

**The 3D Study: Effects of Depth, Directionality, and Distance on  
Children's Acquisition of Anaphora: An Initial Report**

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The 3D Study  
 Effects of Depth, Directionality and Distance  
 On Children's Acquisition of Anaphora:  
 An Initial Report

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In this study we provide an empirical test of the relative roles of 3 factors in the first language acquisition of anaphora in English. Of the 3 factors we study (dominance, directionality and distance), which characterize the relation between an antecedent and an anaphor, the configurational factor of dominance is critical to a theory of Universal Grammar (UG), not only to its fundamental property of structure-dependence, but also specifically to binding theory as well as to various if not all other subsystems of principles in current theory of UG. The experimental study we report argues that the principle of dominance (expressed by the linguistic notion "command") is also critical to first language acquisition of anaphora. We therefore view our experimental data as providing empirical support of one of the fundamental claims of the theory of UG, viz., that it not only provide a profound theory of grammar, but a characterization of the initial state, which provides linguistically significant constraints on first language acquisition.

We restrict our attention here to acquisition of pronominal anaphora, thus using the term "anaphora" in a more general sense than in current theory, but consistent with viewing pronouns as one aspect of "binding theory" which is "concerned with relations of anaphors, pronouns, names and variables to possible antecedents" (Chomsky, 1981, 6).

We do not attempt to provide a full research report here (see Lust and Clifford, in preparation), but to summarize major results and their implications.

### The 3-D Factors

The 3 factors we study in first language are necessary to any linguistic theory which represents well-formedness of anaphora. The issue in linguistic theory is not whether each of these factors are relevant to representation

of anaphora, but how they are interrelated and at what level of the grammar each applies.

Distance from the beginning has been considered a performance factor, which is not in itself critical to a grammatical level of representation (e.g., Wasow, 1979, 61). The issue of the interrelation of dominance and directionality (a factor based on linear order) has been at issue in linguistic theory, however, as a history of work by Langacker (1969), Reinhart (1976, 1981), Lasnik (1976) and Higginbotham (1979) exemplifies. The most basic issue has been: must grammatical theory refer to both constraints independently, or does dominance suffice to provide essential grammatical well-formedness constraints on anaphora.

Currently, the theoretical work in Chomsky, 1981 has intensified the importance of the factor of dominance, implicating it deeply in theory of UG, as I summarize. Here 'c-command' formulates the critical notion of dominance. (See also Koster 1981, on this issue.)

1. "...it is a configurational property - presumably c-command - that determines the operation of the binding theory, not a requirement that anaphors (or pronominals...) search for subjects or objects as antecedents, in some sense of this notion that has any independent sense apart from the configurational properties" (Chomsky, LGB, 1981, 154).

### Acquisition

The basic question for first language acquisition is the following. Given the array of pronominalization data to which the child is exposed in its specific language, where relation between name and pronoun varies along each of the dimensions of dominance, directionality and distance, how does the child construct a coherent theory of the grammar of anaphora predicting in particular where pronominalization may not occur anaphorically, and obeying both universal and linguistically significant constraints. To which factors is the child sensitive and how does it organize these sensitivities. In particular, is the child sensitive to dominance, as a theory of UG would predict.<sup>2</sup> Although there has been some previous study of this issue (Solan, 1981, Lust, Loveland and Kornet, 1980) none has been conclusive. Notably, if children's earliest approach to anaphora were to show sensitivity to and guidance by a principle of linear order alone (direction), this need not be a specifically linguistic principle, it would not necessitate a theory of UG to show how the principle arose. Induction from surface structure facts would suffice. It would not serve the principal role of UG which is to show how it allows quick induction and formulation of a deductive theory of grammar of anaphora which must eventually include dominance. Moreover, if children are not initially sensitive to dominance in anaphora computation, they are not initially constrained by the most critical of UG principles, thus nullifying one of the essential claims of the theory of UG, viz., that it constrain first language acquisition. A priori, however, children's sensitivity to linear order alone is quite possible. Some languages appear to be restricted to forward pronominalization, for example, so if principles of UG were determined by such typological language facts,

and UG constrained language acquisition, the linear order principle in acquisition might be quite tenable on these grounds (cf. Mohanon, to appear).

In fact, there has been some suggestion from acquisition studies that children may be insensitive to dominance at early stages of acquisition. It has been documented by experimental evidence that children learning English demonstrate what has been called a "directionality constraint," on early anaphora, which is stated in 2.

2. In early child language, an antecedent must precede an anaphor in the linear order of surface structure.

Principle 2 is supported by the fact that for children learning English, forward pronominalization is highly favored. Children find it significantly easier to imitate sentences like 3 or 4 than 5.

3. Tommy ran fast when he heard a lion.
4. When Tommy heard a lion he ran fast.
5. When he heard a lion Tommy ran fast.

If given redundancy in 3 or 4, children acquiring English spontaneously pronominalize only forward, never backward, even when backward pronominalization would be grammatically allowed as in 4. When imitating sentences like 5, they frequently make errors which include reversing anaphora direction from backward to forward. This directionality principle is general and abstract in that it also characterizes children's comprehension. Children compute an anaphora/coreference judgment significantly more often for forward pronominalization than for backward. Thus e.g., in 5, children are more likely to compute a noncoreference judgement interpreting a pronoun as someone other than the name Tommy, whereas the reverse is true in 3 or 4. The constraint is general and abstract also in that it has been found to generalize over other forms of anaphora (e.g., null anaphora) in other structures (cf. Tavakolian, 1978, Solan, 1981, Lust, 1981, Lust, Solan, Flynn, Cross and Schuetz, 1981).

Most all researchers who have worked on this problem have assumed or claimed that it demonstrates a simple sensitivity to linear order by the young child, i.e., a sensitivity to the relation "precede," and that it does not involve a sensitivity to dominance. Contrary to this claim however, we have hypothesized that a sensitivity to dominance may lie behind the observed directionality effect in language acquisition, not a mere sensitivity to surface linear order alone. As Reinhart (1976) had noticed, in a right branching language like English, what precedes will usually also command and thus dominance and linear order will usually be confounded. Thus either a sensitivity to dominance or a sensitivity to linear order could provide children with the observed directionality constraint in English. We have hypothesized that 6, not 2, describes the acquisition facts.

6. In early child language, in grammatical anaphora, the direction of anaphora is constrained in direction, (i.e., forward or backward), to correspond to the principal branching direction of the language to be acquired.

Principle 6 predicts that children are initially sensitive to dominance in that they very early pick up the abstract property of their language consisting

of its Principle Branching Direction (PBD) (cf. Lust, in preparation), or recursion direction, and establish directionality principles on anaphora in an attempt to make these (PBD and anaphora relations) cohere. It is because 2 is formulated for acquisition of English that it confounds dominance with linear order, and is therefore incorrect as a sufficient description of the 'directionality' effects observed in child language.

The essential empirical test of this proposed constraint in 6 must come of course from cross-linguistic work which we are now collecting.

However, in this study, we hypothesized that if principle 6 is the correct explanation of the directionality constraint observed in early child language, then it predicts that within a specific language such as English, children should be sensitive to dominance, not just to linear order in their directionality principle.

To test this hypothesis, we elicited both comprehension and production from 94 children between 3 years, 5 months and 7 years, 11 months in 6 month age groups on a set of sentences exemplified in tables 1 and 2.

In all these sentences the subject of the main clause "c-commands" (dominates) what is in the preposed prepositional phrase (PP). These sentences thus reverse the basic right branching (RB) direction of English: what follows, not what precedes, now commands. We will assume the adult judgment that in all these sentences, forward pronominalization is blocked, i.e., not anaphoric.

If children are sensitive to dominance they should block forward pronominalization in these sentences. But if linear order (underlying the directionality principle favoring forward pronominalization) is all children have access to and if they are insensitive to dominance, then children should continue as in all previous studies to show a directionality principle favoring forward pronominalization over backward in these sentences, just as in previous studies where dominance did not block forward pronominalization. Thus they should imitate forward pronominalization significantly better than backward pronominalization and at the same time also make significantly more coreference judgments on forward than on backward pronominalization. They should be more often incorrect (in imitation), and make significantly more noncoreference judgments (in comprehension) on backward than forward pronominalization.

Sentences in Tables 1 and 2 vary factorially in a repeated measures design with two values for each of three factors, Direction, Depth, Distance. They vary in pronominalization Direction (forward or backward pronominalization) (1 to 4 vs. 5 to 8 on tables 1 and 2). They also vary in two other factors which are often confounded with dominance: Depth of embedding of the name or anaphor in the preposed pp and Distance between name and anaphor. Depth is a specific property of dominance. We hypothesized that if children were sensitive to the dominance in these sentences, they should be sensitive to the factor of Depth of embedding. The depth factor varied how many phrase nodes deep the pp term was, e.g., "Under the leg of Ernie, he threw the lollipop" (plus depth)/"Under Oscar the Grouch, he quietly bounced the ball" (minus depth) (e.g., 2 vs. 4 on table 1). The Distance factor involved insertion of a lexical item between name and pronoun e.g., 1 vs. 2 or 3 vs. 4 on Table 1. Since added distance usually

involves increased depth also, the "plus distance minus depth" condition inserted an adverb between name and pronoun, e.g., "On Cookie Monster, quickly, he..." as in 3 on table 1, where it was assumed that this adverb increased distance but did not involve restructuring, or increase depth.

In summary, the study design allowed test by statistical analyses not only of the independent main effects of the three factors of direction, depth and distance which varied in a repeated measures factorial design ( $2 \times 2 \times 2$ ) as the sentence tables suggest, but also allowed testing of their possible interactions. There were 8 conditions or different sentence types,<sup>4</sup> with a replication item for each, in both imitation and comprehension tasks.

We hypothesized that if dominance were critical to children's early anaphora, children would find these sentences markedly difficult (since the forward directionality constraint they have formed for their language on the basis of 6 is not correct here). They should block forward anaphora in comprehension on these sentences. They should show sensitivity to the depth factor; and distance should not be critical as a main effect.

### Imitation results

Elicited imitation data showed that these are marked structures for children, with a mean overall of only less than one half correct, although the sentences improve significantly over the developmental age range we studied.

In addition, factorial analysis of children's success at imitating these sentences showed that children were sensitive to the factors we manipulated in highly specific ways. First, as in previous studies, directionality of pronominalization significantly ( $p < .001$ ) affected children's imitation; forward pronominalization was again significantly easier for children to imitate than backward pronominalization, and children showed significantly more anaphora errors on backward pronominalization. (Mean correct forward 1.07, backward .79.)<sup>5</sup>

Although this directionality effect in itself appears to be a disconfirmation of the hypothesis that children are sensitive to dominance, since forward pronominalization should be blocked as possible anaphora in these sentences, the preference in imitation for forward pronominalization over backward in these cases does not confirm that children are insensitive to dominance, as it does not confirm that children compute an actual anaphora relation when they successfully imitate a forward pronominalization.

In fact, children were found to be highly sensitive to the depth factor in imitation as predicted ( $p < .001$ ). There was significantly greater imitation success with more depth (mean correct 1.14) than with less (.73), and correspondingly fewer anaphora errors (whether a forward or backward pronominalization was involved). The factor of distance, as predicted, was not significant as a main effect ( $p = .41$ ). The factor of Distance did interact with the factor of Depth however. This interaction showed that Distance has an effect only where there is no depth. The Directionality effect (favoring forward pronominalization over backward) was virtually nullified in the

case where there is no depth and added distance (e.g., 3 or 7 on Table 1). (We might say this is the case where most all structural information has been removed from the relation between name and anaphor.)

Moreover analysis of children's errors in imitating these sentences revealed that children frequently either moved or copied or reconstructed the preposed preposition phrase to its unmarked postposed position. Critically however, they did so significantly more often on the backward pronominalization cases, thus confirming that (1) these sentences were not marked for children simply because of their preposed PP, but because of the fact that these sentences permute both anaphora direction and embedding direction; (2) many of children's errors on backward pronominalization are explained by the child's attempt to change both the dominance and the pronoun direction, not simply the pronoun direction; and thus confirming a tight correlation between anaphora direction and dominance direction in children's responses to these sentences.

Summary of imitation data. On their production of these sentences, children don't totally negate their directionality effect, as they again show a directionality principle favoring forward over backward pronominalization. But depth of embedding is significant to pronominalization in general; and the directionality effect in production can be nullified if all structural information is removed (no depth +distance). The above results suggest that children are sensitive to structural not merely performance (e.g., distance) factors. The general depression of correct production on these sentences overall as well as the sensitivity to depth, suggests, by our assumptions, a sensitivity to the structural principle of dominance, which co-occurs with a general forward directionality principle.

#### Analyses of comprehension data

Analysis of children's successful comprehension of these sentences as tested by an act-out task (cf. fn. 4) confirmed more specifically the hypothesis that children were sensitive to dominance, by suggesting that even though the directionality principle held in general in children's production of these sentences (as measured by the imitation task) children were significantly restricting a forward anaphora judgment. Correct comprehension of these sentences was again depressed overall, although it improved significantly over the age range studied. In comprehension success, children were again significantly sensitive to the factor of directionality, but in this case children's comprehension success was significantly greater on backward than forward pronominalization.

#### Coreference options

Analysis of children's coreference judgments (CRJ) (i.e., analysis of whether they chose same doll or different doll to interpret the pronoun as the name in these sentences) confirmed that this increased success on comprehension of backward anaphora was not simply due to increased probability for success due to more correct response options on backward cases (which represent free anaphora and are therefore correct no matter which doll is chosen for pronoun interpretation). Children made significantly

more ( $p < .01$ ) coreference judgments in the backward cases than they did in the forward. (Mean number of CRJ is .46 and .36 respectively.) Although this effect was generally consistent over development, it is most marked at the youngest groups (I and II) where 25% of backward cases received a coreference judgment by children, whereas only 14% of forward cases did.

Moreover, children made a similar number of coreference and noncoreference judgments overall on these sentences, and made as many noncoreference judgments (choosing another doll than the one named) for the forward as for the backward pronominal cases.

This pattern of results clearly distinguishes these interpretation data from other in the literature, e.g., from what children show in interpreting preposed subordinate clauses with varied anaphora direction, which were tested in previous studies. As we noted, in these previous studies CRJ's predominate in children's responses overall, there is a depression of CRJ on backward relative to forward, and there is a usual increase of NCR judgment on backward relative to forward pronominalization.

The set of results in this 3-D study clearly suggests that children are responding to the forward pronominalizations in these sentences with preposed PP differently from other forward pronominalization and more nearly like backward pronominalization. This suggests that therefore young children are sensitive to the dominance relations which characterize the pronominalization in this set of sentences and that this sensitivity interacts with the directionality constraint on pronominalization which had been thought to be based on linear order alone.

The fact that 'depth' was also a significant factor on the comprehension task, with increased depth causing increased coreference judgments, also generally supported the argument that dominance was consulted in these sentences.

### Conclusions

In conclusion, then, this experimental study suggested that children do show a general depressed performance in both production and comprehension on sentences with reversed dominance direction and marked anaphora patterns; at the same time that they show strong sensitivity to the several manipulated dimensions of linguistic properties which characterize locality in the relation between name and pronominal anaphor: namely, depth of dominance, directionality and distance (as an interaction).

Although the general depression of performance on these sentences in itself might be thought to be explained by their marked nature in grammar for English, the specific sensitivities to the design factors and their specific interactions can not be so explained. The subtle pattern of interactions (all highly significant statistically) which the data showed suggest that in general, children are bringing a highly structured competence to bear on these data.



Moreover, the data suggest a specific sensitivity to the configuration factor of dominance, not only in their general depression, but in showing children's specific sensitivity to depth, a property of dominance; in showing observed unified conversions in imitation to forward pronominalization and rightward dominance; and specifically in showing more depressed coreference judgments in forward pronominalization compared to backward, thus indicating a blockage of anaphora. Children acquiring English thus clearly were modulating the general directionality principle (favoring forward pronominalization) which they hold for their language.

The general depression in children's performance on these sentences may therefore be due to children's sensitivity to the reversed dominance in these sentences and their sensitivity to the incompatibility of their general hypothesized directionality principle for pronominalization which in these cases has been formulated to go forward for the English language.

The sensitivity to dominance confirms a particularly significant linguistic principle as part of early language competence, and it seriously questions the previous claim that young children are using a strictly linear order based locality principle which is independent of properties of dominance in anaphora at any stage of acquisition. It suggests that 6, not 2, is the correct description of the "directionality" effects observed in early child language.

Notably these data also suggest, however, that children are not simply building a theory based directly on surface structure "command." They do not simply reverse their directionality principle for their language in these preposed left branching structures which have reversed surface structure command. Rather they are sensitive to an abstract property of dominance which is a property of their language as a system (namely its basic recursion direction) and they build a coherent theory of anaphora for their specific language based on the Universal Grammar- derived principle implied by 6 (that command and binding are integrally related).

Order then (such as evidenced in the directionality principle on children's anaphora) is a parameter set for a specific language learned in accord with the UG determined principle implied by 6. It is set to work 'forward' in a right-branching language such as English.

Finally, since the structures tested in this study are marked structures for English (they are not only infrequent, but adult judgments are notoriously insecure on these), they are most probably what one would want to consider outside of "core grammar." It is particularly notable therefore that the patterned results in these data show that children are not using simple learning theory-based non-structure dependent principles for acquisition of even these structures, but to a large degree are bringing general abstract constraints consistent with the unmarked dominance and anaphora principles in their language to bear on these marked structures as well.

## FOOTNOTES

<sup>1</sup>This paper is prepared with the partial support of NSF grant BNS 7825115.

This paper is based on a rather large experimental study which will be reported in detail elsewhere (Lust and Clifford, in preparation a, b).

<sup>2</sup>Of course, if one assumes that empirical first language acquisition data do not significantly reflect the child's 'knowledge of language' (Chomsky, 1980), this claim does not hold. However, although there are grounds for this skeptical view, to make this assumption about child language is to assume that one of the essential empirical predictions of the theory of UG is essentially untestable, and to abdicate responsibility for one of its most critical areas of validation. Highly structured acquisition data such as that from the current study suggest that this skeptical assumption is not necessary.

<sup>3</sup>We use "forward pronominalization" here only to signify that the pronoun follows the name. Only backward pronominalization is actually possible as anaphoric in these sentences.

<sup>4</sup>The elicited imitation task tests children's production with the assumption that the child must filter the input sentences through its own competence system in order to successfully imitate. The comprehension task is an act-out task which asks children to act out a stimulus sentence (by choosing and performing with doll(s) selected from a set of 3 to which it is exposed). The act-out task is critical to this study because it directly reflects children's coreference or non-coreference judgments (use of same or different doll respectively to act-out preposed PP and main clause).

<sup>5</sup>Score range is 0-2, since there were 2 items for each sentence type.

Table 1

## Examples of Sentences in Imitation Task

<u>Forward</u>	<u>Backward</u>
<u>+Depth</u>	
<u>+Distance</u>	
1. On the side of <u>Ernie's</u> face, <u>he</u> put the kleenex	5. Under the bottom of <u>his</u> foot, <u>Ernie</u> rolled the ball
<u>-Distance</u>	
2. Under the leg of <u>Ernie</u> , <u>he</u> threw the lollipop	6. Under that toe of <u>his</u> , <u>Oscar</u> dropped the ice cream
<u>-Depth</u>	
<u>+Distance</u>	
3. On <u>Cookie Monster</u> , quickly, <u>he</u> poured the chocolate milk	7. On <u>him</u> , quietly, <u>Big Bird</u> spilled the grape juice
<u>-Distance</u>	
4. Under <u>Oscar the Grouch</u> , <u>he</u> quietly bounced the ball	8. On <u>him</u> , <u>Cookie Monster</u> quickly poured the orange juice

Table 2

## Examples of Sentences in Act-Out Task

ForwardBackward+Depth+Distance

1. On the top of Oscar's head, he rubbed the donut.

5. Under the toe of his foot, Ernie put the donut.

-Distance

2. Under the foot of Ernie, he put the pillow.

6. On that foot of his, Cookie Monster dropped the donut.

-Depth+Distance

3. Under Big Bird, quickly, he threw the choo-choo train.

7. On him, quietly, Oscar the Grouch rubbed the pillow

-Distance

4. On Cookie Monster, he quickly dropped the choo-choo train.

8. Under him, Big Bird quietly pushed the choo-choo train.

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