowing only the "not all" interpretation. Musolino et al. found that children, unlike adults, displayed a strong preference for the "none" interpretation of sentences like (8), i.e. (8a). In addition, Musolino et al. were able to tell that this effect was not conceptual in nature because the "not all" reading which was rejected in sentences like (8) was accepted in sentences like (9), where it is the only possible reading. In sum, when the quantificational expression was in subject position, children rejected the reading in which negation took scope over the quantifier. When the quantifier was in object position, however, they accepted this reading.

Musolino et al., described this phenomenon as an isomorphism effect: the scope of quantificational elements with respect to negation is determined by surface position. However, these results are consistent either with the possibility that surface position is defined in terms of precedence relations or with the possibility that surface position is defined in terms of hierarchical structure. On the former view, if the quantificational expression precedes negation, then it takes scope over negation; and, if the linear order is reversed, then so are the scopal relations (cf. Johnson-Laird 1969, Kroch 1974, Ioup

1975, Fodor 1982, Bunt 1985, Kurtzman and MacDonald 1999). On the latter view, semantic scope is determined by syntactic command relations (Lasnik 1971, Jackendoff 1972, May 1977, Hornstein 1984, Aoun and Li 1989, Hornstein 1995). If the quantificational expression c-commands negation, then it takes scope over negation; if negation c-commands the quantificational expression, then negation takes wider scope.

In addition, Musolino et al.'s hypothesis was built on only partial data. From the observation that children rejected the inverse scope reading of (8), Musolino et al. concluded that the surface scope reading was available. However, they were unable to test the surface reading directly due to the truth-conditions of the two propositions. This is because the interpretation of a universal quantifier outside the scope of negation (8a) entails the interpretation in which negation takes wider scope (8b). That is, every situation that makes (8a) true also makes (8b) true. If it is true that none of the horses jumped over the fence, (8a), it necessarily follows that not all the horses jumped over the fence, (8b); but not vice versa. Hence, Musolino et al., could test only the former directly. These entailment patterns are shown below.

(X) a. $\forall x[\neg P(x)] \rightarrow \neg[\forall x\,[P(x)]]$ none $\rightarrow$ not all

b. $\neg[\forall x[P(x)]] \not\rightarrow \forall x[\neg P(x)]$ not all $\not\rightarrow$ none

To deal with these problems, Lidz and Musolino (2002) examined the scope of negation with respect to numerally quantified NPs in object position in English and Kannada. The use of numerally quantified NPs averts the entailment problem. The two readings of ambiguous sentences involving the scope of negation with respect to a

numerally quantified NP do not stand in an entailment relation to each other.[3] For each reading it is possible to construct scenarios that make that reading true and the other false (see Lidz and Musolino, 2002). Consequently both the surface and inverse scope readings could be tested directly.

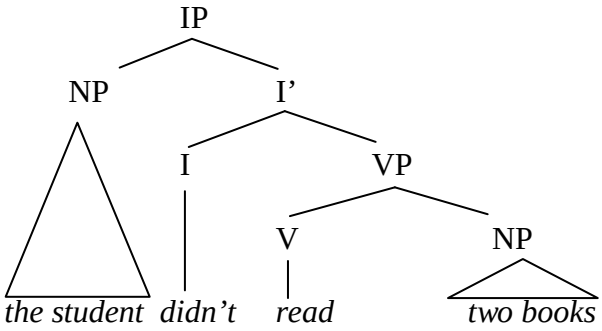
With respect to the cause of isomorphism, the two languages tested by Lidz and Musolino enabled them to distinguish a linear interpretation of the effect from a hierarchical interpretation of it. English and Kannada are alike in that negation c-commands the object position at S-structure in both languages; however, these languages differ in terms of linear order. In English, negation precedes the object NP whereas in Kannada negation follows the object NP. This state of affairs is illustrated in (10) and (11).

(10) a. The student didn't read two books

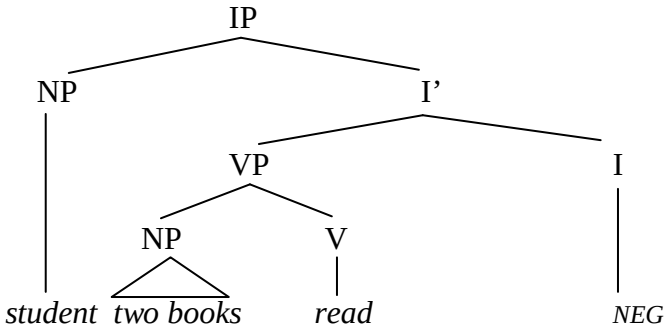
b. vidyaarthi eraDu pustaka ooD-al-illa (Kannada)
student two book read-INF-NEG
'The student didn't read two books.'

[3] Consider for example the sentence *The student didn't read two books* which can either mean that it is not the case that the student in question read two books (i.e. not > two) or that there are two specific books that the student didn't read (i.e. two > not). In a situation in which the student has four books, reads two and fails to read the other two, the wide scope reading of the numeral is true (i.e. there are indeed two books that the student didn't read) while the narrow scope reading is false (i.e. it is false that it is not the case that the student read two books since s/he read exactly two books). Conversely, in a situation is which the student has two books, reads one and fails to read the other one, the wide scope reading of the numeral is false (since there is now only one book that the student didn't read – and not two) while the narrow scope reading is now true since it is indeed not the case that the student read two books; i.e. s/he only read one. Thus, since the two readings can be true or false independently of each other, no entailment relation holds between them.

(11) a. English



b. Kannada



Because English and Kannada exhibit the same hierarchical relations with a different word order, a comparison of children's behavior in the two languages enabled Lidz and Musolino to distinguish the linear interpretation of isomorphism from the hierarchical interpretation. If the isomorphism effect is due to a one-to-one mapping from precedence to scope, then Kannada children were predicted to show a preference for the wide scope reading of *two cookies*. By contrast, if the effect is due to a one-to-one mapping from c-command to scope, then Kannada children were predicted to display a preference for the narrow scope reading.

As expected, adults in both languages were equally likely to accept the two interpretations of sentences like (10). Four-year-olds, on the other hand, displayed a significant preference for the narrow scope reading of the numeral, independent of language. In both languages, children accepted the reading in which negation took scope

over the object significantly more often than they accepted the inverse scope interpretation. Lidz and Musolino concluded on the basis of these studies that the isomorphism effect is a consequence of hierarchical structure rather than linear order. Children's interpretations of scopally ambiguous sentences are determined by the surface c-command relations that hold between the two scope bearing elements. For children, a scope bearing element takes scope over everything that it c-commands on the surface. Thus, children differ from adults not in the principles used to map syntactic structure to semantic structure but only in their willingness to allow an expression to be pronounced in one position and interpreted in another. Both children and adults compute scope on the basis of the c-command relation. Children, however, require the pronunciation position and the interpretation position to coincide.

This result directly bears on the Continuity Hypothesis. First, it shows that young learners possess abstract linguistic knowledge - in this case knowledge of the c-command relation. Second, this result supports the view that emerging linguistic systems are best described in terms of the same formal principles and mechanisms invoked in accounts of adult grammars. In the case at hand, notice that c-command relation, invoked here to account for young children's interpretative preferences, is a fundamental aspect of syntactic theory that is a component of the explanation of countless grammatical phenomena in adult languages. This latter point directly echoes Pinker's formulation of the Continuity Hypothesis: " … in the absence of compelling evidence to the contrary, the child's grammatical rules should be drawn from the same basic rule types, and be composed of primitive symbols from the same class, as the grammatical rules attributed to adults in standard linguistic investigations." (1984: 7).

However, it should be equally clear that inferring that children possess knowledge of c-command on the basis of their non-adult behavior crucially relies on the assumption that no alternative account can be found which would explain children's behavior without invoking the notion of c-command. In this regard, several objections have recently been raised against Lidz and Musolino's c-command account. Moreover, alternative accounts have been proposed which claim to explain children's 'isomorphic' behavior without relying on the notion of c-command (e.g., Krämer, 2000). In the following section, we review these objections and alternative accounts. We then present the results of a new study designed to test the predictions of the various accounts invoked to explain children's isomorphic behavior.

4. Alternative accounts of the isomorphism effect

As noted above, using numerally quantified NPs allowed Lidz and Musolino to avoid the entailment problem posed by the use of universally quantified NPs. Solving the entailment problem, however, introduced another potential confound. The scenarios required to make the wide scope reading of the numerally quantified NP true and the narrow scope reading false are slightly more complex than the scenarios required to make the wide scope reading false and narrow scope reading true. Consider the kind of sentence tested by Lidz and Musolino:

(12) He didn't eat two cookies

In order to make the wide scope reading of the quantificational NP true and the narrow scope reading false, the stories required four cookies. Two of the cookies were eaten and two of the cookies were not eaten. In this scenario, then, the wide scope reading is true

because there are two cookies that the character didn't eat. At the same time, the narrow scope reading is false. That is, it is false that it is not the case that he ate two cookies. However, in order to reverse the truth of these readings, the stories required only two cookies. In these stories, one cookie was eaten and one was not. Thus, the wide scope reading (there are two cookies that the character didn't eat) is false; and, the narrow scope reading (it is not the case that the character ate two cookies) is true. Consequently, the stories on which the children accepted the puppet's statement (12) were arguably simpler than the stories on which the children rejected it since the former contained fewer objects than the latter. So, the observation that children accept the narrow scope reading of the quantificational phrase but reject the wide scope reading may be a fact not about their grammars, but rather about the complexity of the stories. Given the readings, it is simply not possible to match the conditions for complexity. We will call this the "complexity problem" and return to it below.[4]

A related concern involves the relative salience of the objects under consideration. In the example discussed above, Cookie Monster ate two cookies but there were also two cookies that he didn't eat. In this situation, children typically rejected the statement that 'Cookie Monster didn't eat two cookies' on the grounds that Cookie Monster did eat two cookies. It is conceivable in this situation that the cookies that Cookie Monster ate are somehow more salient than the ones that he didn't eat – perhaps simply because something happened to these cookies – and so one could imagine that the difference in salience between the two sets of cookies (i.e. the two that were eaten vs. the two that were not eaten) compels children to preferentially take into account the cookies that were

[4] Notice also that if we had used an equal number of cookies in each story, say three, then the two readings would both be true or false in the same set of circumstances. If the boy eats two out of three cookies, then both readings are false. If the boy eats one out of three, then both readings are true.

eaten when asked to interpret the sentence. To be sure, if one has in mind the two cookies that Cookie Monster ate and then hears the sentence *Cookie Monster didn't eat two cookies*, it would be natural to object and reply that Cookie Monster did in fact eat two cookies. We call this the 'focus problem' and return to it below.

Another potential confound in Lidz and Musolino's paper concerned the manipulation of word order in the two languages. Although it was the choice of languages with different word order that led to the conclusion that hierarchical structure and not linear order was the relevant factor in determining children's scope interpretations, this choice is ultimately problematic. By comparing an SVO language with an SOV language, the possibility that the order of the verb with respect to the object determines how scope is computed makes the previous work inconclusive. That is, it is possible that scope is determined on the basis of precedence in SVO languages and subsequence in SOV languages, independent of hierarchical structure. This would make sense if the learner noted the significance of linear order in one domain (e.g., complementation) and then extended it to other domains (e.g., scope). On this view, the parallel between English and Kannada-speaking children is not a consequence of hierarchical structure but rather a consequence of linear order being used differently in the two languages. Since negation precedes the object in English and English is an SVO language, children assign negation scope over the object. And, since negation follows the object in Kannada and Kannada is an SOV language, children assign negation scope over the object. We will call this the "word order" problem and return to it below.

Finally, because Lidz and Musolino tested indefinites, it is possible that their results do not inform us about how children compute scope relations *per se*. This possibility

arises out of the idea that indefinites (including NPs with numeral determiners) are non-quantificational (Kamp 1981, Heim 1981, Fodor and Sag 1982, Kratzer 1989, Diesing 1992, vanGeenhoven 1996). The idea that indefinites do not carry existential force of their own grows out of the observation that the quantificational force of an indefinite varies depending on its surrounding context (Lewis 1975):

(13) a. A psychologist usually ignores syntactic theory.

b. A psychologist rarely ignores syntactic theory.

In, (13a), we interpret the indefinite as referring to most psychologists whereas in (13b), we interpret it as referring to few psychologists. In other words, indefinites do not simply introduce their own quantificational force but rather can also take their quantificational force from other elements in the sentence (such as adverbs like *usually* and *rarely*). Kamp 1981 and Heim 1982 took these observations as evidence that indefinites are not quantificational, but rather are best treated as free variables that come to be bound by other quantificational elements in the sentence. For example, the sentences in (13) would have semantic representations like (14):

(14) a. usually(x) [[psychologist(x)] $\rightarrow$ [x ignores syntactic theory]]

b. rarely(x) [[psychologist(x)] $\rightarrow$ [x ignores syntactic theory]].

In these examples, the interpretation of the variable introduced by the indefinite depends on the choice of adverbial. Further, in the absence of other quantificational elements, indefinites are bound by an existential quantifier inserted by a default operation of existential closure (Kamp 1981, Heim 1982, Diesing 1992).

(15) a. A psychologist ignores syntax
b. psychologist(x) & x ignores syntax (variables unbound)
c. $\exists$x [psychologist(x) & x ignores syntax] (variables bound by $\exists$ closure)

Thus, if indefinites are non-quantificational, then children's interpretations of indefinites do not bear on the question of whether children use hierarchical syntactic relations to compute quantifier scope.[5]

However, Diesing (1992), building on work by Milsark (1974), demonstrates that indefinites do sometimes have existential force of their own. Diesing argues that indefinites must therefore be given two representations: a free variable representation, as discussed above; and, a quantificational representation. Under this view, the two interpretations of (12) are those in (16):

(16) a. $\neg$ [$\exists$x [He ate 2(x) & cookie(x)]] (indefinite = free variable)
b. $\exists_2$x [cookie(x) & $\neg$[he ate x)]] (indefinite = quantifier)

In (16a), the numeral is treated as a cardinality predicate which, in conjunction with the default existential closure operation, asserts the existence of a set whose size is determined by the cardinality predicate. In (16b), the numeral is treated as a canonical instance of restricted quantification.

So, the problem for Lidz and Musolino's account of children's scope interpretations is this: the fact that children in English and Kannada accepted only the narrow scope reading of the indefinite could be a consequence of two factors. First, as proposed by Lidz and Musolino, it could be the case that the children treated the indefinite quantificationally but are restricted such that scope must be isomorphic to the surface structure. Alternatively, it could be the case that the children do not have access to the

[5] van Geenhoven's (1996) alternative theory of indefinites (picked up in the acquisition literature by Kramer 2000) treats these NPs as predicates that get incorporated into the verb by type-shifting the verb to be able to take a predicate as its argument. This approach has essentially the same structure as the Kamp-Heim-Diesing theory, with the existential force of indefinites introduced not by the indefinite per se, but a default operation internal to VP. The arguments we make concerning children's interpretations of indefinites go through independent of which approach is taken.

quantificational reading of indefinites and so treated them as free variables.[6] If children do not have access to the quantificational reading of indefinites, then any conclusions about the syntax of quantifier scope in children based on indefinites must be invalid. Let us refer to this as the "indefinites problem."

We have identified four open questions with respect to children's understanding of scopally ambiguous sentences. The complexity and focus problems are methodological in nature, while the linear order and indefinites problems are linguistic in nature. We propose to address all four questions by testing sentences containing negation and indefinite subjects, as in (17):

(17) Two butterflies didn't go to the city.

This type of sentence involves an indefinite NP in subject position which can interact scopally with negation. The sentence is ambiguous between a reading in which there are two particular butterflies that failed to go to the city and a reading in which some number of butterflies other than two went to the city. Importantly, the subject of a sentence c-commands everything else in the sentence, including negation. Thus, if children's scope preferences are driven by the surface c-command relations of the scope bearing elements, we predict that children will accept only the interpretation of (17) in which the subject is interpreted outside the scope of negation.

Consider now how sentences like (17) address the complexity problem. Recall that in Lidz and Musolino's work, children rejected the nonisomorphic reading in which a numerally quantified object NP took scope over negation and that this reading required a

[6] See Krämer, 2000 for a proposal along these lines that specifically rejects an account of isomorphism based on surface syntactic position, contra Musolino, 1998 and Lidz and Musolino, 2002

more complex story than the surface scope reading that they accepted. Thus children's rejection of the nonisomorphic reading could have been due either to syntax or to the complexity of the stories. By putting the numerally quantified NP in subject position, however, the isomorphic reading becomes more complex than the non-isomorphic reading. In other words, the interpretation in which the QP takes scope over negation is the non-isomorphic interpretation when the QP is in object position, but it is the isomorphic reading when the QP is in subject position. Since this is the reading which required a more complex story, putting the QP in subject position allows us to distinguish an account based on syntactic structure from an account based on the complexity of the stories. If the previous result was based on the complexity of the stories involved, then children should accept only the *non-isomorphic* reading here, since that is now the reading which requires a simpler story. On the other hand, if the previous result was based on children assigning scope solely on the basis of surface syntactic position, then they should accept only the reading which goes along with the more complex story.

The same reasoning applies to the focus problem. If children preferentially consider the set of objects or characters who did perform the action, then we expect them to behave in the same fashion regardless of whether the QP occurs in subject or object position. In the case of (18), for example, where two of the butterflies do go to the city while the other two don't, we expect children to reject the statement that *Two butterflies didn't go to the city* on the grounds that two butterflies did go to the city. By contrast, if children are sensitive to the syntactic position of the QP, we expect them to accept the statement that two butterflies didn't go to the city since there are indeed two butterflies that didn't go to the city.

Consider next the word order problem. The subject of a sentence both precedes and c-commands negation (cf. 11) in both English and Kannada. Thus, if children's scope preferences are based on surface hierarchical structure, then children's interpretations of these sentences should be the same across languages. In both languages we would expect children to display a preference for the wide scope reading of the subject since that is the reading which is isomorphic to the surface structure. On the other hand, if children's scope preferences are based on linear order being used differently in the two languages, then English speaking subjects should reject the narrow scope reading of the subject while Kannada speaking subjects should reject the wide scope reading of the subject.

Finally, sentences with negation and indefinite subjects also address the indefinites problem. Recall that one possible analysis of our previous data was that children fail to treat indefinites quantificationally. On this view, we learn nothing about quantifier scope by testing indefinites because indefinites are non-quantificational. This analysis predicts that an indefinite subject will always take narrow scope with respect to negation. Let us consider why.

First, let us assume that indefinites introduce free variables. Assume further that the domain of existential closure is the VP (as demonstrated by Kadmon 1987, Kratzer 1989, Heim 1990 and Diesing 1992). Thus, the free variable introduced by an indefinite will be bound by existential closure only if it occurs within VP. A free variable outside of VP will be unbound and thus will fail to receive an interpretation. Such a variable would be forced to reconstruct back into VP in order to be interpreted. Thus, if children have only the non-quantificational interpretation of indefinites, then we would expect them to exhibit obligatory reconstruction of indefinite subjects and hence inverse scope with

respect to negation.[7] Alternatively, if children are able to treat indefinites as quantifiers, then if it is true that their scope interpretations are based on surface position, we expect them to exhibit a preference for surface scope with respect to negation. Thus, the hypothesis that children fail to treat NPs with numeral determiners as quantifiers predicts that children (independent of language) will allow only inverse scope in sentences like (17). On the other hand, if children are able to treat these NPs as quantificational, then if scope is in fact restricted by surface syntax, we expect that children will display a preference for the surface scope.

Table 1 summarizes the predictions of each of the accounts of isomorphism discussed above (i.e. c-command, differential linear order, complexity, focus, and indefinites) with respect to sentences like (18). S > neg indicates that the subject takes scope over negation while Neg > S indicates that negatation takes scope over the subject.

Table 1

	S neg V O (English)	S O V neg (Kannada)
C-command	S > neg	S > neg
Linear order	S > neg (precedence)	Neg > S (subsequence)
Indefinites, Complexity, Focus	Neg > S	Neg > S

5. Experiment

[7] Note however that the results of Musolino et al. (2000) demonstrate that children typically fail to access to the reading provided by reconstructing the subject into VP. If this is true, then children who fail to treat indefinites quantificationally should find sentences with indefinite subjects ungrammatical across the board.

We now turn to an experiment which was designed to tease apart the predictions of the various accounts of isomorphism discussed above. The experiment was conducted in the United States and in India where we tested English and Kannada-speaking 4-year-olds on their interpretation of ambiguous sentences involving a numerally quantified subject NP and negation, as illustrated in (18).

(18) a. Two butterflies didn't go to the city

b. eraDu chitte paTNa-kke hoog-al-illa
two butterfly city-DAT go-INF-NEG
'Two butterflies didn't go to the city.'

The isomorphic reading of (18), given in (19a), can be paraphrased as "there are two butterflies that did not go to the city." The non-isomorphic reading, given in (19b), can be paraphrased as "it is not the case that two butterflies went to the city."

(19) a. $\exists_2 x$ [butterfly(x)] & ¬[x go to the city]
b. ¬ $\exists_2 x$ [butterfly(x)] & [x go to the city]

As discussed above, testing children's interpretation of sentences like (19) allows us to determine which of the competing explanations for children's isomorphic behavior reported in earlier work (i.e. Lidz and Musolino, 2002) is likely to be correct.

5.1 Method

Subjects

We tested 20 Kannada-speaking children between the ages of 4;0 and 4;11 (mean 4;5) and 20 English speaking children between the ages of 4;0 and 4;11 (mean 4;6). We chose 4-year-olds because previous studies, i.e. Lidz and Musolino (2002), showed that children of this age displayed a strong preference for the isomorphic interpretations of sentences with negation and quantificational objects. The Kannada-speaking children

were selected from the Pushkarini and Swami Vivekananda preschools in Mysore, India. English-speaking children were tested in the language acquisition laboratory at Northwestern University.

Procedure

As in Lidz and Musolino's study, we tested our subjects using the Truth Value Judgment Task methodology (TVJT) (Crain and Thornton 1998). The TVJT involves two experimenters. The first experimenter acts out short stories in front of the subjects using small toys and props. The second experimenter plays the role of a puppet who watches the stories alongside the puppet. At the end of the story, the puppet makes a statement about what he thinks happened in the story. The subjects' role is to decide whether the puppet's statement is "right" or "wrong". Finally, subjects are asked to justify their answers by explaining why they think the puppet was right or wrong. For a more detailed description of the TVJT, see Crain and Thornton 1998 and Lidz and Musolino, 2002.

The Kannada-speaking children were first introduced to the task as a group and then tested individually in a quiet room away from the class. English-speaking children were introduced to the task when they arrived at the laboratory. Each child, independent of language, received two pretest stories and if the child could answer those appropriately, including appropriate justifications, they would then hear seven more stories: four test stories and three control stories, administered in a pseudorandom order.

Materials

We placed subjects in an experimental situation in which both scope readings of sentences like (18) are relevant in the context of the stories. The stories were constructed in such a way as to make one of the readings false and the other reading true. Answers of

YES or NO to the puppet's statements (along with appropriate justifications) were therefore taken as a measure of subjects' ability to access one reading or the other.[8]

As in Lidz and Musolino's study, two versions of each story were constructed. In the first one, the wide scope reading of the numerally quantified NP in sentences like (18) was true (abbreviated Wt) and the narrow scope reading of this NP was false (abbreviated Nf). In the second version, the wide scope reading of the numerally quantified NP was false (abbreviated Wf) and the narrow scope reading was true (abbreviated Nt). Recall that what we call here the wide scope reading of the NP corresponds to an isomorphic interpretation, since this NP occurs in subject position and therefore c-commands negation. What we are calling the narrow scope reading of the NP corresponds to a non-isomorphic interpretation. Thus, if subjects accept the puppet's statement in the Wt/Nf condition, then we conclude that they are able to access the isomorphic interpretation. If subjects accept the puppet's statement in the Wf/Nt condition, then we conclude that they are capable of accessing the non-isomorphic interpretation.

In the Wt/Nf version of the story corresponding to example (18), four butterflies are flying around on a summer day and decide to go somewhere together. The forest is in sight and so they all fly there. They are all happy because it is nice and cool in the forest. After a while, two of the butterflies complain that it is boring in the forest and decide to go on to the city because there are interesting tall buildings there. But the other two butterflies are worried that it will be too hot in the city and decide to stay. At the end of the story, the puppet says: "I know what happened. Two butterflies didn't go to the city.[9]

[8] Answers in which the subject said that the puppet spoke truthfully are coded as YES and answers in which the subject said that the puppet didn't say the right thing are coded as NO.

[9] Kannada speaking subjects, of course, heard the Kannada version of the story with the utterance in (i) at the end.

Am I right?" In this case, the wide scope (isomorphic) reading of the numeral is true because there are two butterflies who decided not to go to the city. The narrow scope (non-isomorphic) reading is false because two butterflies did go to the city.

In the Wf/Nt version of the story, two butterflies are flying around on a summer day and decide to go somewhere together. The forest is in sight and so they both fly there. They are happy because it is nice and cool in the forest. After a while, one of the butterflies complains that it is boring in the forest and decides to go on to the city because there are interesting tall buildings there. But the other butterfly is worried that it will be too hot in the city and decides to stay. At the end of the story, the puppet says: "I know what happened. Two butterflies didn't go to the city. Am I right?" In this case, the wide scope (isomorphic) reading of the numeral is false because only one butterfly decided against going to the city. The narrow scope (non-isomorphic) reading is true because only one butterfly did go to the city.

The statements made by the puppet on each of the four test trials are given in each of the two languages in Table 1 (see Appendix A for the plots).

(i) eraDu chitte paTNa-kke hoog-al-illa
two butterfly city-DAT go-INF-NEG
'two butterflies didn't go to the city.'

English	
Test story 1	Two butterflies didn't go to the city
Test story 2	Two frogs didn't jump over the rock
Test story 3	Two lions didn't buy a cookie
Test story 4	Two dinosaurs didn't eat fish
Kannada	
Test story 1	eraDu chitte paTNakke hoogalilla two butterfly city-dat go-inf-neg 'Two butterflies didn't go to the city.'
Test story 2	eraDu kappe baNDe meeLe negeyalilla two frog rock over jump-inf-neg 'Two frogs didn't jump over the rock.'
Test story 3	eraDu simba biskitannu karedisalilla two lion cookie-acc buy-inf-neg 'Two lion's didn't buy a cookie.'
Test story 4	eraDu moSaLe miinuvannu tinnalilla two dinosaur fish-acc eat-inf-neg 'Two dinosaurs didn't eat fish.'

Table 1: Puppet's statements in test stories in each language

When making these statements, the experimenter playing the role of the puppet was instructed to say the sentences in a way that is most naturally compatible with the sentence being true. This step was taken to ensure that if there are any prosodic cues associated with the different readings, they would be provided to the child subjects.

In addition to the test stories, each subject also witnessed three control stories. Unlike the test items, the statements made by the puppet on the control stories were not ambiguous. The purpose of these stories was to control for children's knowledge of the meaning of the separate linguistic elements involved in the scope ambiguities discussed above (i.e., negation and NPs of the form two N.) The experimenter holding the puppet had a choice between two different statements for each of the control stories. One statement was true in the context of the story and the other was false. If the child had answered YES to a given test story, the experimenter holding the puppet was instructed to pick the statement for the following control story corresponding to a NO answer, and vice-versa. This ensured that the number of YES and NO responses was balanced.

Another precaution that was taken to ensure that children knew the meaning of the word *two* was to have each subject count the number of toys or characters in each of the stories as they were being laid out on the table. The list of statements made by the puppet in the control stories in each language is given in table 2.

English	
Control story 1	The hippos didn't drink milk (true) Two hippos drank milk (false)
Control story 2	Two snakes climbed onto the book (true) Four snakes climbed onto the book (false)
Control story 3	Two frogs danced with bugs (true) The frogs didn't dance (false)
Kannada	
Control story 1	neeraanegaLu haaLu kuDalilla water-elephant-pl milk drink-inf-neg 'The hippos didn't drink milk.' eraDu neeraane haaLu kuDitu two water-elephant milk drink-pst-3sn 'Two hippos drank milk.'
Control story 2	eraDu haavu pustaka meeLe hattitu two snake book onto climb-pst-3sn 'Two snakes climbed onto the book.' muru haavu pustaka meeLe hattitu two snake book onto climb-pst-3sn 'Two snakes climbed onto the book.'
Control story 3	eraDu kappe tigiNeygaLoDane kuNitu two frog bug-pl-with dance-pst-3sn 'Two frogs danced with bugs.' kappegaLu kuNiyalilla frog-pl dance-inf-neg 'The frogs didn't dance.'

Table 2: Puppet statements in control stories in each language

Finally, the 40 subjects (20 English and 20 Kannada) were randomly assigned to each condition (Wt/Nf and Wf/Nt) thus giving rise to a 2x2 design with scope condition and language as between subjects factors with 10 subjects per cell (Table 3).

	Wide True / Narrow False	Wide False / Narrow True
English 4-year-olds (n)	10	10
Kannada 4-year-olds (n)	10	10

Table 3: 2x2 design

Since the puppet's statements on critical trials are ambiguous, we chose to treat scope condition as a between subjects factor, instead of a within subjects factor, in order to avoid potential contaminating effects between the two possible readings. That is, once children become aware of one of the possible interpretations of the ambiguous statements, they may find it difficult to later assign a different interpretation to a similar statement. In other words, the initial interpretation that children assign to statements of the form *Two N didn't VP* may influence the way they interpret subsequent statements of the same form.

Results

In the analysis below, our dependent measure was the proportion of YES responses to the puppet's statements. Beginning with subjects' responses to the test items (Figure 1), we found that subjects in both languages accepted the puppet's statements reliably more often in the WtNf condition, as compared to the WfNt condition (20% vs. 87.5 %, respectively ($t(38) = -8.516$, $p < .0001$). The proportions of YES responses were entered into an analysis of variance (ANOVA) with two factors: language (English, Kannada) and condition (WtNf, WfNt). The analysis revealed a significant main effect of condition ($F(1,36) = 75.85$, $p < .0001$, no reliable effect of language ($F(1,36) = 0$, $p = 1$) and no reliable interaction between language and condition ($F(1,36) = 3.75$, $p > .06$).[10]

[10] The interaction does approach significance. This is not a consequence of a qualitative difference in preferences across the languages but rather the magnitude of these preferences. The Kannada speaking children were slightly more likely to accept the isomorphic interpretation than the English speaking children and they were slightly less likely to accept the nonisomorphic interpretation than the English speaking children.

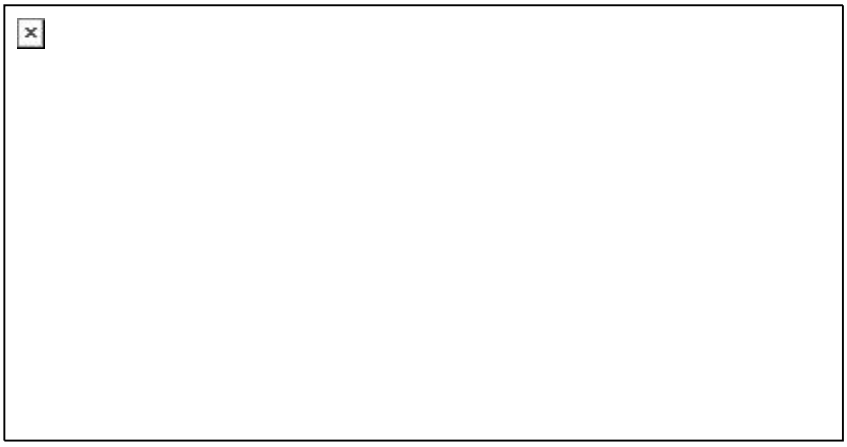


Figure 1: Proportion of YES responses to test trials for Kannada- and English-speaking children in each of the two conditions

On the control items, the children gave correct answers 94% of the time in both conditions. An ANOVA with two factors (language and condition) was performed on the proportion of correct responses to the control items. We found no reliable effect of language ($F(1,36) = 0.439$, $p > .51$), no reliable effect of condition ($F(1,36) = 0$, $p = 1$) and no interaction between language and condition ($F(1,36) = 0.439$, $p > .51$).

Finally, turning to children's justifications, we found that in the WtNf condition, children overwhelmingly accepted the puppet's statements (i.e. 80% and 95% in English and Kannada, respectively). When asked to justify their answers, children typically explained that the puppet was right because there were indeed two Ns that didn't V. In the WfNt condition, we found that children overwhelmingly rejected the puppet's statements (i.e. 72.5% of the time in English and 87.5% of the time in Kannada). When asked to justify their answer, children typically explained that the puppet was wrong because only one N didn't V.

Discussion

First, it is important to note that the results presented above replicate the effect reported in earlier studies (Musolino, Crain and Thornton, 2000; Lidz and Musolino, 2002;

Musolino and Lidz, submitted). That is, children display a reliable preference for one of the two interpretations of scopally ambiguous sentences. Furthermore, children's near perfect performance on control items, also found in previous studies, demonstrates that they did not experience any difficulty with the task. The TVJT has by now been used successfully to test children's interpretation of a wide range of linguistic constructions in languages such as English, Italian (Crain and Thornton, 1998) Kannada (Lidz and Musolino, 2002) and Greek (Papafragou and Musolino, in press) with children as young as 3 and a half. It has also been clearly demonstrated that children in that age range are perfectly capable of dealing with complex sentences involving negation and quantificational expressions. That is, not only has it been shown that children know the individual meanings of these expressions (Lidz and Musolino, 2002; Papafragou and Musolino, in press) but children are also perfectly capable of repeating the complex sentences they hear on these tasks (*ibid*) and provide justifications for their answers which only make sense if children have in fact parsed all the elements in theses sentences.

The real question then, concerns the nature of the isomorphism effect, observed in previous studies, and replicated in the present one. What we found here is that 4-year-old speakers of English and Kannada display a strong preference for the interpretation of sentences of the form *Two N didn't VP* on which the subject NP takes scope over negation, i.e. Subj > neg, regardless of language. In this regard, recall the predictions of the various accounts of isomorphism discussed above.

Table 1

	S neg V O (English)	S O V neg (Kannada)
C-command	S > neg	S > neg
Linear order	S > neg (precedence)	Neg > S (subsequence)
Indefinites, Complexity, Focus	Neg > S	Neg > S

Clearly, our results are incompatible with the accounts of the isomorphism effect which do not crucially rely on the idea that children's interpretation of scopally ambiguous sentences is constrained by the c-command relations between the quantificational elements involved. Thus, isomorphism is not due to the differential complexity of the stories, the fact that children only focus on a subset of the objects in the story, the idea that linear order is computed differently in different languages or the idea that children never allow indefinites to be interpreted quantificationally. We conclude that the best available explanation of the isomorphism effect remains the one originally proposed by Lidz and Musolino (2002).

There is another potential explanation of the pattern of children's interpretations of indefinites. On this view, the interpretation in which the subject appears to take scope over negation is not due to the children treating the indefinite quantificationally but rather it is due to them treating the indefinite referentially (cf. Fodor and Sag 1982). This possibility arises out of the observation that indefinites can appear to take scope out of environments that other quantificational phrases cannot:

(20) a. The professor doesn't like any student who read two books.

b. The professor doesn't like any student who read every book.

Here we see that the indefinite can take scope over negation even when the negative element occurs outside of the relative clause containing the indefinite. That is, (20a) can be interpreted as meaning that there are two books such that the professor doesn't like any student who read them. In (20b), however, the universal quantifier cannot take scope out of the syntactic island. Thus, (20b) does not have the interpretation that every book is such that the professor doesn't like any student who read it. Rather it means only that the professor doesn't like the well read students. This contrast has been taken by many to show that certain apparent wide scope readings of indefinites are not scopal at all, but rather are due to the scopelessness of referential NPs. In other words, the indefinite in (20a) is treated like the name of a two book set (say, the set containing Gravity's Rainbow and The Crying of Lot 49) and like any name, this NP has no scope per se but rather simply refers to that pair of books.[11] Given this view, one might say that the wide scope readings of indefinites that we find in subject position are not due to scope but rather to these indefinites being treated referentially by the children. This approach is problematic, however, because it fails to explain why the referential interpretation of indefinites is available only to subject NPs. That is, if the referential interpretation is available to subject NPs, then we would also expect it to be available to object NPs, leading to the appearance of nonisomorphic interpreations for objects. But, as Lidz and Musolino's

[11] One current implementation of this idea is to treat indefinites as choice functions (i.e., functions which map from a set to an individual member of that set). On this view, an indefinite can denote a function variable which is bound by a root existential closure operation over that type of variable. It is the root existential closure operation which is responsible for the lack of island effects (Reinhart 1997, Kratzer 1998, see Lidz 1999 for choice functions in Kannada).

(2002) data show, children do not accept such interpretations. Thus, the most explanatory account of children's behavior is one in which children are just like adults in allowing indefinites to be quantificational.

6. Conclusions

Our results can be summarized as follows: young children's interpretations of ambiguous sentences containing numerally quantified expressions and negation are constrained by the surface c-command relations between these elements. Putting together our present results with those reported in Lidz and Musolino (2002), it is now clear that *only* an account based on the notion of c-command explains the full patterns of facts (see table 4).

Table 4

	S neg V O (English)	S O V neg (Kannada)
Children's Preferences	S > Neg Neg > O	S > Neg Neg > O
	Predictions of Alternative accounts	
C-command	S > neg Neg > O	S > neg Neg> O
Linear order	S > neg (precedence) Neg > O	Neg > S (subsequence) Neg > O
Indefinites, Complexity, Focus	Neg > S Neg > O	Neg > S Neg > O

Thus, focusing our experimental microscope on the seemingly arcane behavior of quantificational expressions allows us to demonstrate that children honor very abstract and general principles of linguistic organization (in this case the explanatory role of the c-command relation in grammar). In light of the recent debate over children's early syntactic knowledge, our results underscore two points. The first is that young learners do possess abstract syntactic knowledge. The second is that it does make sense to explain children's emerging linguistic systems in terms of the same abstract principles invoked in accounts of adult grammars. In sum, our results lend support to the Continuity Assumption.

Of course, we are aware of the fact that even though the children we tested in our study are young, they are not *that* young. The recent challenges to the continuity assumption have been advanced on the basis of data from 2-year-olds (Tomasello, 2000). Ideally then, and in order to be fair, one would want to present data showing that 2-year-olds have knowledge of c-command. However, experimental paradigms have their limitations and the TVJT cannot be used with children as young as 2-years-old (for data showing hierarchical syntactic representations in 18-month-olds, see Lidz, Waxman and Freedman, 2002). Nevertheless, we believe that our data pose a challenge to non-continuous models of language acquisition. The challenge, of course, is to explain how children come to possess such abstract linguistic knowledge. And even if the facts that we have explained by invoking abstract and language-specific notions such as c-command are to eventually be explained as growing out of more domain-general learning principles, the challenge would still be to specify what these general principles are and to show that their empirical coverage is equivalent to that of the notion they are meant to

replace. We are at present not aware of such an account, and thus, until one becomes available, the best explanation of children's behavior remains one that is based on the notion of c-command.

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