



Syntactic priming in young children[☆]

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Received 10 April 2003; revision received 12 August 2003

Abstract

This paper presents three experiments which show syntactic priming effects in four- and five-year-old children. The experiments are modeled after priming studies with adults involving transitive and dative constructions. In Study 1 children were presented with a picture that was described by an experimenter. They repeated the experimenter's sentence and then were presented with a new picture to describe. Children were more likely to use a particular syntactic form if it had been used by the experimenter. In Study 2 the procedure was identical except that children did not repeat the experimenter's sentence. Priming effects were comparable to those in Study 1. In Study 3, after hearing the experimenter's sentences, children were presented with a block of pictures to describe. Across the entire block, children were more likely to use a particular form if it had been used by the experimenter. Together these results indicate that children represent syntactic form independently of particular lexical items.

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Keywords: Children; Syntax; Priming

Recent work indicates that there is a substantial relation between the language input children receive and their language acquisition. This is true both for vocabulary (Hoff & Naigles, 2002; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991) and for syntax (Hoff-Ginsberg, 1998; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). A relation of input to syntactic development has been found in the early period when children first form multi-word utterances (Hoff-Ginsberg, 1998) and much later when they use more complex syntax (Huttenlocher et al., 2002).

In the Huttenlocher et al. (2002) study, a striking relation was found between the complexity of caregiver

speech and children's syntax. The proportion of multi-clause sentences in the speech of caregivers was related to the mastery of these forms as seen in both production and comprehension by four-year-olds. A strong relation also was found between the average number of noun phrases in caregiver and child speech. For both measures, the relation was roughly linear, extending across the entire range of input variation. This would suggest that acquisition may involve a gradual process in which amount of exposure is a major source of growth.

In one of our studies, the input provider was a parent; hence it was possible that the relation was mediated, at least in part, by genetic factors. In the other study, the input provider was a day care teacher. We found that, at the start of the school year, the complexity of teachers' speech was not related to the syntactic levels of children in their classes; but the complexity of their speech *was* related to the amount of syntactic growth in the children over the school year. This finding clearly indicates that caregiver input is not simply a correlate, but rather is a determining factor in the growth of syntactic skill.

[☆] The research reported here was supported, in part, by a grant from the National Institutes of Health (PO1-HD40605), by a grant from the McCormick Tribune Foundation, and by a National Science Foundation Predoctoral Fellowship to Priya Shimpi. The authors thank Mary C. Potter for her helpful comments on the manuscript.

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The Huttenlocher et al. (2002) results indicate that the levels of syntactic skill in children depend on exposure to sentences of particular forms. However, existing findings do not provide information about how best to characterize children's competence at various points in the developmental process, nor do they indicate the mechanisms by which input affects the growth of skill. To explore these issues, it is desirable to employ experimental methods in which variations in input could be manipulated systematically and the relation to children's use of particular syntactic forms could be examined.

In the present study we use an experimental design in which we attempt to induce syntactic priming in young children. Syntactic priming in this context refers to an increase in the likelihood of producing a sentence of a particular form as a result of recent prior experience with that form. The use of the priming paradigm can provide information concerning the nature of a person's representation of language. The technique involves testing whether a person is likely to produce a sentence that has the same structure as a prior (priming) sentence, even if there are no words in common with that priming sentence. Such findings provide evidence that people have represented syntactic form at an abstract level, independent of particular lexical items.

The original studies of syntactic priming were carried out with adults (Bock, 1986; Bock, 1990; Bock, Loebell, & Morey, 1992). They aimed to obtain experimental evidence that syntactic form itself was represented. In a series of experiments, people listened to and repeated a sentence produced by an experimenter. One type of priming sentence involved a transitive construction, described in either an active or a passive form. The other type of priming sentence involved a dative construction, described with either a prepositional phrase or double object. Following the priming event, the participants were shown a picture and were asked to describe it. People were more likely to use a particular syntactic form if that form had occurred in the experimenter's sentence. Thus hearing and producing a sentence of a certain syntactic form increased the likelihood of using that form subsequently. Since the experimenter's sentences and the participants' sentences involved different lexical items, the observed effect indicates that people have abstracted the syntactic form of the experimenter's sentences.

It was initially believed that syntactic priming depends on accessing procedures associated with sentence production. That is, repeating the experimenter's sentence was viewed as critical to obtaining a priming effect. Later work by Branigan and colleagues showed that repetition of the priming sentence is not necessary for the effect to occur (Branigan, Pickering, & Cleland, 2000; Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995; Pickering, Branigan, Cleland, & Stewart, 2000). This work demonstrated that in the course of a

dialogue, adults were more likely to produce a dative sentence of a particular form (prepositional phrase versus double object) if their partner used that form in the preceding conversational turn. The investigators concluded that syntactic priming is not limited to situations where people produce a certain syntactic form; it also occurs when they only hear that syntactic form. The question of whether priming effects are stronger when the primed item is repeated has not been systematically examined.

It also was believed initially that priming is a short-term effect in which a form becomes temporarily activated, making it more likely that, for a very brief period, a person will produce that form again. However, Bock and Griffin (2000) demonstrated that priming effects last even when several trials involving sentences of different forms intervene between the priming sentence and a person's production of a sentence to a picture. The priming effect with zero lag was similar in size to the priming effect found with a lag of 10 trials. These results suggest that the effect is longer lasting than originally believed, leading Bock and Griffin (2000) to argue that priming may "grow out of some kind of experience-dependent adjustment within a system that builds utterances" (p. 178). It is not clear how the size of such adjustments may depend on amount of exposure to particular sentence forms, and on the distribution of exposures over time.

The findings with adults suggest that use of the priming technique may allow us to obtain important information about children's syntactic development. If children exhibit priming effects that are parallel to those of adults, it would allow us to answer a question that has been of theoretical interest to investigators of child language. That is, it would allow us to determine whether children represent syntactic form apart from lexical items. Recently, some investigators have argued that in the early stages of syntactic development children possess lexically-based word patterns rather than general grammatical form (e.g., Tomasello, 2000). Children's early uses of certain sentence forms may involve only a few lexical items (Olguin & Tomasello, 1993; Pine, Lieven, & Rowland, 1998; Tomasello, 1992). It should be noted that in some views, lexically based combinations remain a factor even in adults' representation of syntax (e.g., Goldberg, 1998). Clearly though, fluent adult speakers possess fairly general syntactic patterns that guide their utterances. It is not known when such general patterns emerge in childhood. The existence of priming effects at a particular age would provide evidence that, by that age, children have abstracted syntactic patterns that can be used with different lexical items.

What limited evidence there is from experimental work indicates that preschool children might show syntactic priming effects. Whitehurst, Ironsmith, and

Goldfein (1974) studied the effects of presenting children with transitive sentences on the comprehension and production of those sentences. In their study, children were shown a set of pictures described in the passive form by the experimenter. Interspersed with these pictures, there were test pictures that the child described. A control group was simply presented with the same test pictures described by children in the experimental group. The results indicated that children who heard passive forms were more likely to produce and comprehend passives than the control group. Fisher and Song (2001) studied children's sensitivity to forms of dative construction. Children were asked to repeat a target sentence that contained a verb in either double-object or prepositional phrase form. The target sentence was preceded by two sentences that contained the same verb; they were presented either in the same form as the target or in the alternative form. Children more accurately imitated the target sentence if it had the same form as the two preceding sentences.

The present study

In this study we present three experiments examining priming in preschool children. Our purpose is to determine whether children's use of certain grammatical forms can be affected by exposure to these forms. We utilize priming designs similar to those introduced in studies with adults, including the syntactic constructions used by Bock, i.e., transitive and dative constructions. As discussed above, there is suggestive evidence that for preschoolers, the production of particular forms of these constructions might be affected by recent exposure (Fisher & Song, 2001; Whitehurst et al., 1974).

Before investigating priming with transitive and dative sentences, we explored the use of these forms in children's spontaneous speech. We examined the speech of four-year-olds from the Huttenlocher et al. (2002) study, in particular, of children from the top quartile in that study (12 of the 48 children), as indicated by their syntax comprehension scores. We analyzed all uses of transitive and dative constructions in the speech of these children during a 90-min observation period. None of the children ever produced a full passive. Four of them used truncated passives, but two of these children produced only one such utterance, and the other two used only one verb in their utterances. For the dative construction, we found prepositional phrases in 6 of the 12 children, but only three of them used the construction more than once. Datives involving double-objects were used more often (by 10 of the 12 children). This is in agreement by findings by Snyder and Stromswold (1997), namely that double object datives seem to emerge before the use of prepositional datives. It should be noted,

however, that in our data, the double object datives generally involved the same expression, i.e., "give me X." In short, our examination of preschoolers' spontaneous speech suggests that the use of these forms is limited to very few lexical frames.

Our first experiment was modeled on Bock's initial priming study in 1986. The purpose was to determine if repeating sentences of a particular syntactic form affects the probability of children producing that form in describing a picture. To anticipate, we obtained a substantial effect when children reproduced the priming sentence. Therefore we did a second experiment to explore whether hearing a syntactic form without repeating it is sufficient to produce priming, and whether the effect is of similar magnitude as in the repetition condition. To anticipate again, there was as large an effect in the hearing as in the repetition condition. Finally we did a third experiment to explore whether the priming effect lasts over a series of trials and found that it did.

Experiment 1

In this experiment we aim to determine whether children are more likely to produce a syntactic form after having heard and repeated that form. The question here is whether children's representation of a syntactic form is sufficiently abstract to increase the likelihood of using that form in a sentence that describes different objects and actions and, consequently, involves different nouns and verbs.

Participants

Thirty children, aged 4;5–5;8 years (16 males, 14 females; mean age 4;8) participated in this study. The participants in this and the following experiments were native speakers of English; they were recruited from daycare centers in the Greater Chicago area.

Materials

There were two sets of 20 drawings for each sentence type in the study (40 total). One group of twenty depicted situations that could be described with transitive sentences (active/passive), and the other group of twenty depicted situations that could be described with dative sentences (double-object/prepositional phrase). Half (10) of the drawings in each set were used for the experimenter's sentences and the other half (10) served as test pictures for children to describe. The Appendix presents an example of priming and test stimuli for both transitive and dative conditions. The sentences used by the experimenter to describe priming pictures are also listed in the Appendix.

Procedure

Each child was tested individually. The child was told by the experimenter that they would play a game with pictures. On each trial, the experimenter showed the child a picture and described it. The child was then asked to repeat the experimenter's sentence. Next, the child was presented with a new picture and was asked to describe it. Each child received 10 trials with transitive sentences and 10 trials with dative sentences. Half the children were first tested with the block of transitive sentences and then with the block of dative sentences and the other half received the reversed order. Within a block of transitive trials, children were randomly assigned to receive either active or passive primes. Within a block of dative trials, children were randomly assigned to receive either double-object or prepositional phrases. For each of the two blocks, the pictures that were designated as experimenter's pictures were paired randomly with pictures that were used for children's descriptions. The procedure was audio taped and the children's descriptions were later transcribed.

Results and conclusions

Children's responses were divided into three categories: those that matched the form of the experimenter's sentence, those that used the alternative form (e.g., passive when primed with active or double-object when primed with prepositional datives), and those that matched neither form.

Transitive condition (active/passive)

Sentences were scored as active if they contained an agent in the subject position followed by a transitive verb. These included sentences where the object was either expressed, (e.g., "The bunny was eating the flower") or omitted ("The bunny was eating"). Sentences were scored as passive if they contained a patient in the subject position, followed by an auxiliary (be, get) followed by a transitive verb. As in other developmental language research (e.g., Harris & Flora, 1982; Israel, Johnson, & Brooks, 2000), the passive group included sentences with full passives (e.g., "The flower was eaten by the bunny") and truncated passives, (e.g., "The flower was eaten") (see Fig. 1).

Sentences were scored as "other" when utterances used neither the primed nor the alternative form. This category contained partial sentences (fragments), including the naming of one of the objects, as well as various kinds of complete sentences, for example, full sentences with intransitive verbs (e.g., "He is sleeping."). We calculated the proportion of children's sentences in each category (active, passive, or other) relative to the total number of responses produced by children.

Table 1 shows the number and percentage of sentences in each category that were produced following either active or passive primes. Overall, children were much more likely to produce active sentences in describing pictures of transitive actions. However, they were more likely to use active sentences if they were primed with active sentences (87%) than if they were primed with passive sentences (71%). The use of passive sentences also depended on the priming condition. The likelihood of using passive sentences was negligible after active primes (1%) but was higher after passive primes (15%). Not only did children very rarely produce passives following an active sentence, but the passives they did produce were all truncated. In contrast, 41% of passives, which followed the experimenter's passive sentences, were full passives. It should be noted that for the active priming condition, 12% of children's utterances did not involve a transitive sentence. The "other" responses included fragments (22%) and full intransitive sentences (78%). For the passive priming condition, 14% of children's responses did not involve a transitive sentence. These included fragments (5%), full intransitive sentences (90%), and failure to respond (5%).

Generally, the priming effect is captured by the difference between the use of a particular form following the experimenter's use of that form versus use of that form following the experimenter's use of the alternate form. The examination of active responses showed that children were 16% more likely to produce the active when the experimenter produced an active sentence than when the experimenter produced a passive sentence. The examination of passive responses showed that children were 14% more likely to produce the passive when the experimenter produced a passive than when the experimenter produced an active sentence.

We carried out an ANOVA to determine whether the observed effects of the priming condition were significant. Following Bock and Griffin (2000), we used the proportion of children's utterances containing the less frequent form, the passive, as the dependent variable. As independent variables, we used priming condition (active or passive), gender, and order (i.e., whether transitive or dative constructions were presented first).

Table 1
Priming effects in the repetition condition: Transitive constructions

Priming condition	Child utterance form		
	Active	Passive	Other
Active	131 (87%)	1 (<1%)	18 (12%)
Passive	107 (71%)	22 (15%)	21 (14%)
Difference	+24 (16%)	+21 (14%)	

Number and percentage of children's utterances of particular syntactic forms following experimenter's sentences of the same or alternative form.



The flower was watered by the rain. /
The rain watered the flower.



Fig. 1. Transitive condition. Examples of priming and target stimuli given to children in the transitive condition.



The girl is throwing the boy a ball. /
The girl is throwing a ball to the boy.



Fig. 2. Dative condition. Examples of priming and target stimuli given to children in the dative condition.

The results indicate that there was no significant effect of gender, $F(1, 22) = 2.48$, $p = .13$ or order $F(1, 22) = 2.23$, $p = .10$, nor were there any significant interactions produced by these factors (in all interactions, $p > .05$). The effect of priming condition was highly significant, $F(1, 22) = 12.22$, $p < .01$.

Finally, we investigated whether the observed priming effects could be due to lexical rather than syntactic priming. We found that the verb used by the experimenter in the priming sentence was almost never repeated in the child's sentence. Out of a total of 300 responses (produced by 30 children over 10 trials), only three responses contained the same verb as was used in the prime. Two of these cases involved the verb 'hit'; it was presented in the passive form and used by children in the active form. The third case involved the verb 'break' that was used in active form by both the experimenter and the child.

Dative condition (double object/preposition)

We scored children's sentences as double-object datives if they contained all three arguments of the dative verb with the theme following the goal without a preposition (e.g., "The teacher is reading the children a book"). Sentences were scored as prepositional datives if they contained all three arguments of the dative verb with the goal following the theme and with the prepositions "to" or "for" (e.g., "The teacher is reading a book to the children"). The category of "other" was used to describe children's utterances that followed neither dative form. This category contained partial sentences (fragments), including the naming of one of the objects, as well as various kinds of complete sentences, for example, full sentences with intransitive verbs (e.g., "He is sleeping.") and full sentences with transitive verbs (e.g., "She is kissing the boy"). We calculated the proportion of children's sentences in each category (double-object, prepositional, or other) relative to the total number of responses produced by children (see Fig. 2).

Table 2 shows the number and percentage of sentences in each category produced following either double-object primes or prepositional primes. Unlike in case of actives and passives, there was no overall tendency to produce one of these forms with a higher probability than the other. The likelihood of producing a particular

Table 2
Priming effects in the repetition condition: Dative constructions

Priming condition	Child utterance form		
	Double-object	Preposition	Other
Double-Object	77 (51%)	29 (19%)	44 (30%)
Preposition	20 (13%)	69 (46%)	61 (41%)
Difference	+17 (38%)	+40 (27%)	

Number and percentage of children's utterances of particular syntactic forms following experimenter's sentences of the same or alternative form.

form here was mainly affected by the nature of the experimenter's priming sentence. Children were 38% more likely to produce a double-object dative sentence when the experimenter produced a double-object dative sentence than when the experimenter produced prepositional dative sentences. Children were 27% more likely to produce a prepositional dative sentence when the experimenter produced a prepositional dative sentence than when the experimenter produced double-object dative sentences.

"Other" utterance types were found in 30% of sentences following a double object dative prime. These included full transitive sentences (68%), full intransitive sentences (27%), fragments (3%), and failure to respond (2%). Following prepositional primes, children produced 41% of sentences categorized as "other." These responses categorized as "other" included full transitive sentences (80%), full intransitive sentences (16%), fragments (2%), and failure to respond (2%). Note that four sentences produced by children included a dative verb "give" without one of the required arguments (e.g., "he's giving a banana). They were categorized as "other."

We carried out an ANOVA to determine whether the observed effects of the priming condition were significant. As with transitives, we used the proportion of utterances with the less frequent form, the prepositional dative, as the dependent variable. As independent variables, we used priming condition (prepositional phrase or double-object), gender, and order (i.e., whether transitive or dative constructions were presented first). The results indicate that there was no significant effect of gender, $F(1, 22) = .10$, $p = .75$ or order $F(1, 22) = .01$, $p = .94$, nor were there any significant interactions produced by these factors (in all interactions, $p > .05$). The effect of priming condition was highly significant $F(1, 22) = 11.62$, $p < .01$.

As in the transitive condition, we examined how often children's responses contained the same verb as was presented in the preceding prime by the experimenter. We found a relatively high number (17) of repetitions of

the verb 'give.' However, a closer examination of the data reveals that this finding is more likely to be due to children's frequent use of this verb throughout their responses (114 children's dative sentences contained that verb) than to the effects of lexical priming. Since only one of our priming sentences contained the verb 'give,' we were able to compare the frequency of children's use of that verb before and after it was presented to them. This analysis showed that children were no more likely to use the verb 'give' in their responses following the priming sentence containing this verb (48 times) than prior to that sentence (66 times).

Comparison of transitives and datives

We conducted an analysis to compare how likely children were to produce the primed form in the transitive versus dative conditions. We carried out a paired samples t test with the number of trials in which the child used the primed form as the dependent variable. The results showed no significant difference $t(29) = .37$, $p = .71$, suggesting that there was no difference in sensitivity to these two syntactic constructions.

In conclusion, this study examined whether we would find in young children a phenomenon reported in adults. The phenomenon is that people who repeat a sentence of a particular form are then more likely to use that form to describe a picture involving different objects and actions. This finding in adults was interpreted as indicating that syntactic form is represented independently of particular lexical items. We obtained similar findings in young children: four- and five-year-olds were more likely to use a particular form if it had been used by the experimenter on the previous trial. Since the effect was so clear cut, we next asked whether hearing speech without repeating it is also effective in children. This question is particularly important because listening to speech without repeating it is the most common situation in which natural language acquisition occurs.

Experiment 2

Experiment 2 was designed to explore whether children will be likely to use the experimenter's syntactic form even if they do not repeat the experimenter's sentences. The design of Experiment 2 is identical to Experiment 1, except that, after seeing the experimenter's picture and hearing the sentence, children were not asked to repeat that sentence but rather were immediately presented with their own picture to describe. As noted above, the issue of whether children will use syntactic forms they hear, even if they do not repeat the experimenter's sentence, is potentially important to determining if the processes involved in priming are like those involved in acquisition, since most input to young children is heard without being repeated.

Participants

Thirty children, aged 4;2–5;7 years (14 males, 16 females; mean age 4;5) participated in this study.

Materials

The materials used in this experiment were the same as those used in Experiment 1.

Procedure

The procedure was identical to that in Experiment 1 with one exception: children were presented with the priming sentences by the experimenter but were not asked to repeat them.

Results and conclusions

As in Experiment 1, children's responses were transcribed from audio tape and scored as to whether they matched the presented form, the alternative form, or neither.

Transitive condition (active/passive)

Children were overall more likely to produce active rather than passive sentences. However, the use of both active and passive forms varied depending on the priming condition. As shown in Table 3, children were far more likely to use the active when the experimenter produced active sentences (89%) than when the experimenter produced a passive sentence (67%). Passive sentences rarely occurred following an active sentence (1%), but they occurred more frequently following a passive sentence (24%). Thus, children were 22% more likely to produce the active sentence following an active rather than a passive prime. Furthermore, children were 23% more likely to produce a passive sentence following a passive rather than an active prime. Note that in 8% of the passives, children used the "verb + from" construction (e.g., "The man was hurt from the storm"). The remaining utterances were scored as "other"; these

Table 3
Priming effects in the no-repetition condition: Transitive constructions

Priming condition	Child utterance form		
	Active	Passive	Other
Active	133 (89%)	2 (1%)	15 (10%)
Passive	100 (67%)	36 (24%)	14 (9%)
Difference	+33 (22%)	+34 (23%)	

Number and percentage of children's utterances of particular syntactic forms following experimenter's sentences of the same or alternative form.

included 10% of utterances produced after active primes and 9% of utterances produced after passive primes. For the active priming condition, 67% of "other" responses were full intransitive sentences, and 33% were fragments. For the passive priming condition, 72% of "other" were full intransitive sentences, 14% were fragments, and 14% were failure to respond.

We carried out an ANOVA to determine whether the effects of the priming condition were significant. We used the proportion of utterances containing passives relative to the total number of transitive utterances produced by the child as the dependent variable. As independent variables, we used priming condition (passive or active), gender, and order (i.e., whether transitive or dative constructions were presented first). The results indicate that there was no significant effect of gender, $F(1, 22) = .49, p = .49$ or order $F(1, 22) = .03, p = .88$, nor were there any significant interactions produced by these factors (in all interactions, $p > .05$). The effect of priming condition was highly significant $F(1, 22) = 29.22, p < .001$.

We investigated whether the observed priming effects could be due to lexical rather than syntactic priming. As in Experiment 1, we found that the verb used by the experimenter in the priming sentence was almost never repeated in the child's sentence. In fact, there was just one response sentence in which the same verb ("eat") was used; it was presented in a passive prime and used by the child in the active form.

Dative condition (double object/preposition)

The results for the dative condition are presented in Table 4. As in Experiment 1, there was no overall tendency to produce one of the dative forms with a higher probability than the other. This is in contrast to transitive sentences, where children show an overall tendency to produce active rather than passive sentences. The likelihood of producing a particular form here was mainly affected by the nature of the experimenter's sentence. Children were far more likely to use the

Table 4
Priming effects in the no-repetition condition: Dative constructions

Priming condition	Child utterance form		
	Double-object	Preposition	Other
Double-object	63 (42%)	22 (15%)	65 (43%)
Preposition	41 (27%)	61 (41%)	48 (32%)
Difference	+22 (15%)	+39 (26%)	

Number and percentage of children's utterances of particular syntactic forms following experimenter's sentences of the same or alternative form.

double-object form when primed with double-object sentences (42%) than if they were primed with prepositional sentences (27%). Children were also far more likely to use the prepositional form when primed with prepositional sentences (41%) than when primed with double-object sentences (15%). Similar to the dative results in Experiment 1, 32% of children's utterances produced in the double-object priming condition were "other," that is, not of the dative form. These included full transitive sentences (68%), full intransitive sentences (17%), fragments (9%), and failure to respond (6%). Following prepositional primes, children produced 43% of sentences categorized as "other." These included full transitive sentences (77%), full intransitive sentences (17%), fragments (2%), and failure to respond (4%). Note that four sentences produced by children included a dative verb "give" without one of the required arguments (e.g., "He's giving a banana). They were categorized as "other."

We carried out an ANOVA to determine whether the effects of the priming condition were significant. We used the proportion of utterances containing a prepositional dative relative to the total number of dative utterances produced by the child as the dependent variable. As independent variables, we used priming condition (prepositional phrase or double-object), gender, and order (i.e., whether transitive or dative constructions were presented first). The results indicate that there was no significant effect of gender, $F(1, 22) = .28$, $p = .60$ or order $F(1, 22) = 1.96$, $p = .18$, nor were there any significant interactions produced by these factors (in all interactions, $p > .05$). The effect of priming condition was significant $F(1, 22) = 7.46$, $p = .01$.

We examined how often children's responses contained the same verb as was presented in the preceding prime by the experimenter. The results were very similar to those in Experiment 1. We found a relatively high number (18) of repetitions of the verb 'give,' as well as an overall high frequency of children's use of that verb (127 responses). Again, we found that children were no more likely to use 'give' following the priming sentence containing that verb (53) than prior to that sentence (74).

Comparison of transitives and datives

We compared how likely children were to produce the primed form in the transitive versus dative conditions. We carried out a paired samples *t* test using the number of trials in which the child used the primed form as the dependent variable. The results showed no significant difference $t(29) = 1.83$, $p = .08$.

Comparison of priming with and without repetition

We addressed the further question of whether the priming effect varied depending on whether the child repeated the experimenter's sentence (as in Experiment 1) or simply listened to it (as in Experiment 2). We were

able to compare results across experiments statistically because, although these experiments were run in succession, the subject pool was determined prior to running any subjects, and the participants for particular experiments were randomly selected for each experiment.

The priming effects across the two experiments we examined separately for transitives and datives. For transitives, we carried out an ANOVA with two independent variables (repetition condition—Experiment 1 versus Experiment 2, and priming condition—active versus passive). The dependent variable was the proportion of passives relative to the total number of transitive utterances produced by the child. The results of this analysis showed a highly significant effect of priming condition $F(1, 56) = 47.92$, $p < .0001$. The repetition condition (i.e., Experiment 1 vs. 2) was not a significant factor $F(1, 56) = 3.22$, $p > .05$. For datives, we carried out an ANOVA with two independent variables parallel to those in the analysis above. The dependent variable was proportion of prepositional datives relative to the total number of dative utterances produced by the child. The results of this analysis showed a highly significant effect of priming $F(1, 56) = 29.09$, $p < .0001$. The repetition condition (i.e., Experiment 1 vs. 2) was not a significant factor $F(1, 56) = .94$, $p > .05$.

In conclusion, our experiments demonstrated that just listening to the priming sentences increases the likelihood of producing the primed form. We directly compared the priming effects with or without repetition of the priming sentence. Previous work with adults did not allow for such comparison because very different tasks were employed in the two kinds of studies. Here, we used the same task and varied only whether the child repeated the sentence or not; we found that the priming effect was similar in size whether or not the child repeated the priming sentence.

Experiment 3

In this study, we examined whether priming lasts past just one trial. Bock and Griffin (2000) found that priming lasts even when several trials involving different syntactic forms intervene. In this study, we presented children with a block of 10 pictures, each described by the experimenter. Then children described a set of 10 test pictures in succession without further input from the experimenter. We examined whether children's picture descriptions were affected by the form of the experimenter's sentences over the entire set of test trials.

Participants

Thirty children, aged 4;1–5;7 years (16 males, 14 females; mean age 5;3) participated in this study.

Materials

The materials used in this experiment were the same as those used in Experiments 1 and 2.

Procedure

Children were tested individually. They were told that they were going to play a game, and that they would first listen to the experimenter describe some pictures, and later would be asked to describe some new pictures. The experimenter proceeded to describe a set of 10 pictures, using a particular sentence form. Children were then shown a new set of 10 pictures which they were asked to describe. As with the previous experiments, each child received both transitive and dative trials. The trials were blocked by type of sentence—half of the children first were tested in the transitive condition and then in the dative condition and for the other half of children the order was reversed. Within a block of transitive trials, children were randomly assigned to receive either active or passive primes. Within a block of dative trials, children were randomly assigned to receive either double-object or prepositional phrases. The procedure was audio taped and children's responses were transcribed from audiotape.

Results and conclusions

As in Experiments 1 and 2, children's picture descriptions were scored as to whether they matched the presented form, the alternative form, or neither of these forms.

Transitive condition (active/passive)

Table 5 shows that children were more likely to produce active rather than passive sentences. Again, children were more likely to use active sentences when primed with actives (79%) than when primed with passives (74%). The use of passives also depended on the priming condition. Passive sentences rarely occurred following active sentences (3%) but were more frequent

Table 5
Priming effects in the blocked condition: Transitive constructions

Priming condition	Child utterance form		
	Active	Passive	Other
Active	118 (79%)	5 (3%)	27 (18%)
Passive	111 (74%)	24 (16%)	15 (10%)
Difference	+7 (5%)	+19 (13%)	

Number and percentage of children's utterances of particular syntactic forms following experimenter's sentences of the same or alternative form.

following a passive sentence (16%). Thus, children were 5% more likely to produce the active after the experimenter produced an active sentence than after the experimenter produced a passive sentence, an effect that is smaller than in the previous priming conditions. Children were 13% more likely to produce a passive sentence following a passive rather than an active prime. Note that in 7% of the passives, children used the "verb + from" construction (e.g., "The man was hurt from the storm"). The remaining sentences were scored as "other." Nineteen percent of these sentences were produced following active primes; 37% of them were full intransitive sentences; 48% were fragments; 15% were failure to respond. After passive primes, 10% of responses were counted as "other;" these included full intransitive (47%) sentences, fragments (47%), and failure to respond (6%).

We carried out an ANOVA to determine whether the effects of the priming condition were significant. We used the proportion of utterances containing a passive relative to the total number of transitive utterances produced by the child as the dependent variable. As independent variables, we used priming condition (passive or active), gender, and order (i.e., whether transitive or dative constructions were presented first). The results indicate that there was no significant effect of gender, $F(1, 22) = 1.10, p = .32$ or order $F(1, 22) = .10, p = .75$, nor were there any significant interactions produced by these factors (in all interactions, $p > .05$). The effect of priming condition was significant $F(1, 22) = 7.80, p = .01$.

Dative condition (double object/preposition)

Table 6 shows that as in Experiments 1 and 2, there was no overall tendency to produce one of these forms with a higher probability than the other. This is in contrast to transitive sentences, where children showed an overall tendency to produce active rather than passive sentences. The likelihood of producing a particular form here was mainly affected by the nature of the experimenter's sentence. Children were far more likely to

Table 6
Priming effects in the blocked condition: Dative constructions

Priming Condition	Child Utterance Form		
	Double-Object	Preposition	Other
Double-object	55 (37%)	35 (23%)	60 (40%)
Preposition	32 (21%)	53 (35%)	66 (44%)
Difference	+24 (16%)	+18 (12%)	

Number and percentage of children's utterances of particular syntactic forms following experimenter's sentences of the same or alternative form.

use the double-object form when primed with double-object sentences (37%) than if they were primed with prepositional sentences (21%). They were also far more likely to use the prepositional form when primed with prepositional sentences (35%) than when primed with double-object sentences (23%). Thus, children are 16% more likely to use the double-object dative when the experimenter produced a double-object sentence than when the experimenter used a prepositional sentence. Children were 12% more likely to use the prepositional dative when the experimenter used a prepositional sentence.

The remaining responses were scored as “other.” Following double-object primes, children produced 40% of such responses. These included full transitive sentences (63%), full intransitive sentences (15%), fragments (20%), and failure to respond (2%). Following prepositional primes, children produced 44% of sentences categorized as “other.” These included full transitive sentences (53%), full intransitive sentences (15%), fragments (30%), and failure to respond (2%). Note that three sentences produced by children included a dative verb “give” without one of the required arguments (e.g., “He’s giving a banana”). They were categorized as “other.”

We carried out an ANOVA to determine whether the effects of the priming condition were significant. We used the proportion of utterances containing a prepositional dative relative to the total number of dative utterances produced by the child as the dependent variable. As independent variables, we used priming condition, gender, and order (i.e., whether transitive or dative constructions were presented first). The results indicate that there was no significant effect of gender, $F(1, 22) = .61, p = .44$ or order $F(1, 22) = 1.40, p = .25$, nor were there any significant interactions produced by these factors (in all interactions, $p > .05$). The effect of priming condition was marginally significant $F(1, 22) = 4.21, p = .05$.

Comparison of transitives and datives

In further analysis, we compared how likely children were to produce the primed form in the transitive versus dative conditions. We carried out a paired samples t test using the number of trials in which the child used the primed form as the dependent variable. The results showed no significant difference $t(29) = 1.63, p = .11$ in the size of the priming effect for the two syntactic constructions.

Priming effects over time

We examined the time course of the priming effect across the 10 test trials in which children produced their picture descriptions. Unlike Experiments 1 and 2, where every test trial was preceded by a priming event, here 10 priming sentences were massed in the beginning of the

procedure, and then there were 10 test trials where children produced their sentences without any additional input from the experimenter. If the priming effect observed over the course of the 10 trials would decrease, it would indicate that the priming effect is brief, and critically depends on the proximity to exposure to the primed form. To examine this issue, we compared the likelihood of the child producing the “primed” form in the first versus second half of the test trials. There was no significant difference either for the transitive condition, $t(30) = .19, p > .05$ or for the dative condition, $t(30) = .59, p > .05$. Thus the effect does not decrease over 10 trials. There are two possible explanations for this finding. The first possibility is that children’s sentences on a particular trial might serve as primes for the next trial. The second possibility is that the effect of exposure to experimenter’s sentences lasts for at least 10 trials.

To determine if the priming effects in this experiment could be due to an influence of children’s own responses on their subsequent performance, we examined the likelihood that children would produce a particular form after producing it versus not producing it on the immediately preceding trial. For the transitive condition, we analyzed children’s passives; we found that 25% of their passives were produced following their own passive utterances, whereas 75% of their passives were following other forms. For the dative condition, we analyzed children’s prepositional phrase datives; we found that 29% of such datives were produced following their own utterances with prepositional phrase datives, whereas 71% of their prepositional phrase datives followed other forms. Thus, in both cases, children were no more likely to produce a particular form given that they had produced it on the previous trial than otherwise. This pattern of results indicates that priming effects last for at least 10 trials.

Overall discussion

In our earlier work we found substantial effects of input on the level of syntactic skill in four-year-olds (Huttenlocher et al., 2002). This work showed that the complexity of incoming speech by parents and teachers was strongly related to the complexity of children’s spontaneous speech and to their comprehension ability. However, in that study, we did not address the question of how children’s competence should be characterized. It seemed to us that the experimental technique of syntactic priming, used in work with adults, might be of value in this regard. The priming technique involves presenting sentences of particular syntactic forms and determining if people are likely to use the same forms in describing situations that involve different objects and events (and hence require the use of different lexical

items). Thus the priming technique provides a test of sensitivity to syntactic forms across a range of lexical items.

In the present study we used the priming technique with preschool children. We presented the same constructions as in the adult studies (transitives and datives) to examine if the alternate forms of these constructions can be primed in children. Before carrying out the priming studies we examined spontaneous speech to determine the productivity of these forms in children. We found that the use of passives and the two forms of the dative was restricted to a limited number of lexical frames. While the productivity of these forms in the speech of four-year-old children was limited, we found that it was easily possible to increase their usage by the manipulation of input in the priming task.

In our first experiment, children listened to the priming sentence, repeated it and then were asked to describe pictures of simple events. Children showed substantial priming effects for both transitive and dative constructions. In our second study, the procedure was parallel except that children simply listened to the priming sentence before being presented with the test picture. We found that priming effects in this task were comparable to those obtained in the first study. In our third study we explored the possibility of increasing the productivity of transitive and dative forms in a different design. We presented children with a block of sentences of a particular form and then examined the effect of this exposure on children's use of that form over a set of test trials. We found that priming sentences had an effect on children's production of syntactic forms over a whole set of test trials. Let us consider the implications of the findings of the present studies.

The representation of syntactic form

Some investigators of syntactic development in very young children have argued that early syntactic representations may be tied to a small set of lexical items (Olguin & Tomasello, 1993; Pine et al., 1998; Tomasello, 2000). In this case syntactic priming would not be found because there would be no link among sentences that have a common syntactic form but different lexical items. In the present studies we examined somewhat older children. We found indications that children do represent certain syntactic patterns at an abstract level. Namely, the finding that children showed priming effects across the range of lexical items indicates that they have generalized syntactic forms for expressing transitive and dative relations. Recall that, in our priming tasks, the test pictures involved objects and actions that were different from those used in the set of priming sentences. In fact, the test pictures were randomly paired with priming sentences across children to ensure that the effects were not based on differential similarity of particular pairings.

One might expect that extracting a common syntactic structure from sentences with different lexical items would require a high level of proficiency with various instances of the form. However, our analysis of spontaneous speech suggests an alternative possibility. We found that passives and the two forms of the dative construction were infrequent in spontaneous production, and were used within a limited number of lexical frames. Furthermore, our previous work has shown that comprehension tasks involving dative and passive sentences were difficult for children of four and five years of age. These results suggest that children may demonstrate the use of an abstract form in a priming study even when that form is not fully available for on-line use in various situations.

There has not yet been a systematic investigation of the relation between the level of abstractness of syntactic representations and proficiency in the use of syntactic structures. It is not yet clear when abstract representations of syntactic structures emerge. Children may begin by acquiring patternings of particular lexical items. As Tomasello (2000) argued, they may then start to notice similarities among different specific patternings that they acquired, forming initial generalizations about syntactic forms and their pairings with meaning. Even after generalizations have been formed, children may require favorable circumstances to produce particular syntactic forms—they may use them only in situations that are familiar and hence easily conceptualized, or after recent exposure to the lexical items or the forms. Further exposure may be needed to achieve sufficient ease of access to support on-line use in production or comprehension situations. Our findings show that the abstract form needed to obtain priming effects may arise before the representation of syntactic structure is mature. It seems that a syntactic form may be represented at some general level, and yet can be further strengthened through experience.

The relation between comprehension and production

As in work with adults, the present studies with preschool children show priming effects in both repetition and no-repetition conditions. However, the magnitude of the effect across these conditions could not be compared in the adult studies because very different methods were used (Bock, 1986; Branigan et al., 2000). Our studies with children showed that priming effects in the two conditions were comparable. That is, listening to and producing the sentence (as in Experiment 1) and simply listening to the sentence (as in Experiment 2) had a similar impact on children's subsequent sentence production. This finding lends support to the view that a common representational system underlies both the production and comprehension of syntactic forms.

Another type of evidence pointing to the link between comprehension and production comes from developmental literature showing that, starting quite early in grammatical development, the levels of performance on comprehension and production tasks are closely linked (although some data suggest that in the earliest multi-word utterances these two aspects of syntax are somewhat distinct, e.g., Hirsh-Pasek & Golinkoff, 1991). In the Huttenlocher et al. (2002) study we found a very strong relation between the ability of four-year-old children to comprehend complex syntactic forms and their production of these forms.

The idea that there is a relation between comprehension and production of various aspects of language has a long history. In the domain of speech sounds, the motor theory of speech perception held that “perception of phonemes made reference to the system involved in producing those same sounds” (Liberman, 1993; also see Liberman & Mattingly, 1985; Studdert-Kennedy, Liberman, Harris, & Cooper, 1970). In the domain of syntax, Branigan et al. (2000) provide data indicating syntactic alignment between people comprehending and producing speech in dialogue. It has been suggested that such alignment provides an effective mechanism for carrying out a conversation – “... a representation that has just been constructed for the purposes of comprehension can then be used for production (or vice versa)” (Pickering & Garrod, in press).

Findings showing a correspondence between comprehension and production of language lend support to a general theoretical view which holds that many aspects of behavior involve structures that link the observation of action to the execution of action (Rizzolatti & Arbib, 1998). This phenomenon has been discussed with respect to gesture and grasping as well as language. Indeed, mirror neurons have been found which respond selectively both to the observation of various actions and to the execution of those actions (Rizzolatti, Fadiga, Fogassi, & Gallese, 2002). If there is such a system that links incoming language to production, one would predict the results we obtained in our studies, namely that priming effects are similar regardless of whether people simply listen to an experimenter’s sentence or have to produce it. Note though that positing a common representational system does not imply that the processing mechanisms involved in comprehension and production are the same.

Retention of syntactic form over time

Recall that it was originally believed that priming involved a very brief activation of syntactic structures. However, later studies provided evidence that the effect lasts over a number of trials (Bock & Griffin, 2000). Having found that priming in adults persisted over trials, Bock and Griffin interpreted this finding as possible

evidence of implicit learning—“structural priming can arise within a system that is organized for learning how to produce sequences of words” (p. 189). These studies led us to carry out our third experiment where we presented children with a block of priming sentences and then asked them to describe a series of 10 pictures without further exposure to the primed form. We found that the priming effect in children lasted over the entire set of test trials, and that the effect was not due to children priming their own responses.

While our data are not directly relevant to questions of language acquisition, the findings do suggest the possibility that the effect we have observed involves learning. That is, we have seen that exposure to particular syntactic forms increases children’s use of these forms, at least over 10 trials. The question of whether syntactic priming reflects transient activation or implicit learning clearly depends on whether increase in use of particular forms persists over even longer periods of time. Determining the mental processes underlying syntactic priming is an ongoing endeavor, and further studies are needed to establish whether a long-lasting structural change underlies the effects observed in priming studies, or whether the syntactic form is only temporarily activated for sentence processing.

Sentence retention: Form and meaning

In studies of sentence recall, it has been shown that people retain the meanings of sentences for a longer period of time than the syntactic structures of the sentences (Jarvella, 1971; Sachs, 1967; cf., Clark & Clark, 1977). Indeed, it has been claimed that surface structure is processed in the service of extracting meaning and that, once the meaning of a sentence is extracted, its syntactic structure is lost. In attempting to recall a sentence later, people would then use sentence meaning to regenerate grammatical form. In this case, any of the possible forms in which the meaning could be expressed might appear in recalled sentences. However, more recent research has shown that the syntactic structure of the original sentence is in fact retained.

Lombardi and Potter (1992) found that, when presented with a sentence containing a dative construction in one of its two possible forms, adults tend to recall the sentence as involving that same surface form as the original sentence. Although the dative construction can be expressed in two alternative forms, and either form can potentially be used to express the meaning of the sentence, they produced the form they had heard. In constructivist grammar it has been claimed that sentence form is inseparable from sentence meaning (Goldberg, 1998; Langacker, 2000). As Goldberg suggests, “the basic clausal pattern of language represents pairings of form and function” (p. 215). In some cases, it is obvious that surface syntactic form is essential in conveying

meaning—as in the case of poetry. Our findings indicate that young children, like adults, are sensitive to syntactic form itself—they retain and use particular syntactic forms even when there are alternative ways to express the same meaning.

Appendix

The following sentences were paired with pictures as priming stimuli:

Transitive sentences (passive/active)

1. The town was flooded by the river./The river flooded the town.
2. The window was broken by the ball./The ball broke the window.
3. The house was hit by the truck./The truck hit the house.
4. The school was struck by the tornado./The tornado struck the school.
5. The car was buried by the snow./The snow buried the car.
6. The boat was rocked by the waves./The waves rocked the boat.
7. The car was covered with the blanket./The blanket covered the car.
8. The tree was eaten by the beaver./The beaver ate the tree.
9. The dirt was dumped by the truck./The truck dumped the dirt.
10. The flower was watered by the rain./The rain watered the flower.

Dative sentences (double object/prepositional dative)

1. The boy is feeding the dog a bone./The boy is feeding a bone to the dog.
2. The man is showing the children a rock./The man is showing a rock to the children.
3. The boy is bringing his mother some tea./The boy is bringing some tea to his mother.
4. The lady is serving the man some salad./The lady is serving some salad to the man.
5. The girl is teaching her dog a trick./The girl is teaching a trick to the dog.
6. The mother is buying her baby some clothes./The mother is buying some clothes for her baby.
7. The dad is giving his daughter some ice cream./The dad is giving some ice cream to his daughter.
8. The mother is baking a pie for her children./The mother is baking her children a pie.
9. The postman is delivering a letter to the girl./The postman is delivering the girl a letter.
10. The boy is throwing the girl a ball./The boy is throwing a ball to the girl.

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