Can You Believe It? 12-Month-Olds Use Word Order to Distinguish Between Declaratives and Polar Interrogatives

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PLEASE SCROLL DOWN FOR ARTICLE
Can You Believe It? 12-Month-Olds Use Word Order to Distinguish Between Declaratives and Polar Interrogatives

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Word order is a core mechanism for conveying syntactic structure, yet interrogatives usually disrupt canonical word orders. For example, in English, polar interrogatives typically invert the subject and auxiliary verb and insert an utterance-initial *do* if no auxiliary is present. These word order patterns result from differences in the underlying syntactic structures; therefore, distinguishing interrogatives from declaratives is crucial for learning the syntax of interrogatives. More broadly, the ability to differentiate sentence types is critical for avoiding errors in syntax acquisition that would occur if interrogatives and declaratives were evaluated as the same type of utterance. Despite the importance of this issue, little is known about when and how infants begin to differentiate sentence types. In this study we exposed one group of 12-month-old infants to auditory passages of polar interrogatives and another group to passages of declaratives. To test sentence discrimination, infants in both groups were played new sets of declaratives and interrogatives in a procedure in which infants controlled how long they listened to each set. The sentences were acoustically modified to remove all prosodic cues that could differentiate them. Regardless of group, infants listened longer to the type of sentence that was different from the type to which they were initially exposed, indicating that they differentiated the sentence types based on lexical distributional patterns. We thus established that, despite only just beginning to produce single word utterances, 12-month-olds are sensitive to word-order properties that differentiate declaratives from interrogatives.

Word order is a core mechanism for conveying syntactic structure in many languages. Languages typically have a canonical word order that is exemplified in simple transitive declarative sentences (Slobin & Bever, 1982). In English, the canonical ordering is subject-verb-object (as in *Anna likes chocolate*), but interrogatives usually disrupt canonical word orders. For example, polar interrogatives (i.e., yes/no questions) invert the subject and auxiliary verb and insert an utterance-initial *do* if no auxiliary is present (*Anna can climb rocks* becomes *Can Anna climb rocks?* and *Anna climbs rocks* becomes *Does Anna climb rocks?*). Although the order of the subject with
respect to the main verb has not changed, the re-ordering of subject and auxiliary verb, and the appearance of do—called do-support—disrupt canonical word order patterns. In addition, in cases of do-support, the main verb no longer agrees with the subject, as it does when no auxiliary is present (Anna climbs ...). Moreover, in so-called wh-questions, a grammatical phrase that normally occurs as an argument or adjunct in the declarative form—for example, as an object noun phrase (NP)—is realized as a wh-word—e.g., who, what, where, how, etc.—that occurs at the beginning of the sentence (What, does Anna climb ti?). 1 Similar kinds of word order variations occur in many other languages.

Because interrogatives differ structurally from declaratives, distinguishing the two sentence types is crucial for learning the syntax of interrogatives. More broadly, the ability to differentiate sentence types is critical for avoiding errors in syntax acquisition that would occur if interrogatives and declaratives were evaluated as the same type of utterance (Pinker, 1984; Slobin & Bever, 1982). Forming generalizations about distinct word order patterns from different sentence types would not even be possible if the generalization mechanisms analyzed declaratives and interrogatives together. Since interrogatives constitute a significant portion of young children’s input (e.g., Newport, 1977, found that 23% of child-directed utterances are polar interrogatives, and 21% are wh-questions), understanding when and how learners start to differentiate interrogatives and declaratives is important for understanding grammatical acquisition more broadly. In particular, understanding when infants can differentiate declaratives and interrogatives based on lexical properties establishes a point during language development when learners, in principle, could learn more abstract syntactic properties associated with the distinct sentence types.

In this study, we focused our empirical investigation on the latter question and show that infants of approximately 1 year of age have already acquired some knowledge about the word-order properties that differentiate interrogatives from declaratives. We chose to investigate infants at this age because they can track word-order patterns in their input and have considerable knowledge about sequential regularities in their language. For example, by 12 months, infants can use lexical distributional patterns to categorize novel words (Mintz, 2006) and to distinguish novel grammatical and ungrammatical utterances in an artificial language (Gómez & Gerken, 1999). Eleven-month-olds even show limited knowledge of word categories, such as determiners (Hallé, Durand, & de Boysson-Bardies, 2008). These processing and representational abilities are important for representing differences between declaratives and interrogatives because they are necessary for detecting and representing noncanonical word order properties of interrogatives, such as auxiliary inversion, do-support, and wh-fronting. Thus, although infants are just beginning to produce single-word utterances at around a year of age, there is evidence that they possess the requisite processing abilities that would allow them to differentiate declaratives and interrogatives based on their distinct word-order patterns.

After presenting our findings that 12-month-olds can, indeed, use word-order to differentiate declaratives and interrogatives, we then turn our discussion to the question of how they could have acquired that knowledge. We propose that infants initially use phonological information to differentiate sentence types, then learn generalizations about the corresponding word-order patterns.

1The t stands for trace, and indicates how the wh-word that shares its index (i) should be interpreted within the structure of the sentence—in this case, as the direct object of climb.
EXPERIMENT

We used a version of the Head-turn Preference Procedure (HPP; Kemler Nelson et al., 1995) to evaluate whether word order information is sufficient for 12-month-olds to distinguish declaratives and polar interrogatives. In this version of the procedure (Saffran, Aslin, & Newport, 1996), infants receive an uninterrupted auditory familiarization trial in which a stimulus set with a property of experimental interest is presented. Infants are then tested on materials that differ in their similarity to the familiarization material with respect to the property of interest. Differences in the dependent measure of listening time to the different categories of test trials indicate that infants represented the property of interest.

We exposed half the infants to passages containing only declaratives, and the other half to passages containing only polar interrogatives. The passages were resynthesized to have a monotone pitch, and we equated utterance-final rhythmic properties across sentence types as well. In this way we neutralized prosodic difference between the declaratives and interrogatives. We then tested both groups of infants on novel test sentences, half of which were declaratives, and half of which were polar interrogatives. We predicted that if infants were able to use word order to differentiate declaratives and interrogatives, they should differ in their listening times to familiarized versus unfamiliarized sentence types.

Methods

Subjects. Thirty-one typically developing English-learning 12-month-olds were recruited from county birth records, with their parents contacted first by letter and then by phone or e-mail to schedule an appointment. Data from five infants were excluded from the final analysis due to fussiness (1), failure to complete study (3), moving out of camera range (1). Of the remaining 26 infants (mean age 12.05 months, range: 11.23–12.77 months, 11 female), 13 were randomly assigned to the declarative familiarization group and 13 to the interrogative familiarization group.

Stimuli and design. Stimuli consisted of 10 declaratives and 10 interrogatives. Eight sentences of each type served as familiarization sentences, and the remaining two sentences of each type served as test sentences. A given subject only heard one type of familiarization sentence, but all infants heard the same test sentences. We selected sentences that varied in terms of individual initial words. Specifically, within a familiarization type (declarative or interrogative), there were no more than two sentence pairs that shared an initial word, and the initial words of test items were different from every initial word of familiarization items. Materials were also controlled at the level of initial sounds: One test exemplar each of declaratives and interrogatives began with a [k], as did one and only one sentence in each familiarization set. The other test exemplars began with a segment that did not occur as an initial segment in any familiarization sentence. Thus, the utterance-initial properties of test items were equal in comparison to both sets of familiarization utterances, ensuring that any effects of sentence-type familiarity could not be attributed to surface-level similarities between specific test items and familiarization items. Finally, stimuli were matched on number of syllables and approximate duration. See Table 1 for a full list of stimuli.

\[^2\]If an infant cried during the experiment, or was so squirmy that the experimenter judged that they were not attending to the stimuli, then the experimenter made a note that the child was fussy, and these data were not used.
TABLE 1  
Familiarization and Test Sentences for Both Familiarization Groups. Infants heard familiarization material following group assignment (either declarative or interrogative familiarization), but all infants heard the same test sentences

<table>
<thead>
<tr>
<th>Declarative Familiarization</th>
<th>Test Sentences</th>
<th>Interrogative Familiarization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chips should be eaten with salsa.</td>
<td>Did the water in the cup freeze?</td>
<td></td>
</tr>
<tr>
<td>Tommy hurt his knee yesterday.</td>
<td>Is Patty afraid of the dark?</td>
<td></td>
</tr>
<tr>
<td>There are elephants at the zoo.</td>
<td>Will Becky be home for supper?</td>
<td></td>
</tr>
<tr>
<td>Kings and queens attend royal balls.</td>
<td>Is next Monday a holiday?</td>
<td></td>
</tr>
<tr>
<td>Roller coasters can be scary.</td>
<td>Would you like a tuna sandwich?</td>
<td></td>
</tr>
<tr>
<td>The playground is closed on Sundays.</td>
<td>Could you pick up the dinosaur?</td>
<td></td>
</tr>
<tr>
<td>The moon was very bright last night.</td>
<td>Do flamingos live at the zoo?</td>
<td></td>
</tr>
<tr>
<td>Learning to ride a bike is great.</td>
<td>Did you remember the popcorn?</td>
<td></td>
</tr>
<tr>
<td>Caramel apples are my favorite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver spoons are for eating cake.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you visiting your parents?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can you do the electric slide?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stimuli were recorded by a female native English speaker in an infant-directed register, which exaggerates prosodic dimensions and is intrinsically appealing to infants (Fernald, 1984). All recordings were made in a sound-attenuating booth using an EDIROL UA-25 USB Digital Audio/MIDI Recording Interface. Sentences were digitized at a sampling rate of 44.1 kHz. Stimuli were resynthesized to have a monotone intonation contour and equalized utterance-final vowel lengthening. To do this, we calculated the average pitch and final vowel duration for all 20 sentences (declaratives and interrogatives) based on measurements taken with Praat (Boersma & Weenink, 2011). The average pitch was 280 Hz and the average final vowel duration was 134 ms. We used a Praat script (Vicenik, 2009) to automatically generate a new pitch tier for each sentence, with the value set to 280 Hz for the entire sentence, and to resynthesize each sentence with the new, flat F0 contour. We used a second procedure and Praat script (Plichta, 2004) to adjust the final vowel duration of each sentence to 134 ms: Coders first marked vowel boundaries by examining the spectrogram and listening to the corresponding waveform. We then calculated the average final vowel duration across all 20 sentences, selected the region containing the final vowel in each sentence, and changed each sentence individually to match the average final vowel duration. Thus all sentences were similar with respect to the acoustic cues that have been reported to differ between declaratives and polar interrogatives (Bartels, 1999; Hedberg, Sosa, & Fadden, 2004).

Although discussion of prosodic differences between declaratives and interrogatives usually focuses on differences in the final portion of utterances, there are also potentially sentence-initial rhythmic differences. This is because interrogatives typically start with short function words—auxiliaries or wh-words—whereas declaratives can begin with longer open-class words. As a result, the initial sequence of syllables or words in interrogatives might exhibit a noticeable short-long rhythmic pattern, whereas declaratives might be more likely to start with a relatively long duration syllable or word. (Indeed, five of the eight declaratives in our familiarization material began with an open-class word.) Since infants have been shown to be exquisitely sensitive to this type of rhythmic difference (Yoshida et al., 2010), and since we did not manipulate utterance-initial durations, it was important to determine whether these utterance-initial rhythmic...
properties were confounded with our experimental manipulation. To be a confound, the rhythmic similarity of test sentences to familiarization sentences would have to mirror patterns of sentence-type similarity. Such a scenario would arise, for instance, if interrogative familiarization items were more similar to interrogative test items than to declarative test items, and if the opposite relationship held with respect to declarative familiarization items. To test for this kind of situation we first calculated, for all sentences, the duration difference from the first syllable (or word) to the second syllable (or word) by subtracting the duration of the second from the duration of the first position. We calculated difference scores across the first two syllables and, separately, across the first two words, since it is plausible that infants are sensitive to rhythmic patterns at either level of analysis. For example, in the word level analysis of Will Becky be home for supper?, we calculated duration(Will)-duration(Becky); at the syllable level, we calculated duration(Will)-duration(Beck). We then computed mean difference scores for the two familiarization types and the two test sentence types (Table 2). Then for each familiarization type, we compared the difference scores for the familiarization sentences to each of the test sentence types, using Welch two sample t-tests, which adjusts for potential unequal variances; we carried out this analysis with respect to syllable and words. Table 3 summarizes the quantitative results of these analyses. The main result was that, for a given familiarization type, test sentence types did not differ with respect to their similarity to the familiarization type. Specifically, neither declarative test sentences nor interrogative test sentences differed from declarative familiarization sentences in a statistically reliable way, and this was true for the syllable-level and word-level analyses. In addition, both declarative test sentences and interrogative test sentences had duration difference scores that were different from interrogative familiarization sentences, and the differences were in the same direction; this pattern occurred at the word-level and syllable-level analysis. Thus, the

<table>
<thead>
<tr>
<th>Analysis Level</th>
<th>Sentence Type</th>
<th>Mean Duration Diff (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Word</td>
</tr>
<tr>
<td></td>
<td>Interrogative Familiarization</td>
<td>173 (69)</td>
</tr>
<tr>
<td></td>
<td>Declarative Familiarization</td>
<td>−2 (88)</td>
</tr>
<tr>
<td></td>
<td>Interrogative Test</td>
<td>−12 (0.20)</td>
</tr>
<tr>
<td></td>
<td>Declarative Test</td>
<td>−27 (18)</td>
</tr>
<tr>
<td></td>
<td>Syllable</td>
<td>Interrogative Familiarization</td>
</tr>
<tr>
<td></td>
<td>Declarative Familiarization</td>
<td>54 (66)</td>
</tr>
<tr>
<td></td>
<td>Interrogative Test</td>
<td>−12 (0.20)</td>
</tr>
<tr>
<td></td>
<td>Declarative Test</td>
<td>−151 (32)</td>
</tr>
</tbody>
</table>

3We are grateful to two anonymous reviewers for bringing this possibility to our attention.

4Since the acoustic analyses showed a marginally significant overall difference in variance between declaratives and interrogatives, we could not assume equal variances between the sentence types. The Welch’s t-test incorporates sample size and the variance of each group to calculate degrees of freedom (dfs), which can generate dfs with fractional components, as well as different dfs, despite the same sample size.
sentence-initial rhythmic properties of both types of test sentences differed from the interrogative familiarization sentences in the same way, and neither test sentence type differed from declarative familiarization sentences in sentence-initial rhythmic properties. Taken together, these analyses indicate that, across familiarization conditions, rhythmic (dis)similarity of test items compared to familiarization items was not confounded with sentence type similarity—our critical independent variable.

The remaining reliable difference between the sentence types was the modified word order, with interrogatives beginning with an auxiliary followed by the subject NP, and declaratives with the subject in the canonical sentence-initial position.

**Apparatus and procedure.** The experiment was conducted in a darkened, sound-attenuated room. Infants were seated in their parent’s lap in the center of the room, facing a wall with a red light. One yellow light was mounted on the wall to the left of the infant’s center line and one was mounted on the wall to the right. The lights were approximately at the same height as the subject’s eyes. Auditory stimuli were presented from loudspeakers mounted under the yellow side lights. A video camera mounted below the center red light was focused on the infant and sent a continuous signal to a monitor in a separate control room. The experimenter observed the infant from the control room, via the video feed, and indicated the infant’s looking behavior to the computer that controlled the experiment.

The familiarization phase was initiated by flashing the center light to orient the infant to the neutral, center position. When the child was settled and facing the red light, the red light was extinguished and the familiarization phase began. During this phase, the 8 familiarization sentences associated with the infant’s group—declarative or interrogative, Table 1—were played through both loudspeakers. The familiarization sentences were played in four blocks, with the order of the sentences randomized within each block. There were approximately 525 ms silences between each sentence. Once the familiarization phase started, the stimuli were presented without interruption and independent of where the infant was looking. The familiarization phase lasted approximately 80 seconds.
In order to familiarize the infant to the contingency between its looking behavior and the activity of the lights, which was critical for the testing phase, the lights were also activated while the familiarization stimuli played, but the light activity was contingent on infants’ looking behavior (Saffran et al., 1996). Specifically, as soon as the familiarization phase began, the red light was extinguished and one of the yellow side lights was randomly selected to begin flashing. It continued to flash until the infant oriented towards the light, and then looked away for at least two consecutive seconds. At that point, the side light was extinguished and the center light started flashing again. When the infant reoriented towards the center light, the process repeated for the duration of the familiarization period, while the auditory stimuli played continuously.

The familiarization phase was followed by an audiovisual-contingency phase. This phase was similar to the familiarization phase, except that the presentation of the auditory stimulus began only when the infant was oriented toward the flashing yellow light, and only through the loudspeaker that was on the same side as the flashing light. The auditory stimulus for each of two trials was a synthetic pure tone with a pitch of 440 Hz and a duration of 500 ms. Once initiated, the stimulus was repeated, with an inter-stimulus interval of 100 ms, for 15 repetitions or until the infant looked away from the light for two consecutive seconds. When the sound stopped playing (for either reason), the side light stopped flashing, terminating the trial, and the center light began flashing, marking a new trial. This phase demonstrated a contingency between the presentation of the auditory and visual stimuli, which was absent in the familiarization phase but is critical in the test phase. This phase does not occur in most experiments using HPP; however, we find that in some experimental situations, infants’ orientation to the first one or two test trials are exceptionally long if they do not experience the audio-visual contingency until the test phase. Some labs use warm-up trials as a way of mitigating against this effect; the audiovisual-contingency phase is essentially a set of warm-up trials with non-linguistic material.

The test phase immediately followed the contingency phase. The procedure in the test phase was identical to the audiovisual-contingency phase, except that the dependent measure of orientation time was recorded by the controlling computer during each trial. There were eight trials in total: four novel trials and four familiar trials. Familiar trials consisted of two new sentences that matched the familiarization type, and novel trials consisted of two new sentences that did not match the familiarization type. Critically, all test trials contained sentences that did not appear in the familiarization phase. The order of presentation of the trials was random, with the constraint that the first two trials were different types. The selection of the side light was random, with the constraint that a given side could be selected in no more than three consecutive trials. The computer recorded infants’ looking time to the flashing light during each trial.

Parents were told that if their child should become wiggly, the best time to readjust them was when the red light was flashing, which indicated that data were not being collected.

RESULTS

To make a sentence-type assessment in a given trial, an infant must, at minimum, listen to one sentence. Since sentences were approximately two seconds long, we removed listening times that were under two seconds. This resulted in the removal of approximately 7% of the trials (15 out of 216). We then analyzed trials within each subject and excluded outliers defined as listening times that were greater than \((1.5 \times \text{InterQuartileRange} + 3\text{rdQuartile})\) or less than \((1\text{stQuartile} - \text{InterQuartileRange})\).
1.5°InterQuartileRange). This resulted in excluding five additional trials. After this process, all 26 infants still had at least six data points out of a possible eight.

Shapiro-Wilk tests for normality indicated that infants’ responses to novel and familiar trials were not normally distributed (W=.74, p<.001 for novel trials, W=.82, p<.001 for familiar trials). Our analyses compared median listening times to novel versus familiar trial types within participants, and we summarized group data with medians of the subject medians (Gómez & Lakusta, 2004). Regardless of familiarization type, infants listened longer to novel (Mdn = 9.0 s) versus familiar sentence types (Mdn = 7.9 s). Twenty out of 26 infants listened longer to novel versus familiar trials (p < .01, two-sided binomial test). To assess the statistical reliability of the listening time difference, we calculated difference scores for each subject by subtracting the median familiar looking time from median novel looking time (Figure 1). The median difference score was 1.8 seconds, which was significantly different from chance (0) by a Wilcoxon signed rank test (V = 285, p < .005), indicating that 12-month-olds discriminated the sentence types. To test for an interaction of the discrimination ability with familiarization type, we used a Wilcoxon rank sum test to compare median difference scores for infants familiarized to declaratives (M=1.9s) and infants familiarized to interrogatives (M=3.0s) and found no significant difference (W = 90, p = 0.801). Thus, infants discriminated declaratives and interrogatives equally whether familiarized to declaratives or interrogatives.5

5A potential confound that is related to sentence-initial durational differences—discussed in the Stimuli and Design section—involves the pattern of frequent and infrequent words at the beginnings of sentences. Infants have been shown to use patterns of frequent and infrequent syllables to organize speech (Gervain, Nespor, Mazuka, Horie, & Mehler, 2008), attesting to their sensitivity to lexical frequencies and patterns involving frequency. Because all our interrogatives began with high frequency function words, but only some of our declarative familiarization utterances did, and none of our declarative test items did, there is a concern that infants could base responses on the familiarity of word-initial frequency patterns, as opposed to sentence type. While we cannot rule out this possibility, we find it unlikely. Almost half of our
DISCUSSION

Our results show that 12-month-olds can discriminate interrogatives from declaratives solely on the basis of word order patterns. To our knowledge, this is the first demonstration that infants can rely on word order alone to make distinctions between sentence types and demonstrates that by the time they are a year old, infants represent something about the distributional differences between declaratives and interrogatives. However, these results raise two further questions: 1) What is the nature of the distributional properties that infants use to differentiate declaratives and interrogatives? 2) How do they initially learn to link the distributional properties to sentence categories?

What Distributional Properties do Infants Use to Discriminate Declaratives and Interrogatives?

The interrogatives in this experiment were polar interrogatives, characterized by a sentence-initial auxiliary, followed by the subject NP. Since word positions that are aligned with utterance boundaries are salient to young learners (Newport, Gleitman, & Gleitman, 1977; Seidl & Johnson, 2006; Slobin, 1973), a straightforward possibility is that infants use utterance-initial words as a basis for sentence classification. On that view, prior to coming into the lab, infants in our experiment had learned to associate the initial occurrence of auxiliaries with interrogatives. However, it is important to note that infants would have had to have made generalizations beyond simply matching particular auxiliaries across familiarization and test utterances, since interrogatives in the test set contained different auxiliaries from interrogatives in the familiarization set. This means that either infants had previously learned to associate each utterance-initial auxiliary with the interrogative sentence type, or they treated auxiliaries as a category, and associated the utterance-initial occurrence of the auxiliary category with the interrogative sentence type.

A related yet different possibility is that infants based their sentence discrimination on the non-canonical sequential placement of the subject NP (as a consequence of subject-auxiliary inversion). That is, sequences like do they go, would you like, can you do, etc., constitute disruptions to the canonical sequencing of these words in declarative sentences (with or without the auxiliary verb), displacing rightward the NPs that are sentence-initial in declaratives (e.g., they go, you like, you do, etc.). Infants could use this displacement pattern as a basis for discriminating interrogatives and declaratives. On this view, the critical information is that a word that often occurs in first position {she, you, the, . . . } is now preceded by one of a small set of declarative familiarization items began with high-frequency functors (the and there). Infants in the declarative familiarization group were thus exposed to almost equal numbers of frequent-first and infrequent-first items. If their responses were driven only by this stimulus dimension, we would not expect differences in responses to sentence types in the declarative familiarization group, with the sentence-type discrimination driven by infants in the interrogative familiarization group. As we just reported, we found no statistical difference in responses to familiar/novel test items across familiarization group (although numerically the novelty preference was higher in the interrogative familiarization condition). Thus, although we cannot rule out the possibility that the distribution of frequent words played a role in determining infants’ listening behavior, it does not appear that it could fully account for our results.

When we refer to the question sentence type in the context of infants’ knowledge, we intend the term only to designate a formal differentiation from the canonical statement type. We do not intend to imply any semantic or functional knowledge associated with the formal distinction.
words, for example, *can you* instead of *you*, or *does the* instead of *the*, and so on. Thus, this possibility differs subtly from the one we discussed first, where the defining property of the polar interrogative is that it begins with an auxiliary verb. Even without representing categories, it is possible that infants use these *displacement patterns*—shifting typical sentence-initial material to the right—to discriminate interrogatives from declaratives. In principle, these relational patterns may be sufficient for infants to mark the interrogatives as formally noncanonical.

Our findings do not provide evidence regarding the particular distributional patterns infants used, and whether the representations involved grammatical categories or were more item-specific. However, there is reason to be cautious in ascribing a functional category such as auxiliary verb (AUX) to 12-month-olds. While there is cross-linguistic evidence that 14-month-olds have some representation of the functional categories (Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Shi & Melançon, 2010), no such category evidence has been found in 12-month-olds (Höhle et al., 2004). The latter do, nevertheless, have some expectations about the correct placement of determiners within noun-phrases (Hallé et al., 2008). If infants’ representation of auxiliary verbs is similarly limited, it is unlikely that they could initially identify polar interrogatives based on the sentence-initial occurrence of AUX.

Regardless of the precise nature of the representations infants use to represent the sentence type distinction, our study suggests that these representations generalize over a range of surface forms that constitute polar interrogatives.

### How do Infants Learn to Associate Distinct Distributional Patterns With Different Sentence Types?

The question of how infants initially learn to associate the distinct distributional patterns with distinct sentence types essentially asks how infants come to categorize sentences based on those particular distributional properties, as opposed to concluding that the distributional differences constitute variable patterns within one class of sentences.

One possibility is that the distributional patterns that infants responded to in our study are the basis for infants’ initial discrimination. In this view, infants differentiate interrogatives from declaratives purely on distributional grounds from the beginning, similar to some proposals that infants initially categorize words into form classes based on distributional information (Mintz, Newport, & Bever, 2002; Redington, Chater, & Finch, 1998). Under the assumption that infants are predisposed to categorize utterances based on distributional information, they could use whatever distributional information they used in our study to discriminate sentences—as enumerated in the previous section—to discriminate sentences from the outset. For example, if infants represent auxiliary verbs as a category, they would be able to use the sentence-initial occurrence of AUX as a cue that the sentence is distinct from declaratives, which typically begin with an NP. If, on the other hand, infants did not have a category for auxiliaries, they could instead determine sentence type by the displacement of typically sentence-initial words.

There is certainly evidence that 12-month-olds are able to carry out distributional analyses (e.g., Gómez & Gerken, 1999; Mintz, 2006). However, while it is theoretically straightforward to extend the idea that infants used distributional information in our study to the idea that they use distributional patterns as an initial basis for sentence discrimination, the reality may not be so simple. For example, learners tracking the patterns in the sequences of the first several words
across utterances might correctly determine that sentences fitting the pattern in (1a) are distinct from those fitting the pattern in (1b), where the underlined sentence-initial sequences are displaced. But wouldn’t learners attending to these kinds of patterns also conclude (erroneously) that sentences adhering to (1a) are also distinct from sentences that follow patterns in (1c) for similar reasons (e.g., left-displacement of the verb, presence versus absence of determiners), even though both types consist syntactically of an NP followed by a verb? In other words, without recourse to something like the AUX category (and perhaps the ability to represent NP constituents), the superficial distributional properties that could distinguish between interrogatives and declaratives (1a vs. 1b) could cause learners to differentiate sentence types that are syntactically similar (1a vs. 1c):

1a. {the, my, her, a, their, . . . } + {car, doggy, ball, doll, . . . } + {goes, sees, comes, looks, . . . }

1b. {can, does, would, will, do, . . . } + {the, my, her, a, their, . . . } +
{car, doggy, ball, doll, . . . } + . . .

1c. {it, she, he, Daddy, . . . } + {goes, sees, comes, looks, . . . }

In summary, while there are certainly distributional patterns that correlate with sentence type (to which we argue infants in our study were sensitive), it is not clear that those patterns would be felicitous as an initial basis for sentence-type discrimination. We base our caution on a) the available evidence about infants’ representations of functional categories and b) on the nature of the distributional variability that exists within sentences of the same type. Given this uncertainty, we now discuss other properties of their input that could lead infants to differentiate declaratives and interrogatives, and from which they could learn how distributional patterns correlate with sentence type. In particular, we discuss two ways in which infants could use phonological information to discriminate sentence types: 1) by attending to prosody and 2) by attending to phonological properties of sentence-initial words.

In many languages, the final pitch contour is an important perceptual cue for sentence-type discrimination (American English—Sáfáróvá & Swerts, 2004; Australian English—Wales & Taylor, 1987; French—Vion & Colas, 2006). In adult-directed speech, polar interrogatives typically end with a final rise in pitch, while declaratives end with final falling or flat intonation (Bartels, 1999; Hedberg et al., 2004). There is a wealth of evidence demonstrating infants’ sensitivity to prosodic information from early on (e.g., Mehler et al., 1988; Moon, Cooper, & Fifer, 1993; Nazzi, Bertoncini, & Mehler, 1998), and some evidence that infants exploit prosodic information to discriminate declaratives and interrogatives. For instance, Frota, Butler, and Vigário (2014) tested infants learning European Portuguese, a language that distinguishes between sentence types using only prosodic information, and found that infants as young as five to six months can distinguish between declaratives and polar interrogatives. Similarly, Soderstrom, Ko, and Nevzorova (2011) tested English-learning infants between 4.5 and 24 months of age on their ability to distinguish declarative statements from declarative questions (e.g., Anna likes chocolate?), which have an exaggerated utterance final pitch rise similar to polar interrogatives. They found that infants were able to distinguish declarative questions and statements which differ only in their prosodic contours. However, declarative questions do not exhibit the noncanonical word order patterns that motivated the research here. In order to mark their functional difference compared with structurally identical declaratives, speakers may exaggerate the prosodic properties.
compared to questions with subject-auxiliary inversion and other word order differences. Thus, while informative, the findings regarding declarative questions—either in European Portuguese or English—do not directly address the question of infants’ ability to use prosody to discriminate interrogatives that have different word order properties from declaratives—that is, the kind of interrogative that motivated the present research.

Research from Geffen and Mintz (2011) bears on that question more directly. Using a method similar to the one in the present study but with prosodically unmodified sentences, Geffen and Mintz found that 7-month-olds could discriminate declaratives from polar interrogatives. Since there is little evidence that infants of that age could use distributional patterns to make those distinctions, they speculated that infants were responding to prosodic differences. However, unlike in the materials used here, the items in that study contained some sentence-initial lexical overlap between familiarization and test items; hence, while those results are suggestive of the role of prosody, it is also possible that infants in that study were responding to non-prosodic properties of the material (i.e., the similarity of the sentence-initial words).

Overall, infants’ early sensitivity to prosodic information is consistent with the hypothesis that they initially differentiate declaratives and interrogatives based on prosody, although direct empirical tests of this hypothesis, while suggestive, are not conclusive. If infants can use prosodic information to differentiate interrogatives from declaratives early on, this would allow them to notice the characteristic auxiliary-subject inversion patterns, which they could then associate with a distinct utterance type. In this way, the distributional distinctions that 12-month-olds showed here could have originated from distinctions based on prosody.

However, it is important to note that infants’ ability to use prosodic cues to distinguish between declaratives and polar interrogatives may not generalize to interrogatives more broadly. Recent evidence demonstrates that wh-questions are prosodically more similar to declaratives than polar interrogatives in infant-directed speech (Geffen & Mintz, 2014), as is the case for adult-directed speech (Hedberg et al., 2004). Therefore, infants could not use prosody to differentiate every type of interrogative from declaratives; a complete theory of infants’ ability to discriminate sentence types would need to address this issue. But consider that the characteristic inversion of auxiliaries and subjects in polar interrogatives also occurs in wh-questions, after the wh-word (e.g. What did you have for lunch?). If infants could differentiate polar interrogatives from declaratives based on prosody, then once they begin to learn the distributional properties of polar interrogatives, they could apply those patterns to detect wh-questions as well. In this way, the learned associations between word order and prosodic patterns in polar interrogatives may allow infants to generalize to wh-questions, despite their prosodic similarity to declaratives (Bartels, 1999; Geffen & Mintz, 2014; Hedberg et al., 2004).

**Sentence-initial phonology.** Another way that phonological information could provide cues to sentence-type distinctions in fact focuses on wh-questions. Specifically, unlike the sentence-initial auxiliaries in polar interrogatives, the wh-words that begin wh-questions are phonologically similar; for example, they begin with /w/ or /h/ in English, with comparable phonological similarities in question operators in other languages. Also unlike sentence-initial auxiliaries in polar interrogatives, sentence-initial wh-words are immediately followed by a restricted set of words, that is, auxiliaries. Thus, wh-questions have a unique set of very local phonological and distributional cues that could make them relatively easy to distinguish from
declaratives. A mechanism that responded to such an over-determined set of cues might not be prone to the same kind of erroneous distinctions that we argued were possible (see 1a-c) if only distributional facts about polar interrogatives were considered, in the absence of prosodic information.\footnote{We are grateful to an anonymous reviewer for suggesting this interesting possibility.} The more general distributional properties of questions, that is, subject-auxiliary inversion and \textit{do}-support, could then be detected and used as criteria for classifying polar interrogatives together with \textit{wh}-questions.

CONCLUSION

Although many questions remain, the current study yields insights into the time-course and mechanisms underlying infants’ ability to differentiate sentence types, a critical ability in language acquisition. By 12 months of age, infants are able to distinguish at least some types of interrogatives from declaratives based on lexical distributional patterns. This finding informs theories of early syntactic development by establishing that, at the age when infants are only just starting to produce single words, they are nonetheless poised to associate abstract syntactic structures with utterances without the risk of applying the same analyses to interrogatives and declaratives (Pinker, 1984). In addition, we have speculated that the prosodic properties of polar interrogatives or the unique phonological properties of \textit{wh}-questions (perhaps in combination with their unique sentence-initial distributional patterns) could provide infants with an initial basis for identifying interrogatives. Each possibility yields testable predictions regarding infants’ phonological and distributional sensitivities. While an important goal for future research will be to test these predictions, the current study provides important evidence that informs these broader questions. Regardless of which type of question is first discriminated from declaratives by infants, once identified as a distinct sentence type, we speculated that infants would use the distributional similarity in the auxiliary-inversion and \textit{do}-support to treat \textit{wh}-questions and polar interrogatives as similar types. This predicts that infants at the age we tested should also discriminate \textit{wh}-questions from declaratives and treat the two question types similarly, as our findings suggest they already represent distributional information about polar interrogatives. We are currently carrying out a study similar to this one, but with \textit{wh}-questions, to test this prediction. Finally, by mapping the genesis and development of sentence discrimination abilities in typically developing children, these future studies could lead to the development of a method for assessing individual differences in early language perception for individuals at risk for language impairments.

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