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PROSODIC STRUCTURE IN YOUNG CHILDREN'S LANGUAGE PRODUCTION

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Research in prosodic phonology, as well as experiments on adult speech production, suggest that segmental and suprasegmental processes in language are not governed directly by syntactic structure. Rather these processes reflect an independent prosodic structure, which includes prosodic categories such as metrical foot, prosodic word, and phonological phrase. Five experiments examined English-speaking two-year-olds' omissions of object articles in different prosodic structures. The data indicate that children omit unfooted syllables and that foot boundaries, in turn, are influenced by prosodic word and phonological phrase boundaries. Thus, it appears that children create prosodic structures remarkably similar to those proposed in theories of prosodic phonology.*

1. Introduction. Recent work in linguistics has focused on the relationship between phonology and syntax (Ferreira 1991, 1993, Gee & Grosjean 1983, Hayes 1989, Inkelas & Zec 1990, Kaisse 1985, Nespor & Vogel 1986, Selkirk 1986). In particular, there is a growing interest in the notion that syntactic units, such as word and phrase, do not directly influence phonological phenomena such as stress assignment and pausing. Rather, a variety of observations suggest that these phenomena reflect an independent prosodic structure. Prosodic structures are influenced by syntactic structures, but comprise hierarchical arrangements of prosodic units, such as syllable, foot, prosodic word, and phonological phrase. Prosodic Phonology is the name given to the study of these prosodic units and their structural relations.

Prosodic phonology has several implications for language development. If adults produce prosodic changes in accordance with prosodic structure, infants and young children might use prosodic cues in the speech stream to discover this structure. Consistent with this hypothesis, Gerken et al. 1994 found that, when prosodic structure was not isomorphic with syntactic structure, nine-month-olds were sensitive to prosodic units, not syntactic units. Other research suggests that even very young children use prosodic units to organize their own intended utterances (Allen & Hawkins 1980, Demuth 1995, Fee in press, Fikkert 1994, Gerken 1991, 1994a,b, Kehoe 1994, Wijnen et al. 1994). Although most of these studies focused on prosodic effects in children's word productions, some data suggest that children employ prosodic structure to organize their intended sentences as well (Gerken 1991, 1994a,b, Gerken et al. 1990).

The goal of this article is to expand upon previous observations of prosody's role in young children's sentence production, and in particular, to test the hypothesis that children organize their intended utterances into metrical feet, which are embedded within prosodic words, which are in turn embedded within

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phonological phrases. They omit object articles that are unfooted in these prosodic structures. Data from five experiments support this hypothesis and suggest that children create prosodic structures quite similar to those currently proposed within theories of prosodic phonology and as evidenced by experiments on adult speech production.

2. OVERVIEW OF PROSODIC PHONOLOGY. Before turning to evidence for prosodic structure in the speech of young children, let us begin with a brief overview of some prosodic units and their proposed organization within theories of prosodic phonology (see also Dresher 1996). The units that are important for the present discussion are the syllable, foot, prosodic word, and phonological phrase. Prosodic structure can be expressed as well-formed trees (or bracketing equivalents), such that the lines of the tree cannot cross (e.g. syllables that belong to a single foot cannot belong to two prosodic words; see Fig. 1). It has also been proposed that prosodic structures conform to one or more domination constraints, sometimes referred to as strict layering constraints (Inkelas 1989, Ito & Mester in press, McCarthy & Prince 1993, Nespor & Vogel 1986, Selkirk 1980, 1984). According to Selkirk 1996 there are four domination constraints: The LAYEREDNESS CONSTRAINT holds that a lower category (e.g. syllable) cannot dominate a higher category (e.g. foot). The HEADEDNESS CONSTRAINT holds that each higher category must dominate the next lower category (e.g. a prosodic word must dominate a foot). The NONRECURSIVITY CONSTRAINT holds that no prosodic category can dominate itself (e.g. a foot cannot dominate a foot). Finally, the EXHAUSTIVITY CONSTRAINT, which is critical for the current discussion, states that each unit in the prosodic hierarchy is dominated by the immediately higher unit (e.g. a prosodic word cannot immediately dominate a syllable). Selkirk and others further suggest that the layeredness and headedness constraints are inviolable, while the nonrecursivity and exhaustivity constraints can be violated. Violations of the exhaustivity constraint are at the heart of the proposal offered here and will be discussed in more detail below.

Beginning with the smallest prosodic unit under consideration, all utterances can be thought of as comprising some number of syllables. Syllables can either be stressed (denoted by S) or stressless (denoted by w for weak). Metrical feet are composed of a single stressed syllable plus at most one adjacent unstressed syllable. Thus, in Fig. 1, the lexical word *likes* comprises a monosyllabic foot, and *brother* and *bananas* each comprises a disyllabic foot. The first syllable of

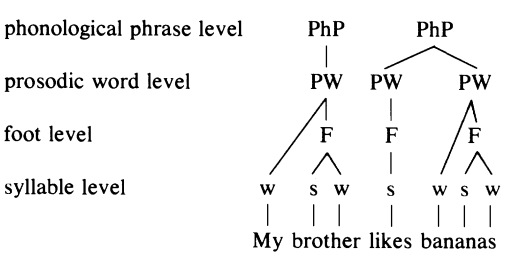


FIGURE 1. Prosodic structure of a sentence

bananas does not belong to any foot and therefore constitutes a violation of the exhaustivity constraint outlined above. Such unfooted initial syllables are relatively common in English words, although no words have more than one, which will be important in the research presented here (see experiment 2).

The prosodic level above the metrical foot is the prosodic word, which is the first prosodic category applicable to multiword utterances.[1] Prosodic words are composed of one or more feet from a single lexical word plus adjacent function words, such as auxiliaries, conjunctions, and prepositions (Hayes 1989, Kaisse 1983, Klavans 1985, Nespor & Vogel 1986, Selkirk 1984, Selkirk & Shen 1990, Zwicky & Pullum 1983). In Fig. 1, the function word *my* forms a prosodic word with the following lexical word *brother*. Note that, like the first syllable of *bananas, my* does not belong to a foot but attaches directly to a prosodic word and therefore constitutes a violation of the exhaustivity constraint. On most accounts of prosodic phonology, function words form prosodic words with the adjacent content word in the same syntactic phrase (e.g. Nespor & Vogel 1986). Thus, an object article would form a prosodic word with the following noun, because both are contained in the same NP (but see Wheeldon & Lahiri 1995). This constraint is not absolute, however; for example, an auxiliary verb can form a prosodic word with the sentential subject (e.g. *Mary's* coming), even though the auxiliary is part of the VP (Inkelas 1989, Kaisse 1985, Klavans 1985, Selkirk 1996).

Phonological phrases are composed of prosodic words up to and including the heads of syntactic phrases (Hayes 1989, Jackendoff 1977, Nespor & Vogel 1986). Heads must be members of the syntactic categories Noun, Verb, or Adjective (Nespor & Vogel 1986). Thus, the subject NP *my brother* is both a syntactic phrase and a phonological phrase. In some languages, including English, a phonological phrase that comprises only one prosodic word, and that is the complement of a preceding syntactic head, may be incorporated into the phonological phrase containing the head (phonological phrase restructuring, Nespor & Vogel 1986). Consistent with phonological phrase restructuring, the verb and object NP form a single phonological phrase in Fig. 1.

Because phonological phrases are defined in terms of syntactic phrases, one form of evidence for the existence of phonological phrases as distinct entities comes from cases in which phonological and syntactic phrases are not isomorphic. Two cases will be important in the current work. One nonsyntactic influence on phonological phrase structure is discourse level information. This is illustrated in the comparison of sentences 1a and 1b, below (PhP = phonological phrase). In 1a, the verb and object NP occupy the same phonological phrase. But in 1b, the presence of focal or contrastive stress on the verb causes the placement of a phonological phrase boundary after the stressed word (Rochemont 1986, Selkirk 1984, Vogel & Kenesei 1990). Research with infants

[1] The prosodic unit labeled PROSODIC WORD in the current discussion is very similar in character to the CLITIC GROUP in other works (e.g. Gerken 1994a, Hayes 1989, Nespor & Vogel 1986). The reason that I have chosen to use prosodic word is that the data suggest that this unit in fact behaves much like a lexical word (see experiment 2; also see Dresher 1996).

suggests that they detect a phonological phrase boundary after words receiving focal stress (Gerken et al. 1994).

(1) a. [He kissed the dog]$_{PhP}$ b. [He **kissed**]$_{PhP}$ [the dog]$_{PhP}$

The other nonsyntactic influence on phonological phrase structure that will figure in the current work is phrase length. Within prosodic phonology, object NPs comprising two or more prosodic words cannot be incorporated into the phonological phrase containing the verb. Thus, while an object NP that comprises a determiner and a noun typically forms a phonological phrase with the verb (2a), an object NP comprising an adjective-noun sequence must form its own phonological phrase (2b) (Hayes 1989, Nespor & Vogel 1986).

(2) a. [He kissed the dog]$_{PhP}$ b. [He kissed]$_{PhP}$ [the big dog]$_{PhP}$

In the foregoing description of prosodic phonology, it is possible to discern two general types of constraints on prosodic structures. One type is prosodic domination constraints that govern the relations among prosodic units at different levels in a prosodic structure (e.g. the exhaustivity constraint). The other type of constraint specifies the mapping between syntactic and prosodic structures. Prosodic words, for example, should respect syntactic constituency. As they have been described here, neither the exhaustivity constraint nor prosody-syntax mapping constraints appear to be absolute. For example, weak initial syllables of lexical words violate exhaustivity by not attaching to a foot, and prosodic words can sometimes be formed across syntactic boundaries. The notion that prosodic structures are formed based on a set of violable constraints is consistent with optimality theoretic approaches to prosodic phonology (e.g. Demuth 1995, Fee in press, Hammond et al. 1995, McCarthy & Prince 1993, Selkirk 1996). In optimality theory (OT), constraints are ranked, and an optimal structure may conform to higher ranked constraints while violating lower ranked ones. I adopt here the flavor of OT, but a full OT analysis of the data is beyond the scope of this article (see Massar 1996).

The five experiments presented below examine the role of three prosodic units and their structural organization in young children's sentence production. Experiments 1 and 2 examined the role of feet. Experiment 3 tested the hypothesis that feet are contained within prosodic words. Experiments 4a–b examined the influence of focal stress on phonological phrase boundaries, and experiments 5a–c tested the role of phrase length on phonological phrase restructuring.

3. EXPERIMENT 1. Young children learning English, as well as other languages, often fail to produce many of the weak syllables that would be included in the adult forms of their utterances. For example, *giraffe* is often produced as *raffe*. Several researchers have observed patterns in children's weak syllable omissions that implicate the metrical foot as an important prosodic unit in their speech production (Allen & Hawkins 1980, Demuth 1992, 1995, Gerken 1991, 1994a,b, Gerken et al. 1990, Kehoe 1994, Pye 1983, Wijnen et al. 1994). In particular, researchers have observed that children do not omit all weak syllables equally frequently, but rather omit weak syllables occurring in some metrical patterns more frequently than others. For example, children do not omit

the word-final weak syllable of strong-weak (Sw) words like *zebra,* while they frequently omit the initial weak syllable of wS words like *giraffe* and wSw words like *banana* (e.g. Klein 1981).

To account for this pattern of weak syllable omissions, Gerken (1991, 1994a,b, Gerken et al. 1990) proposed that young English-speakers apply to their intended utterances a metrical foot production template for a strong syllable followed by an optional weak syllable (S-(w)). Strong syllables of the template are aligned with strong syllables in the intended utterance, and weak syllables that do not fit the template are omitted. Within the theory of prosodic phonology, the S-(w) PRODUCTION TEMPLATE HYPOTHESIS can be stated in terms of the exhaustivity constraint defined earlier: Syllables that do not attach to feet, and therefore violate the exhaustivity constraint, are more likely to be omitted than syllables that obey the exhaustivity constraint. The EXHAUSTIVITY HYPOTHESIS is the focus of all the experiments reported here.

The foot structures of three multisyllabic words are illustrated in sentences 3a–c (capital letters indicate strong syllables). The two syllables of *zebra* form a disyllabic foot. In contrast, neither the first syllable of *giraffe* nor that of *banana* belongs to a foot. Therefore the first syllables of both words violate the exhaustivity constraint, as indicated by the asterisks.[2]

(3) a. ZEbra b. giRAFFE c. baNAna

```
  | |        | |          | | |
 S---w      *  S-(w)     *  S--w
```

Examples like those in 3 leave open the possibility that children omit word-initial weak syllables, not syllables that do not attach to feet (e.g. Echols 1993, Echols & Newport 1992). Observations of children's weak syllable omissions from longer words, however, suggest that unfooted syllables, not word-initial syllables, are the ones susceptible to omission (Gerken 1994a,b, Kehoe 1994, Wijnen et al. 1994). I found for instance (Gerken 1994a,b) that children omitted the second weak syllable more frequently than the first in their imitations of four-syllable nonsense words, like 4, that exhibited an SwwS pattern. Note that the most frequently omitted syllable is not word initial, but it does fail to attach to an S-w foot. Therefore, it appears that unfooted syllables are susceptible to omission from children's productions of multisyllabic words.

(4) ZAMpakaSIS

```
|    | | |
S----w * S-(w)
```

There is also some indication that children omit unfooted syllables from sentences: they omit unstressed function words that occur in sentence-initial position more frequently than those occurring inside the sentence (Gerken 1991; see also McGregor & Leonard 1994). Children omit the subject pronoun in 5a more frequently than the object pronoun, and they omit the subject article in 5b more frequently than the object article.

[2] Only two levels of stress, stressed (capitalized syllables) and unstressed (lower case syllables) are needed for the current discussion.

(5) a. he KISSED her

```
|  |       |
*  S---------w
```

b. the LAMB KISSED the BEAR

```
|  |     |       |  |
*  S-(w)  S--------w  S-(w)
```

Children also appear to omit unfooted syllables in sentence-internal positions. For example, they omit the object article more frequently than the syllabic verb inflection in sentences like 6 (Gerken 1994a, Gerken et al. 1990). However, one problem with the unfooted-syllable account of children's omissions in 6 is that the retained weak syllable is a bound verb inflection, while the omitted syllable is a free morpheme and an article. Therefore, in order to demonstrate more clearly that children omit unfooted syllables from sentences as well as from words, it would be desirable to show differential omission of the same morpheme in two metrical patterns. This was the goal of experiments 1 and 2.

(6) PETE KISSes the BEAR

```
|      |  |  |  |
S-(w)  S-- w  *  S-(w)
```

Children in experiment 1 were asked to imitate sentences like 7a–b. The metrical pattern of these sentences was manipulated by adding a third person singular present inflection to verbs ending in either a nonstrident consonant and therefore requiring a nonsyllabic allomorph (*-s,* 7a) or in a strident requiring a syllabic allomorph (*-es,* 7b). If children analyze sentences into a series of S-(w) feet, the object article in 7a belongs to the foot containing the verb. But in 7b the syllabic verb inflection forms a foot with the verb, leaving the article unfooted. If children omit unfooted syllables from both words and sentences, they should omit the object article in 7b more frequently than the one in 7a.

(7) a. he KICKS the PIG

```
|  |       |  |
*  S--------w  S-(w)
```

b. he CATCHes the PIG

```
|  |      |  |  |
*  S-------w  *  S-(w)
```

METHOD

Subjects

Potential subjects for all experiments reported here were identified from archival records of birth announcements in the Buffalo, NY area. Eighteen children ranging in age from 25 to 27 months, with a mean of 26 months, participated in experiment 1. Each subject's mean length of utterance (MLU, Brown 1973) was calculated based on the spontaneous speech she or he produced during the experimental visit. MLUs ranged from 1.51 to 3.59, with a mean of 2.61 morphemes. An additional ten children were excluded, either because they failed to imitate at least half of the sentences (n = 7) or because they did not omit any object articles in their imitations (n = 3). The latter group was excluded because the children were judged to exhibit linguistic development too advanced for the current research.

Materials

Stimuli were 10 four-word, five-morpheme sentences like those shown in 7a–b above.[3] All of the sentences had *he* or *she* as the subject, and each sentence

[3] As part of another study (Boyle & Gerken in press), children who participated in experiment 1 imitated 20 sentences in all, 10 with familiar object nouns and 10 with unfamiliar nouns. Only the data from the 10 familiar-noun sentences is reported here.

contained a different verb. The sentences varied as to whether the verb inflection was nonsyllabic (7a) or syllabic (7b). Each child imitated five sentences of each type.

Procedure

An experimenter visited children at their homes. At the beginning of a session, the experimenter and child looked through a picture book for ten to fifteen minutes until the child seemed comfortable. The child was then asked to play a game and look at some pictures. The experimenter showed the child a picture and said the appropriate sentence. The child was asked to repeat what the experimenter had said. If the child did not imitate after three repetitions, the experimenter went on to the next sentence. All sessions were audiotaped and the responses to the test sentences were noted during the experiment. Following each visit, the audio tapes were transcribed by the experimenter and checked by another person. Any disagreements about transcription were resolved through replay and discussion between experimenter and checker.

RESULTS AND DISCUSSION

Each imitation in which the child produced the verb and object noun was coded for preservations of the object article and the verb inflection if it was syllabic (see Table 1). One-way analyses of variance (ANOVAs) by subjects and by items performed on the object article preservations demonstrated that, as predicted, children preserved more articles following nonsyllabic verb inflections than syllabic inflections ($F_s(1,17) = 26.70$, $p < .0001$; $F_i(1,18) = 49.15$; $p < .0001$).

Thus, a single sentential element, in this case an object article, was preserved or omitted depending on the metrical context in which it occurred. These data suggest that in both word and sentence production, children are more likely to omit syllables that do not belong to feet but rather attach directly to prosodic words. That is, children omit syllables that violate the exhaustivity constraint. An alternative explanation for the data in experiment 1 is the different verbs in the nonsyllabic vs. syllabic inflection conditions. Perhaps it was some property of the verbs themselves, for example their segmental content, and not the inflections per se, that affected children's object article omissions. This possibility was addressed in experiment 2. If the exhaustivity hypothesis is supported by the data from experiment 2, two related questions arise: Are feet contained within prosodic words in children's linguistic representations as they are in representations proposed for adults? Is the number of violations of ex-

	PERCENT WEAK SYLLABLES PRESERVED (STANDARD ERROR)		
SENTENCE	SYLLABIC VERB INFLECTION	OBJECT ARTICLE	FIRST SYLLABLE OF *GIRAFFE*
7a. He kicks the pig	—	84% (5)	—
7b. He catches the pig	71% (6)	52% (7)	—
8a. Tom pushed the zebra	—	78% (6)	—
8b. Tom pushes the zebra	77% (6)	58% (12)	—
8c. Tom pushed the giraffe	—	72% (9)	44% (15)
8d. Tom pushes the giraffe	70% (6)	28% (8)	49% (11)

TABLE 1. Weak syllables preserved and standard errors in experiments 1 (7a–b) and 2 (8a–d)

haustivity related to frequency of omission, such that single violations result in fewer omissions than multiple violations? These questions were also addressed in experiment 2.

4. EXPERIMENT 2. Experiment 2, like experiment 1, examined the effect of the verb's meter on the omission of a following object article. However, in experiment 2, meter was manipulated through verb tense, not verb-stem coda. A single set of verbs ending in a strident consonant was inflected with either a nonsyllabic third person singular past morpheme (*-ed,* 8a and 8c) or a syllabic third person singular present morpheme (*-es,* 8b and 8d; PW = prosodic word). If children omit unfooted syllables, they should preserve the object article more frequently in 8a and 8c than in 8b and 8d.

(8) a. [TOM]$_{PW}$ [PUSHED the]$_{PW}$ [ZEbra]$_{PW}$
S-(w) S----------w S---w

b. [TOM]$_{PW}$ [PUSHes]$_{PW}$ [the ZEbra]$_{PW}$
S-(w) S-----w * S---w

c. [TOM]$_{PW}$ [PUSHED the]$_{PW}$ [giRAFFE]$_{PW}$
S-(w) S----------w * S-(w)

d. [TOM]$_{PW}$ [PUSHes]$_{PW}$ the [giRAFFE]$_{PW}$
S-(w) S-----w ** * S-(w)

Experiment 2 also asked whether children's linguistic representations include prosodic words and whether the number of violations of exhaustivity is related to the frequency of syllable omission. To understand how the pattern of chil-

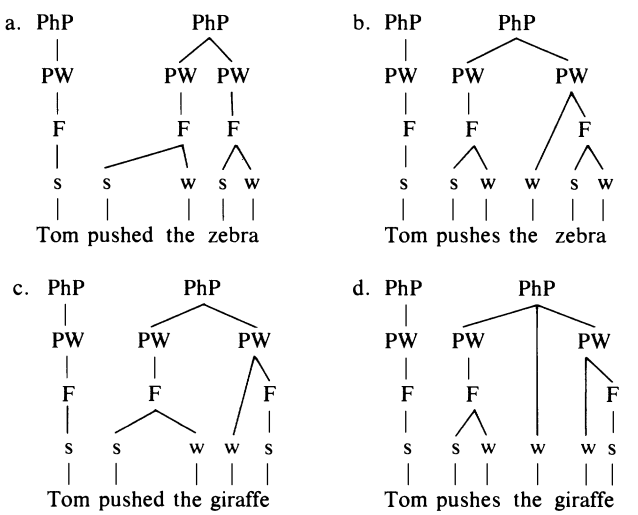


FIGURE 2. Prosodic structures of the sentences in experiment 2

dren's weak syllable omissions might be used to address these questions, consider the prosodic word analyses of 8a–d, which are also shown as prosodic trees in Fig. 2a–d, respectively. Beginning with 8a, the exhaustivity account of the data from experiment 1 suggests that an object article following a verb with nonsyllabic inflection forms an S-w foot with the verb. Because prosodic trees cannot have crossing branches, the object article in 8a forms a prosodic word as well as a foot with the preceding verb.

Next consider sentence 8b. The syllabic inflection prevents the object article from forming an S-w foot with the verb. It might be possible for the article to be an unfooted syllable in the prosodic word containing the verb (thereby violating exhaustivity). Such a structure is dispreferred, however, because it violates both exhaustivity and the prosodic-syntax mapping constraint on prosodic words to conform to syntactic constituency. Because both constraints would be violated by forming a prosodic word from the verb plus article, the object article is instead attached to the prosodic word containing the noun. However, the object article does not belong to a foot (i.e. violates exhaustivity) and should therefore be omitted.[4]

Finally consider sentences 8c–d, which unlike 8a–b contain an object noun exhibiting a wS metrical pattern. The prosodic word analysis of 8c is identical to that of 8a. In 8d, the verb has a syllabic inflection, just as in 8b, and the article cannot form a foot with the verb. Therefore, in both 8b and 8d, joining the object article and verb into a prosodic word would violate both exhaustivity (because the article is unfooted) and the prosody-syntax mapping constraint. Perhaps a more optimal structure might be formed by attaching the article to the prosodic-word-containing noun, with *the giraffe* in 8d forming a prosodic word just like *the zebra* in 8b. *The giraffe,* however, exhibits a wwS metrical pattern, which is impossible for an English lexical word (e.g. Hayes 1982). Because a lexical word uttered in isolation (i.e. in its citation form) is a prosodic word, we might hypothesize that the constraint responsible for the metrical form of English lexical words is a constraint on prosodic words (McCarthy & Prince 1993), that is, prosodic words cannot contain more than a single unfooted syllable. If this is true, the object article in 8d belongs neither to a foot nor to a prosodic word. Instead, it must belong to the next higher unit in the prosodic structure, the phonological phrase (for alternative analyses, see McCarthy & Prince 1993, Selkirk 1996, and the discussion pertaining to Fig. 3). Thus, the article violates exhaustivity twice, once at the foot level and once at the prosodic word level.

If children assign the prosodic word analyses shown in 8a–d, and if number of violations of the exhaustivity constraint is related to the frequency of syllable omissions, then the following pattern of object article preservations should be observed in experiment 2: 8a = 8c > 8b > 8d.

[4] Although the article should be omitted from sentences like 8b regardless of whether it formed a prosodic word with the verb or the object noun, the analysis of 8d crucially depends on the latter structure. I thank Mike Hammond and Marina Nespor for comments that led to the analyses in Fig. 2.

METHOD

Subjects

Sixteen children ranging in age from 25 to 31 months, with a mean of 28 months, participated in experiment 2. MLUs ranged from 1.84 to 4.74 morphemes per utterance, with a mean of 2.53. An additional nine children were tested but were not included in the data analysis because they failed to imitate at least half of the sentences.

Materials

Stimuli were 16 four-word, five-morpheme sentences like those shown in 8a–d above. All of the sentences had *Tom* as the subject; each sentence contained a different verb. The sentences varied in the syllabicity of the verb inflection and the meter of the object noun. Half of the children imitated sentences with a past tense nonsyllabic verb inflection (8a and 8c), and half imitated sentences with a present tense syllabic inflection (8b and 8d). All children imitated eight sentences in which the object NP contained the Sw noun *zebra* and eight sentences containing the wS noun *giraffe*. Four lists of sentences were created so that each verb appeared with each inflection and with each object noun on one of the lists. Children imitated stimuli from only one list.

Procedure

Each child was visited at home by a team of two experimenters, who brought books and stuffed animals, including a bear named Tom, a zebra, and a giraffe. Experimenter A was primarily in charge of interacting with the child during the imitation task, and Experimenter B noted the child's imitations. During a brief warm-up session, the child was introduced to the animals and their names. Experimenter A said that she would say something that the animals could do, and if the child wanted to see the animals perform this action, s/he had to say the same thing. For example, she might say, 'Tom kissed the giraffe. Can you say that? Tom kissed the giraffe.' If the child attempted to say the sentence, the experimenter acted it out with the appropriate animals. If the child did not say the sentence after three attempts, the experimenter acted it out and moved on to the next stimulus sentence. Experimental sessions were audiotaped, and within three days after a session, Experimenter A transcribed the tape. Experimenter B checked this transcription for errors and to determine if A's transcriptions of children's imitations agreed with those made during the session itself. Disagreements in transcription were resolved by replay and further discussion.

RESULTS AND DISCUSSION

Each imitation in which the child produced the verb and object noun was coded for preservations of the object article, the verb inflection if it was syllabic, and the first syllable of *giraffe* (see Table 1). The three types of preservations were analyzed separately. Turning first to the object article preservations, two-way ANOVAs by subjects and by items were performed with Inflection (nonsyllabic, syllabic) and Object Noun Meter (Sw, wS) as factors. As predicted by the exhaustivity hypothesis, there was a main effect of Inflection. Children preserved the object article more frequently when it followed a nonsyllabic inflection (75%) than when it followed a syllabic inflection (43%; $F_s(1,14)$ =

8.02, $p < .02$; $F_i(1,15) = 33.22$, $p < .0001$). Thus, experiment 2 replicated the major finding of experiment 1, even though the alternation between nonsyllabic and syllabic inflections was achieved differently in the two experiments.

The analysis of object article preservations also showed a main effect of Object Noun Meter (zebra 68%, giraffe 50%, $F_s(1,14) = 9.98$, $p < .01$; $F_i(1,15) = 4.79$, $p < .05$) and a significant Inflection X Object Noun Meter interaction ($F_s(1,14) = 4.25$, $p < .06$; $F_i(1,15) = 14.61$, $p < .01$). Pairwise comparisons (Newman-Keuls, $p = .05$) revealed the following pattern of preservations: 8a = 8c > 8b > 8d. This pattern is exactly the one predicted by the hypothesis that children assign the prosodic word analyses shown in 8a–d and that more violations of exhaustivity result in fewer syllable preservations.

As predicted, one-way ANOVAs on preservations of the *-es* inflection showed no effect of Object Noun Meter ($F_s(1,7) = 4.76$, n.s.; $F_i(1,15) = 2.11$, n.s.). It is also interesting to note that the rate of preservation of syllabic verb inflections (73%) is nearly identical to the rate of preservation of object articles belonging to a foot (75%). This similarity is consistent with the exhaustivity hypothesis and suggests that a syllable's foot status is an important determinant of whether it is preserved or omitted. One-way ANOVAs on children's preservations of the first weak syllable of *giraffe* showed that, as predicted, there was no effect of Inflection (all F's < 1).

In summary, the data from experiment 2 suggest that children analyze their intended utterances into feet and prosodic words, with the exhaustivity constraint more highly ranked than prosody-syntax mapping constraints. When utterances are analyzed in this way, syllables that do not violate exhaustivity are produced more frequently than syllables that violate the constraint once, which are in turn omitted more frequently than syllables violating exhaustivity twice. Note that in the current proposal, the exhaustivity constraint on syllables to belong to feet appears to influence the placement of prosodic word boundaries. Thus, children create a prosodic word from an object article and the preceding verb when doing so results in the verb and article forming an S-w foot. Otherwise, the object article forms a prosodic word or phonological phrase with the following noun. One question left open by the first two experiments is the relation between the exhaustivity constraint that causes children to adjoin object articles to the preceding verb under some circumstances and the prosody-syntax mapping constraint for prosodic words to contain material from only one lexical word. Experiment 3 was designed to probe this relation.

5. EXPERIMENT 3. Children in experiment 3 were asked to imitate sentences like 9a–d below. The critical comparison can be seen in examples 9a–b vs. 9c–d. Based on the findings of experiments 1 and 2, it was hypothesized that children producing 9a would form a foot and prosodic word from the verb and following object article and consequently preserve the article. In 9b, the object article should form a prosodic word with the following noun, resulting in its being unfooted and therefore susceptible to omission. Thus, just as in experiments 1 and 2, it was predicted that in experiment 3 children would omit object articles following syllabic inflections more frequently than articles following

nonsyllabic inflections. Now consider 9c–d, which exhibit the same metrical patterns as 9a–b, respectively. The difference is that the weak syllable that corresponds to the object article in 9a–b belongs to a lexical word in 9c–d. A prosodic word is defined as one and only one lexical word plus adjacent function morphemes. According to this definition, the first syllable of *Michele* cannot form a prosodic word with the preceding verb, because the prosodic word would contain (parts of) two lexical words (*push* and *Michele*). If children uphold this constraint, the first syllable of *Michele* does not belong to a foot in either 9c or 9d. The prosodic word analyses in 9a–d predict that the syllabic status of a verb inflection should influence the preservations of object articles (i.e., 9a > 9b), but not the preservation of first syllable of a lexical word like *Michele* (i.e. 9c = 9d).

(9) a. [TOM]$_{PW}$ [PUSHED the]$_{PW}$ [PIG]$_{PW}$
S-(w) S----------w S-(w)

b. [TOM]$_{PW}$ [PUSHes]$_{PW}$ [the PIG]$_{PW}$
S-(w) S-----w * S-(w)

c. [TOM]$_{PW}$ [PUSHED]$_{PW}$ [miCHELE]$_{PW}$
S-(w) S-(w) * S-(w)

d. [TOM]$_{PW}$ [PUSHes]$_{PW}$ [miCHELE]$_{PW}$
S-(w) S-----w * S-(w)

METHOD

Subjects

Eighteen children ranging in age from 25 to 29 months, with a mean of 26 months, participated in experiment 3. MLUs ranged from 1.75 to 4.35 morphemes per utterance, with a mean of 2.47. An additional 11 children were tested but were not included in the data analysis, because they failed to imitate at least half of the stimulus sentences (n = 9) or failed to omit any weak syllables and were therefore beyond the development stage of interest (n = 2).

Materials

Stimuli were 10 four- to five-syllable sentences like those shown in 9a–d above. All of the sentences had *Tom* as the subject, and each sentence contained a different verb. The sentences varied in the syllabicity of the verb inflection and object NP. Half of the children imitated sentences with a nonsyllabic past tense verb inflection (9a and 9c), and half imitated sentences with a syllabic present tense inflection (9b and 9d). All children imitated five sentences in which the object NP was *the pig* and five sentences in which the object NP was *Michele*.[5] Six lists of sentences were created so that each verb appeared

[5] There was a third condition that is not of interest for the present discussion. The sentences in this condition were of the form *Tom kissed/s Michael*. Because of the inclusion of the third condition, there were 15 different verbs instead of 10 and six lists instead of four.

with each inflection and with each object noun on one of the lists. Children imitated stimuli from only one list.

Procedure

The procedure was the same as in experiment 1, except that the experimenter showed children actions performed by puppets instead of pictures in a book.

RESULTS AND DISCUSSION

Each imitation in which the child produced the verb and object noun was coded for preservations of the first syllable of the object NP (either the object article or the first syllable of *Michele*) and the verb inflection if it was syllabic (see Table 2). The two types of preservations were analyzed separately. Beginning with the first syllable of the object NP, two-way ANOVAs by subjects and by items were performed with Inflection (nonsyllabic, syllabic) and Object NP (*the pig, Michele*) as factors. The main effect of Inflection was not significant in the analysis by subjects, but it was in the analysis by items ($F_s(1,16) = 1.97$, n.s.; $F_i(1,14) = 9.79$, $p < .01$). The main effect of Object NP was not significant ($F_s(1,16) = 1.01$, n.s.; $F_i(1,14) = 2.69$, n.s.). As predicted, there was a significant Inflection X Object NP interaction ($F_s(1,16) = 4.62$, $p < .05$; $F_i(1,14) = 6.06$, $p < .05$). Pairwise comparisons (Newman-Keuls, $p = .05$) demonstrated that children preserved the object article from *the pig* significantly more frequently when it followed a nonsyllabic inflection than when it followed a syllabic inflection. This finding is a replication of experiments 1 and 2. In contrast, children showed virtually no difference in their preservations of the first syllable of *Michele* when it followed a nonsyllabic or syllabic inflection. Under the current proposal, the first syllable of *Michele* cannot form a prosodic word with the preceding verb. Therefore, the metrical pattern of the verb itself does not influence how frequently children preserve the weak syllable of the name.

Turning to children's preservations of the syllabic verb inflection, the prosodic analyses in 9a and 9c do not predict any effect of the following noun. Indeed there was none (all F's < 1). As in experiment 2, however, children preserved the object article following a nonsyllabic inflection (66%) and the syllabic verb inflection (71%) at similar rates. This pattern is consistent with the notion that the metrical pattern in which a syllable appears, regardless of its syntactic or morphological status, affects whether it is preserved.

In summary, the data from experiments 1–3 suggest that children analyze their intended sentences into metrical feet and that these feet are contained within prosodic words. Syllables that do not belong to a foot, and therefore

	PERCENT WEAK SYLLABLES PRESERVED (STANDARD ERROR)		
SENTENCE	SYLLABIC VERB INFLECTION	OBJECT ARTICLE	FIRST SYLLABLE OF *MICHELE*
9a. Tom pushed the pig	—	66% (14)	—
9b. Tom pushes the pig	73% (4)	29% (11)	—
9c. Tom pushed Michele	—	—	42% (11)
9d. Tom pushes Michele	68% (10)	—	38% (11)

TABLE 2. Weak syllables preserved and standard errors in experiment 3

violate exhaustivity, are susceptible to omission. The new information added by experiment 3 is that the prosody-syntax mapping constraint for prosodic words to contain one and only one lexical word is more important in children's prosodic representations than the exhaustivity constraint on syllables to belong to feet. Experiments 4–5 continue to focus on children's object article omissions and test for an influence of phonological phrases on their sentence productions.

6. EXPERIMENT 4. Recall from the overview of prosodic phonology that one source of non-isomorphism between syntactic and phonological phrases is the presence of focal stress. The verb and object NP form a single phonological phrase in a sentence that does not contain a focally stressed word (10a). In contrast, the object NP forms a separate phonological phrase when the verb receives focal stress (10b). If the constraint to place a phonological phrase boundary after a word receiving focal stress is more important than the exhaustivity constraint, the object article in 10b cannot form a foot with the preceding verb (assuming no crossing lines in prosodic trees). Therefore, the object article does not belong to a foot in the structure in 10b and should be preserved less frequently than the article in 10a.

(10) a. [[he KISSED the]$_{PW}$ [DOG]$_{PW}$]$_{PhP}$
| | | | |
* S----- w S-(w)

b. [[he **KISSED**]$_{PW}$]$_{PhP}$ [[the DOG]$_{PW}$]$_{PhP}$
| | | |
* S-(w) * S-(w)

METHOD

Subjects

Experiment 4 comprised two subexperiments, 4a and 4b. Children in experiment 4a participated in a between-subjects design, such that half of the children imitated sentences without focal stress and half imitated sentences with focal stress. This group had 24 children ranging in age from 25 to 29 months, with a mean of 26 months. MLUs ranged from 1.35 to 3.87 morphemes per utterance, with a mean of 2.26. An additional 17 children were tested for experiment 4a but were not included because they failed to imitate at least one third of the stimulus sentence (n = 9), to omit any object articles (n = 7), or because the experimental session was not recorded due to equipment failure (n = 1). Children in experiment 4b participated in a within-subjects design, such that all children imitated sentences with and without focal stress. The second group had 16 children ranging in age from 25 to 28 months, with a mean age of 26 months. MLUs ranged from 1.49 to 2.90 morphemes per utterance, with a mean of 2.26. An additional 6 children were tested for experiment 4b but failed to imitate at least one third of the stimulus sentences (n = 4) or to omit any object articles (n = 2).

Materials

Stimuli were 18 four-word sentences like those shown in 10 above. Each sentence contained a different verb. Half of the sentences had *he* as the subject and *the pig* as the object, and the other half had *she* and *the bear,* as the subject

and object, respectively. Sentences in the no-focal-stress condition were produced without focal stress, while sentences in the focal stress condition were produced with focal stress on the verb. In order to ensure the intended stress placement, all stimuli were generated using DECTalk text-to-speech synthesizer (version 1.8, voice = Beautiful Betty, average pitch = 250 Hz, pitch range = 120%, speaking rate = 120 words per minute). DECTalk creates focal stress by increasing the frequency and amplitude of the designated syllable.

Pilot testing suggested that once children imitated a sentence containing focal stress, they tended to produce subsequent sentences with the same stress pattern, even if the target sentence was not produced this way. To circumvent this problem, two different experimental designs were employed with different groups of children. As noted above, children in experiment 4a participated in a between-subjects design, such that half of the children imitated sentences with focal stress on the verb and half imitated sentences with no focal stress. Two lists of sentences were created so that each verb appeared in each focal-stress condition on one of the lists. Children imitated stimuli from only one list. Children in experiment 4b participated in a within-subjects design imitating the nine no-focal-stress sentences before the nine focal-stress sentences.

Procedure

The procedure was the same as in experiment 2, except that the experimenter brought a toy robot in addition to the other toys. After the warm-up session, the experimenter asked the child if s/he would like to hear the robot talk. The experimenter told the child that the robot would say something that two puppets did, and if the child wanted to see the puppets perform this action, s/he had to say what the robot said. The experimenter then played the first stimulus sentence, in which the robot (placed on top of a small speaker) might 'say', 'He kissed the pig. Can you say that? He kissed the pig.' If the child attempted to say the sentence, the experimenter acted it out with the appropriate puppets. If the child did not say the sentence after three attempts, the experimenter acted it out and moved on to the next stimulus sentence.

RESULTS AND DISCUSSION

Each imitation in which the child produced the verb and object noun was coded for whether the object article was preserved (see Table 3). In both experiments 4a and 4b, the percentage of object articles preserved was numerically greater in the no-focal-stress condition than in the focal-stress condition. This pattern is consistent with children assigning structures 10a and b. One-way ANOVAs by subjects and by items revealed in experiment 4a a nonsignificant

	PERCENT OBJECT ARTICLES PRESERVED (STANDARD ERROR)	
SENTENCE TYPE	EXPERIMENT 4a	EXPERIMENT 4b
10a. He kissed the dog	67% (7)	68% (9)
10b. He **kissed** the dog	50% (10)	58% (8)

TABLE 3. Object articles preserved and standard errors for Experiments 4a and 4b. (Focal stress was a between subjects factor in Experiment 4a and a within subjects factor in Experiment 4b, see text.)

effect by subjects ($F_s(1,23) = 1.69$, n.s.) but a highly significant effect by items ($F_i(17) = 19.96$, $p < .001$). In Experiment 4b, the analysis revealed that the difference was marginally significant by subjects ($F_s(1,15) = 4.20$, $p < .06$) and strongly significant by items ($F_i(17) = 9.43$, $p < .01$). Taken together, the data from experiments 4a–b suggest that children's preservation of object articles is influenced by whether or not the preceding verb receives focal stress. The effect of focal stress was predicted by the structures in 10a–10b. It appears, therefore, that focal stress influences the placement of phonological phrase boundaries, which in turn influence the placement of prosodic word and foot boundaries. The influence of focal stress on foot boundaries causes the object article in 10b to be unfooted and therefore susceptible to omission.

The finding that lower level units in a prosodic structure (e.g. prosodic words and feet) align with phonological phrase boundaries is consistent with observations of Shanghai Chinese made by Selkirk and Shen (1990). Experiments 5a–5c examine another influence on phonological phrase boundaries, object NP length, to determine if feet and prosodic words continue to align with these boundaries.

7. EXPERIMENT 5. Experiment 5 comprised three subexperiments, 5a, 5b, and 5c. In experiment 5a children were asked to imitate sentences like 11a–f, below. Recall that an object NP containing a single prosodic word is part of the phonological phrase containing the verb (11a–b and 11d–e). In contrast, an object NP containing more than one prosodic word must form its own phonological phrase (11c and 11f). As noted above, the results from experiment 4 suggest that prosodic word and foot boundaries must align with phonological phrase boundaries. If this formulation is correct, what are the consequences for children's productions of 11a–f? In 11a–b and 11d–e, in which there is no phonological phrase boundary after the verb, the object article should form a foot with the verb and therefore be preserved. In contrast, the presence of a phonological phrase boundary after the verb in 11c and 11f causes the object article to be unfooted and therefore susceptible to omission. Thus, the following pattern of object article preservations for 11a–f was predicted: 11a = 11b = 11d = 11e > 11c = 11f.

(11) a. 4 words, 5 morphemes
[[he KISSED the]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | | |
* S----------w S-(w)

b. 4 words, 5 morphemes
[[he KISSED the]$_{PW}$ [BAby]$_{PW}$]$_{PhP}$
| | | | |
* S----------w S-(w)

c. 5 words, 6 morphemes
[[he KISSED]$_{PW}$]$_{PhP}$ [[the BROWN]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | | | |
* S-(w) * S-(w) S-(w)

d. 4 words, 5 morphemes
[[TOM]$_{PW}$]$_{PhP}$ [[KISSED] the]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | |
S-(w) S----------w S-(w)

e. 4 words, 5 morphemes
[[TOM]$_{PW}$]$_{PhP}$ [[KISSED] the]$_{PW}$ [BAby]$_{PW}$]$_{PhP}$
| | |
S-(w) S----w S-w

f. 5 words, 6 morphemes
[[TOM]$_{PW}$]$_{PhP}$ [[KISSED]$_{PW}$]$_{PhP}$ [[the BROWN]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | | |
S-(w) S-(w) * S-(w) S-(w)

Note that the critical sentences in experiment 5a, 11c and 11f, contain a greater number of words and morphemes than any of the other sentences. In order to rule out an interpretation of the data based on the number of words and morphemes, two changes were made to the sentences in 11 to create the stimuli for experiment 5b, shown in 12a–f. First, the disyllabic noun objects in 11b and 11e were replaced with compound nouns like *football* in 12b and 12e, thereby equating the number of morphemes in 12b–c and 12e–f.[6] Second, subject NPs comprising a proper name in 11d–f were replaced by a determiner-noun sequence in 12d–f, thereby equalizing the number of words in 12c and 12d. If the prosodic structure, and not the number of words or morphemes, is responsible for children's omissions, children should show the same pattern of object article preservations for the sentences in 12 as for those in 11. The predicted pattern is: 12a = 12b = 12d = 12e > 12c = 12f. Critically, children should preserve more object articles in 12d than 12c, even though both sentences contain the same number of words and morphemes.

(12) a. 4 words, 5 morphemes
[[he KISSED the]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | |
* S----------w S-(w)

b. 4 words, 6 morphemes
[[he KISSED the]$_{PW}$ [FOOTBALL]$_{PW}$]$_{PhP}$
| | | | |
* S----------w S-(w) S-(w)

c. 5 words, 6 morphemes
[[he KISSED]$_{PW}$]$_{PhP}$ [[the BROWN]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | | |
* S-(w) * S-(w) S-(w)

d. 5 words, 6 morphemes
[[the BEAR]$_{PW}$]$_{PhP}$ [[KISSED] the]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
| | | | |
* S-(w) S----------w S-(w)

[6] It is assumed that compound nouns comprise only a single prosodic word (Nespor & Vogel 1986, Wheeldon & Lahiri 1995; for the opposite claim, see Levelt 1989).

e. 5 words, 7 morphemes
[[the BEAR]$_{PW}$]$_{PhP}$ [[KISSED] the]$_{PW}$ [FOOTBALL]$_{PW}$]$_{PhP}$
* S-(w) S----------w S-(w) S-(w)

f. 6 words, 7 morphemes
[[the BEAR]$_{PW}$]$_{PhP}$ [[KISSED]$_{PW}$]$_{PhP}$ [[the BROWN]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
* S-(w) S-(w) * S-(w) S-(w)

Note that the presence of an adjective may make the critical c and f cases in examples 11 and 12 more syntactically or semantically complex for young children than the other sentences. In order to determine whether prosodic structure, and not syntactic or semantic complexity, accounts for any differences in object article preservations, another set of stimuli was created for experiment 5c, shown in 13a–i. The object NPs in 13a–b, 13d–e, and 13g–h contain one prosodic word and are contained in the same phonological phrase as the verb. Therefore, the object article in these sentences is able to form a foot with the verb and should be preserved. In contrast, the object NPs in 13c, 13f, and 13i contain a genitive construction and are therefore composed of two prosodic words, just as the adjective-noun objects were in experiments 5a and 5b. Therefore, the object NPs in 13c, 13f and 13i should occupy their own phonological phrase, separate from the verb. If prosodic word and foot boundaries align with phonological phrase boundaries, the object articles in these sentences cannot form a foot or prosodic word with the preceding verb. The resulting structure leaves the article unfooted and susceptible to omission. The inclusion of sentences 13g–i, which contain a genitive construction in the subject NP, makes it possible to equate the syntactic/semantic complexity of the sentences 13c, 13f, 13g and 13h, all of which contain a single genitive construction. If prosodic structure, and not syntactic or semantic complexity, is responsible for children's omissions, children should show the following pattern of object article preservations for sentences 13a–i: 13a = 13b = 13d = 13e = 13g = 13h > 13c = 13f = 13i. Critically, children should preserve more object articles in 13g than 13c and 13f, even though all three sentences contain the same number of words and morphemes and a genitive construction.

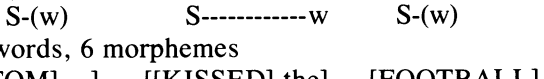
(13) a. 4 words, 5 morphemes
[[he KISSED the]$_{PW}$ [PIG]$_{PW}$]$_{PhP}$
* S----------w S-(w)

b. 4 words, 6 morphemes
[[he KISSED the]$_{PW}$ [FOOTBALL]$_{PW}$]$_{PhP}$
* S----------w S-(w) S-(w)

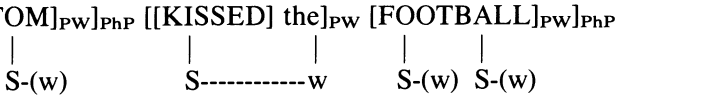
c. 5 words, 7 morphemes
[[he KISSED]$_{PW}$]$_{PhP}$ [[the PIG'S]$_{PW}$ [NOSE]$_{PW}$]$_{PhP}$
* S-(w) * S-(w) S-(w)

d. 4 words, 5 morphemes

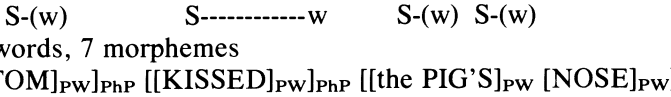
e. 4 words, 6 morphemes



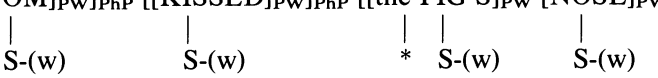
f. 5 words, 7 morphemes



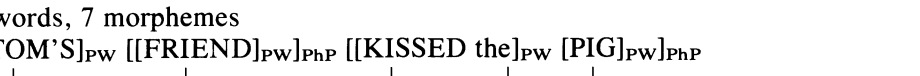
g. 5 words, 7 morphemes



h. 5 words, 8 morphemes



i. 6 words, 9 morphemes



METHOD

Subjects

Eighteen children ranging in age from 24 to 28 months, with a mean of 26 months, participated in experiment 5a. MLUs ranged from 1.06 to 3.27 morphemes per utterance, with a mean of 2.14. An additional 3 children were tested but either failed to imitate at least one third of the stimulus sentences (n = 2) or to make any object article omissions (n = 1). Eighteen children, ranging in age from 25 to 28 months, with a mean of 27 months, participated in experiment 5b. MLUs ranged from 1.05 to 3.02, with a mean of 2.28 morphemes. An additional seven children were tested but failed to imitate at least one third of the stimulus sentences (n = 5) or to make any object article omissions (n = 2). Twenty-seven children ranging in age from 24 to 29 months, with a mean of 27 months, participated in experiment 5c. MLUs ranged from 1.40 to 4.52 morphemes per utterance, with a mean of 2.54. An additional five children were tested but either failed to imitate one third of the sentences (n = 4) or to omit any object articles (n = 1).

Materials

For experiments 5a and 5b, three tokens of each of the six sentence types (11a–f or 12a–f) were created, yielding 18 stimulus sentences in all. Six lists of stimuli were created, so that a particular verb (e.g. *kiss*) occurred with each possible subject and object type. Children were asked to imitate the stimuli from only a single list. In order to control for possible stress and naturalness

differences among stimuli that might be introduced by a human talker, all stimuli for experiments 5a and 5b were generated using DECTalk text-to-speech synthesizer (version 1.8, voice = Beautiful Betty, average pitch = 250 Hz, pitch range = 120%, speaking rate = 120 words per minute.)[7]

For experiment 5c, two tokens of each of the nine sentence types were created, yielding 18 stimulus sentences in all. Nine lists of stimuli were created, so that a particular verb (e.g., *kiss*) occurred with each possible subject and object type. Children were asked to imitate the stimuli from only a single list. Unlike in experiments 5a–b, stimuli were read to children by the experimenter.

Procedure

The procedure was similar to the one used in experiments 4a–b, except that the set of toys the experimenter brought to the child's home was increased. The toys now included a large stuffed bear named Tom, a large pink pig named Jane, a small bear, who was referred to as 'the short bear' (exps. 5a–b) or 'Tom's friend' (exp. 5c), and a small brown pig, who was referred to as 'the brown pig' (exp. 5a–b) or 'Jane's friend' (exp. 5c). The experimenter spent approximately ten minutes at the beginning of the session playing with these toys to ensure that children recognized each one by its appropriate designation.

RESULTS AND DISCUSSION

In experiments 5a–c, each imitation in which the child produced the verb and object noun was coded as to whether the object article was preserved (see Table 4). Let us first consider the pattern of object article preservations in experiment 5a: 3 Object NP (monosyllabic, disyllabic, adjective-noun) X 2 Subject NP (pronoun, proper name) ANOVAs by subjects and by items revealed a highly significant main effect of Object NP (monosyllabic 59%, disyllabic 62%, adjective-noun 33%; $F_s(2,34) = 14.98$, $p < .00001$; $F_i(2,34) = 6.53$, $p < .005$). Pairwise comparisons (Newman-Keuls, $p = .05$) revealed that, as predicted, object articles were preserved significantly more frequently in sentences with monosyllabic and disyllabic nouns than in sentences with adjective-noun sequences. This finding is consistent with the hypothesis that sentences with adjectives in the object NP were produced with a phonological phrase boundary after the verb, which prevented the object article from forming a foot with the verb. The main effect of Subject NP and the Object NP X Subject NP

[7] In natural speech, adult talkers typically place a phonological phrase boundary after a lexical subject. Therefore, the proper name subject stimuli were created with a short pause after the subject. At the time the stimuli were created, it was hypothesized that children have a bias to produce utterances comprising two phonological phrases whenever possible, causing them to place a phonological phrase boundary after the verb in sentences with pronoun subjects (Gerken 1994a). The data from experiments 4a–b suggest that a better explanation of the data from previous studies is the differential placement of focal stress in sentences with lexical vs. pronoun subjects (Selkirk, p.c.). However, in keeping with the earlier hypothesis, pronoun subject stimuli in experiments 5a–b were created with a pause after the verb, regardless of the nature of the object NP. Children's imitations did not appear to be affected by this (incorrect) pausing information, but rather appeared to be consistent with the correct phonological phrase structure given in the sentences in 11 and 12.

SENTENCE	PERCENT OBJECT ARTICLES PRESERVED (STANDARD ERROR)
EXPERIMENT 5a	
11a. He kissed the pig	59% (10)
11b. He kissed the baby	61% (9)
11c. He kissed the brown pig	33% (8)
11d. Tom kissed the pig	59% (7)
11e. Tom kissed the baby	63% (8)
11f. Tom kissed the brown pig	33% (8)
EXPERIMENT 5b	
12a. He kissed the pig	69% (8)
12b. He kissed the football	72% (7)
12c. He kissed the brown pig	52% (9)
12d. The bear kissed the pig	67% (8)
12e. The bear kissed the football	48% (9)
12f. The bear kissed the brown pig	39% (9)
EXPERIMENT 5c	
13a. He kissed the pig	85% (6)
13b. He kissed the football	71% (8)
13c. He kissed the pig's nose	54% (7)
13d. Tom kissed the pig	82% (6)
13e. Tom kissed the football	65% (8)
13f. Tom kissed the pig's nose	41% (8)
13g. Tom's friend kissed the pig	67% (7)
13h. Tom's friend kissed the football	56% (8)
13i. Tom's friend kissed the pig's nose	50% (8)

TABLE 4. Object articles preserved and standard errors in Experiment 5.

interaction did not approach significance (pronoun 51%, proper name 52%; all F's < 1).

Now let us consider the data from experiment 5b. As in experiment 5a, 3 Object NP (monosyllabic, compound adjective-noun) X 2 Subject NP (pronoun, common NP) ANOVAs by subjects and by items revealed a significant main effect of Object NP (monosyllabic 68%, compound 60%, adjective-noun 45%; $F_s(2,34) = 5.49$, $p < .01$; $F_i(2,34) = 9.25$, $p < .001$). Pairwise comparisons revealed that children preserved more articles preceding monosyllabic or compound noun objects than preceding adjective-noun objects. As in experiment 5a, the data are consistent with the hypothesis that sentences with adjectives in the object NP were produced with a phonological phrase boundary after the verb, which prevented the object article from forming a foot with the verb. Unlike in experiment 5a, there was a significant main effect of Subject NP in experiment 5b, such that more object articles were preserved from sentences with pronoun subjects (64%) than with common NP subjects (51%; $F_s(1,17) = 10.28$, $p < .01$; $F_i(1,17) = 5.10$, $p < .05$). The Object NP X Subject NP interaction was not significant ($F_s(2,34) = 1.82$, n.s.; $F_i(2,34) = 1.61$, n.s.). Because sentences with lexical NP subjects were longer in words and morphemes than sentences with pronoun subjects, the effect of Subject NP in experiment 5b suggests that length affected children's object article omissions (Brown & Fraser 1964, Gerken 1991, Valian et al. 1994).

In order to determine if prosodic structure played a role independent of length in experiment 5b, we need to examine children's article preservations in sentence 12c vs. 12d. Both of these sentences contain five words and six morphemes. Sentence 12c, however, has an adjective-noun sequence in the object NP, which prevents the object article from forming a phonological phrase, and therefore from forming a foot, with the verb. If children omit unfooted syllables, they should preserve more object articles in 12d than 12c. Planned *t*-tests by subjects and by items revealed this to be the case ($t_s(17) = 1.78$, $p < .05$, 1-tailed; $t_i(17) = 2.24$, $p < .025$, 1-tailed). Therefore, although length may play a role in children's omissions, prosodic structure does as well.

Let us now turn to children's object article preservations in experiment 5c: 3 Object NP (monosyllabic, compound, adjective-noun) X 3 Subject NP (pronoun, proper name, possessive) ANOVAs by subjects and by items revealed highly significant main effect of Object NP (monosyllabic 78%, compound 64%, possessive 48%; $F_s(2,52) = 21.92$, $p < .00001$; $F_i(2,34) = 9.49$, $p < .0001$). Pairwise comparisons revealed that children preserved significantly more object articles in sentences with monosyllabic object NPs and compound object NPs than in sentences with possessive object NPs. As in experiments 5a and b, the data are consistent with the hypothesis that sentences with two prosodic words in the object NP were produced with a phonological phrase boundary after the verb. The resulting structure prevented the object article from forming a foot with the verb. The main effect of Subject NP was significant in the analysis by subjects but not in the analysis by items (pronoun 70%, proper name 63%, possessive 58%; $F_s(2,52) = 4.67$, $p < .05$; $F_i(2,34) = 2.08$, n.s.), and the Subject NP X Object NP interaction was not significant ($F_s(4,104) = 1.49$, n.s.; $F_i(4,68) = .1.85$, n.s.). The trend for children to preserve fewer object articles in sentences with two-word possessive subjects than with pronoun or single noun subjects is consistent with the results of experiment 5b and suggests an effect of length in addition to the effect of prosody.

In order to determine whether the syntactic or semantic complexity of sentences could account for the data, planned *t*-tests by subjects and by items compared five-word seven-morpheme sentences with possessive subjects (13g) with five-word seven-morpheme sentences with possessive objects (13c and 13f). Children preserved more object articles from 13g than 13c ($t_s(26) = 1.73$, $p < .05$, 1-tailed; $t_i(17) = 1.81$, $p < .05$, 1-tailed) or 13f ($t_s(26) = 3.47$, $p < .001$, 1-tailed; $t_i(17) = 3.36$, $p < .005$, 1-tailed). These results are consistent with the exhaustivity hypothesis, but not with an account based on syntactic/semantic complexity.

In summary, the data from experiments 5a–c indicate that children's prosodic structures contain a phonological phrase boundary after the verb when the object NP comprises more than a single prosodic word. The effect of the number of prosodic words in the object NP was found regardless of whether children imitated tape recorded synthetic speech (experiments 5a and b) or natural speech produced by the experimenter (experiment 5c). The effect was also found when word/morpheme length and syntactic/semantic complexity were held constant. Consistent with the findings of experiments 4a–b, the data from

experiments 5a–c indicate that children align feet and prosodic words with phonological phrase boundaries. This alignment prevents an object article following a phonological phrase boundary from forming a foot with the preceding verb, making the article susceptible to omission.

8. GENERAL DISCUSSION AND CONCLUSION. The experiments discussed above examined young children's omission of a single morphosyntactic element, *the,* from a single syntactic position, object NP. By keeping syntax constant, it was possible to evaluate the effects of prosody on children's omissions. Most generally, the data demonstrate that the prosodic pattern in which a morpheme occurs influences whether it is omitted. Therefore, prosody not only affects children's omissions of weak syllables from multisyllabic words, but also influences omissions at the sentence level. More specifically, all five experiments are consistent with the hypothesis that children omit from sentences, as well as from words, syllables that violate the exhaustivity constraint of Prosodic Phonology.

In experiments 1–3, children omitted more articles following a syllabically inflected verb than a verb with a nonsyllabic inflection. My account for this pattern is that the syllabic verb inflection formed a foot with the verb, thereby leaving the following article unfooted. Experiment 2 also revealed an effect of object noun meter on object article omissions. This effect was taken to suggest that articles not forming a foot with the preceding verb form either a prosodic word or a phonological phrase with material on their right. In the resulting structure, articles that violate exhaustivity once (by being unfooted) are susceptible to omission. Articles violating exhaustivity twice (by not attaching to a foot or a prosodic word) are omitted even more frequently. Experiment 3 further confirmed the hypothesis that feet are contained in prosodic words by demonstrating that feet cannot contain syllables from more than one lexical word.

Experiments 4a and 4b examined the effect of focal stress on children's assignment of phonological phrases. Children omitted more object articles following a verb bearing focal stress. This effect was taken to indicate that children align foot and prosodic word boundaries with phonological phrase boundaries. Syllables in the resulting structure that do not belong to a foot are susceptible to omission. Experiments 5a–c examined the effect of object NP length on children's assignment of phonological phrases. Children omitted more object articles preceding an object NP containing two prosodic words than objects containing one prosodic word. Consistent with experiments 4a and 4b, this effect suggests that children align foot and prosodic word boundaries with phonological phrases, omitting syllables that are unfooted in the resulting structure.

8.1. RELATION TO LINGUISTIC THEORY. The research presented here suggests that young children assign prosodic structures remarkably consistent with those posited in theories of prosodic phonology. In particular, the data suggest that children create hierarchical structures containing feet, prosodic words, and phonological phrases and use these structures in their language planning and production. Children's prosodic structures, as revealed by the object article omission patterns, also differ in several ways from structures posited in pro-

sodic phonology. One difference is the relation of prosody-syntax mapping constraints and the exhaustivity constraint for syllables to belong to feet. In many accounts of prosodic phonology, function morphemes form prosodic words with the lexical word in the same syntactic phrase. Thus, an object article should form a prosodic word with the following noun. In contrast, the data from experiments 1–3 suggest that children form a prosodic word from an object article and the preceding verb, when doing so results in the object article belonging to a foot. In OT terms, constraints on exhaustivity appear to be more highly ranked in children's utterances than are prosody-syntax mapping constraints.

Are children's prosodic representations deviant from those of adults in this regard? Some recent experimental work with adults suggests not. Wheeldon and Lahiri (1995) examined adult Dutch speakers' latencies to begin utterances containing different amounts of material in the first prosodic word. English versions of sentences like those used by Wheeldon and Lahiri, along with the prosodic word analyses, are shown in 14a–b. Note that, in 14a, the object article forms a prosodic word with the preceding verb.

(14) a. [I drink the]$_{PW}$ [water]$_{PW}$ b. [I drink]$_{PW}$ [John's]$_{PW}$ [water]$_{PW}$

The experimenters reasoned from Levelt's (1989) speech production model, that speakers could not begin speaking until they had formulated the first prosodic word. If adults form a prosodic word containing a verb plus the following object article, the first prosodic word in 14a is longer, and hence should take longer to prepare and initiate, than the first prosodic word in 14b. The results support this hypothesis. Therefore, there is at least some experimental evidence that both adults and children can form prosodic words across syntactic phrase boundaries.

Another difference between children's prosodic structures and structures posited by prosodic phonology is the metrical form of prosodic words. In earlier accounts, function morphemes form prosodic words with adjacent lexical words without regard to the resulting metrical pattern (e.g. Nespor & Vogel 1986, see n. 1). The comparison of children's performance on sentences like 8b vs. 8d in experiment 2 can be interpreted as evidence against such a proposal. Note that the proposed prosodic analyses of these two sentences (shown in Fig. 2b and 2d, respectively) show the object article forming a prosodic word with the following noun *zebra* in Fig. 2b. The article, however, does not form a prosodic word with *giraffe* in 2d, because the resulting prosodic word would contain two initial weak syllables, an impossible pattern for English lexical words. The current proposal, consistent with McCarthy and Prince (1993: 5, 19), is that the constraint on the metrical form of lexical words is a constraint on prosodic words. Thus, the object article in Fig. 2d must attach to the prosodic structure at the level of the phonological phrase.

A third difference between the current proposal and theories of prosodic phonology can be found by comparing Fig. 2b and 2d and the prosodic structures proposed for the same sentences by Selkirk 1996 and McCarthy & Prince 1993, shown in Fig. 3. As noted above, the object article attaches to the prosodic word with the object noun in 2b, but cannot do so in 2d due to the constraint

on prosodic words to contain at most one unfooted syllable. The structures in Fig. 2b and 2d support the hypothesis that the number of violations of exhaustivity influences the frequency of omissions, with more object articles omitted in 2d than in 2b. In contrast, Selkirk's analyses (Fig. 3a and 3b) show the object article attached to the phonological phrase node, and thus violating exhaustivity twice, in both structures. Because these two structures do not differ, they cannot account for the different pattern of omissions observed in children's productions. Now consider the analyses of the same sentences proposed by McCarthy and Prince (Fig. 3c and 3d). These analyses differ from those in Fig. 2b and 2d, because McCarthy and Prince allow the nonrecursivity constraint to be violated for prosodic words (also see Selkirk 1996). The structures in 3c–d are consistent with the omission data if we assume that skipping attachment to a lower prosodic word node, while attaching to a higher one, violates exhaustivity. Future research must determine whether children allow recursion of prosodic words and therefore whether Fig. 2b and 2d or Fig. 3c and 3d better reflect children's prosodic representations.

Despite potential differences in the specific prosodic structures proposed here and those assigned by various theories of prosodic phonology, there are important points of deep correspondence. Not only do children appear to represent the types of prosodic categories proposed for adults, but the constraints on prosodic structures needed to account for the child data appear to correspond to the constraints needed for adult data. One such point of correspondence concerns prosodic domination constraints. Recall from the overview of prosodic phonology that two constraints, layeredness and headedness, have been

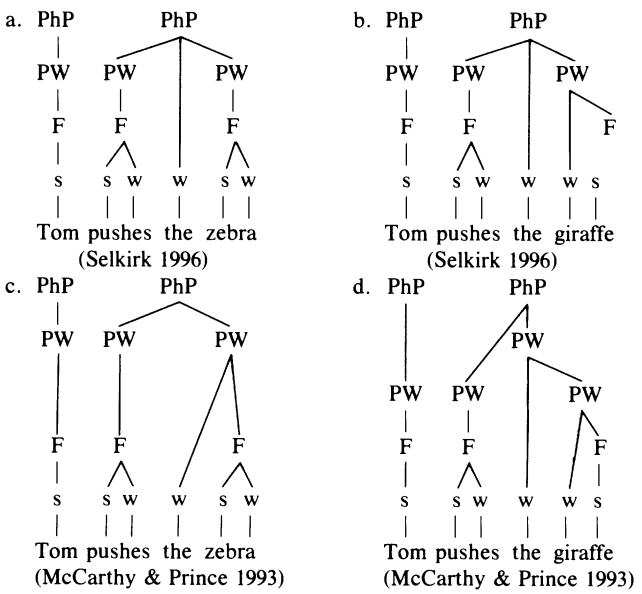


FIGURE 3. Prosodic structures assigned by Selkirk 1996 and McCarthy & Prince 1993

proposed to be inviolable properties of prosodic structures, while two others, nonrecursivity and exhaustivity, have been proposed to be violable. With respect to layeredness and headedness, the fact that children's prosodic structures appear to comprise a hierarchical arrangement of prosodic categories supports the centrality of these constraints in their representations. With respect to nonrecursivity, future research must determine whether children represent recursive prosodic word categories as have been proposed for adults. The exhaustivity constraint has been the focus of the research presented here. This research shows that children form prosodic representations similar to those of adults. From these representations, they omit syllables that violate exhaustivity, with more violations associated with more omissions. One way of construing these results is to posit that exhaustivity is more important (i.e. ranked higher) in young children's representations than in adults'. On such a view, becoming a more fluent speaker entails allowing less optimal prosodic structures—allowing violations of exhaustivity—in favor of including all of the material in the intended utterance.

A final point of correspondence between the research presented here and recent work in linguistics involves the use of optimality theory. OT offers a system that can handle violable constraints, which, as noted above, are critical to the current analysis. Therefore, insofar as my analysis captures important facts about children's language production, it supports OT approaches to prosodic phonology (see also Demuth 1995, Fee in press, McCarthy & Prince 1993, Selkirk 1996), but the analysis adopts only the flavor of OT without employing its presentational conventions and therefore without providing a formal OT analysis of the data. Such an analysis must also be left for future research (see Massar 1996).

8.2. IMPLICATIONS FOR THEORIES OF LANGUAGE ACQUISITION. The research presented here has several implications for theories of language acquisition. Perhaps the most obvious of these concerns children's representation of functional categories, such as articles. Children's omission of functional categories from their early utterances has been taken by many researchers to suggest that they do not perceive or represent these linguistic elements (e.g. Lebeaux 1988, Pinker 1984). In contrast to this view, my research demonstrates that children differentially preserved object articles depending on an article's place in a complex prosodic structure. It is only by assuming that children represented the article at some point prior to actual production that we can account for the pattern of omissions observed. Insofar as the current data reflect general properties of children's language production, they provide strong evidence against proposals in which children do not represent functional categories.

My research also has implications for prosodic bootstrapping approaches to language acquisition. The PROSODIC BOOTSTRAPPING HYPOTHESIS is based on claims by numerous researchers that prosodic changes, such as pausing, syllable lengthening and pitch resetting, tend to occur at syntactic boundaries (e.g. Cooper 1975, Cooper & Paccia-Cooper 1980, Klatt 1975), and that prosodic information appears to be especially salient in speech to infants and young children (e.g. Fernald 1985, Fernald & Kuhl 1987, Jusczyk et al. 1992). Accord-

ing to the prosodic bootstrapping hypothesis, the purported correlation of prosodic changes and syntactic boundaries, coupled with infants' and children's sensitivity to these changes, might allow learners to use prosody to infer the location and structural arrangement of syntactic units in the speech stream (Gleitman et al. 1988, Gleitman & Wanner 1982, Hirsh-Pasek et al. 1987, Jusczyk et al. 1992, Kemler Nelson et al. 1989, Morgan 1986, Morgan & Newport 1981, Morgan et al. 1987, Peters 1983, 1985). However, research in prosodic phonology suggests that prosodic structure, not syntactic structure, controls prosody (Hayes 1989, Nespor & Vogel 1986, Selkirk 1986). Consistent with this view, the research reported here suggests that learners use prosodic information in the speech stream to infer prosodic structure, not necessarily syntactic structure (Ferreira & Morrison 1994, Fisher & Tokura 1996, Gerken 1994a, Gerken et al. 1994, Read & Schreiber 1982). While the possibility remains that children might go on to infer aspects of syntactic structure from prosodic structure, the current research, along with other studies, suggests that the route from prosody to syntax is not nearly as direct as the prosodic bootstrapping hypothesis might suggest.

Finally, my research suggests that, although children's productions cannot be taken to directly reflect their underlying linguistic representations, neither should child utterances be dismissed as merely reflecting performance constraints. Rather, studying children's productions within the joint context of models of language production and linguistic theory can provide a detailed look at their developing representations of language.

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