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DISENTANGLING MULTIPLE SOURCES OF STRESS IN INFANT-DIRECTED SPEECH

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1. INTRODUCTION

In arguing against alternatives to semantic bootstrapping, Pinker (1984) coined the term *prosodic bootstrapping* and wrote, "Morgan and Newport (1981)...speculate that prosodic cues might provide the child with [constituent structure] information, and thereby allow the child to coin rules containing the right sorts of units...I am pessimistic [because] the effects [of syntax on prosody] are quite small in comparison with the effects of intrinsic word length, syllable structure, phonetic composition, sentence length, word frequency, word-finding difficulties, and other confounding factors. Thus the child must have some way of mentally subtracting the effects of all these factors in natural discourse before he or she can invert the syntax-to-speech encoding function and recover the syntactic analyses of sentences. I think it is fairly unlikely that a universally valid subtraction-and-inversion procedure of this sort exists, let alone that it is available to a child who has not yet learned anything about his or her language." (1984, p. 51-52)

A parallel argument could be constructed concerning the possibility of infants extracting word-shapes from fluent speech. No universal recipe for word-shape exists, and word-shapes are subject to distortion by a variety of phonological processes. Segments at the edges of words vary phonetically as a function of coarticulation with sounds at the edges of adjacent words and vary phonemically as a function of language-particular sandhi rules (such as elision and liaison in French). The stress patterns of words vary depending on their syntactic category, position in sentential metrical structure, and discourse status. Words are pronounced differently by dialect and idiolect; speakers pronounce words differently depending on alertness, affect, facial expression, and so forth. Thus the child must have some way of mentally subtracting the effects of all these factors in natural discourse before he or she can invert the lexicon-to-speech encoding function and recover the lexical analyses of sentences. The

work reported here examines how mothers alter prosodic cues in infant-directed speech relative to adult-directed speech in order to help their children disentangle the multiple influences on prosodic characteristics of word-shapes.

2. The Given/New Contract in Infant-Directed Speech

When words are newly introduced to discourse in adult-directed speech, they receive distinctive *new* stress; in subsequent mentions, the same words are pronounced with non-emphatic *given* stress. In accordance with the given/new contract (Chafe, 1976; Clark & Haviland, 1977; Halliday, 1967; Haviland & Clark, 1974), speakers switch to given stress after only a single use of new stress. But given that repetition is well-documented in infant-directed speech (Bernstein-Ratner, 1986; Fernald, 1985), the stress pattern that sequential repetitions follow is relevant to understanding the layers of complexity inherent to such speech. In infant-directed speech, adults stress their first mention of a word as new and switch to given stress for the second mention of that word (Fisher & Tokura, 1995). That is, adults attenuate stress when speaking to infants to the same degree that they do when speaking to other adults. But how does given/new stress pattern for mentions subsequent to the first and second?

Adults' tendency to repeat words when addressing infants may be attributed to their view of infants as novice listeners, according to which young children generally must hear a word several times before they can recognize that word in subsequent usage. If this is the case, then it seems just as important to consider the pattern of stress these repetitions follow. The question we address here is with regard to the prosodic nature of infant-directed speech. Subsequent studies will address alterations between new and given stress actually influence infants' ability to identify words. That is, we want to determine whether infant word-shape segmentation and identification actually benefit from familiarization with new-stressed target words. We also want to determine how many times infants need to hear a word pronounced with new stress before they can recognize that word when it occurs with given stress in fluent speech. However, before we can answer these questions, we need a clearer understanding of how mothers mark given and new information in when speaking to infants.

3. Analyses of the Given/New Contract in Infant-Directed Speech

In this preliminary study, we explore the patterns of given/new stress that mothers display in their speech to infants.

Stimuli

Consistent with earlier work (Fisher & Tokura, 1995), we used an elicitation method that allowed us to influence mothers into using for the given/new stress patterns of words. To extend previous work, we manipulated our target words such that half carried word-initial stress (e.g., stress on the first syllable of a two-syllable word) and half carried non-word-initial stress (e.g., stress on the second syllable of a two-syllable word). Target words are listed in Table 1.

Table 1. Disyllabic stimuli used in puppet show to control for target words' lexical stress.

Disyllabic Target Words	
Word-Initial Stress	Non-Word-Initial Stress
Monkey	Giraffe
Walrus	Baboon
Chicken	Gazelle
Zebra	Raccoon

Subjects

Speakers were 8 English-speaking mothers of infants between the ages of 13- and 15-months (mean age of infant was 14.2 months). Analyses reported here are based on data from eight of those 20 mothers (mean age of infant was 13.9 months). Mothers watched a puppet show with their infants seated on their laps. They were instructed to describe the events enacted in the puppet show to their infants as they occurred. The simple events the mothers described were designed so that the mothers produced specific content words using IDS. This method of collecting speech stimuli was crucial in order for us to elicit naturally produced, fluent speech samples. These samples will be used in subsequent studies on the effects of varieties of stress on preverbal speech segmentation (e.g., the influence of given/new and lexical stress on infant word recognition). The present study focuses on whether and in what ways mothers adjust the given/new contract in their speech to infants and how given/new stress interacts acoustically with lexical stress.

METHOD

Each event had two animal puppet participants. Actions were performed by a common puppet on new puppets that entered for each separate event. These eight events were designed so that they could be described with eight different verbs so as not to encourage use of contrastive stress. The events were presented in two rounds (to manipulate the infants' familiarity with each puppet). Presentation of these two rounds was counterbalanced across mothers. Within each round, events were presented in random order. Each round consisted of four puppets whose disyllabic names consisted of word-initial stress (e.g., *zebra*) and four whose disyllabic names consisted of non-word-initial stress (e.g., *giraffe*).

During the puppet show, mothers were shown cue cards prior to each scene prompting them with the label for the animal puppet and the event that scene involved. This ensured that mothers used the same words to describe the different animal puppets, while preventing infants from hearing any of the puppets' names prior to their mothers introducing them. Finally, since the animal puppets were always patients of actions, each was typically named in sentence-final position. This placement allowed us to consider the influences of given/new and lexical stress, while abstracting away from the known effects of final position on the acoustic form of words (Bernstein-Ratner, 1986; Cooper & Paccia-Cooper, 1980; Cooper & Sorenson, 1977; Fisher & Tokura, 1995; Grosjean, 1983; Morgan, 1996).

The puppets were manipulated by an experimenter hidden behind a puppet stage. In an initial brief episode, the common puppet appeared alone. Each subsequent episode followed the same sequence: both puppets appeared together on the stage and remained still until the mother labeled them both (using new stress to introduce the novel puppet to her infant). Then the experimenter began to enact the event repeatedly, which the mother described to her infant (eventually using given stress on the novel puppet's name). Each event concluded when the mother stopped talking and remained silent for at least two seconds. The next event was then shown in the same manner. By describing each event in this way, mothers produced new and given tokens of the labels assigned to the animal puppets. Mothers were audio-taped throughout the puppet show. Each mother's description of the puppet show was transcribed for subsequent analysis.

UTTERANCE SELECTION

Analyses were conducted to help determine whether and when mothers switch from new to given stress in their speech to infants, in addition to how prosodic marking of the given/new contract interacts with lexical stress in such speech. Transcripts of mothers who consistently produced multiple mentions of target words (at least two mentions for each of the eight target animals) were selected for analyses. The analyses reported here are based on target words occurring in utterance final position. Only target words where mothers did not add any additional information (e.g., modifiers, possessives) were selected for analysis, since a word used as a noun differs in duration from the same word used as an adjective (Cooper & Paccia-Cooper, 1980). Finally, only utterances produced during the first round of the puppet show are relevant to the present study. Utterances produced during the second round of the puppet show are relevant to a different set of questions that will be addressed in future studies.

Utterances containing first and subsequent mentions of target words were selected from the transcripts. These selections were then verified via an acoustic comparison of the transcription with their corresponding audio-tape (e.g., to verify that the target word was, indeed, utterance final based on clause structure and pause length). Once the relevant target words were identified, acoustic analyses were carried out on each of those words.

ACOUSTIC ANALYSES

Selected target words were digitized for acoustic analysis using the Bliss Speech Analysis System (developed at Brown University). Measurements consistent with previous research examining the given/new contract in speech to infants (Fisher & Tokura, 1995) were carried out for analysis. We carried out several additional measurements that are relevant to the examination of lexical stress. This involved comparing stress within as well as between target words. Target words were analyzed for word duration, minimum and maximum fundamental frequency for both the first and second syllable of each disyllabic word, and overall pitch peak within target words.

4. RESULTS

DURATION

We first looked at target words collapsed across stress type by comparing each mention (up to the sixth) based on average word length. The mean length of words for each of six mentions are listed in Table 2.

Table 2. Mean duration (in milliseconds) of the first through sixth mention.

First	Second	Third	Fourth	Fifth	Sixth
793.89	584.01	672.70	600.28	733.70	504.98

The pattern that emerges is one in which new stress alternates with given stress (if one accepts duration as an appropriate measure of given/new stress). If we consider the first, third, and fifth mentions to be "new" and the second, fourth, and sixth to be "given" (based on the differences in mean duration), we can then compare the pitch peaks of given and new stressed words, collapsing across lexical stress type. The average difference between new and given words' minimum and maximum *F0* is significantly different, such that words with new stress have a wider pitch range (128 Hz difference between min and max *F0*) than words with given stress (78 Hz difference between min and max *F0*).

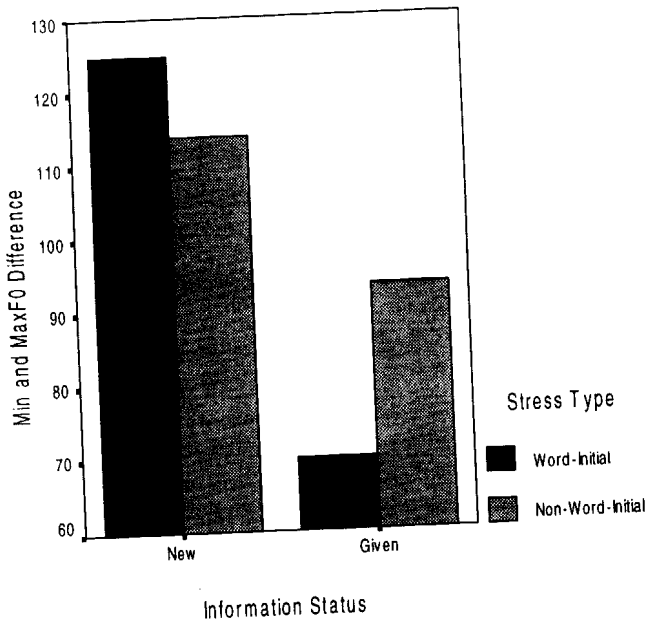
PITCH EXCURSION

We then compared pitch excursion across lexical stress and information status stress types. Pitch excursion was measured as the average difference between minimum and maximum *F0* for each syllable in the disyllabic words. Average pitch excursion was than calculated for each word by collapsing across syllables. Again, lexical stress included words with either word-initial or non-word-initial stress and information status stress included words with either new or given stress. Again, information status was determined according to the categories (given/new) established earlier based on mean word duration per mention across six mentions.

Our findings indicate that English-speaking mothers attenuate the stress difference between given and new words for non-word-initial stressed words relative to word-initial stressed words. This finding is consistent with the Metrical Segmentation Strategy (Cutler, 1990) posited for infant speech segmentation. That is, words with non-word-initial lexical stress are the exception in English and, as such, should be more difficult for English-exposed infants to learn.

Mothers in our study did not reduce the stress for these less common words when they were mentioned in given position to the same degree that they did for words with word-initial lexical stress (the stress pattern typical of English). This attenuation pattern is shown in Figure 1. Mothers' exception to their normal given/new stress pattern (e.g., heavier stress for new words; lighter stress for given words) when using words with atypical (non-word-initial) lexical stress with their infants may ultimately serve to guide infants' recognition of these less common words.

Figure 1. Mean pitch excursion (based on the difference between minimum and maximum *F0)* by Information Status (either given or new) and Stress Type (either word-initial or non-word-initial)



5. DISCUSSION

Our analyses indicate that the acoustic display of given and new stress in infant-directed speech is consistent with that in adult-directed speech (Chafe, 1976; Clark & Haviland, 1977; Fisher & Tokura, 1995; Halliday, 1967; Haviland & Clark, 1974). We also

found that mothers follow a pattern in which they alternate between new and given stress while repeating single content words to their infants (in a manner characteristic of infant-directed speech). We interpret this finding as indicating that, while still sensitive to their infants' status as novice listeners, mothers do not change the intonation *pattern* that they follow to mark information status in their normal (adult-directed) speech (e.g., new stress on first mention; given stress on second mention). Rather, when addressing their infants, mothers simply *extend* this normal intonation pattern across all subsequent mentions of the relevant content word. That is, regardless of how many mentions of a single content word mothers might make, they continue to alternate between new and given stress.

Furthermore, we found that mothers attenuate the difference between the minimum and maximum fundamental frequencies of English words with non-word-initial stress for instances of given relative to new stress. This finding indicates that the typical given/new stress pattern for words with lexical stress patterns typical of the target language (e.g., word-initial stress in English) is followed by English speaking mothers when addressing their infants, but that when the lexical stress pattern is not typical of the language (e.g., non-word-initial stress), the same mothers attenuate the marked difference in pitch excursion noted for given as opposed to new words with lexical stress patterns typical of the language. That mothers in our study *attenuated* their normal tendency to *reduce* words discursively marked as given is compelling in light of other findings supporting prosodically-based speech segmentation (Cutler, 1990; Jusczyk, Culter, & Redanz, 1993). We conclude that mothers attenuate the difference between new and given stress when the word in question follows a lexical stress pattern less typical of the native language in order to guide infants' recognition of these more challenging lexical items. Our findings highlight the importance of manipulating stress at both the lexical and sentential level in studies of first language acquisition, as these factors clearly interact in infants' daily language input.

This work was supported by NIH-NICHD Grant 5 F32 HD 08394-02, a National Research Service Award to the first author. We thank John Mertus of Brown University for providing technical and programming support.

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