Quantifier Raising in 4-year-olds

Jeffrey Lidz, Erin McMahon, Kristen Syrett, Joshua Viau, Florencia Anggoro, Jessica Peterson-Hicks, Elisa Sneed, Ann Bunger, Taki Flevaris, Anne Graham, Kristy Grohne, Yongeun Lee, and John Evar Strid
Northwestern University

Several studies on the acquisition of quantification (Musolino 1998, Musolino, Crain and Thornton, 2001, Lidz and Musolino 2001) have shown that 4- to 6-year-old children differ systematically from adults in their ability to assign inverse scope to ambiguous sentences like (1) and (2).

(1)   The Smurf didn't catch two birds
(2)   Every horse didn't jump over the fence

Using the Truth Value Judgment Task (Crain and McKee 1985, Crain and Thornton 1998, Gordon 1996), these authors found that adults were able to assign either reading of (3) and (4) to sentences like (1) and (2), respectively.[1]

(3)   a.   There are two birds that the Smurf didn't catch   (two > not)
        b.   It is not the case that the Smurf caught two birds   (not > two)

(4)   a.   Not every horse jumped over the fence   (not > every)
        b.   No horses jumped over the fence   (every > not)

Four and five-year-old children, however, systematically rejected the inverse scope readings (3a/4a) of the quantificational expressions *two birds*/*every horse* in favor of the surface scope readings (3b/4b). We can refer to this result as "the isomorphism effect": children, unlike adults, assign relative scope to negation and quantified NPs on the basis of their surface positions. Thus, although adults are aware of the imperfect mapping between surface syntactic structure and semantic structure, children seem to rely more heavily on the surface structure in assigning a semantic representation.

An important question left open by these studies is why children differ from adults with respect to their ability to assign inverse scope. Why do children initially fail to assign inverse scope to ambiguous sentences containing a quantifier and negation? In principle, two types of explanation are possible. One explanation would hold that until a certain stage in grammatical development,

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[1] Throughout this paper, the symbol ">" should be interpreted as "takes scope over".

children's grammars simply do not generate such interpretations. On such an account, children reject nonisomorphic interpretations because their grammars do not include the covert displacement operation (or its equivalent) that is required to generate these readings. If this turned out to be the case, we would find ourselves in a particularly troubling theoretical position. Given that there is no evidence in the string for the application of covert displacement operations, what factors in the external world could drive the child to hypothesize its existence?

A second possible explanation would be that children's interpretations result from some limitation on the computational resources that children deploy during language comprehension. On this view, although children's grammars may generate both possible readings, they may not be able to access the non-isomorphic interpretations because they are computationally too taxing (Frazier 2000). On this view, the child and the adult are assumed to share the same grammatical knowledge but to differ in the way they implement that knowledge in the course of language comprehension (Grodzinsky and Reinhart 1993). One possibility suggested by recent findings on children's ability to resolve ambiguities on-line is that children may experience a garden-path effect from which they cannot recover (Trueswell et al., 1999). In the case at hand, children may initially access the isomorphic reading and end up being stuck with it for lack of the ability to revise that initial interpretation. Indeed, there is evidence from adult sentence processing suggesting that adults prefer surface scope over inverse scope (Tunstall 1998, Frazier et al., 1998), suggesting that the problem children have here may be an exaggerated version of a preference found in adults (Musolino and Lidz, in press).[2]

In order to test whether children's failures to access inverse scope readings are a consequence of a grammatical failure or a performance problem, we conducted two studies testing the interpretation of quantifiers in unambiguous contexts that require QR to apply. Children showed adult-like interpretations of such sentences. Because these sentences were unambiguous, the processing difficulty associated with the ambiguity was alleviated, enabling children to show their knowledge of QR. We can conclude, then, that children's problems in accessing inverse scope for ambiguous sentences in previous studies were due to properties of the language processor and not to incomplete grammatical knowledge.

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[2] A related possible explanation is offered by Gualmini (2003), who claims that the isomorphism effect is due to the failure of previous research to take into proper consideration the role of pragmatics in interpreting negation. With respect to the experimentation reported here, this explanation makes the same predictions as the processing account described above and will therefore be lumped together with it. Future research will examine the relative roles of pragmatic and processing factors in the isomorphism effect.

1. Experiment 1: Quantifier-variable Binding

In sentences such as (5) below, the quantificational noun phrase (QNP) *every boy* does not c-command the pronoun at surface structure, as illustrated in (6a).

(5)   The king kissed every boy before the queen introduced him

The pronoun *him* is contained within an adjunct clause which is adjoined to VP and so is not in the c-command domain of the object QNP.[3] It is only after covert displacement that this QNP is in a position to bind the pronoun (May 1985, Hornstein 1995), as illustrated in (6b).

(6) a.   The king [$_{VP}$ [$_{VP}$ kissed every boy] [before the queen introduced him]]
     b.   [every boy [the king [$_{VP}$ [$_{VP}$ kissed t] before the queen introduced
                                                                    him]]]]

So, if children are able to interpret the pronoun as a variable bound by the QNP, then they must have QR in their grammars. If, on the other hand, children fail to treat the pronoun as a variable bound by the QNP, we must conclude that their grammars do not have QR.

Twenty 4-year-old (mean 4;5) and twenty adult participants were presented with sentences containing a QNP and a pronoun in two conditions. In the subject condition, the QNP was in the matrix subject position with the pronoun inside the adjunct clause, as in (7a). In the scenarios for the subject condition, the sentence was true if the pronoun was bound by the matrix subject and false if the pronoun was bound by the matrix object, as illustrated in (7b).

(7)   a.   Every dancer kissed Kermit before she went on stage
         b.   This story features Kermit, three dancers and a singer. The
               dancers and the singer are performing in a show. Kermit tells them that
               it is good luck to kiss a frog before performing. The singer tells Kermit

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[3] We can verify that the surface position of the quantifier does not c-command the pronoun because wh-movement from this position licenses a parasitic gap in the position of the pronoun:
     i.   Who did the king kiss t before the queen introduced e
Since there is a surface anti-c-command requirement on parasitic gap formation (Engdahl 1983, Chomsky 1982), we can conclude that the QP does not c-command the pronoun at the surface in (6a).

In addition, a pronoun in object position can be coreferential with a name in the adjunct clause. The lack of principle C effect here indicates that the object does not c-command into the adjunct clause.

that she is sick and so she cannot kiss Kermit. Then she goes on stage to sing. The three dancers each kiss Kermit and go on stage.

Note that in this story, the sentence (7a) is true if the pronoun is taken to be bound by the matrix subject, but false if the pronoun is taken to refer to the singer. Participants in this condition were therefore expected to accept the sentence as true, since no covert movement was required to find an antecedent for the pronoun.

In the object condition, the QNP was in the matrix object position with the pronoun inside the adjunct clause, as in (8a). The scenarios for these sentences were such that the sentence was false when the pronoun was bound by the matrix subject and true when the pronoun was bound by the matrix object, as illustrated in (8b).

(8) a. Kermit kissed every dancer before she went on stage
     b. This story features Kermit, three dancers and a singer. The dancers and the singer are performing in a show. Kermit tells them that it is good luck to get a kiss from a frog before performing. The singer tells Kermit that she is sick and so she cannot be kissed by Kermit. Then she goes on stage to sing. The three dancers each get kissed by Kermit and then go on stage.

Note that in this story, the sentence (8a) is true if the pronoun is taken to be bound by the matrix object (the QNP) but false if it is taken to refer to the singer. Predictions about participants' behavior in the object condition depended on whether they were able to apply QR. If children failed to apply QR, then they were predicted to reject the sentence because failure to apply QR would leave only the sentence external character (i.e. the singer) available as an antecedent and the sentence was false on that interpretation. On the other hand, if children can apply QR effectively, then they should accept (8a) as true. Note that in these stimuli there is no scope ambiguity and so there is only one structural description for the LF of this sentence (i.e., the one in which covert displacement has applied). Although there is ambiguity with respect to pronominal interpretation, it has been shown that, with nonquantificational antecedents, children are able to access either reading of pronouns in similar structures and similar tasks (Arnold et al., 2001, Song and Fisher 2001).

Each subject was presented with four test items with this structure. In addition to the test items, all subjects were presented with two warm-up items and three control items to ensure that they could appropriately tell the puppet whether he is right or wrong and to ensure that they understood the meaning of *before* and *after*. Ten adults and ten 4-year-olds were tested in each condition yielding a 2 (condition: subject vs object) x 2 (age: adult vs. child) design.[4]

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[4] A potential concern with this design centers around the question of whether children attach the adjunct clause at the appropriate height. Work by Cairns and

1.1 Results

Adult participants overwhelmingly accepted the sentences in both conditions as true, indicating that adults can apply QR appropriately, as expected. Child participants did not differ from adults, accepting the sentences in both conditions at the same rate. The data are given in Figure 1:
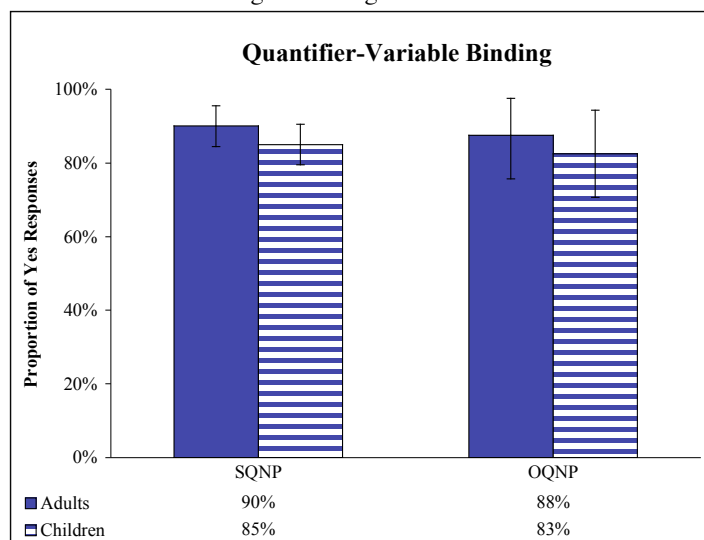
Quantifier-Variable Binding

	SQNP	OQNP
Adults	90%	88%
Children	85%	83%

Figure 1: Mean proportion "Yes" responses in the Subject (SQNP) and Object (OQNP) conditions by children and adults

These data indicate that children do not differ from adults in their ability to apply the covert displacement operation QR. Because children can treat a pronoun in an adjunct clause as bound by a QNP that does not c-command it in

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colleagues (McDaniel, Cairns and Hsu 1991, Hsu, Cairns and Fiengo 1985, Cairns, McDaniel, Hsu and Rapp 1994) suggests that some children attach temporal adjuncts in a position such that the object does c-command into them. If that were the case, then we would also expect children to allow an object QNP to bind into the adjunct clause, but without applying QR. In order to eliminate this concern, we tested adults and children on sentences like (i), which allow coreference between an object pronoun and a name in the adjunct clause.

   (i)   Scooby licked him_i before $Clifford_i$ opened his present.

If children had a nonadult phrase structure for temporal adjuncts, then we would expect them to reject these sentences as Principle C violations. However, children behaved like adults in accepting coreference in this condition, suggesting that the object does not c-command into the adjunct clause for children of this age.

the surface structure representation, we can conclude that they do have QR in their grammars.

2. Experiment 2: Antecedent Contained Deletion

One of the strongest pieces of evidence for covert displacement operations concerns the phenomenon known as antecedent contained deletion (ACD), illustrated in (9) (Sag 1976, May 1985, Kennedy 1997):

(9) Smurfette jumped over every frog that Minnie did

In general, elided VPs require a linguistic antecedent (Hankamer and Sag 1976). For example, in (10), the elided VP is interpreted as identical to the underlined VP.

(10) Smurfette jumped over every frog and Minnie did too.

However, in (9), the elided VP is contained within the only possible VP antecedent. So, if we replaced the elided VP with the matrix VP, there will be an ellipsis in the replacement VP as well:

(11) Smurfette jumped over every frog that Minnie [jumped over every frog that Minnie did]

Trying to find an antecedent for the novel elided VP will lead to another elided VP, ad infinitum.

An operation of covert displacement, however, averts this infinite regress. After movement of the QNP, the elided VP can find an appropriate antecedent, as illustrated in (12):

(12) a. [every frog that Minnie did] [Smurfette [jumped over t]] (after QR)
     b. [every frog that Minnie did [jump over t]] [Smurfette [jumped over t]]
              (after QR & ellipsis resolution)

In short, QR must apply in ACD environments because if it did not, there would be no way to assign a meaning to the elided VP.

Given this analysis of ACD, if children lack covert displacement operations altogether, they should be unable to generate an appropriate meaning for ACD sentences because they would be unable to avert the infinite regress. A question arises at this point concerning what kind of representation the children would generate for a sentence that has an unresolvable ellipsis inside a relative clause. Hamburger and Crain (1982), building on Tavakolian (1981), showed that infelicitous relative clauses are interpreted by children as coordinate clauses. Thus, for a child lacking covert displacement operations, the relative clause

containing the elided VP would be uninterpretable and should therefore be converted by the child into a coordinate clause like (10).

Experiment 2 is designed to test whether children interpret ACD sentences appropriately. To the extent that they do not, then that is evidence that they lack covert displacement operations like QR. Conversely, if children do interpret ACD appropriately, then that is evidence that they have QR in their grammars.

Sentences like (9) were presented in two contexts. In one context (which we will refer to as the "one set context", for reasons that will become apparent), the ACD version was true and the meaning corresponding to the coordinate structure was false. In the other context (which we will refer to as the "two set context"), the ACD version was false and the meaning corresponding to the coordinate structure was true. By testing adults and children on their interpretations of ACD we can determine whether children interpret ACD sentences like adults, allowing us to determine whether they have QR in their grammars. This gives us a design with 2 x 2 design: Meaning (ACD-true vs. Coord-true) x Age (4-year-old vs. adult). (13) illustrates the two story types for the Meaning condition, with the puppet statements given in (14):

(13)　　a. <u>One-set context (ACD-true)</u>: Smurfette and Minnie Mouse　are competing at the annual frog jumping contest. There are four frogs to jump over. Minnie jumps over three but gets tired and sits down. Then Smurfette jumps over three and gets tired too. The judge says that no one wins the prize.

　　b. <u>Two-set context (Coordinate-true)</u>: Smurfette and Minnie Mouse are competing at the annual frog jumping contest. Each contestant has a set of frogs to jump over. Each contestant jumps over all of her respective frogs, so both get a prize.

(14)　　a.　　　Smurfette jumped over every frog that Minnie did
　　b.　　　Smurfette jumped over every frog and Minnie did too

Scenario (13a) makes (14a) true and (14b) false since both contestants jumped over the same frogs but neither jumped over every frog. Scenario (13b) makes (14a) false and (14b) true since the two contestants jumped over different frogs but both jumped over every contextually appropriate frog.

If children's grammars lack covert displacement, then they are predicted to reject the ACD sentence (14a) in the ACD-true scenario (13a) and accept it in Coord-true scenario (13b). This is because, by hypothesis, a child lacking covert displacement would treat ACD as a coordinate structure. That is, if children lack covert displacement, they should be unlike adults and assign the same meaning to ACD sentences and coordinate VP ellipsis sentences. On the other hand, if children do not lack covert displacement, then they should be adult-like in treating the ACD sentences as distinct from the coordinate VP ellipsis sentences.

Ten 4-year-olds (mean age 4;6) and 10 adults were tested in each condition. Each participant was presented with four test items in each condition. In addition to the test items, all participants were presented with two warm-up items and three control items to ensure that they could appropriately tell the puppet whether he is right or wrong and to ensure that they could appropriately interpret relative clauses lacking ACD.

2.1 Results

As expected, adults overwhelmingly accepted the ACD sentences in the one-set (ACD-true) condition and rejected it in the two-set (Coord-true) condition. Children displayed an identical pattern of responses. The data are given in Figure 2:
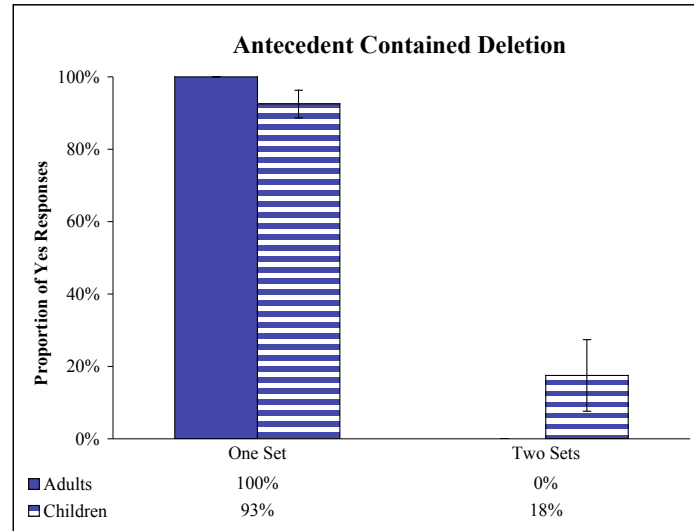
Antecedent Contained Deletion

	One Set	Two Sets
■ Adults	100%	0%
▤ Children	93%	18%

Figure 2: Mean proportion "yes" responses to ACD sentences in the 1 set and 2 set conditions by age.

These data indicate that children do not differ from adults in their ability to apply the covert displacement operation QR. Because children can resolve sentences containing ACD in an adult-like fashion, we can conclude that they do have QR in their grammars.

3. Conclusions

The experimentation described above indicates that children's grammars do indeed have the covert displacement operation QR. Because children behave in an adult-like fashion on unambiguous sentences that require QR, we can conclude that their grammars do generate the structures created by applying QR.

These results shed light on the Isomorphism Effect described at the beginning of this paper. With scopally ambiguous sentences, children show an overwhelming preference for the surface scope interpretation. We now know that this preference is not the result of a failure to apply QR, but rather to a problem with the processing system. Given scopally ambiguous sentences, children's parsers somehow prevent them from accessing non-surface representations.

These results leave open a number of important questions. First, what aspect of children's parsers is responsible for the Isomorphism Effect? Is this effect due to general problems with structural ambiguity or only to problems with ambiguities that result from covert displacement? Second, what is the role of pragmatics in giving rise to the Isomorphism effect? Is this effect due to problems interpreting ambiguous sentences containing negation and the felicity conditions surrounding negation (as suggested by Gualmini 2003), or does the effect derive from general problems of recognizing the appropriate conditions for each reading of ambiguous sentences more generally. Third, can experience with certain uses of ambiguous sentences help learners develop the ability to access inverse scope? We leave these important questions for future research, already underway in our laboratory.

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