Fig. 2

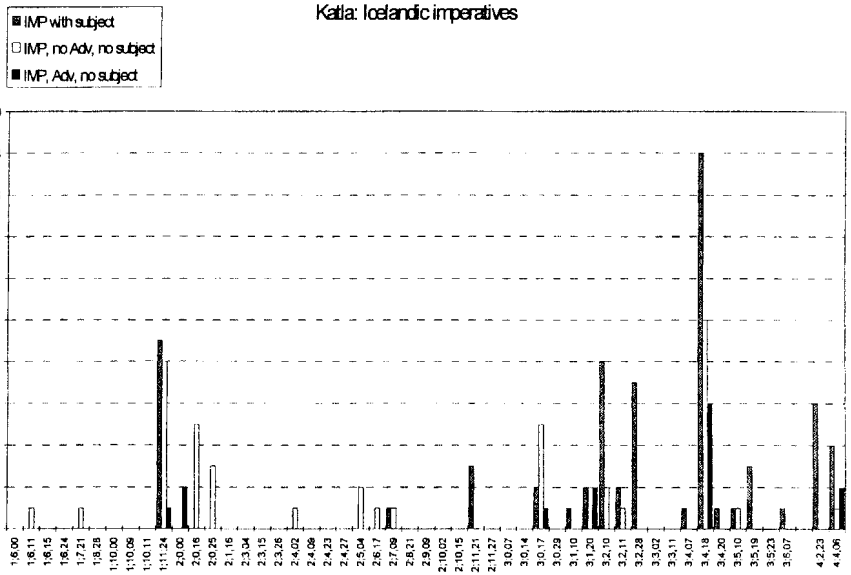
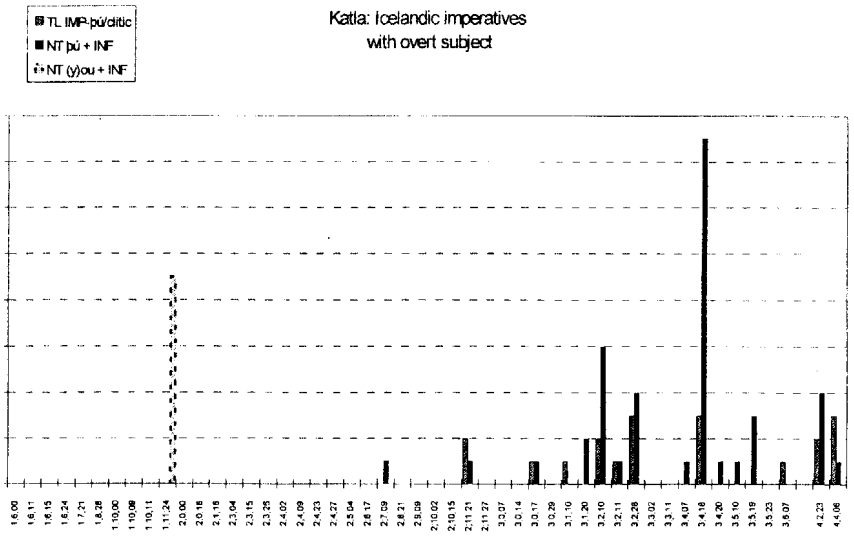


Fig. 3



The Influence of Focusing Stress on Infants' Recognition of Words in Fluent Speech

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Abstract

In a series of studies, we examined how natural prosodic marking of the given/new distinction in mothers' speech influences infants' identification of multisyllabic words. Stimuli were selected based on acoustic analyses and independent ratings of the given/new stress present in naturally produced infant-directed speech (Bortfeld & Morgan, 1998). Using the Headturn Preference Procedure, we first tested two groups of 12 English-exposed infants (7½ and 10 months of age) on their ability to detect familiarized disyllabic words in fluent speech. Key manipulations in these experiments were the age of infants and whether familiarization items carried all new stress or alternated between new and given stress. Target words within test passages alternated between new and given stress from sentence to sentence. Seven-and-a-half-month-olds listened longer to passages containing familiar words than to those containing unfamiliar words, regardless of whether familiarization stimuli carried all new stress or alternated between new and given stress. In a final experiment, 12 7½-month-olds were familiarized with one word carrying all new stress and another carrying alternating stress. Mean listening times were higher for passages containing the word familiarized with all new stress than for those containing the word familiarized with alternating stress, which in turn were higher than for passages containing unfamiliar controls. These results highlight infants' emerging ability to abstract types from tokens and the importance of focusing stress in directing this ability.

Introduction: Pattern of Focusing Stress in Mothers' Speech to Infants

When words are newly introduced to discourse in adult-directed speech, they receive distinctive *new* stress, while 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. In infant-directed speech, adults also 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. However,

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adults also repeat words when addressing infants (Bernstein-Ratner, 1986). This tendency 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. Regardless of the reason, since repetition is typical of infant-directed speech, it seems just as important to consider the pattern of focusing stress these subsequent repetitions follow.

In previous work, we examined how mothers prosodically mark the given/new distinction (Bortfeld & Morgan, 1998) across repetitions. We used a cued puppet show (Fisher and Tokura, 1995) to elicit new- and given-stressed tokens of specific words. Mothers watched a puppet show with their infants seated on their laps and were instructed to describe the events enacted in the puppet show to their infants as they occurred. Puppet show descriptions were elicited from eight mothers of 9-month-olds and were later analyzed for a variety of acoustic characteristics.

Our acoustic analyses supported previous findings that the acoustic display of given and new stress in infant-directed speech is consistent with that in adult-directed speech (Fisher & Tokura, 1995). Even more interesting was our finding that mothers follow a stress pattern in which they consistently alternate between new and given stress across repetitions of single content words to their infants (in the manner characteristic of infant-directed speech). We interpreted this as indicating that, while still sensitive to their infants' status as novice listeners (and thus repeating content words often), mothers do not change the intonation pattern that they follow in their normal (adult-directed) speech (e.g., new stress on first mention; given stress on second mention). Rather, mothers simply extend their normal intonation pattern across subsequent mentions of the relevant content word.

Current Study

The goal of the present study was to examine the influence of focusing stress on infants' recognition of words in fluent speech. In these experiments, infant's age and the form of focusing stress on training tokens were varied, while the form of focusing stress on test tokens was held constant. Using a word-monitoring paradigm, which is described in more detail below, we trained 7½-month- and 10-month-old infants to turn their heads discriminatively upon hearing certain words. Infants then heard a series of sentences that either contained or did not contain the familiarized words. This design allowed us to measure the influence of focusing stress on infants' speech segmentation biases.

Paradigm: Headturn Preference Procedure

In recent work, Peter Jusczyk and co-workers (Jusczyk & Aslin, 1995; Jusczyk & Hohne, 1997; Newsome & Jusczyk, 1995) have used the Headturn Preference Procedure in studies of infants' abilities to detect words in fluent speech. Jusczyk and Aslin (1995) familiarized 7½-month-old infants with two

of four target words and later presented them with sets of sentences including each of the four target words. They found that the infants preferred to listen to those sentence sets that contained the familiarized words. Newsome and Jusczyk (1995) extended these findings to disyllabic targets, showing that 7½-month-olds and 10½-month-olds both recognize familiarized strong-weak disyllables in fluent speech. These studies stand among the first laboratory demonstrations of word-shape segmentation and identification abilities in infants under one year of age.

The Headturn Preference Procedure yields a binary distinction: either the infant displays a preference for one of a pair of stimulus sets, or not. If the infant displays a preference, it is reasonable to conclude that the infant can discriminate between the two stimulus sets. The perceptual studies described here were all conducted using the Headturn Preference Procedure. Infants were familiarized with particular words repeated several times in isolation and then tested for differential response (in the form of listening times) to passages constructed of sentences that either contained the familiarized words or did not contain those words. If infants listened longer to passages containing familiarized words, we interpreted this as recognition.

Selection of Sentences for Fluent Test Passages

We selected sentences for the test passages from a corpus of infant-directed speech collected during our focusing stress production study (Bortfeld & Morgan, 1998). This helped ensure that our fluent test passages consisted of speech similar to that which infants typically hear.

From our original corpus, we chose 60 utterances that contained target words following a strong/weak lexical stress pattern, since that is the lexical stress pattern that characterizes the majority of English words. In order to control for the influence of utterance position on the acoustic realization of a word, we chose 20 utterances that had the target word in utterance initial position, 20 that had the target word in utterance middle position, and 20 that had the target word in utterance final position. Of the 20 utterances in each of the three utterance positions, roughly 10 of the targets words carried new stress and 10 carried given stress (based on acoustic analyses from our previous production study). Acoustic analyses were conducting using BLISS, a speech analysis software system developed at Brown University.

Twenty college-aged adults (9 males and 11 females) listened to the 60 digitized sentences extracted from the transcripts. Using a pencil and paper questionnaire, in which each utterance was transcribed and followed by a 7-point Likert scale, these listeners rated each of the 60 sentences for how "given" or "new" the target word within each utterance sounded, where 1 was anchored as "very new" and 7 was anchored as "very given". The target word within each transcribed utterance was underlined to indicate which word was to be rated. An experimenter first explained what the difference between "given" and "new" stress was, providing several example sentences. Participants then rated 5

practice sentences before rating the 60 target sentences. Participants heard each sentence twice and were allowed to take as much time as they needed to rate the target word.

Test Passage and Familiarization Stimuli Construction

The average ratings for each position were: 4.85 (SD = 1.18) for initial position, 3.84 (SD = .89) for middle position, and 3.57 (SD = 1.52) for final position. The higher overall ratings for target words in initial position indicate that words in this position tend to be reduced acoustically. Therefore, the mean ratings we obtained for the three sentence positions supported our view that we needed to control for stress at different sentence positions in our acoustic stimuli. Using a means distribution of the given/new ratings, we identified sentences containing target words that participants unambiguously rated one way or the other (that is, as very given or very new sounding). This left us with two sentences for each of the three sentence positions, one carrying new stress and one carrying given stress. We selected the 3 new-sounding sentences (one per target word position) and the 3 given-sounding sentences (also one per target word position) that had the most extreme ratings still within half a point of each other on the scale (2.75, 2.78, 2.59 and 5.47, 5.17, 5.33, respectively). We did this to ensure that our given stress tokens were all equally stressed and that our new stressed tokens were all equally stressed. To summarize, we had six sentences in all, two per sentence position, three with given stress and three with new stress.

In order to control for speaker effects, a trained actor (also the mother of a 6-month-old) mimicked each sentence while replacing the actual animal name with each of six disyllabic (strong/weak) animal names (see Table 1 for one example passage). Isolated target words for use in familiarization sessions were likewise produced by our actor, who again mimicked mothers' production of the different words carrying given and new stress, this time in isolation.

Table 1. Example Test Passage

He's nudging the chicken
Oh I think chicken is tough to push
He's lifting the chicken right up in the air
Chicken is being rocked
He's tickling the chicken
Chicken is all gone

The sentences (six per animal name) were digitally arranged to create six different passages, one per animal name, with sentence ordered in each passage such that focusing stress on the animal name alternated between new and given from one sentence to the next. Each passage consisted of the same six sentences; however, a different animal name was substituted in target position in each sentence for each of the six passages.

The six passages were used in both Experiments 1 and 2, in which infants were familiarized with three target words. Since we reduced familiarization in Experiment 3 from three to two words, testing in Experiment 3 consisted of only four of the six passages. We randomly chose two of the original six passages to eliminate. Nonetheless, these passages still contained the original six sentences. This left us with four animal names, from which the two target words for use in Experiment 3 were selected.

Experiment 1

In this experiment, we were interested in testing infants' ability to recognize familiarized words in fluent passages, when these words alternate between new- and given-like stress during familiarization. Since our earlier work showed that mothers naturally alternate between marking central content words with new and given stress in their speech to infants, we wanted to likewise familiarize infants with words carrying this alternating stress. The key manipulation in Experiment 1 was the age of infants.

For the younger infants, we predicted longer listening times to those passages containing familiar items than to those containing unfamiliar items. In contrast, we anticipated that the older infants would prefer passages containing unfamiliar items, since the passages were identical in all other respects and older infants tend to prefer novelty (Friedman, 1972; Spelke, 1985; Tighe & Leaton, 1976).

Subjects

Two groups of 12 English-exposed infants who were 7½ and 10 months of age (6 and 7 females, respectively) were tested on their ability to detect familiarized disyllabic words in fluent speech. The average age of the 7½-month-olds was 230 days (SD = 3.73); the average age of the 10-month-olds was 332 days (SD = 6.96).

Apparatus

Our implementation of the Headturn Preference Procedure was conducted in a three-sided testing booth that resembles an over-sized polling booth. Each of the three sides were constructed of pegboard. The center panel of the testing booth had a red light mounted at eye level. Single green lights were mounted, also at eye level, on each of the two side panels. Loudspeakers were located behind the side pegboard panels such that they were behind and slightly below each of the two green lights. A video camera was situated behind the center panel with its lens trained through a 5-cm hole cut just above the red light, such that the camera's view encompassed the width of the testing booth. The video camera, speakers, and lights were all controlled from a room located down the

hall. A computer program run from this room controlled the starting and stopping of the three lights and the presentation of auditory stimuli to the infant.

During testing, the caregiver was seated in a chair in the center of the testing booth with the infant seated on his or her lap. Each trial began when the red light located at eye level on the center panel started blinking. When the infant oriented toward the blinking red light, the experimenter called for a trial. At this point, the blinking red light was extinguished and one of the two green lights located to the left and to the right of the infant began to blink. When the infant turned his or her head in the direction of the blinking green light, the auditory stimuli began playing through the loudspeaker on that side of the testing booth.

Presentation of both lights and auditory stimuli were controlled by the computer based on the direction and duration of the infant'sheadturns. This was observed and recorded by an experimenter in the control room, who could watch the infant's behavior over closed-circuit television. The experimenter held a mouse button down once a headturn was initiated and released it when the baby looked away. A trial automatically terminated if the infant looked away for more than 2 seconds. If the infant turned briefly away from the target in any direction, but for less than 2 seconds, and then looked back again, the time spent looking away was not included in the total orientation time. The maximum orientation time for a given trial was the duration of the entire sample (e.g., the 12 repetitions of the words during the familiarization phase or one complete passage during the test phase). The green light remained flashing during the duration of a trial.

The experimenter was unable to hear the auditory stimuli or see which side light was blinking. In addition, both the experimenter and the infant's caregiver listened to masking music over close-fitting, noise cancellation headphones. The masking music was recorded such that it had few silent periods.

Familiarization Phase

During familiarization, infants heard repetitions of the three target words is isolation on alternating trials until they accumulated at least 20 seconds of listening time to each word. If the infant achieved criterion for one word, but not the other two, the trials continued to alternate until criterion was reached for all three. Half of the infants were familiarized with the words *zebra*, *falcon*, and *chicken*; the other half were familiarized with the words *monkey*, *turtle*, and *dolphin*.

Test Phase

Test trials began immediately following attainment of familiarization criterion for the three target words. During the test phase, all the infants heard blocks of the same six passages consisting of the six sentences selected and produced in the manner outlined earlier. The order of the sentences within each

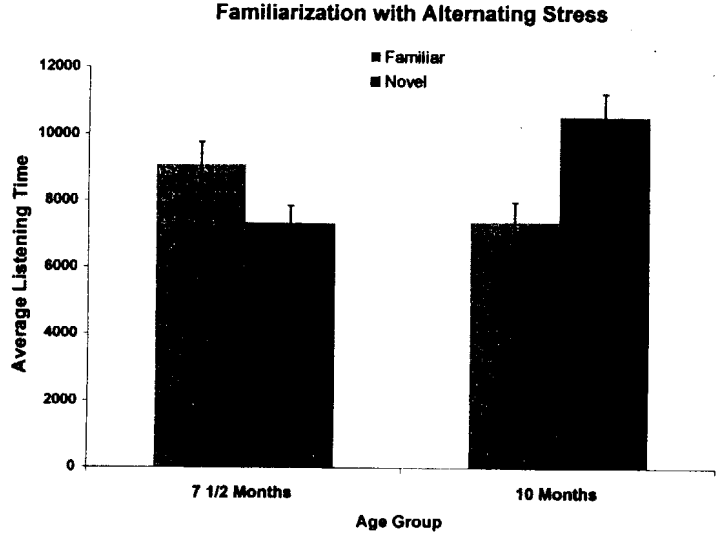
passage was fixed, such that stress on control and target words alternated between new and given from sentence to sentence. Test trials were blocked in groups of six so that each passage occurred once within a given block. Each infant was tested on three blocks, for a total of 18 test trials.

Results and Discussion

Mean listening times to the six different passages were calculated for each infant across the three blocks of trials. These mean listening times were then averaged for passages containing the familiar words and for those containing the unfamiliar words.

Overall, mean listening times for 7½-month-olds were higher for familiar words (9.08 s; SD = 2.8) than for unfamiliar words (7.34 s; SD = 1.27). A paired *t* test indicated that this difference in average listening times is significant ($t(11) = 3.61$, $p = .004$). On the other hand (and consistent with findings in the literature), 10-month-olds listened longer to the unfamiliar words (10.55 s; SD = 2.62) than they did to the familiar words (7.37 s; SD = 1.70). This difference is also significant ($t(11) = 5.21$, $p < .001$). The opposite preference by the two age groups also resulted in a significant interaction by ages, such that 7½-month-olds' preference for familiar words interacted with 10-month-olds preference for novel words ($F(2, 21) = 14.46$; $p < .001$; see Figure 1). The fact that the 7½-month-olds' showed a preference for the familiarized words demonstrates that they recognized words in fluent speech that follow the same stress pattern that was heard during familiarization.

Figure 1.



Experiment 2

Experiment 1 demonstrated that infants can recognize words in fluent speech following familiarization with those words in isolation when the same alternating pattern of focusing stress is followed. But since the word stress during familiarization in that experiment exactly matched the word stress in the subsequent fluent passages, it is not clear if what matters to infants is hearing the word (period), or hearing the word with matching stress. Experiment 2 was designed to address this question.

As in the first experiment, the key manipulation in Experiment 2 was the age of infants. This time, however, we familiarized infants with words carrying only all new stress rather than with words alternating between new and given. As in Experiment 1, fluent test passages consisted of sentences in which target and control word stress alternated between new and given stress. If infants do a simple matching of word forms and so must hear words with both forms of stress for subsequent identification, we would not expect to see a significant difference in listening times to familiar words over controls. On the other hand, if infants simply need input that leads them to abstract types from tokens, then we would expect to again see longer listening times for familiar words.

Subjects

Two groups of 12 English-exposed infants who were 7½ and 10 months of age (6 and 8 females, respectively) were tested on their ability to detect familiarized disyllabic words in fluent speech. The 7½-month-olds averaged 231 days old (SD = 5.49); 10-month-olds averaged 327 days old (SD = 9.08).

Familiarization Phase

Stimuli consisted of English target words produced with all new stress. As in Experiment 1, infants were familiarized with the three target words on alternating trials until they accumulated at least 20 seconds of listening time to each word. Again, criterion for all three words had to be reached before the test phase began. Familiarization trials continued to alternate from word to word until criterion was reached for all three. Which of the six words served as targets and which served as controls was again counterbalanced across infants.

Test Phase

Test trials began immediately following attainment of familiarization criterion for the three target words. The test phase consisted of the same six passages that were used in Experiment 1, with target words in each sentence alternating between new and given stress across each passage. Stress on control and target words alternated between new and given within each of the six passages. Passage presentation was block designed as in Experiment 1.

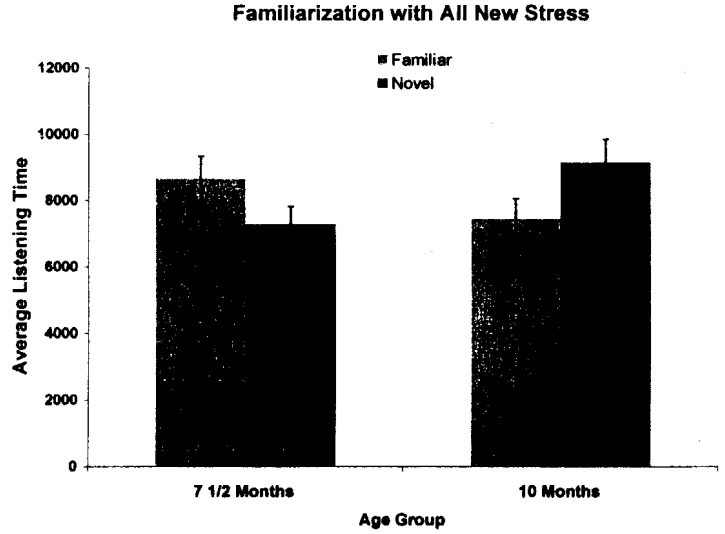
Results and Discussion

Mean listening times to the six different passages were calculated for each infant across the three blocks of trials. These times were then averaged for passages containing familiar words and for those containing unfamiliar words.

Again, mean listening times for 7½-month-olds were higher for familiar words (8.65 s; SD = 2.35) than for unfamiliar words (7.29 s; SD = 1.80). Also consistent with findings from Experiment 1, the 10-month-olds listened longer to the unfamiliar words (9.15 s; SD = 2.41) than to the familiarized words (7.45 s; SD = 2.07). Paired *t* tests indicated that these differences are significant ($t(11) = 3.77$, $p = .003$ and $t(11) = 4.70$, $p = .001$, respectively). Again, the interaction between age groups and preference for familiar versus unfamiliar words is significant ($F(2, 21) = 5.98$; $p = .019$; see Figure 2).

The 7½-month-olds' data indicate that infants are not doing a simple matching of word forms. If this were the case, then infants should not have matched their familiarized version of the target words to the tokens in the passages carrying given stress, since familiarization took place with new stressed tokens only. However, the same pattern of results was obtained in Experiments 1 and 2, regardless of the form of stress at familiarization. Infants appear to abstract types from tokens, as when recognizing the familiar words in the alternating stress pattern when only one of the two forms of stress was present during familiarization. Both forms of stress at familiarization led to subsequent recognition.

Figure 2.



Experiment 3

Experiments 1 and 2 were between-subject demonstrations of the influence of particular forms of stress at familiarization on subsequent word recognition. In order to determine which kind of familiarization best promotes subsequent word recognition, we needed to compare the two forms of familiarization directly (that is, within-subjects). Therefore, Experiment 3 was designed to determine which familiarization condition was *most* effective in prompting word preference. In order to answer this question, in Experiment 3 we compared a single group of infants' preferences for words following familiarization with both forms of stress.

Given their preference for familiarity, we predicted that the 7½-month-olds would demonstrate what, if any, differential recognition of words exists following familiarization with the two different forms of focusing stress (where the 10-month-olds' preference for novelty would not tell us anything about possible differences in recognition given different familiarization conditions). Therefore, we tested a single group of 7½-month-old infants, familiarizing them with two words. One word was produced with all new stress during familiarization, while the other word was produced with alternating stress during familiarization. Test passages were those used as in the previous experiments.

Again, there are a couple of possibilities regarding the influence of the form of stress at familiarization on subsequent word recognition. First, if infants are doing a simple matching of word forms, then they must need to hear words with both forms of stress for optimal subsequent identification. In this case, we would expect to see longer listening times for the word familiarized with alternating stress, since that would provide infants with tokens of both word forms. Alternatively, if infants need input that leads them to *optimally* abstract types from tokens, we should expect to see longer listening times for words familiarized with all new stress, since this realization provides the ideal token from which infants can abstract types.

Subjects

Twelve 7½-month-old, English-exposed infants (6 females and 6 males) were tested on their ability to detect familiarized disyllabic words in fluent speech. The 12 infants averaged 224 days old (SD = 7.44).

Familiarization Phase

For the familiarization phase of this third and final experiment, infants were familiarized with one target word that carried all new stress and with another target word that consistently alternated between new and given stress. We randomly eliminated two of the original six animal names, such that we had two left for use as targets and two for controls.

During familiarization, infants heard repetitions of the two target words on alternating trials until they accumulated at least 30 seconds of listening time to each word. If the infant achieved criterion for one word, but not the other, the trials continued to alternate until criterion was reached for both. Half of the infants were familiarized with the words *falcon* and *chicken*; the other half were familiarized with the words *monkey* and *dolphin*.

Test Phase

Infants were tested on the same passages used in Experiments 1 and 2. However, since we reduced the number of target words during familiarization from three to two words, the test phase consisted of only four of the original six 6-sentence passages. As before, these passages consisted of sentences containing animal names alternating between new and given stress.

Test trials began immediately following attainment of familiarization criterion for the two target words. During the test phase, infants heard blocks of the same four 6-sentence passages. As in the previous two experiments, the order of the sentences within each passage was fixed, such that stress on control and target words alternated between new and given from sentence to sentence. Test trials were blocked in groups of four so that each passage occurred once within a given block. Each infant was tested on four blocks, for a total of 16 test trials.

Results and Discussion

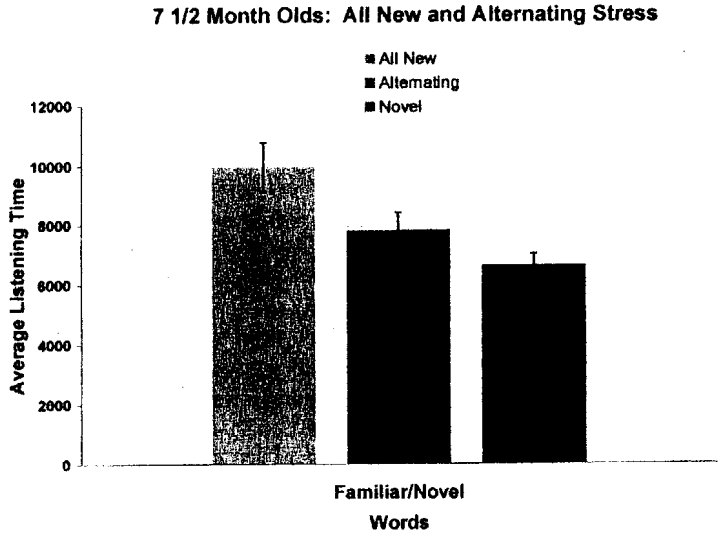
Mean listening times to the four different passages were calculated for each infant across the four blocks of trials, then times for passages containing unfamiliar words were averaged. This gave us infants' average listening times for the two familiarization conditions and the unfamiliar condition.

Overall, mean listening times for the three conditions were significantly different from one another ($F(2, 33) = 7.25, p = .002$). Specifically, mean listening times were higher for familiarization items with all new stress (9.94 s; SD = 2.85) than for those with alternating stress (7.81 s; SD = 2.07). This significant difference between listening times ($t(11) = 2.29, p = .04$) reflects the superior attention-attracting and attention-maintaining qualities of new-stressed words. Furthermore, mean listening times for familiarization items with alternating stress were higher than for unfamiliar items (7.81 s; SD = 2.07 vs. 6.62 s; SD = 1.29), also a significant difference ($t(11) = 2.90, p = .014$; see Figure 3). These differences indicate that, even though familiarization with alternating stress certainly seems to help guide infants' recognition, the acoustic reduction that is typical of tokens with given stress to some degree compromises infants' ability to abstract types from tokens.

If infants were doing a simple matching of word forms, then we would have seen longer listening times for the alternating stress pattern in the test passage when stress on familiarization items had also alternated. Since our results were

the same regardless of familiarization stress, it seems that infants are able to abstract types from tokens.

Figure 3.



General Discussion

Infants' greater preference for those words familiarized with all new stress than for those familiarized with alternating (new/given) stress may be attributable to a more abstract representation of the words than a simple-matching hypothesis would predict. Based on the data presented here, it seems clear that infants' word preferences aren't guided by an exact match or even by some close acoustic form (given the pronounced differences between familiarization items carrying all new stress and the subsequent test passages carrying alternating stress). New-like stress must be most effective at promoting this strong preference. However, alternating stress also appears to do the job, as our initial experiment demonstrates. Whether this preference is based on a lexical representation or rather on some abstract acoustical representation is unclear. But one thing seems certain based on these data: Stress at the discourse level helps guide infants in their emerging ability to abstract types from tokens and so recognize words in fluent speech.

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References

Bernstein-Ratner, N. (1986). Durational cues which mark clause boundaries in mother-child speech. *Journal of Phonetics, 14*, 303-309.

Bortfeld, H., & Morgan, J. (1998). Disentangling multiple sources of stress in infant-directed speech. In A. Greenhill, H. Littlefield & C. Tano (Eds.), *Proceedings of the 23rd Annual Boston University Conference on Language Development, Volume 1.* Somerville, MA: Cascadilla Press.

Chafe, W. (1976). Givenness, contrastiveness, definiteness, subjects, topics, and points of view. In C. Li (Ed.), *Subject and topic.* New York, NY: Academic Press.

Clark, H., & Haviland, S. (1977). Comprehension and the given/new contract. In R. Freedle (Ed.), *Discourse production and comprehension.* Norwood, NJ: Ablex Publishing.

Fisher, C., & Tokura, H. (1995). The given/new contract in speech to infants. *Journal of Memory and Language, 34*, 287-310.

Friedman, S. (1972). Newborn visual attention to repeated exposure of redundant vs. 'novel' targets. *Perception and Psychophysics, 12*, 291-294.

Halliday, M. (1967). Notes on transitivity and theme in English, Part 2. *Journal of Linguistics, 3*, 199-244.

Haviland, S., & Clark, H. (1974). What's new? Acquiring new information as a process in comprehension. *Journal of Verbal Learning and Verbal Behavior, 13(5)*, 512-521.

Jusczyk, P., & Aslin, R. (1995). Infants' detection of the sound patterns of words in fluent speech. *Cognitive Psychology, 29*, 1-23.

Jusczyk, P., & Hohne, E. (1997). Infants' memory for spoken words. *Science, 277*, 1984-1986.

Newsome, M., & Jusczyk, P. (1995). Do infants use stress as a cue for segmenting fluent speech? In D. McLaughlin & S. McEwen (Eds.), *Proceedings of the 19th Annual Boston University Conference on Language Development, Volume 2.* Somerville, MA: Cascadilla Press.

Spelke, E. (1985). Preferential looking methods as tools for the study of cognition in infancy. In G. Gottlieb & N. Krasnegor (Eds.), *Measurement of Audition and Vision in the First Year of Postnatal Life.* Norwood, NJ: Ablex.

Tighe, E., & Leaton, R. (1976). *Habituation.* New York, NY: Academic Press.