

Receptive Grammatical Knowledge of Familiar Content Words and Inflection in 16-Month-Olds

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This study examines 16-month-olds' understanding of word order and inflectional properties of familiar nouns and verbs. Infants preferred grammatical sentences over ungrammatical sentences when the ungrammaticality was cued by both misplaced inflection and word order reversal of nouns and verbs. Infants were also sensitive to inflection alone as a cue to grammaticality, but not word order alone. The preference for grammatical sentence forms was also disrupted when adjacent function word cues were removed from the stimuli, and when familiar content words were replaced by nonce words. These results suggest that sensitivity to the *relationship* between functional morphemes and content words, rather than sensitivity to either independently, drives the development of early grammatical knowledge. Furthermore, infants showed some ability to generalize from familiar to nonce content word contexts.

Although languages vary greatly in their surface form, traditional linguistic theory suggests that similar types of underlying structural or syntactic principles govern all languages. The task of the language learner is to infer the underlying syntactic principles governing the target language based on observations of the surface form of the linguistic input. Setting aside important differences in phonological and lexical properties, languages manifest this underlying structure in two main ways: the order in which words appear, and the inflectional endings on words. Languages like English rely heavily on word order in determining how words relate to one another in a sentence (e.g., “Mary liked Bill” vs. “Bill liked Mary”). However, inflection, like the *-s* on the end of both *plays* and *cards* in “Bill plays cards” (either a

third singular verbal inflection or a plural noun inflection), also plays a role in English, although to a lesser extent than in languages like Russian or German, which have case marking and noun–adjective agreement. English is relatively impoverished in its inflectional properties, but those inflections that do appear still contribute information about the syntactic structure of a sentence. The primary focus of this article is to examine the development of infants’ understanding of the word order and inflectional properties of English.

SYNTACTIC CATEGORIES

Different categories of words, by definition, exhibit different syntactic behavior. Therefore, to acquire both the word order and inflectional systems, infants must be able to group words into different categories with different properties. At the highest level, infants must group words into content words, like nouns and verbs, which bear the larger semantic load and have a small token/type ratio, and function words (e.g., *the, is, she*), which are more structural in nature and have a high token/type ratio. There is evidence that infants can perceptually distinguish content and function words from very early on (Shi, Werker, & Morgan, 1999). These categories are further subdivided: function words into determiners, auxiliaries and pronouns, and so on, and content words into classes like noun and verb. At some point, learners must be able to distinguish these finer categories as well.

There is currently a debate regarding the relationship between the acquisition of syntactic categories and the development of the syntactic system in which these word categories operate. Some theoretical perspectives (e.g., Pinker, 1994) would suggest that syntactic categories like noun and verb are part of the infant’s innate endowment, and learning a language consists of discovering the specific ways in which these categories interact in the syntactic structure. Others have argued that the syntactic characteristics of content words are learned in an item-based fashion (Theakston & Lieven, 2005; Tomasello, 2000), and infants must form syntactic categories by detecting similarities in how individual words pattern within sentences. This latter perspective also entails that infants should be more sensitive to the grammatical properties of highly familiar words than those of less familiar words. One goal of this article is to examine the role that word familiarity plays in infants’ developing understanding of the grammatical properties of content words, to inform this debate. In particular, we focus on the development of knowledge regarding the relationship of content words to functional morphemes.

FUNCTIONAL MORPHEMES

Function words may play a particularly important role in the early development of syntax because of the structural role they play in sentences. They may be thought

of as the bones on which the “meat” of the sentence, the content words like nouns and verbs, appear. The importance of functional markers for acquiring a grammar is demonstrated by studies of adults learning artificial languages (e.g., Morgan & Newport, 1981; Valian & Coulson, 1988). Recent computational work has also suggested that the presence of highly frequent words in speech may serve as a cue to structural properties of speech (Mintz, 2003). Mintz found that a word’s “frame,” the pair of words immediately preceding and following a word, is a very good predictor of the grammatical category of that word, if the frame occurs frequently in the input. Notably, most frequent frames are pairs of function words (the _ is, you _ the, a _ of, etc.). This study examines the possibility that inflectional morphemes, which play a similar structural role in the sentence, may also play a similar role in the acquisition process. Both free and bound functional morphemes (function words and inflection, respectively) may together serve as the early basis for the development of grammatical structure.

Although computational work and studies of learning in adults points to the potential importance of functional morphemes in aiding children’s acquisition of syntactic knowledge, both function words and inflections are absent from children’s own speech until the third year of life or later (Brown, 1973). However, learners who are themselves not using functional morphemes in their speech show signs that they are aware of their presence.¹ During the second year of life, infants begin to demonstrate grammatical knowledge of the inflectional properties of English. For example, Santelmann and Jusczyk (1998) found that 18-month-olds, but not 15-month-olds, detect violations in the dependency between the auxiliary *is* and the gerund verbal ending *-ing*. Infants preferred listening to grammatical sentences like “The baker is baking bread” to ungrammatical sentences in which *is* was replaced by the modal *can*: “The baker can baking bread.” Recent work has found evidence for similar abilities in German-learning infants (Höhle, Schmitz, Santelmann, & Weissenborn, 2006). Evidence also suggests that 19-month-olds (but not 16-month-olds) are sensitive to the presence of the plural/third-person singular present tense verbal inflection *-s*. Nineteen-month-olds prefer passages that contain inflection, such as “The baker bakes bread,” to those that do not, as in “The baker bake bread” (Soderstrom, 2002; Soderstrom, Wexler, & Jusczyk, 2002).

There is also considerable evidence that young children are sensitive to function words like pronouns and auxiliaries before they are used productively. Toddlers who do not spontaneously use function words respond more appropriately to commands in full English sentences than to sentences in which function words are replaced with nonce words or removed entirely (Gerken & McIntosh, 1993; Petretic & Tweney, 1977; Shipley, Smith, & Gleitman, 1969). Even young infants show

¹Table 1 provides a summary of the following paragraphs describing the developmental trajectory of grammatical knowledge.

TABLE 1
Approximate Timeline of the Development of Grammatical Knowledge
(in English Unless Otherwise Indicated)

At:	Infants ...
10 months	<ul style="list-style-type: none"> • Are sensitive to the word order of determiners and nouns. • Detect when function words are replaced by nonsense words.
12 months	<ul style="list-style-type: none"> • Can learn function–content word-like pairings in an artificial grammar. • Can use frequent frames to group words into categories.
14 months	<ul style="list-style-type: none"> • Use determiners to classify nouns (German). • Detect when the locations of function words are interchanged.
16 months	<ul style="list-style-type: none"> • Fail to detect when content words are replaced with nonsense words. • Use determiners as indicators of common versus proper nouns.
18 months	<ul style="list-style-type: none"> • Are sensitive to auxiliary/inflection dependencies (English). • Begin to form content word combinations in their own productions. • Use word order of simple noun–verb–noun sentences to determine agent and patient. • Are sensitive to presence of <i>-s</i> inflection. • Are sensitive to auxiliary–inflection dependencies (German).
21 months	<ul style="list-style-type: none"> • Can determine agent or patient in noun–verb–noun sentences with unfamiliar verbs.
24 months +	<ul style="list-style-type: none"> • Use verb inflections in their own productions.

perceptual sensitivities to the presence and position of function words. By 11 months, infants show both behavioral effects (changes in listening preferences) and electrophysiological differences when function words are replaced by nonce words (Höhle & Weissenborn, 2003; Shady, 1996; Shafer, Shucard, Shucard, & Gerken, 1998; Shi, Werker, & Cutler, 2006). Recent work suggests that sensitivity to function words may emerge even earlier in infants learning Quebec French (Shi, Marquis, & Gauthier, 2006). By 16 months, infants also detect when the positions of function words have been interchanged in a sentence (Shady, 1996), indicating that they recognize not only that function words have particular structural locations in a sentence, but also that *particular* function words have *particular* locations in the sentence (e.g., pronouns occur just before verb phrases, determiners at the beginning of noun phrases).

CONTENT WORDS

Infants' recognition of violations involving the omission, replacement, and position of functional morphemes reflects considerable knowledge about these elements. By contrast, the evidence regarding their knowledge of content words is much more equivocal. In the same study that showed that 11-month-olds detect when function words have been replaced and 16-month-olds detect when they have been interchanged, Shady (1996) found that 16-month-old infants do not alter

their listening preferences when content words are replaced by nonce words. However, Shady's study does not speak to whether 16-month-olds have knowledge of the appropriate structural positions of content words. The finding that infants do not respond differently when content words are replaced with nonce words indicates only that infants at this age are tolerant of the presence of unfamiliar content words. This is unsurprising. Infants must be very used to hearing novel words in their daily life. In contrast to functional elements, content words are open class, meaning that new members of this category may be added to a language freely.

Although infants may be unsurprised by the presence of novel content words, this does not mean that the familiarity of content words is irrelevant to infants' processing of sentences. For example, the familiarity of content words in a sentence may influence whether infants are able to detect grammaticality violations of function words. Höhle et al. (2006) found that German infants' ability to detect long-distance dependency violations varied as a function of the syntactic category of the content word sequences intervening between the dependent items. Infants were able to detect the dependency relation only when the intervening material consisted of a determiner–noun sequence, but not an adverb.²

By 18 months, English-learning infants appear to use word order to interpret meanings of simple transitive sentences involving familiar verbs, mapping preverbal nouns to the agent and postverbal nouns to the patient in a scene (Hirsh-Pasek & Golinkoff, 1996). It is also around this time that infants begin to form two-word utterances, and can demonstrate some productive knowledge of word order (Brown, 1973). By 21 months, infants are able to correctly assign agent and patient roles to nouns in simple transitive sentences containing novel verbs (Gertner, Fisher, & Eisengart, 2006). These findings suggest that older infants are sensitive to the basic word order structure of very simple noun–verb–noun sentence forms like “The bunny is gorging the duck,” and can use this knowledge to infer meaning. However, children as old as 2 to 3 years may still have difficulty overcoming semantic context to infer meaning based on word order alone (Bushnell & Maratsos, 1984).

RELATIONSHIP BETWEEN CONTENT WORDS AND FUNCTIONAL MORPHEMES

There is also evidence that infants are sensitive to structural relationships between function elements and content words. Infants as young as 10 months are sensitive to changes in word order involving adjacent determiner–noun sequences (Shady, Gerken, & Jusczyk, 1995), differentiating between sentences like “She knew her

²As mentioned later, previous work in their lab had found evidence that infants are sensitive to the syntactic categories of words following determiners, suggesting that infants may have some knowledge of noun phrases at this age (Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004), but not adverbs.

brother's tiny hungry meows" and "She knew brother's her tiny hungry meows." The presence of *the* also appears to aid 11-month-olds' segmentation of nonce content words (Shi, Cutler, Werker, & Cruickshank, 2006). Just a few months later, infants may begin to exploit knowledge of these relationships to classify new content words. Infants as young as 12 months are able to form word-class categories similar to function and content word categories in an artificial grammar of the form aX bY (Gomez & Lakusta, 2004). Recently, Mintz (2006) found evidence that infants at this same age can use the most frequent frames to sort familiar words into categories. By 14 to 16 months, German-speaking infants use adjacency to determiners to classify novel words as nouns (Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004). Seventeen-month-old English-learning infants use the presence of an article to determine whether a novel word is a common noun or a proper name (Katz, Baker, & MacNamara, 1974), and can use morphological markings to form gender categories of Russian nouns (Gerken, Wilson, & Lewis, 2005).

Taken together, there is strong evidence for early receptive knowledge about the grammatical properties of function words, whereas the evidence for early understanding of the properties of content words is relatively weak, and based on their relationship to these function words. Thus, in contrast to the developmental trajectory one might posit based on children's productions, in which functional morphemes appear only after the child has acquired some content word order properties of the language, perceptual studies suggest that the grammatical properties of functional morphemes may be acquired before those of content words. Functional morphemes may then provide the structural backbone on which the syntactic properties of content words are acquired.

This asymmetry between the productive and perceptual findings may be understood by noting again that functional morphemes are both more common individually by token than content words, and fewer by type (the number of content words being essentially unbounded). Therefore their structural and/or statistical properties, or both may be more salient than those of content words. On the other hand, functional morphemes are less critical to the communicative needs of the infant; they are only useful for communication to the extent that they aid in the semantic understanding of the structural word-order relations of the content words. Therefore, on the assumption that infants and young children possess limited production capacities, the primacy of content words in their speech is unsurprising.

However, it is premature to make the general claim that functional morpheme knowledge precedes content word knowledge. For one thing, the ages at which infants display grammatical knowledge of these word categories are quite close. As discussed earlier, infants begin to show sensitivity to content word order by 18 to 21 months (Gertner et al., 2006; Hirsh-Pasek & Golinkoff, 1996), and function word order by 16 months (Shady, 1996). If studies regarding knowledge of word categories are included, this might lower the age to 12 to 14 months (Höhle et al., 2004; Mintz, 2006). The evidence with respect to inflections is even weaker. To date no study has found sensitivity to inflections before 18 months, which is about the *same time* that

sensitivity to content word order begins to develop. What is needed is a direct comparison of these two kinds of knowledge, using the same methodologies and ages.

In addition, the studies examining infants' sensitivity to content word knowledge may simply not have tested the right properties or made the right comparison. For example, because Shady (1996) did not find evidence that 16-month-olds detected nonce content word replacements, she did not examine whether 16-month-olds are able to detect when the positions of familiar content words are exchanged within a sentence. This would be a critical test of whether infants are sensitive to content word order, and would parallel the experiment with function word order in which infants succeeded. As we have argued, infants' lack of response to nonce word replacements is understandable given that the number of content words is unbounded. It is therefore possible that they might be sensitive to the appropriate structural locations of familiar content words, as with function words, while still being insensitive to their replacement. In work by Bushnell and Maratsos (1984), children as old as 5 years still relied more on semantic considerations than word order in judging the grammaticality of sentences, suggesting that sensitivity to the structural locations of content words may develop rather late. However, the task demands in this study were high, as they required explicit judgments on the part of the children. It is entirely possible that much younger children or infants are, in fact, highly sensitive to the appropriate word order of content words, particularly given the findings of Hirsh-Pasek and Golinkoff (1996) and Gertner et al. (2006) that infants can use content word order to infer meaning.

Here we examine 16-month-olds' understanding of word order and the inflectional properties of familiar nouns and verbs. In Experiment 1 we compared infants' perceptual sensitivity to grammatically and ungrammatically ordered sentences, where content words, inflections, or both were shifted from their canonical positions. If sensitivity to content word order emerges first, this would suggest that infants first learn the word order relations of familiar content words, and then observe how these words relate to the highly frequent functional morphemes that surround them. If, on the other hand, sensitivity to functional morphemes emerges first, then this suggests that infants first construct a grammatical framework of functional morphemes. In Experiment 2, we examined whether infants are sensitive to the relationship between function words and inflection, by varying the distance between inflectional endings and preceding function word cues. Finally, in Experiments 3 and 4, we examined whether sensitivity to inflection is dependent on the familiarity of content words, by asking whether infants can detect these violations when the inflection occurs on a novel word.

EXPERIMENT 1

In Experiment 1, we used the paradigm developed by Shady (1996) to examine whether 16-month-olds detect that familiar content words (nouns and verbs) and

familiar inflections (plural *-s* and third person singular *-s*) are out of place in a sentence. If they do, previous research (e.g., Santelmann & Jusczyk, 1998; Shady, 1996) suggests that they should prefer to listen to grammatical sentences over sentences in which the locations of the familiar words have been interchanged. There were three experimental conditions designed to test infants' sensitivity to content word order, and the inflectional properties of the content words. In the first condition (both), both content words and inflection mismatches served as potential cues to the misplacement of the familiar content words. In the second condition (content word position), only content words were misplaced. In the third condition (inflection), only inflection was moved, from the noun to the verb or vice versa. If infants are sensitive to both content word position and inflection, they should show preferences for the grammatical passages in all three conditions. If they are sensitive only to content word position and not inflection, they should show preferences in the both and content word position conditions, but not the inflection condition. However, if they are sensitive only to inflection and not content word position, they should show preferences in the both and inflection conditions, but not the content word position condition. Finally, if they are sensitive neither to content word position nor inflection, they should show no listening preferences.

Method

Participants. A total of 54 16-month-olds from the Providence, Rhode Island, area participated, with 18 in each condition. Across all three conditions, the age range was 468 to 508 days. There were 4 female and 14 male infants in the both condition, 8 female and 10 male infants in the content word position condition, and 7 female and 11 male infants in the inflection condition. An additional 41 infants participated in the study but were not included due to excessive fussiness or squirminess ($n = 33$), computer error ($n = 2$), parental interference ($n = 2$), significant bilingual input ($n = 1$), and failure to turn toward the lights ($n = 3$). Decisions to exclude a participant were made by the judgment of the observer coding the infant's eye gaze (see later) prior to examining the data for that session, so as not to bias the results.

Procedure. We used the Headturn Preference Procedure (Hirsh-Pasek et al., 1987; Kemler Nelson et al., 1995) to examine infants' listening preferences. Infants were seated in a testing booth on a caregiver's lap. The caregiver heard music over headphones to mask the auditory stimuli. Each trial began with a light flashing in the front panel of the booth to draw the infant's attention forward. When the infant was looking forward, one of the side lights began to flash. When the infant looked to this side light, the auditory stimulus (in this case a set of sentences) began to play. The location of the infant's eye gaze toward or away from the light was coded online by an observer over a TV monitor in an adjacent room. For each trial, the auditory stimulus continued to play until the trial reached a maximum length of

20 sec, or until the infant looked away from the light for 2 consecutive sec. Trials on which an infant did not orient for at least 2 sec were repeated to ensure that infants heard the target mismatches. The dependent measure was the total amount of time the infant was oriented toward the light while the stimulus was playing.

Design. We selected a set of six highly familiar nouns (*cats, dog, book, trucks, chairs, and ball*), and six highly familiar verbs (*come, runs, reads, quit, sing, and needs*) to use as the target content words in the stimulus sentences. Due to the nature of the experiment, it was important that the nouns not be confused with verbs and vice versa. However, in English, just about any noun can be “verbed” and most verbs can be “noured.” We therefore chose words that would be highly familiar to the infants only as a noun or as a verb to limit this confusion. An examination of maternal speech to 2 children in the Demuth Providence Corpus (Demuth, Culbertson, & Alter, 2006) verified that these words were indeed highly uniconceptual in the speech that children hear. Across all 12 words, only a single instance of a cross-category usage was found in the mothers’ speech, in the following sentence—“There’s no need for this” (where *need* is being used as a noun)—compared with 248 tokens of this same word used as a verb by that mother. There were also two instances of *book* being used as a verb in adult–adult speech in the corpus. Overall, the six verbs and six nouns used can be considered highly uniconceptual in the experience of infants. A questionnaire given to parents in our study also verified that these words were in fact familiar to the infants.

Each trial in the experiment consisted of a passage containing six sentences (see Appendix A for examples). There were a total of six sets of sentences, each containing a target noun and verb. The sentences were designed so that the target words were located in the beginning, middle, and end of the sentences. The location of the nouns and verbs were counterbalanced so that for half of the sentences, the target verb occurred first, and for the other half, the target noun occurred first. In each sentence, either the verb or the noun was inflected with an “s” (resulting in a third-person singular verb or a plural noun).

For each sentence set, three ungrammatical versions were generated from the grammatical version. For the both condition, this was accomplished simply by interchanging the placement of the target noun with that of the verb. For example, “They used to *sing* in the *chairs* on the porch” became “They used to *chairs* in the *sing* on the porch.” For the content word position condition, the target noun and verb were interchanged, but inflection remained in situ: “They used to *chair* in the *sings* on the porch.” For the inflection condition, only inflection was moved. For this latter condition (which was designed after the previous two conditions had been run) some minor modifications were made to both the grammatical and ungrammatical versions to ensure that the preceding function words contained cues as to the appropriate inflectional ending in otherwise ambiguous cases. For example the grammatical version of “They used to sing in *the* chairs on the porch” be-

came “They used to sing in *these* chairs on the porch” and the ungrammatical version “They used to *sings* in these *chair* on the porch.”

Infants were first presented with two warm-up trials to demonstrate the contingency between the lights and the speech stimuli. The data from these two warm-up trials were not included in the results. For the both and content word position conditions, the [dog/runs] sentence sets (one grammatical and one ungrammatical) were used as warm-up trials, and the remaining sentence sets were used for the 10 test trials. For the inflection condition, the [chairs/sing] stimulus set was used for the warm-up trials, because of the concern that the *s* at the beginning of *sing* might mask the presence or absence of inflection in preceding words. Inflection was the only cue to grammaticality in the inflection condition.

Stimulus analysis. For each sentence, the grammatical and ungrammatical versions were produced by a trained speaker so that they shared the same general prosodic character. One version was produced first, and then the other version was produced immediately afterward to match it as closely as possible. For half, the grammatical version was produced first, and for the other half, the ungrammatical version was produced first. This generated tokens that were highly similar (although not identical) in character. In general, pitch contours were very closely matched. The average length was 2.76 sec for grammatical sentences and 2.81 sec for ungrammatical sentences in the both condition; 2.81 sec and 2.82 sec, respectively, in the content word position condition; and 2.79 sec and 2.80 sec, respectively, for the inflection condition.³ Table 2 provides some additional acoustical data. There were no large or systematic differences found in the acoustic properties of the target words in the grammatical versus the ungrammatical sentences, suggesting that hesitations or other difficulties in producing the ungrammatical forms could not be driving the infants’ listening preferences.

To further verify that a preference for the grammatical sentences could not be attributed to some artifact of the greater difficulty in producing ungrammatical sentences, the sentences from the both condition were low-pass filtered so that individual words were unrecognizable, and presented to 10 adult listeners. The listeners were asked to rate each sentence as natural/grammatical (1) or unnatural/ungrammatical (2). Of the 10 listeners, only 1 showed a significant difference in her ratings between the two stimulus types, and 3 had identical scores for the grammatical and ungrammatical passages. Overall the grammatical sentences received a score of 1.38, whereas the ungrammatical sentences received a score of 1.40, $t(9) = 1.06$, $p > .1$. Exactly half (18 of 36) of the grammatical sentences were rated as more “natural” on average than their ungrammatical counterpart. Overall, there was no evidence that the ungrammatical passages were noticeably more awkward or more unnatural than the grammatical passages.

³Audio files used in these experiments are available from the authors.

TABLE 2
Average Acoustical Properties of Target Words in Experiments 1 Through 3

	<i>Maximum Pitch (Hz)</i>	<i>Prewrite Pause (msec)</i>	<i>Postword Pause (msec)</i>
Experiment 1: Both			
Grammatical	256	17	19
Ungrammatical	260	17	20
Experiment 1: Position			
Grammatical	221	36	26
Ungrammatical	230	28	22
Experiment 1: Inflection			
Grammatical	215	25	18
Ungrammatical	219	22	21
Experiment 2: Adjacent			
Grammatical	231	23	16
Ungrammatical	235	27	16
Experiment 2: Nonadjacent			
Grammatical	233	26	18
Ungrammatical	225	25	23
Experiment 3			
Grammatical	235	21	22
Ungrammatical	235	19	21

Results and Discussion

Figure 1 shows the results from Experiment 1. A mixed analysis of variance (ANOVA) across all three conditions, with one within-subjects factor (grammaticality) and 1 between-subject factor (experimental condition) found a marginal effect of grammaticality, $F(1, 51) = 3.47, p = .068, \eta^2_G = 0.03^4$, and a significant interaction, $F(2, 51) = 3.76, p < .05, \eta^2_G = 0.06$. To explore this interaction, we performed individual ANOVAs comparing the conditions in a pairwise fashion. We found a significant interaction between both and content word position, $F(1, 34) = 6.58, p = .015, \eta^2_G = 0.07$, and between content word position and inflection, $F(1, 34) = 4.82, p < .05, \eta^2_G = 0.05$, but not between both and inflection, $F(1, 34) < 1, p > .5$. There was also a highly significant main effect of grammaticality for the ANOVA comparing both and inflection, $F(1, 34) = 9.34, p < .005, \eta^2_G = 0.12$, but not for the other two pairwise ANOVAs.

We also performed planned t tests examining each condition individually, and found that infants in the both condition preferred the grammatical passages (M listening time = 8.0 sec) over the ungrammatical passages (6.2 sec). This difference was significant by two-tailed t test (all subsequent tests reported are two-tailed),

⁴For an effect size measure for our ANOVAs, we use the generalized eta-squared measure, as described in Olejnik and Algina (2003).



FIGURE 1 Mean looking time to grammatical and ungrammatical passages in Experiment 1. Error bars reflect standard error.

$t(17) = 2.45, p < .05, d = .72$, indicating that 16-month-olds can detect when the sentential positions of familiar nouns and verbs are interchanged and inflectional cues indicate a mismatch. However, in the content word position condition, infants did not show a significant difference in their listening preference, $t(17) = 1.18, p > .25, d = 0.25$, listening to the grammatical passages for an average of 6.4 sec and the ungrammatical passages for 7.2 sec. This suggests that word order alone was not enough to cue the infants to the ungrammaticality. In the inflection condition, infants again showed a preference for the grammatical passages (7.9 sec) over the ungrammatical passages (6.4 sec), although this difference was only marginally significant, $t(17) = 1.90, p = .07, d = 0.49$. Overall, the pattern of results across the ANOVAs and individual t tests suggests that infants are sensitive to the appropriate placement of verbal *-s* inflection on highly familiar nouns and verbs, but not the word order of these same content words. Infants had a significant preference for the grammatical passages in the both condition and a marginal preference for the grammatical passages in the inflection condition; moreover, the ANOVA comparing these two conditions found only a main effect of grammaticality and no interaction. The reverse pattern of results was found when these two conditions were compared with the content word order condition.

This is the first evidence that 16-month-olds are sensitive to agreement morphology in English. Previous work (Soderstrom, 2002) suggested that sensitivity to *-s* inflection did not develop until 19 months. However, these two findings are not necessarily contradictory. In this previous study, the 16-month-olds did show a nonsignificant preference for the inflected passages, and the results with that age group were not significantly different from the results of the 19-month-olds. More importantly, in this experiment the inflectional violation is an explicit mismatch between the inflected noun or verb and a closely preceding function word. In the

previous work, the violation entailed only a missing inflection in the context of a full noun phrase third-person subject, a much subtler violation.

These results also suggest that sensitivity to *-s* inflection might develop earlier than sensitivity to the gerund *-ing*. Santelmann and Jusczyk (1998) did not find a preference for the grammatical passages with the 15-month-olds they tested; only 18-month-olds preferred the grammatical passages to the ungrammatical ones. Such a pattern is puzzling. If anything, the greater salience of the syllabic *-ing*, its earlier emergence in production (Brown, 1973), and the primacy of the present progressive form over the simple present form in English might lead to an expectation that sensitivity to *-ing* should be seen first. One possible explanation is that dependencies involving subject–verb agreement might be learned earlier than auxiliary-verb dependencies. Auxiliary-verb dependencies may be both less critical to the structure of the sentence and less semantically meaningful. In highly inflected languages, subject–verb agreement is critical to interpreting the structure of sentences, as word order is more free. However, the age differences between our result and theirs must be interpreted with caution. We tested an age range between those tested by Santelmann and Jusczyk, and it is clear from earlier work (Soderstrom, 2002; Soderstrom et al., 2002) that 16-month-olds' knowledge of *-s* inflection is by no means fully formed. Furthermore, as different passages were used in their study and ours, it is not clear whether the complexity of the sentences used was equivalent.

Our data demonstrate that 16-month-olds detect violations involving the misplacement of inflection, but not what information they use to do so. The use of prosodic cues is unlikely. Sentential prosody was carefully controlled across sentence types and single-phoneme inflections are too short for lexical prosodic cues. Another possibility is that infants are sensitive to local cues from the co-occurrence of function words like determiners and auxiliaries immediately preceding the inflection-bearing familiar words. Because the Shady (1996) experiments found that infants at this age are sensitive to the locations of function words in a sentence, it may be that these studies are tapping into the same phenomenon, a sensitivity to the co-occurrence relations of familiar determiners with nominal inflections, and familiar auxiliaries or pronouns with verbal inflections. These relations are violated when either the function words or the inflections are moved around. If infants are only using these co-occurrence relations, their knowledge of the inflectional properties of nouns and verbs may be limited to the relations between the inflections on these content words and the adjacent function words. Experiment 2 investigates whether infants will still detect the inflectional violations when these immediate co-occurrence cues are removed from the stimuli.

EXPERIMENT 2

In Experiment 2, we examined the relationship between infants' sensitivity to function words found in Shady's (1996) work, and infants' sensitivity to inflection

in ours. Although function words and inflections have different structural properties (function words are free-standing, whereas inflections are bound to content words), they may be very similar in the roles they play in acquisition. If infants begin by building a syntactic structure based on functional morphemes, infants' detection of grammaticality violations involving either function words or inflections may be tapping into a single phenomenon—the detection of a violation in the relationship between grammatical morphemes, whether words or inflections. This possibility is a strong version of Mintz's (2003, 2006) suggestion that infants are sensitive to highly frequent word frames as a precursor to the development of syntactic word categories. It expands on Mintz's basic proposal by suggesting that inflectional markers (bound morphemes), like function words (their free counterparts), may serve as elements in these frames.

In this second experiment, we asked whether infants can detect violations in inflection when function word cues are no longer adjacent to the target words. If infants are still able to detect the violations in the inflectional endings of content words in the absence of adjacent function word cues, this suggests that infants are sensitive to the structural properties of these inflectional endings with respect to the surrounding content words. If, on the other hand, they no longer detect the inflectional violations when function words are not adjacent to the targets, this suggests that the infants are detecting a relationship between the functional elements in the sentence, independent of the content words.

To test this possibility, we created a new set of passages similar to those from the both condition of Experiment 1, such that there were at least two syllables between the target words and any immediately preceding pronoun, auxiliary, or common determiner in the grammatical passages (see Appendix C). Due to the difficulty in designing such passages, we limited the manipulation to only the most highly frequent function words. These stimuli were then used in Experiment 2 as the test (nonadjacent) condition. For example the grammatical version, "They used to *sing* in the *chairs* on the porch" from Experiment 1 became "They always *sing* in *chairs* on the porch," and the ungrammatical version "They always *chairs* in *sing* on the porch." However, because of the added complexity generated by these modifications, it was first necessary to replicate the result from the Experiment 1 both condition using a set of control passages that matched the added complexity (based on number of syllables and the lexical items used). The stimuli used for this control (adjacent) condition are found in Appendix B.

If infants do not require the presence of an adjacent familiar function word to detect the misplacement of inflection on a familiar content word, then they should show a significant preference for the grammatical sentences in both the adjacent (the replication of the Experiment 1 both condition) and nonadjacent (in which the adjacent cues from preceding pronouns, auxiliaries, and determiners are reduced) conditions. However, if preceding adjacent familiar function words are necessary for infants to detect the inflectional violations, then they should show no preference in the nonadjacent condition.

Method

Participants. A total of 44 infants participated from the Providence, Rhode Island, area. Across the two conditions the age range was 467 to 506 days. In the adjacent condition, there were 13 female and 9 male infants. In the nonadjacent condition, there were 11 female and 11 male infants. An additional 29 infants participated in the study but were not included due to fussiness or squirminess ($n = 27$) or failure to look toward the lights ($n = 2$).

Procedure and design. Procedure and general design were identical to Experiment 1. As described in the introduction, the adjacent condition was a replication of the Experiment 1 both condition, and for the nonadjacent condition, the target words were separated from preceding function words by at least two syllables (see Appendices B and C). The average length was 2.82 sec for grammatical sentences and 2.83 sec for ungrammatical sentences in the adjacent condition, and 2.79 sec and 2.82 sec, respectively, in the nonadjacent condition. Table 1 provides some additional acoustical data.

Results and Discussion

Figure 2 shows the results from Experiment 2. A mixed ANOVA across the two conditions, with one within-subjects factor (grammaticality) and one between-subject factor (experimental condition) found a significant effect of grammaticality, $F(1, 42) = 4.444$, $p < .05$, $\eta^2_G = 0.04$, but no significant interaction, $F(1, 42) < 1$, $p > .1$. Although the interaction did not reach significance, inspection of the data suggested that the effect was being driven primarily by the adjacent condition.

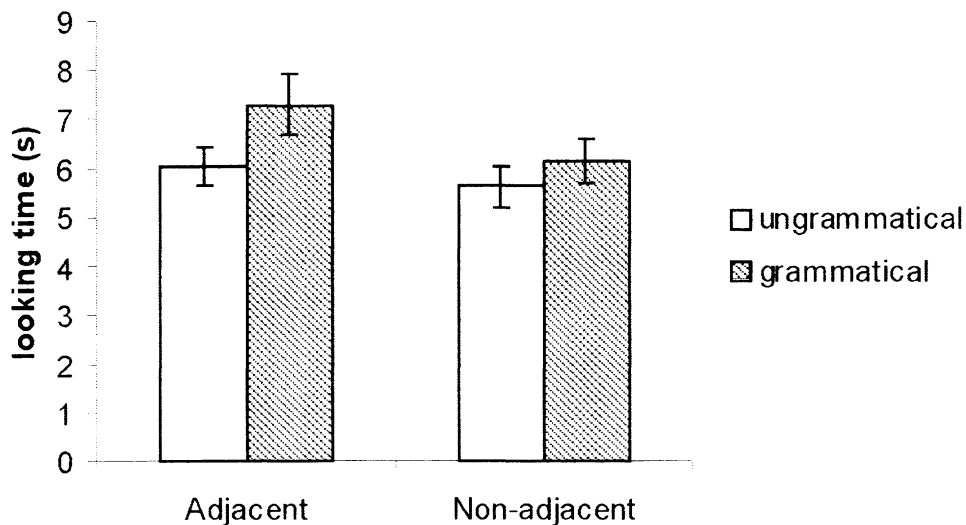


FIGURE 2 Mean looking time to grammatical and ungrammatical passages in Experiment 2. Error bars reflect standard error.

Planned *t* tests examining each condition individually confirmed this impression, finding that infants in the adjacent condition showed a significant preference for the grammatical passages (7.3 sec) over the ungrammatical passages (6.0 sec), $t(21) = 2.08, p < .05, d = .52$, replicating the finding in Experiment 1. However, infants in the nonadjacent condition, in which the function word cues were less accessible, did not show a preference, $t(21) < 1, p > .1, d = .21$, listening to the grammatical sentences an average of 6.1 sec, and to the ungrammatical sentences an average of 5.6 sec.

The significant effect of grammaticality in the adjacent condition provides an important replication of our overall finding in Experiment 1. It also establishes that the failure of the infants to show a significant preference in the nonadjacent condition cannot be attributed solely to an effect of the greater complexity of the stimuli used in Experiment 2. The smaller effect size in the adjacent condition compared with the both condition in Experiment 1 (which contributed to the lack of interaction in the Experiment 2 ANOVA) may be attributed to the added complexity of the stimuli. Planned comparison of the grammatical and ungrammatical passages in the nonadjacent condition found no significant preference for the grammatical passages, suggesting that the adjacency of function words may play an important role in infants' ability to detect grammatical violations involving familiar content words. When the misplacement of either function words, as in Shady's (1996) work, or content words, as in Experiment 2, disrupted this relationship (e.g., of pronouns with verbs or determiners with nouns), infants were able to detect the violation. However, when the relevant content and function words were not adjacent, infants were not able to detect the content word order violation. Because the interaction between grammaticality and condition did not reach significance in the ANOVA, this finding must be stated with caution. It is possible that infants have some ability to detect the grammaticality violations in the absence of such adjacency cues, based on other cues such as the overall content word order and/or the presence of function words in nonpreceding locations, and that such smaller effects ($d = .21$) simply did not reach significance due in part to the added difficulty inherent in the more complex stimuli. Regardless, the pattern of results suggests that infants are indeed sensitive to the relationship between closely colocated inflection and function words, as predicted by an expanded version of the frequent frames proposal. This sensitivity may serve as a powerful cue to syntactic categories.

EXPERIMENT 3

In Experiment 1, we explored whether 16-month-olds are capable of detecting inappropriate use of highly familiar nouns and verbs in a sentence. Despite previous research suggesting that slightly older infants can use word order to determine the semantic relationships of content words, the results of these experiments provide

no evidence that 16-month-olds are sensitive to the differing word order properties of familiar nouns and verbs, whereas they do show sensitivity to their inflectional properties. In hindsight, this result is logical. Although the structural properties of “noun” and “verb” categories are invariant in English, the particular lexical items that make up these categories are not mutually exclusive. Nouns are easily “verbed” and vice versa. This was made clear in the difficulty we had in finding nouns that could not serve as verbs and verbs that could not be used as nouns. We selected nouns and verbs that infants at this age have heard primarily as one or the other, but these included words that belong to both syntactic categories (e.g., the verbs *run*: “I’m going for a run”; and *need*: “He met her needs”; and the nouns *dog*: “He dogged her all day”; and *chair*: “She chairs the session every month”). In fact, these kinds of category changes are highly productive in English. Therefore, infants at this age may be familiar with the grammatical properties of nouns and verbs, but remain unfazed by their usage in “inappropriate” contexts—just as they fail to show sensitivity to their replacement with nonce words.

Together with Shady’s (1996) finding that 16-month-olds are insensitive to the replacement of content words with nonce words, our results might lead to the hypothesis that content words are not relevant in infants’ early understanding of syntactic structure. Such a hypothesis would run counter to the strongest version of item-based explanations for the development of syntactic structure, whereby syntactic relationships are learned in a piecemeal fashion based on co-occurrence relationships between individual words. According to such theories, the ability to detect inflectional violations should not be independent of words on which those inflections appear. An alternative interpretation of our findings, in which infants were sensitive to the inflectional properties of these words because they were highly familiar, however, would be in keeping with some forms of item-based theories.

In Experiments 3 and 4, we explore whether the familiarity of content words plays a role in infants’ recognition of grammaticality violations by examining whether infants can detect the inappropriate inflection when the inflected words are nonce words. If content word familiarity plays a role in the detection of function word violations, infants may have difficulty detecting these violations in the presence of novel words. On the other hand, if 16-month-olds are successful at detecting violations of inflectional endings on unfamiliar content words, this provides strong evidence that they are beginning to build a structural representation based on these functional elements, rather than learning the co-occurrence relations between individual words in an item-based fashion.

In Experiment 3, we used the stimuli from the Experiment 1 inflection condition, but replaced the familiar noun and verb stems with nonce words (nouns: *blem*, *vod*, *zade*, *pab*, *gip*, *nug*; verbs: *klope*, *teeb*, *grole*, *fid*, *pluke*, *meep*). Even if infants do not have a mature understanding of the category membership of the familiar words in Experiments 1 and 2, their very familiarity may still play a role in the infants’ detection of grammaticality violations. Infants might have difficulty parsing

the stem from the inflection in unfamiliar words, and therefore be insensitive to the dependency between function words and these inflections. Or dependency relations may be learned in an item-specific fashion, so that using unfamiliar words should disrupt their ability to detect the grammaticality violations. In Experiment 3, we ask whether the use of unfamiliar stems disrupts the infants' ability to detect the inflectional violation.

Method

Participants. Eighteen 16-month-olds (age range = 469–507 days) from the Providence, Rhode Island, area were included in the experiment (9 female and 9 male). An additional 8 infants participated in the study but were not included due to fussiness or squirminess ($n = 4$), failure to turn toward the lights ($n = 3$), and parental interference ($n = 1$).

Procedure and design. Procedure and general design were identical to Experiments 1 and 2. The passages used for this experiment were identical to the Experiment 1 inflection condition, but with the familiar target words replaced with the following nonce words (nouns: *blem, vod, zade, pab, gip, nug*; verbs: *klope, teeb, grole, fid, pluke, meep*). The average length was 2.77 sec for grammatical sentences and 2.83 sec for ungrammatical sentences in Experiment 3. Table 1 provides some additional acoustical data.

Results and Discussion

Infants showed no preference for the grammatical passages (7.2 sec) over the ungrammatical passages (7.5 sec), $t(17) < 1$, $p > .5$, $d = 0.09$. A mixed ANOVA comparing Experiment 3 with the inflection condition of Experiment 1, with one within-subjects factor (grammaticality) and one between-subject factor (experimental condition) did not find a significant effect of grammaticality, $F(1, 34) = 1.363$, $p > .1$, or a significant interaction, $F(1, 34) = 2.670$, $p > .1$. Despite the lack of significance in this ANOVA, the infants clearly did not show a preference for the grammatical passages when unfamiliar words were used. This suggests that the familiarity of the nouns and verbs in Experiments 1 and 2 played a role in the infants' ability to detect grammaticality violations. Although it is possible that the presence of unfamiliar items in the sentences simply drew the infants' attention away from the inflection violations, we consider this unlikely. Recall that in Shady's (1996) work, infants showed no difference in their looking times to passages containing real content words versus those replaced by nonce words. Furthermore, the infants' overall listening preferences in Experiment 3 were similar to Experiments 1 and 2, providing no support for the possibility that they found the nonce words more or less interesting than the familiar content words.

Another possibility, that infants did not show a preference because it is difficult for infants to detect inflectional endings on unfamiliar stems (compare *blix* with *blicks*) is also disputed by findings in our lab. We ran an additional group of 16-month-olds in a follow-up experiment in which we prefamiliarized the infants with the alternations *vod ... vods* and *teeb ... teeb*s. All test passages then used these two nonce words in the target locations. Eighteen 16-month-olds were tested. Under these conditions, we still did not find a preference for the grammatical or ungrammatical passages ($p > .5$).

Therefore, these results together suggest that infants had difficulty in Experiment 3 not with parsing the inflectional ending, but with detecting the relationship between function words and the inflectional endings on unfamiliar words. Such a finding provides support for the notion that the co-occurrence of function words and inflectional endings may be learned in an item-based fashion, and that the early syntactic structures that infants acquire are not independent of particular content words.

Before making such a strong conclusion, however, we undertook to determine how persistent the infants' failure might be. In Experiment 4, we examined whether infants may be able to detect the grammaticality violations with nonce words under certain conditions, if primed to expect such violations (or to attend to the inflections) by the presence of identical violations on familiar targets. Each infant heard half the passages from the Experiment 1 both condition (containing familiar target nouns and verbs), and half from Experiment 3 (containing nonce words). If infants are simply unable to detect inflectional violations on unfamiliar words, they should show a preference for the grammatical passages containing familiar words over the corresponding ungrammatical passages, but not for the grammatical passages containing nonce words. However, if infants at this age are beginning to form structural representations of functional morphemes independent of individual content words, the presence of sentences in which they are able to detect the inflection violations may help the infants discover these violations in the sentences with nonce words. In this case they may show preferences for the grammatical passages containing nonce words over the ungrammatical passages containing nonce words.

EXPERIMENT 4

In Experiment 3, we found no evidence that infants are sensitive to grammaticality violations of inflectional endings on nonce words. This contrasts with Experiments 1 and 2, in which we found such sensitivity when familiar words are used. In Experiment 4, we further probed our null result in Experiment 3 by contrasting these two conditions (familiar and nonce target words) in a within-subjects design. A within-subjects design provides a powerful test of

whether infants will fail to detect grammaticality violations involving unfamiliar words in all circumstances. If infants are unable to detect these violations on nonce words, then we should see a pattern of results in which the same infant shows a preference for grammatical passages on trials involving familiar words, but not on trials involving nonce words.

Method

Participants. Eighteen 16-month-olds (age range = 481–498 days) from the Providence, Rhode Island, area were included in the experiment (11 female and 7 male). An additional 11 infants participated in the study but were not included due to fussiness or squirminess ($n = 9$), and failure to turn toward the lights ($n = 2$).

Procedure. Procedure was identical to Experiments 1 through 3, except that there were 12 test trials rather than 10.

Design. Infants were counterbalanced into two groups. Group 1 heard the grammatical and ungrammatical versions of passages containing the targets *chairs/sing*, *ball/needs*, and *cats/come* as the familiar passages (from the Experiment 1 both condition), and the other three passages with the target nouns and verbs as nonce words (*nugs/meep*, *zade/groles*, and *gip/plukes*, from Experiment 3). Group 2 heard the passages containing *trucks/quit*, *book/reads*, and *dog/runs* as the familiar passages, and the other three passages contained nonce words (*blems/klope*, *vod/teebs*, and *pab/fids*). Note that all infants heard all 12 test passages (6 grammatical and 6 ungrammatical) once each, and each infant heard a given passage in either its familiar or its nonce form. The 12 test trials were presented in random order.

Because counterbalancing required that all 12 passages were used during the test phase, we used the grammatical and ungrammatical versions of a pretest passage from a different experiment, which had been recorded by the same speaker, as the pretest in this experiment. The grammatical and ungrammatical versions of this passage compared the grammatical *is/-ing* dependency to an ungrammatical *can/-ing* version (see Santelmann & Jusczyk, 1998).

Results and Discussion

A mixed ANOVA with two within-subjects factors (grammaticality and familiarity) and one between-subject factor (group) found a main effect of grammaticality, $F(1, 16) = 7.14$, $p = .017$, $\eta^2_G = 0.06$, with infants preferring the grammatical passages (7.7 sec) over the ungrammatical passages (6.3 sec) and no other significant effects or interactions (see Figure 3). Because the infants had not shown a preference for the grammatical passages in Experiment 3, the lack of interaction between

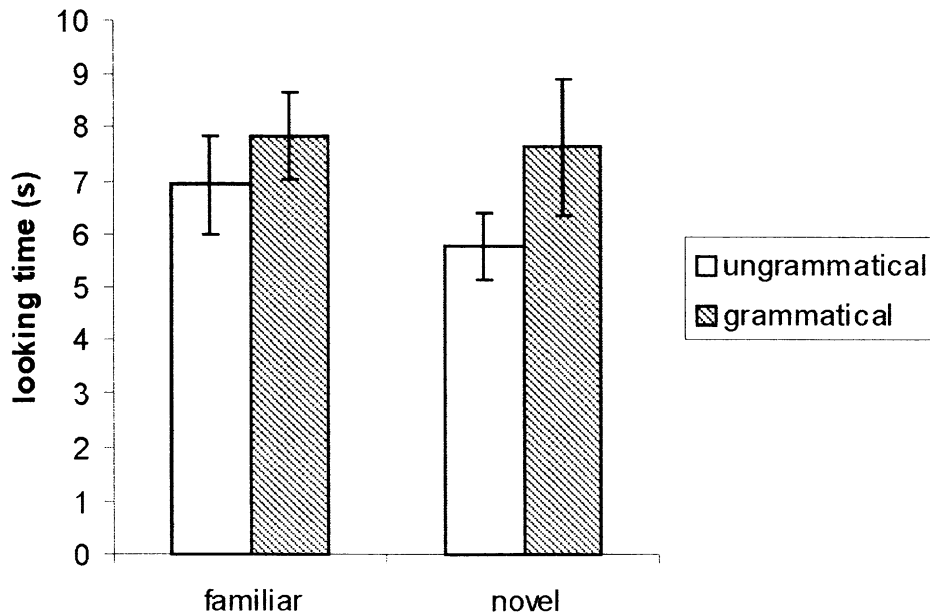


FIGURE 3 Mean looking time to grammatical and ungrammatical passages in Experiment 4. Error bars reflect standard error.

grammaticality and familiarity was surprising. A planned t test examining the listening times to the grammatical and ungrammatical passages of just the passages containing nonce words also found a significant preference for the grammatical passages (7.7 sec) over the ungrammatical passages (5.8 sec), $t(17) = 2.27$, $p < .05$, $d = .44$, confirming that the infants detected the grammaticality violations across the nonce word trials alone. A planned t test examining just the *familiar* items did not reach significance, $t(17) = 1.24$, $p > .1$, $d = .33$. However, these were the identical stimuli as those used in the Experiment 1 both condition, which did reach significance. Moreover, infants' ability to detect grammaticality violations involving familiar words was replicated in the Experiment 2 adjacent condition. The smaller number of trials in this experiment (three in each condition, as opposed to six), as well as the greater complexity of the experimental design, likely made it more difficult to detect an effect in this experiment compared with the t tests in Experiments 1 and 2. What is striking is that, even so, infants showed a significant preference for grammatical sentences containing unfamiliar content words over matched ungrammatical versions.

Contrary to our finding in Experiment 3, the infants in this experiment did prefer the grammatical passages over the ungrammatical passages, even when the inflection occurred on an unfamiliar word. Because an individual infant heard a given sentence only in its familiar or nonce form, but not both, this suggests that infants are able to detect grammaticality violations of inflections on unfamiliar words under certain conditions. This finding argues against a simple interpretation

of the result in Experiment 3 whereby infants are distracted by the presence of unfamiliar words in the stimuli, or unable to parse the inflection on an unfamiliar word. In either of these cases, one would expect infants to have the same difficulty on the nonce-word trials in a within-subjects design. It also argues against a strong item-based view of the acquisition of these grammatical properties. If infants were forming only item-specific representations of functional morpheme co-occurrences, they should not be able to transfer their sensitivity to inflectional violations from one sentence structure to another in an online task.

The infants' success in Experiment 4 suggests instead that infants may be beginning to form item-independent structural representations, although word familiarity is still a factor. Infants may have more difficulty processing sentences in which attentional resources are devoted to unfamiliar words, and in particular have trouble detecting grammaticality violations that occur on or near these unfamiliar words. However, the presence of sentences with more familiar words likely primed or cued infants to the presence of these inflectional ungrammaticalities. This would allow them to detect this same pattern in the sentences with unfamiliar words, despite the fact that these ungrammaticalities were present on the nonce words themselves. This result is especially striking given that the presentation of nonce and familiar trials was randomized (in other words, infants did not have the benefit of a block of familiar trials during which to develop expectations about the presence of violations). Moreover, infants' detection of the similarity across trials developed over the course of the presentation of only 12 test trials.

How this ability might play out in a real learning environment, in which structural comparisons across sentences are less straightforward, is unclear. However, at the very least this result suggests that 16-month-olds are sensitive to inflection on nonce words, albeit under limited conditions. Furthermore, the pattern of results across Experiments 3 and 4 suggests that 16-month-olds may be beginning to generalize structural representations independent of the specific lexical items. Infants had to be sensitive to the parallel in the structure of the familiar word and nonce word sentences for the effect to transfer from familiar word to nonce word trials. One likely explanation for infants' success in Experiment 4 given their apparent lack of success in Experiment 3 at detecting the violations is that infants generalized the pattern of inflectional violations from the sentences with familiar target words to those containing nonce words. Recent work by Lany, Gomez, and Gerken (2005, in press) has found similar evidence for generalized learning of structure across contexts in an artificial grammar paradigm, in both adults and 12-month-olds.

Proponents of item-based accounts might note that the presence of the familiar targets was necessary for infants to detect the grammaticality violations on the nonce words. An interpretation of our result in which the presence of the familiar targets on some trials primed the infants' attention to the violations, or to the inflections themselves, may fit within an item-based account. The generalization across

sentence types can be thought of as the mechanism whereby structural properties of individual items become generalized into more abstract forms—in other words, the formation of syntactic categories from individual lexical items. On the other hand, it is important to reiterate that individual infants did not hear the identical passage across nonce and familiar conditions in Experiment 4. Although it is possible to posit that infants might succeed by forming local analogies across sentences rather than appealing to very abstract syntactic representations, some level of generalization must be occurring at a relatively young age (16 months). This seems at least potentially problematic for very strong item-based hypotheses, in which abstract syntactic representations are not formed until well into the third or even fourth year of life (Akhtar & Tomasello, 1997; Tomasello, 1992).

GENERAL DISCUSSION

Across four experiments, we have shown that by 16 months, infants are sensitive to the inflectional properties of familiar nouns and verbs when they are adjacent to function words like auxiliaries and pronouns. Furthermore, they show some sensitivity to these properties in the presence of unfamiliar content words. However, these results suggest that 16-month-olds may not have full command of the word order properties of even highly familiar content words like *dog* and *sing*. When both word order and morphological inflection were manipulated together (Experiment 1), infants showed significant preferences for the grammatical passages. However, when these variables were manipulated independently, only infants who heard inflection violations showed preferences for the grammatical passages. Similarly, when increased distance reduced potential cues from function words like determiners and auxiliaries (Experiment 2), infants no longer showed a significant preference for the grammatical sentences, although the greater complexity of the stimuli may have also played a role. When unfamiliar/novel content words alone were used (Experiment 3), infants were again unable to detect the inflection violations. However, in the context of other sentences containing only familiar words with this same variation in inflectional grammaticality, infants were then able to detect the violations even on nonce words (Experiment 4). Taken together, these findings indicate that the relationship between function words and inflectional endings may play a crucial role in infants' initial formation of grammatical knowledge. Furthermore, although infants may hold off on committing to particular structural assignments, even for familiar content words, word familiarity does affect infants' ability to detect grammaticality violations.

The relationship between function words and content words in infants' developing grammatical knowledge may affect infants' processing of speech input in a variety of ways. For example, recent evidence suggests that sensitivity to function words speeds infants' processing of familiar content words (Fernald & Hurtado,

2006), and that the frequency of function words may play a role in infants' ability to segment unfamiliar content words from them (Shi, Cutler, et al., 2006; Shi, Marquis, et al., 2006; Shi, Werker, et al., 2006). This study suggests that infants' sensitivity to the relationship between function and content words may also play a more direct role in the development of grammatical knowledge.

Our findings may be viewed in the context of the recent work by Mintz (2003, 2006), who suggested that frequent frames may play a critical role in the formation of grammatical categories. As described in the introduction, Mintz's statistical analyses used the most highly frequent endpoint pairs of word trigrams (A _ B of an A X B trigram) in child-directed speech to reliably sort the internal words of the trigram (the Xs) into grammatical categories. Sorting based on this trigram analysis was much more reliable than that based on bigrams alone. Mintz's computational findings are complemented by behavioral work showing that young infants are highly sensitive to such discontinuous dependencies in artificial grammars (Gomez, 2002; Gomez & Maye, 2005), and his own research showing that 12-month-olds categorize content words based on these frequent frames (Mintz, 2006).

Importantly, the vast majority of these frequent frames are pairs of function words. Given our findings, we believe that the notion of frequent frames should be extended to include inflectional endings as framing elements. Inflectional endings likely play a role similar to that of other functional morphemes in "framing" content words, thereby providing cues to grammatical categories. Like function words, they are also highly frequent in the input. The finding here suggests that infants as young as 16 months may be sensitive to their presence. Furthermore, infants showed a more reliable preference for the grammatical passages when inflectional endings were supported by the presence of closely preceding function words, suggesting that this dependency between function words and inflection may be salient to the infants. The work by Santelmann and colleagues (Höhle et al., 2006; Santelmann & Jusczyk, 1998; Tincoff, Santelmann, & Jusczyk, 2000) has also found infants to be highly sensitive to the relationship between function words and inflection.

Furthermore, the results of multiple studies, including our own, converge to suggest that the familiarity of both the frames themselves and the items being framed play an important role in infants' recognition of such dependencies. For example, Tincoff et al. (2000) found that 18-month-olds detected the dependency violation in the pairings that used only the most common auxiliaries or modals. More analogous to our findings, Höhle et al. (2006) found that the category of the intervening material affected German-learning 19-month-olds' ability to detect dependency violations. Thus, not only do highly frequent, functional elements highlight the internal element, but a familiar internal element helps the learner detect the appropriateness of the relationship between the flanking elements. On the other hand, our results also suggest that, with appropriate contextual support, infants are

able to make certain generalizations across specific lexical items. Lexical familiarity, therefore, may not be necessary in all circumstances. Infants at this young age may be starting to form structural generalizations within which new lexical items may be analyzed.

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APPENDIX A

EXAMPLE STIMULI FOR EXPERIMENT 1

BOTH CONDITION

Book/Reads

Grammatical

I hope he reads this book tomorrow night.
 The boy reads every night from a new book.
 When mommy reads a book, the child is
 happy.
 That yellow book he reads every day.
 It's a book that the young principal reads.
 The girl holds her book and reads it quietly.

Ungrammatical

I hope he book this reads tomorrow night.
 The boy book every night from a new reads.
 When mommy book a reads, the child is
 happy.
 That yellow reads he book every day.
 It's a reads that the young principal book.
 The girl holds her reads and book it quietly.

Chairs/Sing

Grammatical

Chairs are good to stand on when you sing a
 lot.
 Cozy chairs help performers sing well.
 While the kids sing we sit in chairs.
 The man by the chairs likes to hear the birds
 sing.
 The girls sing while their parents wait in
 chairs.
 They used to sing in the chairs on the porch.

Ungrammatical

Sing are good to stand on when you chairs a
 lot.
 Cozy sing help performers chairs well.
 While the kids chairs we sit in sing.
 The man by the sing likes to hear the birds
 chairs.
 The girls chairs while their parents wait in
 sing.
 They used to chairs in the sing on the porch.

APPENDIX B
EXAMPLE STIMULI FOR EXPERIMENT 2
ADJACENT CONDITION

Book/Reads

Grammatical

I hope he reads someone exciting this book tomorrow.
The boy reads each good night from a book that's funny.
When mommy reads a book, the silly child smiles.
That yellow book is the one he reads everyone.
This is a book that the heavy young man reads.
The girl holds this book and she reads each page quietly.

Ungrammatical

I hope he book someone exciting this reads tomorrow.
The boy book each good night from a reads that's funny.
When mommy book a reads, the silly child smiles.
That yellow reads is the one he book everyone.
This is a reads that the heavy young man book.
The girl holds this reads and she book each page quietly.

Chairs/Sing

Grammatical

Chairs are good after you sing and stand a lot.
Those chairs help cozy performers when they sing.
While we sing the kids sit on chairs.
The man with chairs likes to hear young birds when they sing.
Some girls can sing while parents wait in chairs.
I sing often in the chairs on the porch.

Ungrammatical

Sing are good after you chairs and stand a lot.
Those sing help cozy performers when they chairs.
While we chairs the kids sit on sing.
The man with sing likes to hear young birds when they chairs.
Some girls can chairs while parents wait in sing.
I chairs often in the sing on the porch.

APPENDIX C
 EXAMPLE STIMULI FOR EXPERIMENT 2
 NONADJACENT CONDITION

Book/Reads

Grammatical

I hope someone reads this exciting book tomorrow night.
 The good boy reads every night from a funny book.
 When mommy reads a silly book, the child smiles.
 That yellow book is the one everyone reads.
 This is the heavy book that the young man reads.
 The girl holds each book and reads very quietly.

Ungrammatical

I hope someone book this exciting reads tomorrow night.
 The good boy book every night from a funny reads.
 When mommy book a silly reads, the child smiles.
 That yellow reads is the one everyone book.
 This is the heavy reads that the young man book.
 The girl holds each reads and book very quietly.

Chairs/Sing

Grammatical

Chairs are good after you stand and sing a lot.
 Cozy chairs help performers sing well.
 While the kids sing we sit on chairs.
 The man with chairs likes to hear the young birds sing.
 Some girls sing while their parents wait in chairs.
 They always sing in chairs on the porch.

Grammatical

Sing are good after you stand and chairs a lot.
 Cozy sing help performers chairs well.
 While the kids chairs we sit on sing.
 The man with sing likes to hear the young birds chairs.
 Some girls chairs while their parents wait in sing.
 They always chairs in sing on the porch.
