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Language input and child syntax☆

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Abstract

Existing work on the acquisition of syntax has been concerned mainly with the early stages of syntactic development. In the present study we examine later syntactic development in children. Also, existing work has focused on commonalities in the emergence of syntax. Here we explore individual differences among children and their relation to variations in language input. In Study 1 we find substantial individual differences in children's mastery of multiclause sentences and a significant relation between those differences and the proportion of multiclause sentences in parent speech. We also find individual differences in the number of noun phrases in children's utterances and a significant relation between those differences and the number of noun phrases in parent speech. In Study 2 we find greater syntactic growth over a year of preschool in classes where teachers' speech is more syntactically complex. The implications of our findings for the understanding of the sources of syntactic development are discussed.

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1. Introduction

In the present article we report two studies concerning the role of language input in the acquisition of certain aspects of syntax. In recent decades there has been extensive work on syntactic development. While it is widely recognized that the acquisition of syntax depends on innately available structures in the child, it is also acknowledged that the child must receive input in the language he or she is acquiring. Here we investigate the role of input by examining the extent of individual differences in children's syntactic skills (both production and comprehension) and the relation of those skills to variations in input. Further, we explore how that relation is to be explained.

Existing work on the acquisition of syntax has focused primarily on the striking commonalities found across children (cf. Brown, 1973; De Villiers & De Villiers, 1978). Normal children progress through a predictable sequence of stages and master the basic syntactic relations of simple sentences at a relatively early age. Despite the commonalities, however, there is evidence of individual differences in syntactic growth among children. Most of this work concerns the early stages of syntactic development where variations have been found in the rate and course of acquisition (e.g., Fenson et al., 1994; Miller & Chapman, 1981). There are some data to suggest that, at later ages, children show individual differences for more complex aspects of syntax. The first goal of the present study is to examine systematically the extent of individual differences at later points of development.

There also is accumulating evidence that there are substantial variations in the language environments children encounter and that these variations may be correlated with differences in development. The data show a relation between language input and children's skills for some aspects of syntax, but not for other aspects (e.g., Barnes, Gutfreund, Satterly, & Wells, 1983; Furrow, Nelson, & Benedict, 1979; Gleitman, Newport, & Gleitman, 1984; Newport, Gleitman, & Gleitman, 1977). Since existing studies have involved children at early stages of language acquisition, it is not yet clear what syntactic skills are affected by input over the full course of development. It is possible that different aspects of syntax may show sensitivity to particular forms of input at different stages of language development. That is, skills that are found to be unrelated to language input early in development may be found to be related to input later in development. The second goal of the present study is to examine the relation between input and child language at later points in development.

Examining the relation between input and child language is just a first step toward understanding how input is involved in the acquisition process. After all, such a relation can be explained in more than one way. One explanation would be that incoming speech has a direct effect on child syntactic skill (e.g., Nelson, 1977). Alternatively, it is possible that the input the child

receives is itself affected by the child's ability level (e.g., Snow, 1989; Sokolov, 1993). With respect to the input from parents in relation to children's skill levels, genetic similarity within a family may be critical (e.g., Plomin, Fulker, Corley, & DeFries, 1997). It may be difficult to determine which factors are critical in particular cases because of the covariations that occur in natural environments. For example, better input in a family may be provided by higher ability parents.

In order to distinguish among alternative explanations, it is important to design studies in which potentially relevant factors can be assessed separately. Different research designs have been used by investigators who have focused on the role of input (e.g., Morrison, Smith, & Dow-Ehrensberger, 1995) or on the role of genetic factors (e.g., Dale, Dionne, Eley, & Plomin, 2000). The aim of these investigators is to examine the relation between input and child syntax under conditions where only one explanation of this relation seems plausible. The final goal of the present article is to assess whether input has an effect on children's syntactic skills using a design where the potential effect of other factors is minimized.

1.1. Individual differences among children

There have been extensive studies of children's early syntactic development (e.g., Bloom, 1970; Braine, 1976; Brown & Fraser, 1964; Brown & Hanlon, 1970). While this work has focused on commonalities among children, the data show substantial individual differences. In Brown's (1973) description of the early syntactic development of four children, he reported wide variability both in the age of emergence of the basic grammatical relations and in the mean length of children's utterances (MLU) at particular ages. MLU is a measure of children's syntactic development that is independent of the amount they talk. It is generally agreed to provide a valuable assessment method, although not after MLU 4. What is captured in MLU in the early stages of grammatical development is the acquisition of the basic grammatical relations and morphological markings found in simple sentences.

There are studies with large samples of children that provide convincing evidence that MLU varies widely across children. A study of 123 middle-class children ages 17–59 months reveals large standard deviations in the MLU's of children at particular ages (Miller & Chapman, 1981). Using a parent report procedure to assess language skill, Fenson et al. (1994) found extensive variability in the syntactic development of a sample of over 1800 children ages 8–30 months.

Work with older children shows that individual differences in syntactic skills persist. As we have noted, MLU does not provide as valuable a measure of skill level in later stages of syntactic development as at earlier stages (Scarborough, 1990; Scarborough, Rescorla, Tager-Flusberg, Fowler, &

Sudhalter, 1991). There have been reports of later differences based on other indices of syntactic skill. Variability among school-aged children has been reported in the use of expanded noun phrases and prepositional phrases (Scott, 1984) and in the extent to which individuals use complex structures such as dependent clauses in their sentences (Loban, 1976). Individual differences also have been found in the ability of 5- to 10-year-olds to understand coreference relations (Chomsky, 1969; Goodluck, 1981). In fact, individual differences in syntactic skills are found even in adults, as seen in variations in the ability to interpret noun phrases (Gleitman & Gleitman, 1970), to judge grammaticality (e.g., Ross, 1979), and so on.

1.2. The relation of children's syntactic skills to their language environments

As we have seen, there is reason to believe that there are substantial individual differences across the stages of syntactic development. In this section we examine what is known about the relation between such individual differences and variations in the input children receive. Consider the early stages of linguistic development when children acquire basic features of the syntax of their language. Empirical examination indicates that utterances addressed to young children generally include the basic grammatical relations and morphological markers and, indeed, that they are "unswervingly well formed" (Newport et al., 1977, p. 121). Even though the features of simple syntax appear in most utterances addressed to children, there are substantial variations in the numbers of utterances that different caregivers produce in fixed amounts of time (e.g., Bee, Van Egeren, Streissguth, Nyman, & Leckie, 1969; Farian & Haskins, 1980; Hart & Risley, 1992; Hess & Shipman, 1965). Such differences in frequency might be related to development. Indeed, in a study with children beginning in an early stage of syntactic skill (MLU 1.5), it was found that the amount of parent speech directed to children was strongly related to growth in their MLU (Barnes et al., 1983). In discussing findings on the relation of birth order to syntactic development, Hoff-Ginsberg (1997, 1998) attributes more rapid syntactic development of first borns in the early stages of word combination to the greater frequency of parent speech addressed to them.

In contrast to aspects of syntax that appear regularly in most utterances parents produce, there are other aspects of syntax that appear in only some subset of utterances. For the latter, variations in the makeup of parent speech have been shown to be related to children's syntactic development. For example, in a study of the acquisition of auxiliary verb forms, Newport et al. (1977) found that the proportion of auxiliary-fronted yes/no questions in parent speech was strongly and positively related to the development of these forms. This result was replicated in later studies (e.g., Furrow et al., 1979). Also, Hoff-Ginsberg (1985) found a positive relation between

mother's use of "wh-" questions (which contain auxiliaries) and children's auxiliary development. The positive relation of auxiliary-fronted questions to auxiliary growth has been corroborated in experimental studies (e.g., Nelson, Carskaddon, & Bonvillian, 1973; Shatz, Hoff-Ginsberg, & MacIver, 1989). The observed relation may indicate that placing auxiliary verbs in a salient position in a sentence aids in their mastery. On the other hand, the growth in children's use of auxiliaries was negatively related to the proportion of imperatives in parent speech. This negative relation may reflect the fact that auxiliaries are not used at all in positive imperatives.

It has been pointed out that, in many cases, reports of significant relations between parent speech and children's syntactic development have not been replicated in all studies. In fact, Scarborough and Wycoff (1986) and Valian (1999) have questioned whether existing data actually provide evidence of reliable relations between input and syntactic growth. However, there is more than one interpretation of the observed lack of consistency in input studies. Published reports generally involved small numbers of participants, so only very strong relations would be detectable. Further, different input studies may have involved children whose syntactic skills differ, and input effects may be specific to children's language levels.

Several researchers (e.g., Barnes et al., 1983; Furrow et al., 1979; Hoff-Ginsberg, 1985) have noted that the aspects of parent input that are related to syntactic growth may vary with the children's developmental level. For example, while the use of imperatives in parent speech generally is found to be negatively related to syntactic growth, and the use of questions to be positively related to growth, Barnes found the opposite. He attributes this difference to the stage of development of the children in his study. The children he studied were "at the stage at which the child still is just beginning to produce structured utterances" (Barnes et al., p. 76). If the child is just beginning to acquire lexical verbs, the occurrence of verbs in sentence initial position, as in imperatives, might be helpful while the fronting of auxiliaries might not yet be helpful.

It would seem that the aspects of child speech that show a relation to input would necessarily depend on the child's language level. In this context, consider an additional finding of Newport et al. (1977), namely that certain aspects of child speech are unrelated to any of the parent measures they used. They reported "noneffects" for number of noun phrases per utterance and number of verb phrases per utterance in children's speech. One possible explanation for the observed noneffects of input is that number of noun and verb phrases are "indices of the child's exploitation of universal aspects of language structure..." (Newport et al., p. 133) and are truly unrelated to variation in input. Alternatively, however, the reported noneffects may reflect the child's syntactic skill level during the age period studied. At the start of the Newport et al. study, children ranged in age from 12 to 27 months,

with about two-thirds of the group being under 24 months. The children were followed for 6 months. Across this age range, variation in the number of noun phrases and verb phrases in an utterance may be so small that a relation to parent speech would be hard to show. In a study with slightly older children who were between 24 and 30 months at the start of the study, Hoff-Ginsberg (1986) found a significant relation of input to children's use of noun phrases, but not verb phrases.

It is possible that a stronger relation of input to multiple noun phrases or verb phrases in child speech could be found when children are older and begin to use a higher proportion of prepositional phrases, multiple-clause sentences, and so on. The question of whether later syntactic development is related to input has not been systematically studied. Possibly this is because research on syntactic development has focused on the acquisition of the basic grammatical forms that appear early. Yet, the more complex syntax which appears later is a central aspect of language development. Consider, for example, multiclause sentences constructed from simple sentences via recursive devices in which one clause is embedded in or conjoined with another. Such structures provide linguistic tools that allow expression, within a single sentence, of complex thoughts concerning mental states, causal relations, and so on. Recursive devices have been described as a defining characteristic of human language (e.g. Chomsky, 1965). In principle, there is no limit to the complexity of the sentences that can be constructed via recursive devices, although there are constraints in practice and there may be individual differences in the use of these devices.

In addition to multiclause sentences, other aspects of syntax also can be examined to explore later syntactic development and its relation to input. For example, one can examine the number of noun phrases per utterance. While multiclause sentences emerge relatively late (e.g., Hoff-Ginsberg, 1997; Sheldon, 1974; Tavakolian, 1978), noun phrases are seen in children's syntax from the earliest stages of syntactic development. However, the average number of noun phrases per utterance continues to grow past these earliest stages; it increases with the number of clauses in a sentence, and also, in a single clause, with the number of arguments of a verb, as well as with the use of adverbial and prepositional phrases. As the number of noun phrases children use increases, the variability across children may also increase, making it easier to detect a relation to input if one exists.

In examining the relation of input to children's use of multiclause utterances and of utterances with increasing numbers of noun phrases, it should be noted that their use is generally viewed as reflecting advances in syntactic development. However, it is at least possible that variations in production could reflect stylistic differences rather than differences in syntactic knowledge. Hence, in addition to analyzing the relation between syntactic production and input, it is also important to examine comprehension of complex syntactic structures and its relation to input.

1.3. Evaluating the role of input in syntactic development

Above we discussed studies of the relation of language input by parents to child language skill; these were interpreted by the investigators as showing effects (or noneffects) of input. However, as we have noted, the source of correlations between parents and their children is typically ambiguous. To explore whether input is a critical factor, it is important to use designs that make it possible to establish whether variations in input can explain some of the variance in growth (these designs do not, generally, preclude the possibility that other factors also explain some of the variance in growth).

One way of exploring input effects is to examine individual differences among children associated with birth order. Since the genetics of parents does not vary with birth order, a genetic explanation of such individual differences is not plausible. Zajonc and his colleagues described the effects of birth order on intellectual development (e.g., Zajonc & Markus, 1975; Zajonc & Mullally, 1997). They found that, within a family of a particular size, the average level of children's intellectual performance varies with birth order such that older children show better performance than younger children. They suggest that, since older children receive most input from parents (as opposed to younger children who also receive input from their siblings), the input to these children may be more intellectually mature. Hoff-Ginsberg (1998) has explored birth order effects on syntactic development. She found that parents used longer utterances to first borns than to later borns and that the language development of the first born children was accelerated. However, since family size for first and later borns was not equated in her study, input is not definitively implicated.

Another way of exploring the role of input in children's skill levels is to examine input from outside the biological family, notably input at school. However, simply looking at growth in different school environments does not ensure that observed variations in input are causally related to differences in growth. Higher ability parents may send their children to better schools. Also, teachers might provide better input when the children in their classes are more highly skilled at the start. Hence a correlation between school input and child growth could indirectly reflect genetic factors.

Huttenlocher, Levine, and Vevea (1998) introduced a design that clearly implicates school input as a critical factor in growth in a set of domains, including syntax. The design involved a time period comparison in which growth in the same population of children was examined over equal length time periods that varied in input. Growth in kindergarten and first grade children was compared over the period of October–April, which includes most of the school year, to that over the period of April–October, which includes summer vacation. Huttenlocher et al. found substantially greater growth over the school year for a variety of skills, including both vocabulary and syntax. Since the same population is assessed at different time points,

input must be playing a critical role in syntactic growth. However, since the activities in the classroom were not directly assessed, we do not know whether it was *language* input at school that was relevant.

2. The studies

We present two studies of children's syntax in the period after the basic grammatical forms and morphology have been acquired. In both studies, we use large samples of children and draw our samples from a broad range of socioeconomic groups in order to accurately estimate the nature and extent of individual differences in children's syntactic skills and the relation of those differences to their language environments.

In Study 1 we investigate whether aspects of syntax found to be unrelated to variation in parent input at an early age may actually be related to input variation at a later time point. This is an important issue because it pertains to possible limits on the role of induction in the acquisition of syntax. The first part of the study (Study 1A) is a preliminary examination of existing production data from a group of 4-year-old children (Hall, Nagy, & Linn, 1984). To anticipate, the data show sizable individual differences in children's skill levels and a substantial relation of those differences to the complexity of parent speech, motivating us to do Study 1B with a new sample of 4-year-old children. In Study 1B we assess children's comprehension as well as their production of complex sentences and examine the relation of complexity for both measures to parent input. We also determine the relation of the number of noun phrases in parent utterances to the number in child utterances. The data again show a relation between children's skill levels and the complexity of parent speech.

In Study 2 we further explore the relation of children's mastery of complex syntax to input by examining teacher speech at preschools. Our purpose is to distinguish among alternative interpretations of the relation between children's language environments and the levels of skill they achieve. One possibility is that input is a critical factor in the growth of syntax. The other possibilities are that observed relations between input and child language are due to genetic factors or that input providers adjust the complexity of their speech to children's ability levels. To anticipate our results, the observed pattern of correlations in our school study is most consistent with the first interpretation, namely that input is critical to syntactic growth.

3. Study 1A: Preliminary study of parent input and childrens syntax

Our initial step in investigating the relation between children's use of complex sentences and parent input was to examine an existing language corpus obtained by Hall et al. (1984), available in the CHILDES database

(MacWhinney, 1991). Hall et al. gathered a large sample of speech from 4-year-olds and their parents. The authors used the data to examine vocabulary; we have used the data for an initial study of grammatical complexity in children and its relation to parent speech. Although the sample was obtained in the 1970s, it meets important requirements for our study. The children were 4 years of age, by which time complex sentences are used to some extent by all children. The sample included families from different ethnic and socioeconomic groups so that there may be considerable variability in the input. Finally, the child's speech was sampled both at home and at school, making it possible to determine if the use of complex sentences by a child is relatively constant across situations.

For children, our measure is the proportion of multiclause sentences in their speech. This is a measure of their syntactic competence; it indicates the extent to which children express relations captured by complex syntax, independent of the amount of speech they produce. For parents, we use two measures—the overall number of multiclause sentences (frequency) and the proportion of such sentences. Both kinds of measures have been used in previous research on parent input. It would seem that the importance of frequency vs proportional measures may vary with the aspect of input under study. As noted above, for aspects of language that occur regularly in parent utterances, the overall number of utterances in a fixed time period (i.e., frequency) may be strongly related to mastery. However, for aspects of language that occur only in some subset of utterances, such as multiclause sentences, proportional measures may be most important since they indicate how typically certain forms are used in describing particular kinds of situations.

3.1. Method

3.1.1. Participants

Descriptions of the sample (as well as of materials and procedure) appear in Hall et al. (1984). Participants included 34 children ages 54–60 months and one of their parents. Hall et al. divided families into four groups. For the families whose data are examined here, 15 were Caucasian and 19 were African American, approximately equally divided between lower and middle SES. SES was determined by income level and educational indices scales (Warner, Meeker, & Eells, 1949). Lower SES children attended federally funded preschools and middle-SES children attended private preschools. The procedures used in obtaining the sample of families are not described. In all groups, males outnumbered females (overall, 23–11).

3.1.2. Data collection procedure

Children wore vests with microphones that recorded everything they said and heard in 10 different situations: prior to school in the morning, arriving

at school, snack time at school, free play at school, directed activity at school, arriving home from school, before dinner, at dinner time, before bed, and in transition (on the way to school). Each situation was recorded for approximately 15 min on 2 consecutive days for a total of about 5 h of audiotape per child. An observer was present in the home and at school for almost all of the data collection. For the Black families, the observer was Black and for the White families the observer was White. The audio tapes were transcribed and made available in printed form.[1]

3.1.3. Data analysis

We examined complete sentences marked as intelligible in the printed transcripts. We defined sentences as utterances that contained both a subject and a verb. In the case of the imperative, utterances with an understood second person subject were included. Sentences exhibiting copula deletion (e.g., "He tired") were included as complete sentences. This is an important point because the copula is optional in some cases in the African American English dialect.

For parents, all sentences in the transcripts directed to the target child were included, as indicated in the contextual notes of the original transcriptions from Hall et al. (1984). With one exception, the parent was the child's mother. In this one case, we included speech from the child's father because the child's mother appeared in no part of the transcript. Our analyses of child speech included all sentences produced in four situations at school (arriving at school, snack time, free play, and directed activity) and in five situations at home (before school, arriving home from school, before dinner, dinner time, and before bed). We excluded sentences that were exact repetitions of self or other, and sentences that were read directly from written material.

Each sentence was classified as either simple or complex. Simple sentences contained one clause (e.g., "John made a mistake" and "He gave the book to the girl"). Complex sentences contained more than one clause (e.g., "He thought John made a mistake" and "He gave the book to the girl who lived down the street"). For certain forms, categorization of sentences as simple or complex was not obvious. We included as simple sentences utterances with a single lexical verb even when modified by a modal auxiliary, marginal modal, or quasi modal (see Table 1). The tag in a tag question (e.g., "You went to the store, *didn't you*?") was not counted as an additional predication.

We included as complex sentences utterances with infinitival forms of an additional verb (e.g., "I like to play" and "Want to go home?"). Sentences

[1] The corpus of data collected by Hall et al. (1984) is currently available in a digitized audio format, although it was not available in this format when our project began.

Table 1
Auxiliary verbs

Modals	Marginal modals	Quasi modals
can	used to + V[a]	going to + V
could	ought to + V	gonna + V
will	has/have to + V	go + V
would	had better + V	wanna + V
may	would rather + V	got to + V
might	might/could + V	let's + V
shall	may/can + V	supposed to + V
should	need to + V	to come + V
must		to be able to + V

[a] V = Verb.

with verbs like "let" followed by a pronoun with another predication (e.g., "Let them do it") and gerund verb forms (e.g., "Stop hitting me" and "Start picking up your toys") were also included in the complex sentence category. Coordinated clauses with a single subject were treated as complex if they contained more than one verb phrase as in "He read the book and watched TV." Sentences with a conjoined subject or object were not treated as complex (e.g., "Sam and Harry watched TV" and "He ate mashed potatoes and chicken").

After coding each sentence as either simple or complex, we applied our measures to parent and child utterances. For children, we calculated the proportion of complex sentences by dividing the number of complex sentences they produced by the total number of complete sentences. One computation of children's syntactic complexity was made across the five home settings and another computation was made across the four school settings. For parents, we performed the same computation to determine the proportion of complex sentences. In addition, we calculated the total number of multiclause sentences produced by parents in the entire period of observation (which was a constant time period across parents).

3.2. Results

3.2.1. Child speech: Demographic factors

The use of multiclause sentences varied in the four different demographic groups both at home and at school. Table 2 shows the average percentages and standard deviations in these groups. The examination of individual data revealed that all children used at least some complex sentences. However, there was considerable variability across children in the percentage of multiclause sentences produced (range at home was from 7 to 29% and range at school was from 4 to 35%).

An arcsin transformation was carried out on the proportional data for the purpose of statistical analyses. For the child at home, a two-way ANO-

Table 2
Percent of complex sentences by children (Study 1A)

	Lower SES		Middle SES	
	Mean	*SD*	Mean	*SD*
(A) Children at home				
Race				
African American	14.56	4.20	19.76	3.91
White	16.35	4.32	22.34	5.59
(B) Children at school				
Race				
African American	12.96	3.53	16.96	2.22
White	14.05	5.04	23.46	8.30

VA with proportion of multiclause sentences as a dependent variable and SES and race as independent variables revealed a significant main effect for SES, $F(1,32) = 12.13$, $p < .01$, but neither the main effect of race, $F(1,32) = 1.72$, $p = .1998$, nor the interaction of SES by race, $F(1,31) = .02$, $p = .9020$, was significant. For the child at school, we also performed a two-way ANOVA with SES and race as independent variables. Again the ANOVA was significant for SES, $F(1,32) = 15.38$, $p < .001$, but neither race, $F(1,32) = 2.78$, $p = .1057$, nor the SES by race interaction, $F(1,30) = 1.28$, $p = .2661$, was significant.

3.2.2. Parent speech: Demographic factors

Parent speech also varied with demographic factors (see Table 3). We conducted a two-way ANOVA with the proportion of multiclause sentences in parent speech as the dependent variable and with SES and race as independent variables. This ANOVA revealed significant main effects for SES, $F(1,32) = 14.28$, $p < .001$, and race, $F(1,32) = 6.36$, $p < .05$. The SES by race interaction was not significant, $F(1,31) = .35$, $p = .5576$. We also conducted a two-way ANOVA with the frequency of multiclause sentences in parent speech as the dependent variable and with SES and race as independent variables. The ANOVA revealed significant main effects of SES, $F(1,32) = 6.09$, $p < .05$, and race, $F(1,32) = 7.63$, $p < .01$. The SES by race interaction was not significant, $F(1,31) = 2.06$, $p = .162$. Our findings are

Table 3
Percent of complex sentences by parents (Study 1A)

	Lower SES		Middle SES	
	Mean	*SD*	Mean	*SD*
Race				
African American	20.07	5.69	27.34	2.97
White	25.20	4.43	30.90	5.70

consistent with those of earlier studies showing frequency differences in different demographic groups.

3.2.3. Predictors of complexity in children's sentences

We carried out a multiple-regression analysis to determine the independent contributions of the proportion of complex sentences and the frequency of complex sentences in parent speech as well as of SES. First consider the relation of these predictors to child speech at home. The analysis showed that the proportion of multiclause sentences in parent speech was by far the best predictor of such sentences in child speech, accounting for 38.88% of the variance, $F(1, 32) = 20.36$, $p < .0001$. After the proportion of multiclause sentences by parents was accounted for, SES accounted for an additional 5.23% of the variance in children's speech, which is only marginally significant, $F(1, 32) = 2.90$, $p < .10$. The contribution of frequency of complex sentences by parents was negligible ($p > .50$).

We examined the relation between the best predictor identified in the analysis above, the proportion of multiclause sentences in parent speech, and the proportion of multiclause sentences in child speech at home. As shown in Fig. 1, a high correlation was obtained ($r = .6252$, $p < .0001$).

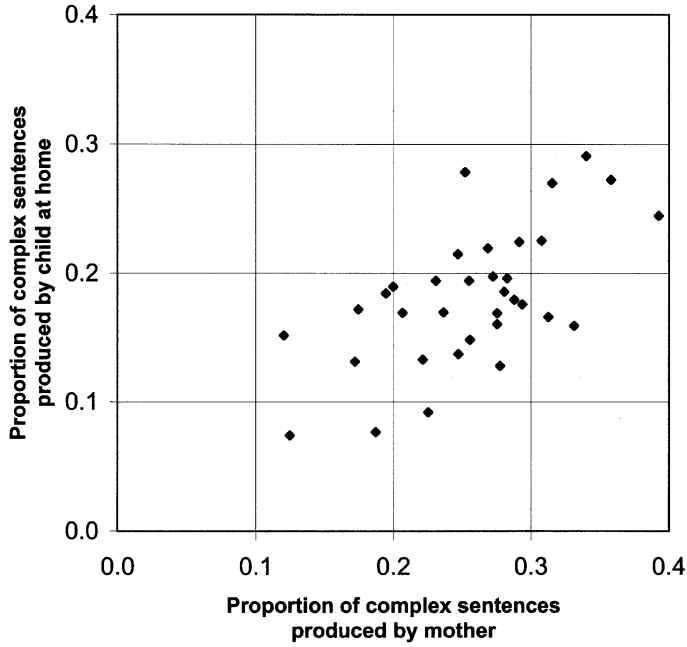

Fig. 1. The relation of the proportion of complex sentences in parent speech to the proportion of complex sentences in child speech at home, Study 1A.

Next consider the relation of the predictors to child speech at school. Multiple-regression analysis showed that the proportion of multiclause sentences by parents again was the best predictor of the proportion of such sentences by the child, accounting for 35.42% of the variance, $F(1, 32) = 17.55$, $p < .001$. After parent speech was accounted for, SES accounted for an additional 7.47% of the variance in child speech at school, which again is only marginally significant, $F(1, 32) = 4.05$, $p < .10$. Frequency of complex sentences in parent speech was not a significant factor, $F(1, 32) = 1.84$, $p = .1852$. As in the analysis of child speech at home, we examined the relation between the proportion of complex sentences in parent speech and the proportion of complex sentences in child speech at school. Again, the correlation was high ($r = .5933$, $p < .001$), as shown in Fig. 2.

The analysis of child speech at home and at school revealed a parallel pattern with respect to the three predictors we considered. Note that the correlations between the proportion of complex sentence in parent speech and the proportion of complex sentences in child speech are highly similar at home and at school. Hence the correlation of parent and child speech observed at home does not reflect the fact that the parents and their children were engaged in shared activities and conversational topics.

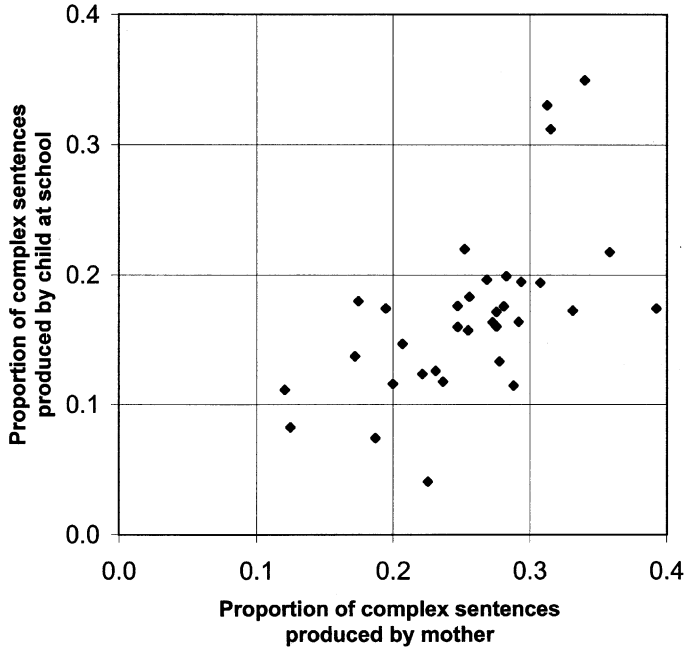

Fig. 2. The relation of the proportion of complex sentences in parent speech to the proportion of complex sentences in child speech at school, Study 1A.

3.3. Discussion

We used an existing data base for a preliminary examination of individual differences in the proportion of multiclause sentences in the spontaneous speech of a group of 4-year-old children. We found sizable differences among children. A multiple-regression analysis revealed that the proportion of multiclause sentences in parent input was the major predictor of complexity in children's speech. Further, this analysis showed that frequency of parent speech was not a significant predictor of child complexity, and SES was only marginally significant. The marginally significant relation to SES could reflect aspects of parents' use of language not captured directly in their speech, such as how language is used in relation to nonlanguage context and use of gesture. The same predictors of complexity in child speech were found at school and at home, indicating that the observed relation to parent input at home was not due to the shared settings or common conversational topics.

4. Study 1B: Parent input and childrens syntax

Given the striking relation between the proportion of multiclause sentences in child speech and in the speech of their parents, we carried out a new study. One goal of the study was to establish the robustness of the findings of Study 1A that were based on data gathered more than 20 years ago. We wanted to determine whether significant findings would be found in a current sample. In doing so, we collected our own tapes of parent–child interaction and created transcripts from sound track rather than using existing transcripts. The transcripts of Hall et al. (1984) used in Study 1A were originally made with the purpose of examining children's vocabulary. Hence it was not critical for the investigators to specifically attend to syntax in transcribing speech. Since our focus is on complex syntax, decisions such as whether an utterance is a multiclause sentence or two separate sentences are critical. In making these decisions, information from the speech signal, including pauses, intonation, and so on can provide important cues. Thus, it seemed important to make sure that a significant relation would appear in a sample where analyses were based on listening to taped speech.

Another goal of the study was to establish with greater certainty than in Study 1A whether it is mastery of multiclause sentences that is related to input. Even though we obtained similar results for production at home and at school in Study lA, it still seemed possible that observed differences in the production of multiclause sentences could reflect variations in the speaking styles of different families. In this interpretation, children who vary in production of such sentences would not differ in their comprehension. If there is a substantial correlation between children's comprehension and their pro-

duction, it would provide strong evidence that production indexes children's underlying language skills, not their styles of speaking. This interpretation would be further supported if comprehension varies with parent speech in a way that parallels the relation found in production. Thus, in the present study we assess comprehension as well as production of multiclause sentences.

A final goal of the study was to further examine the relation between parent syntax and child speech using a different measure of syntactic complexity—the number of noun phrases per utterance. Recall that Newport et al. found no relation of parent speech to number of noun or verb phrases in children's utterances. We noted above that a potential explanation for these negative findings is that the sentences the children used were still very simple and that a relation between children and parents for these measures might be found at later stages of language development. Indeed, Study 1A showed a strong relation between parent and child use of multiclause sentences (a measure parallel to the number of verb phrases per utterance) in older children. Hence we decided to examine the number of noun phrases children used per utterance to investigate whether, at a later stage of syntactic development, this measure may be related to parent speech.

A few additional points should be made in comparing Studies 1A and 1B. We divided our sample into two SES groups as did Hall et al. However, our sample was drawn in Chicago more than 20 years later. It is possible that corresponding SES groups in the two studies are somewhat different. It also should be noted that in the present study child speech data was obtained only at home. The reason is that in Study 1A the proportion of complex sentences in child speech was very similar at home and in school, and the relation to parent speech also was similar in the two situations. Finally, we did additional syntactic analyses in Study 1B. We examined different types of multiclause sentences separately.

4.1. Method

4.1.1. Participants

We studied 48 mother–child pairs. Children varied in age between 47 and 59 months, with the mean age of 54 months. Half the children were from middle SES families and half were from lower SES families. The families were drawn from the different ethnic groups in the greater Chicago area. In obtaining our sample of families we first gathered information about the socioeconomic makeup of different neighborhoods and used this information to prepare a list of preschools from neighborhoods where families from particular SES groups heavily predominated. We obtained permission from a set of schools to approach parents as they picked up their children at the end of the day. We talked to the parents and gave them written information about the study. In addition to the neighborhood criterion, we also set

an educational criterion for SES assignment. We divided educational backgrounds into five levels: 1 = some high school, 2 = high school graduate, 3 = some post high school training, 4 = college graduate, and 5 = some graduate school. For lower SES families, all mothers were from levels 1–3 and for middle SES families all mothers were from levels 4 and 5. Families were paid $50 for participating in the study.

4.1.2. Gathering and analysis of language data

Children were visited in their homes. The child was videotaped during his or her ordinary activities for 2 h. In our lab, a transcriber made a complete record of the speech of the child and the caregiver. Transcription involved breaking the stream of speech into distinct utterances, which was done relying in part on intonation and pauses. Reliability of transcripts was checked by a second transcriber who independently transcribed 100 child utterances and 100 parent utterances from each transcript. Cases of disagreement that would affect grammatical analysis were rare; they were resolved by having the two transcribers reexamine the tape. Each distinct utterance was then placed on a separate line in preparation for grammatical analysis. A third person did the grammatical analysis as described below.

Analysis of production data was similar to that in Study 1A. However, a few differences must be noted. First, while Study 1A included only utterances addressed to the child, Study 1B included all caregiver utterances regardless of who was being addressed. We did this because it was clear from the videotapes that children sometimes reacted to comments and questions that were directed to others, showing that such speech constituted input to them. In fact, it was sometimes difficult to determine who the caregivers were addressing. Although children at the earliest stages of language acquisition may process only speech that is directed to them, at some age they clearly process incoming speech that is not specifically addressed to them. This seems to be the case by 4–5 years.

Second, rather than coding only complete sentences, as in Study 1A, we coded all intelligible utterances. This allowed us to determine the proportion of multiclause sentences relative to the total number of utterances as well as to the total number of sentences. We wanted to determine how these two measures are related. In analyzing types of sentences, four utterance codes were used: 0 for nonpredicative utterances (e.g., "yes" or "no" or an object name, usually in response to another speaker), F for formulaic speech (e.g., "What's up?"), S for simple sentences, and C for multiclause sentences. Multiclause sentences were divided into three types: those involving coordinate clauses, complement clauses, and relative clauses. False starts where, midway through an utterance, the speaker changes to another sentence entirely or stumbles and repeats the sentence from the beginning, were not counted.

Third, we revised the criteria for multiclause sentences. In Study 1A, sentences with "want to" and "let us" were treated as complex, whereas "wan-

na'' and ''let's'' were treated as simple. However, in Study 1B these were all treated as simple. The reason was that it was not clear from the tapes in all cases whether the full two words were being said. Since these forms are fairly frequent in speech of parents and children, the estimates of the proportion of complex sentences may be lower in Study 1B than in Study 1A. This might result in a lower correlation between input and child syntax if it leads to compression of the proportional variation across individuals. We do not regard this as a problem, since our purpose in Study 1B is to establish the robustness of the correlation for multiclause sentences observed in Study 1A.

Fourth, we used an additional measure of syntactic complexity, the mean number of noun phrases per utterance. All simple and complex sentences produced by parents and children were used in determining the number of noun phrases in each utterance. Our coding procedure involved identifying noun phrases as described below (in the examples each noun phrase is bracketed). We counted phrases that included regular nouns (''[Dogs] can scare [little kids]'') as well as pronouns (''[I] like [him]''). Other parts of speech (e.g., adjectives) were counted as forming a noun phrase when they did not modify a noun and served in place of a noun (''[The red] in [that painting] hurt [my eyes],'' ''[I] got [two],'' and ''[Some] are missing''). Possessive nouns were treated as distinct noun phrases (''[[The girl]'s mother] is tired''). Compound nouns were counted as a single noun phrase (''Let go of [the computer cord]''). Once all noun phrases were identified, we divided the total number of noun phrases by the total number of utterances in the transcript to arrive at our noun phrase measure.

4.1.3. Comprehension task

Our comprehension task involved picture selection. A sentence was read to the child and he or she chose from among a set of three pictures which one ''goes with'' that sentence. Fig. 3 shows some sample items. This comprehension task is quite different from the measure of spontaneous production of complex sentences. Hence one would not expect a perfect correlation between comprehension and production even if the same underlying syntactic skill is involved. Our purpose in constructing the task was to measure the extent to which children could successfully process multiclause sentences. That is, we sought a sensitive and reliable assessment of children's skill in processing multiclause sentences. In constructing the task, we examined the multiclause sentences used by parents in Study 1A and drew a sample of these sentences to develop a set of comprehension items.

4.2. Results

In determining the proportion of multiclause sentences in Study 1A, we used the number of such sentences as the numerator and the total number

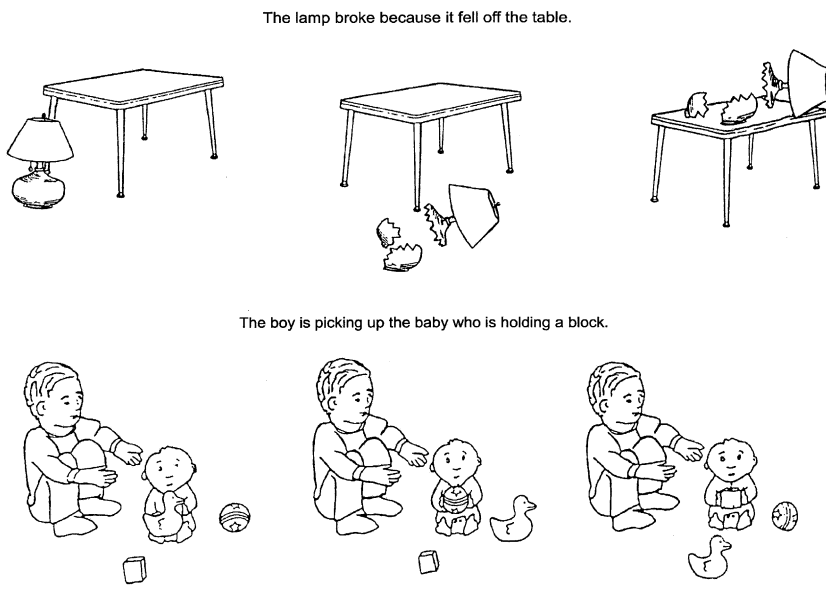

Fig. 3. Two sample items from the comprehension test, Study 1B.

of complete sentences as the denominator. It is possible instead to calculate the proportion relative to all utterances, including formulaic and nonpredicative utterances. For the present study, we wanted to make sure these two measures were comparable. The correlation between the proportion relative to complete sentences and relative to all utterances was .92. Hence, we continue to use the same measure as in Study 1A, proportion of multiclause sentences relative to complete sentences.

Consider the relation between the proportion of multiclause sentences children produce and their comprehension scores. The correlation was .64 ($p < .001$). Given that comprehension and production measures are so different, the high correlation suggests mediation by a common underlying syntactic skill. This interpretation is bolstered by the fact that, as is shown below, comprehension and production measures were related in a similar way to parent speech and demographic factors.

4.2.1. Production of complex sentences: Relation to SES

The average percentages and standard deviations for production of multiclause sentences in children and parents are presented in Table 4 (rows 1 and 2 respectively) separately for each SES group. The analysis of individual data revealed that all children produced at least some multiclause sentences. The mean proportion of such sentences across SES groups was 13% and the range was from 5 to 29% To examine the relation of SES, we performed a two-tailed t test; the relation was not significant, $t(46) = .41$, $p = .68$.

Table 4
Production and comprehension of complex sentences (Study 1B)

	Lower SES		Middle SES	
	Mean	*SD*	Mean	*SD*
Percent produced by children	12.74	5.78	13.25	4.56
Percent produced by parents	19.20	5.38	21.00	5.09
Percent comprehended by children	50.00	14.20	60.31	15.38

For parent speech the mean proportion of multiclause sentences was 20% and the range was from 10 to 30%. To examine if SES was related to the complexity of parent speech, we first conducted a t test with SES as the independent variable and the proportion of complex sentences in parent speech as the dependent variable. There was no significant effect for SES, $t(46) = 1.18$, $p = .24$. Next, we conducted a t test with SES as the independent variable and the frequency of complex sentences in parent speech as the dependent variable. Again, there was no significant effect for SES, $t(46) = 1.45$, $p = .16$.

4.2.2. Predictors of complexity in children's sentences

As in Study 1A, we carried out a multiple-regression analysis to determine how much of the variation in the proportion of children's complex sentences was accounted for by the independent variables investigated in this study. The analysis showed that the proportion of complex sentences by parents was the best predictor of the syntactic complexity of child speech, accounting for 14.08% of the variance, $F(1, 46) = 7.54$, $p < .01$. After the proportion of multiclause sentences by parents was accounted for, additional contributions of the frequency of complex sentences by parents and SES were negligible ($p > .50$).

The correlation between the proportion of multiclause sentences produced by parents and the proportion produced by children is significant, $r = .4111$, $p < .01$. Although this value is lower than the correlation at home in Study 1A, the difference between the correlations for the two studies is not statistically significant ($p > .10$). The relation of syntactic complexity in parent speech to that in children's speech is shown in Fig. 4.

4.2.3. Subcategorizing multiclause sentences

Having found a highly significant relation between input and children's skill levels for multiclause sentences treated together, we next considered whether breaking these sentences into subtypes might further clarify the relation to input. That is, we examined if parents vary in the relative frequencies of different types of multiclause sentences they produced and if those differences are reflected in production differences in their children. We divided the sentences according to whether they involved coordinate clauses,

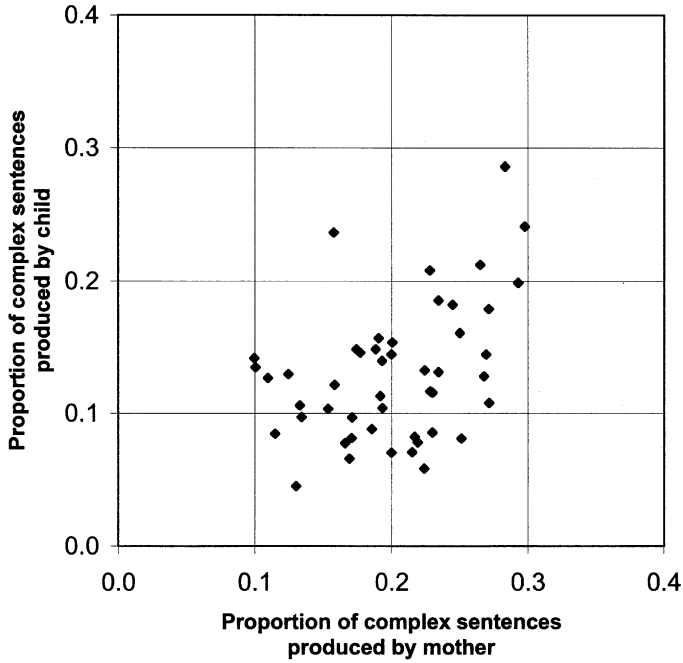

Fig. 4. The relation of the proportion of complex sentences in parent speech to the proportion of complex sentences in child speech, Study 1B.

relative clauses, or complement clauses (complement clauses were mostly object complements; subject complements were very rare). We found that relative frequencies for these different types of sentences were highly similar across all parents. For 44 of 48 parents, the relative frequency of complements was greater than the relative frequency of coordinate clauses, and that of coordinates was greater than that of relative clauses. Complement clauses accounted for 68% of all complex utterances ($SD = 11\%$), coordinate clauses accounted for 30% ($SD = 11\%$), and relative clauses for 2% ($SD = 2\%$). Table 5 shows that the pattern did not vary across SES groups.

The same relative frequencies of different sentence types as found for parents were also found for children. That is, for children, complements accounted for 68% ($SD = 12\%$) of the complex utterances, coordinate clauses accounted for 30% ($SD = 11\%$), and relative clauses accounted for 2% ($SD = 2\%$). Again, Table 5 shows that the pattern is the same across SES groups. Since there were virtually no individual differences in the pattern of relative frequencies for the three types of multiclause sentences, there is no possibility of determining if differences among parents would be related to the level of children's mastery of these different types of the sentences.

Table 5
Percent of different kinds of complex sentences by parents and children in different demographic groups (Study 1B)

	Coordinate	Complement	Relative
Parent speech			
Low SES	33	65	2
Middle SES	28	70	2
Child speech			
Low SES	31	67	2
Middle SES	29	68	3

4.2.4. Comprehension of complex sentences: Relation to SES

Parallel to the finding that children show large variation in the production of multiclause sentences, there also was large variation across children in the comprehension of these sentences (see Table 4, row 3). The range of comprehension scores was from 16 to 90%. Note that if children selected pictures at chance, they would get 33% right. Considering the distribution of scores, one can establish a confidence interval around the chance level. It is possible to say with 95% certainty that a child who got 44% of the items right was not simply choosing randomly. Of the 48 participants, 37 received scores of 44% or above. For the 11 children whose scores were below 44% it is not clear that they could reliably understand multiclause sentences, at least in the context of picture selection tasks. The majority of children (73%) who performed around chance level were from the lower SES group. A two-tailed t test showed that there was a significant difference in comprehension scores between the low SES and middle SES groups, $t(46) = 2.42$, $p < .05$.

4.2.5. Predictors of children's comprehension of complex sentences

A multiple-regression analysis shows that the proportion of complex sentences in parent speech, the frequency of such sentences and SES together account for 21.43% of child comprehension. Multiple-regression analysis using the selection forward procedure reveals that the proportion of complexity in parent speech is the best predictor of children's comprehension of syntactically complex utterances accounting for 13.82% of the variance, $F(1, 46) = 7.37$, $p < .01$. The relation of parent speech to child comprehension is shown in Fig. 5 ($r = .3906$, $p < .01$).

SES accounts for 7.61% of the variance in the comprehension score, $F(1, 46) = 4.36$, $p = .0425$. After the contribution of these two factors is accounted for, the contribution of frequency of complex sentences by parents is negligible ($p > .50$). Note that, for the two factors that are related to children's comprehension, the role of SES as a predictor is less important than the role of the proportion of complex sentences in parent speech.

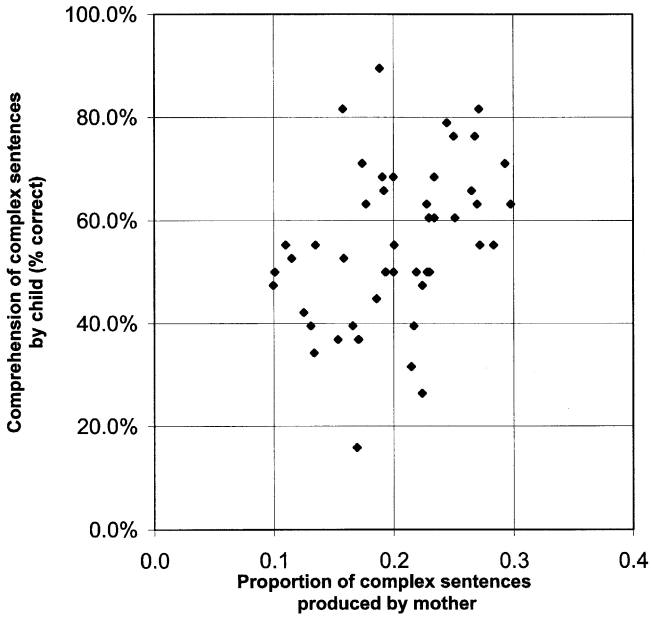

Fig. 5. The relation of the proportion of complex sentences in parent speech to comprehension scores, Study 1B.

4.2.6. Noun phrases in children's production and the relation to input

The mean number of noun phrases per utterance was highly related to our other measure of syntactic complexity, the proportion of multiclause sentences ($r = .68$, $p < .001$ in children; $r = .75$, $p < .001$ in parents). In children, the mean number of noun phrases per utterance varied from 1.14 to 2.11 ($M = 1.65$). To examine the relation of SES to the mean number of noun phrases in children's speech, we performed a two-tailed t test. There was no significant effect of SES, $t(46) = .46$, $p > .1$. In parents, the mean number of noun phrases per utterance varied from 1.20 to 2.22 ($M = 1.76$). To examine the relation of SES to the mean number of noun phrases in parents' speech, we again performed a two-tailed t test. There was no significant effect of SES, $t(46) = 1.53$, $p > .1$.

Finally, and most importantly, we examined the relation between the mean number of noun phrases per utterance in parents' speech to the mean number of noun phrases per utterance in children's speech. The relation is shown in Fig. 6; it is highly significant ($r = .55$, $p < .01$).

4.3. Discussion

Study 1B verified and extended the findings of the preliminary study with the Hall et al. data (Study 1A). We again found that there was substantial

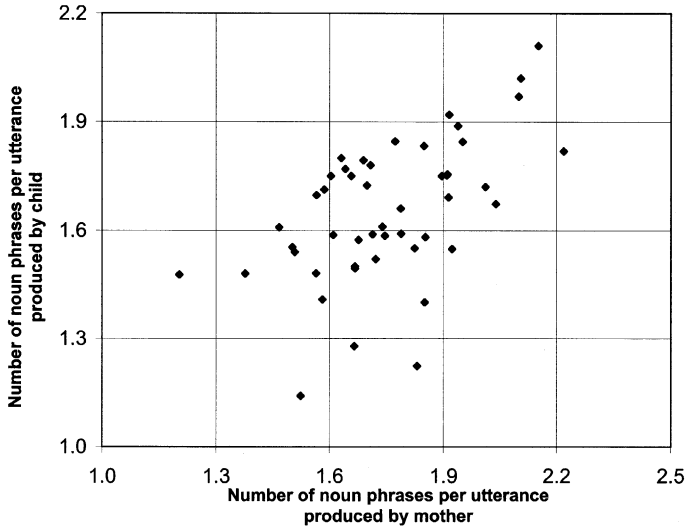

Fig. 6. The relation of the mean number of noun phrases per utterance in parent speech to the mean number of noun phrases per utterance in child speech, Study 1B.

variation in children's syntactic complexity. The proportion of complex sentences in parent input was the major predictor of the proportion of such sentences in children while frequency of complex sentences and SES were not significant predictors. The correlation between parent and child in Study 1B was lower than in Study 1A, but it was highly significant and not statistically different from the correlations in Study 1A.

A major extension in Study 1B was to obtain comprehension data. We found large variations in the comprehension of complex sentences by 4-year-olds. Children's comprehension of complex sentences was highly correlated to the proportion of such sentences in their speech. This finding indicates that production differences among children observed in Studies 1A and 1B are not simply differences in style of speaking. Children's comprehension of complex sentences, like their production of these sentences, was related to the proportion of complex sentences their parents produced. The similarity of the relation between parent input and all our child measures (production at home, production at school, and comprehension) further supports the view that parents' use of complex sentences is related to children's underlying mastery of these forms.

Finally, we examined children's production of noun phrases in relation to the same measure of parent speech. Using this measure we found a high correlation between parents and children. The number of noun phrases per utterance provides a valuable measure of syntactic complexity; it captures the "embellishment" of utterances beyond skeletal simple sentences arising not

only from multiple clauses, but also from prepositional and adverbial phrases.

Our results provide important information about syntactic development. They show a relation of child language to parent input for aspects of syntax that were unrelated to input at earlier stages, notably for multiclause sentences and the number of noun phrases per sentence. However, the finding of a relation between parent speech and children's acquisition does not definitively implicate differences in input as a source of differences in development. The possibility that observed correlations could reflect either genetic similarity or child ability effects on parents remains open.

5. Study 2: Is input a source of syntactic growth?

The purpose of Study 2 is to examine if differences in language input actually are a source of variation in children's syntactic skill levels. To explore this issue we investigate a case where input may play a critical role in an observed relation between speech to children and the children's skill levels, namely the case of teacher speech. There is neither a biological relation of the teacher to the children in her class, nor, at the start of a school year, is there a history of prior input from the teacher. This state of affairs potentially provides a basis for examining the effect of input by analyzing its relation to growth over the school year. However, a simple correlation is not sufficient to implicate input as a source of skill levels in children. To conclude that a relation between teacher language and child growth is an input effect, certain additional conditions must be met.

If teacher input during the school year is correlated with children's skill levels at the start of the year, the interpretation of the role of that input would be ambiguous. It might indicate that teacher input varies with children's ability levels. That is, higher ability families may send their children to schools with higher ability teachers, or teachers may provide better input to children with higher ability levels. On the other hand, if teacher input is not correlated with children's skill levels at the start of the school year but is correlated with the growth of skill, then it would strongly support the view that the input is a critical factor in growth.

At the start of the school year, children's skill levels may be related to their SES. Indeed, a correlation of child comprehension to SES was found in Study 1B. Such a relation might reflect variables having to do with children's families—genetic factors and/or prior input differences. Potentially, SES-related factors might also be responsible for differential growth over the school year. If SES has a stronger relation to child growth over the school year than teacher input, it would be unclear whether input itself plays any role in growth of language skills. However, if child growth is more

highly related to teacher input than to SES, it would indicate that this input is a critical factor.

Finally, note that a correlation between teacher speech and syntactic growth does not necessarily implicate teacher speech per se because teacher speech may be associated with other, more global, teacher characteristics. Further, such a correlation is not necessarily specific to syntactic growth but rather may be associated with more general aspects of cognitive growth. To aid in interpreting correlations if they occur, we use additional measures for teachers and for children. We use additional teacher measures to determine if syntactic growth is more highly associated with teacher syntax than with other teacher measures. We also use other child measures (namely mathematics growth) to determine if it is syntactic growth rather than general cognitive growth that is associated with teacher syntax.

In this study, syntactic input is assessed by recording and analyzing teacher speech on a typical day during the school year. Children's skills are evaluated by assessing children's syntactic comprehension at the beginning and end of the school year. The relation of the teacher's input to language growth in his or her class is evaluated by examining the average growth of that class over the school year (the period in which the teacher provides input to that class). That is, while the unit of analysis in studying parent input is the individual child, the unit of analysis for evaluating the effectiveness of teacher input is the class rather than an individual child.

5.1. Method

5.1.1. Participants

Our sample included 40 classrooms drawn from 17 different preschools in the Greater Chicago area. The schedules for preschools and day care centers are quite variable both in the Chicago area and nationally. About half of our schools were half-day programs and the other half were full-day programs. However, the full-day programs typically involved half-day preschool while the other half-day involved primarily noneducational activities (naps, meals, etc.). About a third of the participating preschools served high-income families, another third (HeadStart schools) served low-income families, and yet another third served families with a mixed socioeconomic background (from middle-class to low-income families). The children were on average 43 months old at the first testing point and 50 months at the final testing point. About half of all participants were boys and half were girls.

All participating children were recruited at the start of the school year. These children, who were in the class over the school year, made up the group used in calculating class scores. Across the 40 classes, 305 children participated in the study. Each class had one primary teacher from whom input data was collected.

5.1.2. Comprehension task

Each child was given a syntax comprehension task. In this task, children were read a sentence and were asked to point to the picture that goes with the sentence. The testing format was similar to that in Study 1B. One difference should be noted: While the comprehension task in Study 1B consisted of multiclause sentences, in the present study we included simple sentences with varying numbers of noun phrases as well as multiclause sentences (see Fig. 7 for two sample items). This was done for two reasons. First, some of the children in Study 1B performed at a chance level and we wanted to have a task that would allow us to differentiate children's syntactic level. Second, when we analyzed number of noun phrases in children's utterances in Study 1B we found an even higher correlation with parent input than for multiclause sentences. Therefore we constructed a syntax comprehension task, including sentences that differed in the number of noun phrases not only because of variations in the number of clauses, but also because of variations in the number of noun phrases within a clause.

5.1.3. Math task

Each child also was given a math task. Children were shown a target picture and had to choose one of a set of pictures that matched the target picture. This measure of mathematical skill was obtained primarily to address other research questions, but in the context of this study, the task provides a

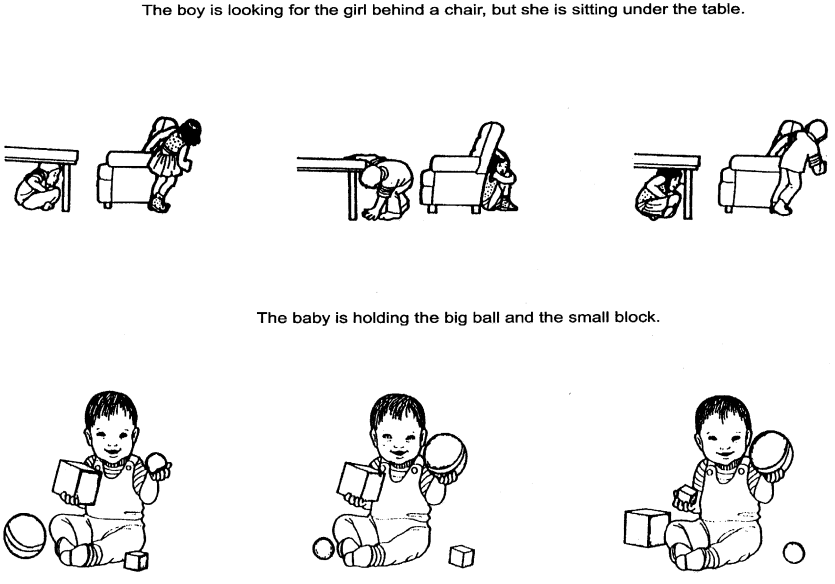

Fig. 7. Two sample items from the comprehension test, Study 2.

way of examining if teacher speech has a stronger effect on children's syntactic growth than on other aspects of children's intellectual development.

5.1.4. Schedule of testing

Children were tested twice, at the beginning and at the end of the school year. To reduce practice effects, each child was given different test forms at the two testing points. Preliminary studies showed that the alternative forms were equivalent in difficulty. Children were tested individually in their preschool. Each testing session lasted 10–15 min. Our concern was to obtain reliable data on the average class score at the beginning and at the end of the year. Most children were tested at both test point 1 and at test point 2. However, some children are absent from school on particular days, and 45 of the children were tested at just one time point. To obtain the most reliable estimate of the average class score at each time point, scores for all children present at a test point are included in the analysis.

5.1.5. Teacher observation

In addition to the testing of the children, classroom observations were conducted. All participating classrooms were visited in the middle of the school year when the teacher speech was recorded and the classroom observation data were collected. Each classroom was observed once for 2.5–3 h. During that period the teacher wore a lapel microphone and the teacher's speech was audiotaped. One hour of the tape was later transcribed and the speech was analyzed. The procedure used in syntactic analysis of teachers' speech was identical to that used in the analysis of parents' speech in Study 1B.

During the classroom observation, the observer filled out a questionnaire describing the teacher's interaction with students. The questionnaire was based on NAEYC checklist for preschools. We included 10 questions which concerned the general quality of teaching, for example, the extent to which teachers use positive reinforcement and redirection, the extent to which they stimulate children's curiosity and interest, and so on. For each question, the observer assigned a score that varied from 1 (*not at all like this classroom*) to 5 (*very much like this classroom*). The average score was calculated over the 10 measures and used as a general quality of teaching measure. In a subset of classrooms the second observer made independent observations. The reliability across observers was .85.

5.2. Results

5.2.1. Comprehension

We calculated the average comprehension score for each class using the scores of individual children. At the first testing point, the comprehension scores for the classes varied from roughly chance level (33% correct) to

65% correct. SES was related to children's initial level of syntactic skill ($r = .48$, $p < .01$). That is, children coming from higher SES families have better syntax comprehension scores at the initial testing than children coming from lower SES families. For each classroom, a growth score was calculated (the average class score at the first testing point was subtracted from the average class score at the second testing point). These growth scores varied dramatically from −.15 to .31; there was a rise in average comprehension scores in 30 of the 40 classrooms. Syntactic growth over the school year was not significantly correlated with SES ($r = .21$, $p > .10$).

5.2.2. Teachers' speech

We examined two measures of teachers' speech, the proportion of multiclause sentences and the mean number of noun phrases per sentence. As in Study 1B, the two measures were highly correlated ($r = .75$, $p < .01$), and the patterns of relation with child measures were the same for both teacher measures. We did not examine the overall frequency of complex sentences since it did not prove to be a significant predictor of children's syntactic complexity in either Study 1A or Study 1B. Below we present the results using the proportion of complex sentences as we did in examining input throughout Study 1. The proportion of multiclause sentences in teachers' speech varied from 11 to 32% with a mean of 21%. For schools with more than one classroom in our target age group, we found considerable variation among teachers within the school. In fact, teachers in different schools, on average, are no more different from each other than teachers within a school. The analysis of teachers' speech indicated that the average variance within schools (.0021) is very similar to variance between schools (.0014).

The correlation between complexity of teachers' speech and SES was not significant ($r = .2873$, $p > .05$) although, as noted above, the correlation between complexity of children's speech at the start of the school year and SES *was* significant. Note that our SES measure indicates the composition of the families in a school, not the background of the teachers in that school. Although there may be some relation between teachers' own SES and the SES of the families served by the school, there is no reason to believe that this would be a very strong relation. The possible dissociation between teacher and family backgrounds should prove useful in separating teacher effects from family effects on children's syntactic growth.

5.2.3. Relation of syntactic growth to teacher input

The level of children's syntactic skill at the start of the school year was *not* significantly related to teachers' syntax ($r = .19$, $p > .25$). Because the initial levels for classes were not related to teacher input, that input can be examined as a possible source of growth without concerns that prior similarities of teachers and children might account for the relation. This result also indicates that teachers' input (that was measured in the middle of the school

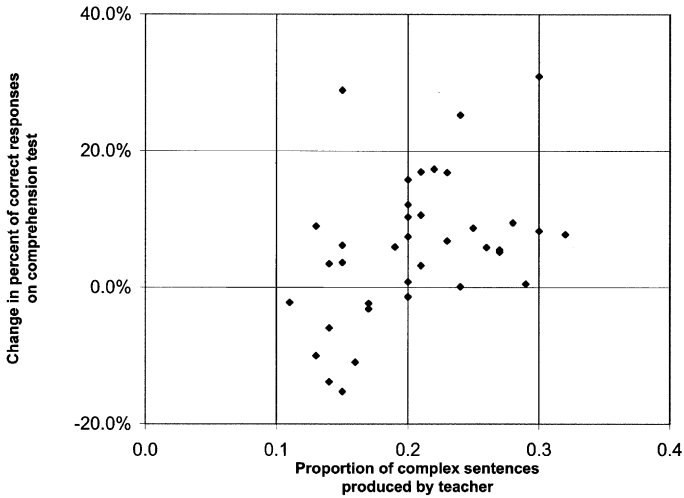

Fig. 8. The relation of the proportion of complex sentences in teacher speech to comprehension scores, Study 2.

year) was not being driven by children's ability level. The examination of syntactic growth in children showed that it was significantly related to the proportion of complex sentences in teachers' speech ($r = .42$, $p < .01$). The relation is shown in Fig. 8. Furthermore, when initial skill levels in different classes were partialed out, the relation between growth and input became stronger ($r = .51$, $p < .01$).

Note the difference in the pattern of relation of children's syntactic skill to SES and to teacher input. As reported above, while SES *was* related to children's skill levels at the start of the school year, it was *not* related to the growth of their skill levels during the school year. On the other hand, teacher speech was *not* related to children's start level but *was* related to their growth. This means that children from low-SES families, whose syntactic level is quite low at the beginning of the year, may grow as much or more than children from higher SES families, if their teachers provide input comparable to or greater than the input in the higher SES preschools.

5.2.4. Other aspects of child growth; other teacher measures

We examined the relation of teacher syntax to our other measure of cognitive growth, nonverbal math. The correlation between the two measures was not significant ($r = -.085$, $p > .10$). Thus, while the correlation between the proportion of complex sentences in teacher's speech and children's growth on syntax comprehension is substantial, there is no relation of teacher syntax to the growth of nonverbal math skill.

Next we examined the relation between the growth in children's syntactic scores and the measure of general quality of teaching. We found that the correlation between these two measures was significant ($r = .32$, $p < .05$). To separate the effects of this teaching measure from specific effects of teacher's syntax, we conducted a regression analysis using a selection forward procedure. The growth score was the dependent variable and the two teacher measures were the independent factors. Teacher syntax was a much stronger predictor of children's growth scores than the other teacher measure. In fact, when the contribution of teachers' complexity is accounted for, 17.8%, $F(1, 38) = 7.99$, $p < .01$, the contribution of the other measure is negligible, 4%, $F(1, 38) = 1.84$, $p > .10$. This pattern of results points to a specific effect of syntactic input on children's syntactic growth.

5.3. Discussion

The results of this study indicate a substantial relation between teachers' syntactic input and syntactic growth in the classes they teach. We conclude from our findings that teacher speech is a critical factor in the extent of growth in comprehension over the school year. Possible alternative explanations for the observed relation are not supported by the data. It would have been possible that more skilled children had teachers with higher skills or that more skilled children elicited better input from teachers. However, the fact that class start levels were not correlated with the complexity of teachers' speech fails to support such interpretations. It seems clear from the results of this study that variations in input are a source of the variation in growth.

6. Overall discussion

Recent interest in the acquisition of syntax has been a natural outcome of emerging concerns in psychology with children's early intellectual development and in linguistics with the characterization of human language. For psychologists, the understanding of development involves specifying intellectual start points as well as the processes by which mature forms of skill are achieved. For linguists, understanding of syntax involves specifying the nature of the grammars that underlie the ability to produce an infinite number of sentences of varying degrees of complexity. In this context, the acquisition of syntax represents a fascinating aspect of cognitive development. During the first few years of life, and across a wide range of environments, children master the intricate patterning of linguistic units that make up the grammar of their language and become able to use the language to express their thoughts and feelings. The complexity of syntax together with

its early mastery pose a challenge in understanding how this intellectual accomplishment is achieved.

One kind of data relevant to determining the sources of syntactic development comes from studies that show commonalities in early syntax across children. These commonalities have been taken as evidence for powerful innate constraints in acquisition. Note, however, that commonalities in language development may depend on either structure in the child, structure in the input, or both. It has been argued that structure in the input is not sufficient to permit induction of a grammar and further that speech in natural context is in any case filled with false starts, incomplete sentences, and so on (Chomsky, 1965). However, empirical investigation of parent utterances to young children has revealed that those utterances actually tend to be highly regular, involving mainly complete sentences (Newport et al., 1977). Hence regularities in the input could be a source of commonalities in early syntactic development, although at present it is not clear to what extent this is the case.

The other kind of data relevant to understanding the sources of syntactic development comes from studies that show individual differences in children's skills and a relation to variations in input. Individual differences among children are found from the start of syntax acquisition. As we have seen, earlier studies had found that some aspects of syntax were related to variations in input, whereas others were not. The finding that there were aspects of syntax that were unaffected by input could have important implications, since it might indicate that there are features of syntax that are not acquired from the input, but rather are innately available. However, existing studies involved very young children and did not explore the possibility that a relation to those aspects of input might be found at later stages of development.

Our first study systematically addressed the possibility of a relation between children's skill levels and input in 4-year-olds. We looked at the proportion of multiclause sentences, a measure parallel to the Newport et al. measure of number of verb phrases per utterance. We also looked at the number of noun phrases per utterance, a measure used by Newport et al. We found sizable individual differences among children in the proportion of multiclause sentences produced as well as comprehended and in the average number of noun phrases in an utterance. The measures of child syntax that we have used were significantly related to variations in input. Thus our data show that a relation of child language to parent input can be observed for syntactic skills that are unrelated to input at earlier stages.

The findings of Study 1 suggest that different aspects of syntax may show sensitivity to input at differing points in children's language development. Indeed, a relation between the growth of particular forms and the variation in parent speech should be expected only over the period when those forms are growing. Once a child has fully mastered a form, such a relation will not

be found, nor will a relation be found before the form emerges. Earlier research has shown a relation of input to certain aspects of syntactic skill in very young children. Our work has demonstrated a relation between input and other aspects of skill at later stages of syntactic development. The results, taken together, provide evidence that the aspects of syntax that have been examined so far show input sensitivity at some point during the course of language development.

Our results in Study 1 are consistent with the idea that processes sensitive to patterning in the input are central to the acquisition of syntax. If children learn language from the input, higher skill levels should be found in individuals who receive better input. However, since the input findings in Study 1, like most input findings, are based on parent–child relations, it is possible that biological factors might account for the observed results. That is, since individuals from the same biological family are more similar in genetic makeup than unrelated individuals, one might expect parent–child correlations even if input were not relevant to children's syntactic skill levels.

Some investigators might even argue that, for the aspects of syntax examined in this article, a genetic hypothesis is especially plausible. It has been argued that innate ability differences are most strongly seen for complex skills; simple skills are acquired relatively early even by low ability level individuals (e.g., Jensen & Inouye, 1980). Pursuing this line of argument for syntax, one would expect that basic grammatical relations and morphology of simple sentences would be mastered by humans across a very wide range of ability levels, although there might be some differences in timing. For more complex aspects of syntax, however, genetic differences should be especially clear. According to this argument, the findings in Study 1 might not be due to differential input at all but, rather, only to the genetic similarity of parent–child pairs.

In our second study we examined whether the nature of the input actually affects the level of child skill. As we have noted, studies of families are generally ambiguous with respect to causation since parents and children are biological relatives. In a design to evaluate whether certain features of input have an effect on particular aspects of syntactic skill, the input provider should not be a biological relative of the child and the ability level of the provider should not be related to that of the child. An additional issue in interpreting the role of particular aspects of parent input is that parents are input providers across the entire period of language acquisition. Hence there will be ambiguity as to whether the growth of particular syntactic skills over delimited time periods is due to the characteristics of input during that period. For a design to implicate input over a particular period of time in the growth of a target skill, the interaction of the provider with the child should be limited to that time period.

Potentially the teacher–child relation can provide an appropriate context for exploring input effects. In Study 2 we investigated teacher input and

child growth over the school year. We found that teacher speech was *not* significantly related to children's skill levels at the start of the school year, but *was* significantly related to growth in children's skill levels over the school year. This pattern suggests that the correlation of input to growth was not due to similarities in underlying ability levels of teachers and children nor to adjustment of input to child ability levels. Further, the observed correlation could not be explained in terms of other characteristics of teachers or growth in general cognitive skills of the children. Our finding was specific to syntax—complexity of teacher speech and growth of syntactic comprehension in the children. These results implicate the syntax of input providers as a factor that affects the extent of syntactic growth.

While our findings show the importance of input in the acquisition of syntax, it is clear that prior mental structure also is critical. In fact, existing work on syntactic development has focused more on delineating the prior structure in the child necessary for acquisition of syntax than on the needed input. That focus is understandable given the salient facts about language development—that only humans develop a grammar and that it develops rapidly in early childhood. However, it is important to remember that both input and prior structure are critical to development in all domains, even though the role of prior structure may be especially great for the development of syntax. In this context, we should note the evidence presented by Goldin-Meadow (1982) that the spontaneous gestures of deaf children may exhibit complex structure even though the children have received no linguistic or gestural input to support it. The existence of such structure in spontaneous communication would seem to reflect preexisting mechanisms in the child.

Note, however, that while the very capacity to use complex structure may not be actually *produced* by input, input *is* required for acquiring a conventional system that captures such structure. The processes that underlie acquisition of a conventional system differ from those that underlie spontaneous gesturing behavior. Proficiency in using complex syntax to express complex ideas in a particular language requires exposure to the ways sentences can be embellished through combining clauses and through the use of prepositional and adverbial phrases in that language. For example, the English-learning child must learn that two clauses can be conjoined by "but" or "because" to express particular relations between clauses.

In fact, we find that it takes considerable exposure to complex linguistic forms to achieve proficiency in producing those forms and reliability in comprehending them. For all our measures in both studies, we have found a linear relation between children's syntactic skill levels and language input over the entire range of variation in input complexity. The existence of such a relation is relevant to the interpretation of the role of input in acquisition. Some investigators have argued that input functions as a trigger to allow children to "set parameters" within a highly constrained set of syntactic pos-

sibilities (Chomsky, 1981). This notion suggests that a relatively small amount of input should be sufficient to trigger the setting of the parameters. Yet our findings indicate that the greater the proportion of complex syntactic forms in the input, the higher the level of skill with these forms.

At present, we can only speculate about why greater proportions of complex syntactic forms in caregiver speech allow children to achieve higher levels of proficiency in both comprehension and production. It seems clear that children must experience these forms in a variety of linguistic contexts across various situations to become familiar with the patterning of units in their language and to establish the mappings of those patterns onto conceptualizations of events. Hearing speech with a high proportion of particular syntactic forms may facilitate the encoding of events in ways that map onto those forms. A possible way of thinking about such a facilitation is that language experience affects children's skills in representing events in a form appropriate for verbalization, i.e., "thinking for speaking" (Slobin, 1996; Vygotsky, 1962). Slobin has, in fact, proposed that "acquiring a first language involves learning particular ways of thinking for speaking" (p. 76).

In addition to the importance of multiple exposures to complex speech in forming generalizations about linguistic forms and their pairings with meanings, further exposure may be needed to achieve sufficient ease of access to support on-line use in production or comprehension situations. Difficulty of access may account for low levels of production of complex sentences by some children in our studies. These children may require favorable circumstances to produce such sentences—for example, recent exposure to particular syntactic forms or lexical items, situations that are familiar and hence are easily conceptualized, and so on. Difficulty of access may also account for unreliable comprehension. Some children performed at chance on our comprehension task even though they produced some complex sentences, showing that they did not completely lack skill with such sentences. Clearly, further investigation will be needed to arrive at the proper formulation of the ways in which children achieve proficiency as language users.

It should be noted that the fact that individual differences in language skills are reflected by variations in input does not imply that genetic factors are not also relevant. Pinker and Bloom (1990) argue that if language is a biologically regulated skill shaped by evolutionary forces, genetically based variations in skill levels are to be expected. Studies which suggest that genetic factors may contribute to individual differences in syntactic skill across children have been reviewed by Stromswold (2001). Genetic differences might affect the ease of learning the code itself, of conceptualizing situations in ways that map onto complex syntax, and so on. Our data showing input effects on syntactic growth do not account for all the variability in skill among children, and it is possible that differences in genetic endowment explain some of the remaining variance.

In conclusion, while language development has received considerable attention in recent decades, our understanding of the acquisition process is at present very incomplete. Despite the fact that syntactic acquisition has been the focus of many theoretical discussions, systematic empirical work on the role of input has been limited. The present article provides evidence concerning the relation of input to aspects of syntax that are regarded as epitomizing the human language capacity—the ability to embellish simple sentences using multiple noun phrases and to combine clauses to form multiclause sentences. It is already clear that level of syntactic skill varies substantially across children. It also is clear that input affects the skill levels that individuals achieve. Our findings suggest that it is critical to specify the nature of the interplay between the roles of structure in the child and structure in the language environment in order to develop adequate theories of language acquisition.

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