

Intonational differences between the reduplicative babbling of French- and English-learning infants*

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ABSTRACT

The two- and three-syllable reduplicative babbling of five French-learning and five English-learning infants (0;5 to 1;1) was examined in two ways for intonational differences. The first measure was a categorization into one of five categories (RISING, FALLING, RISE-FALL, FALL-RISE, LEVEL) by expert listeners. The second was the fundamental frequency (F_0) from the early, middle and late portion of each syllable. Both measures showed significant differences between the two language groups. 65% of the utterances from both groups were classified as either rising or falling. For the French children, these were divided equally into the rising and the falling categories, while 75% of those utterances for the English children were judged to have falling intonation. Proportions of the other three categories were not significantly different by language environment. In both languages, though, three-syllable utterances were more likely to have a complex contour than two-syllable ones. Analysis of the F_0 patterns confirmed the perceptual assessment. Several aspects of the target languages help explain these intonational differences in prelinguistic babbling.

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INTRODUCTION

The transition from babbling to language has been the focus of much recent research (e.g. Thevenin, Eilers, Oller & Lavoie, 1985; Vihman, Macken, Miller, Simons & Miller, 1985; Vihman, Ferguson & Elbert, 1986). This wide range of studies has an equally wide range of implications. On the one hand, there is substantial evidence of universal developments, which seem to reflect a maturational process independent of the language environment (e.g. Locke, 1983). On the other hand, there is equally compelling evidence for language-specific changes, where the character of the babble begins to reflect the composition of the adults' language (e.g. de Boysson-Bardies, Sagart & Durand, 1984). Given the current evidence for the continuity between prelinguistic utterances and the acquisition of the ambient language, it could hardly be otherwise than that there would be evidence of both kinds of process. The task now is to trace further the emergence of various attributes of the adult language.

Previous studies of both maturational and language-specific influences in the babbling of infants from different linguistic communities have rarely combined both perceptual and instrumental analyses. These two approaches to the study of prelinguistic speech complement one another well. Perceptual studies with an instrumental check are useful in determining the physical properties of the stimulus that are the source of the perceptual judgement. Furthermore, instrumental analyses have sometimes revealed linguistically-predicted differences that were not captured in the original transcriptions (Macken & Barton, 1980).

One aspect of babbling that deserves special attention is its intonation. Infants often appear to imitate intonation patterns before they imitate segmental structure (Lewis, 1936; Weir, 1966; Crystal, 1973). There is also some evidence that children can begin mastering the F_0 changes that represent lexical tone before they command the segmental distinctions of their language environment (Li & Thompson, 1976). French children use intonation to express different meanings at the one-word stage (Marcos, 1987). Despite this early success with intonation, control of syntactically appropriate intonation is a later development (Weir, 1966; Crystal, 1979). Furthermore, heightened F_0 excursion is a salient characteristic of motherese, a speaking style that infants pay particular attention to (Ferguson, 1964; Garnica, 1977; Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies & Fukui, 1989). It has been suggested that it is indeed the intonation pattern of the F_0 that attracts infants' attention (Fernald & Kuhl, 1987).

Do the F_0 contours in the child's babbling reflect the predominant patterns in the adult language? Very little work to date has been addressed to this question. The present work will make a start by examining the reduplicative babbling of five children from French environments and five from English

environments. These languages differ not only in their inventories of contours (e.g. Pierrehumbert, 1980; Cruttenden, 1986, for English; Kenning, 1979; Leach, 1988, for French) but also in which of their intonation contours are most typical. Infants will be more likely to incorporate those patterns that they hear more frequently – a hypothesis which leads to the examination of more statistically-oriented studies. Delattre (1961), classifying patterns from one French and one American female speaker into rising or falling, found 90% of American English contours were falling, while 87% of French contours were rising. Pike (1945: 155), using five categories, found a preponderance (53.7%) of falling contours in all sentence positions for American English, but very few rising contours (9.6%). A further salient difference between the two languages is that the contour signalling the speaker's intent to continue is usually rising in French but falling, or falling then rising, in English (Delattre, 1961; Rossi, 1980; Grover, Jamieson & Dobrovolsky, 1987). This gives a different sound to the two languages, despite the presence of a final declarative fall for both of them.

Our first goal, then, was to determine whether intonation differences, if they exist between these two groups of infants, mirror the marked differences between falling and rising F_0 in the two language environments. This was assessed both perceptually, by having expert listeners classify the intonation patterns, and instrumentally, by an analysis of the actual F_0 . A comparison of the two measurements is made possible by our restriction to reduplicative babbles, given that infants as well as adults have F_0 s which depend in part on the quality of the vowel they are producing (Bauer, 1988). Such intrinsic F_0 effects make the comparison of the two measurements difficult if there are different vowels in the utterances, since the different vowels would, in some cases, have different F_0 s and yet sound as if they had the same pitch (Lehiste, 1970; Silverman, 1986). The acoustic analysis by itself is insufficient for the purpose of delimiting perceptually relevant changes in intonation (Crompton 1980: 152; Leach 1988: 125).

I PERCEPTUAL ANALYSIS

METHOD

Subjects

The subjects for the present study were natives of France and the United States, growing up in monolingual French or English environments respectively. The average age of the children in the first recording used was 0;7.10, the last recording was at an average of 0;11.3 (ranging from 0;5 to 1;1: see Table 1).

Stimuli

The stimuli for the present study were selected from recordings made at weekly intervals by the parents of the children. Each infant was recorded in the home on a cassette taperecorder using a high quality microphone. Individual recording sessions lasted approximately 10-20 minutes. The parents were asked to choose a time when the child was likely to be alert and happy. As far as possible, the microphone was held 20 cm from the baby. If necessary, the parent could attempt to induce babbling by interacting with the child (stopping, of course, when the infant began). Additional comments about the session were recorded by the parent on a form provided with each tape.

All the usable two- and three-syllable reduplicative babbles were selected for this study. This was done by extracting them from computer digitizations. The recordings were low-pass filtered at 4.8 kHz and sampled at 10 kHz via the Haskins PCM system (Whalen, Wiley, Rubin & Cooper, 1990). While all the utterances in the sessions have been transcribed for other purposes, we chose only the reduplicative babblers for this study, in order to eliminate vowel changes as a source of F_0 confound. We limited the length of the utterance to three syllables both because longer utterances can have more complicated intonations than could be easily compared and because the number of such utterances is too small for systematic comparisons. (At least 750 msec of silence occurred after the last syllable.) Using these criteria, we obtained 156 stimuli. These were almost equally divided between the two language groups (76 for the English children, 80 for the French), though the differences among the individuals in the number of usable utterances were large (see Table 1).

Listeners

The listeners were the first two authors and two colleagues familiar with infant vocalizations but not with the stimuli in question. Since the third author was in charge of selecting the stimuli, the authors were able to make their judgements on the stimuli blind to the language background of the infant. All the listeners were native speakers of a variety of American English.

Procedure

The two- and three-syllable utterances were recorded on audiotape for presentation to the listeners. Each was repeated three times with 1 sec between repetitions. After the third repetition, there was a 4.5 sec pause for the listener to write down a response. Two randomizations, each containing

INTONATION IN FRENCH AND ENGLISH BABBLING

 TABLE 1. *Description of the source of the 156 stimuli*

	English-learning infants					French-learning infants				
initials	AB	MM	VB	CR	MA	EC	MS	MB	NM-B	JZ
sex	F	M	F	M	M	M	M	M	F	M
no. 2-sylls	11	10	13	3	11	24	10	11	5	0
no. 3-sylls	4	13	4	3	4	11	8	7	1	3
first age	0;7	0;7	0;7	0;9	0;8	0;6	0;7	0;8	0;9	0;5
last age	0;11	1;0	0;11	0;10	1;0	1;0	1;0	0;11	1;1	0;7

one triplet of each of the 156 stimuli, were prepared. The listeners heard the two tapes in balanced order.

Each intonation pattern was to be classified as RISING, FALLING, RISE-FALL, FALL-RISE, or LEVEL. It was made clear that the contour did not have to be within one syllable. Thus two syllables which had a level pitch within-syllable but with a difference between syllables should be judged to have a contour. However, a sizable contour on a single syllable could also be considered in the overall judgement. Similarly, it was not necessary for there to be no pitch change at all for a judgement of 'level'. Rather, those utterances which lacked large pitch changes and which had no clear pattern to the small ones that were present were also to be classified as 'level'. Even in uncertain cases, a single response was to be written. For some of the complex patterns, no single pattern could be expected to be the majority decision.

RESULTS

There was good agreement on the intonation of most of the stimuli. In 60% of the cases, one category accounted for at least 75% of the judgements from all the listeners, and in 91% there was one category that accounted for at least 50% (the 'majority' decision).

As can be seen in Fig. 1, there were differences in the judged intonation of the babbles from the children in the two different language environments. For the French children, most of the utterances had simple rising or falling patterns, and about equal numbers of each. For the English children, the falling pattern was a sizable majority. For both groups, the other three categories accounted for about a third of the responses, with no clear pattern within or across languages. The results were almost identical for the two-syllable and three-syllable utterances. The only noticeable shift was toward slightly more rise-fall for the three syllable, and more level for the two-syllable utterances.

The eight judgements on each stimulus were submitted to a repeated measures analysis of variance. To code the contours numerically, we counted the level contour as 0 and counted deviations from that in two directions.

CHILD LANGUAGE

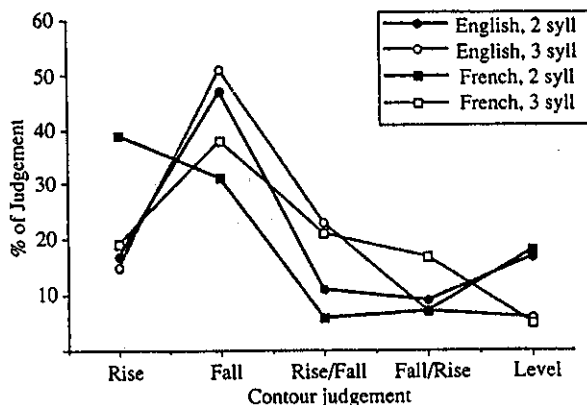
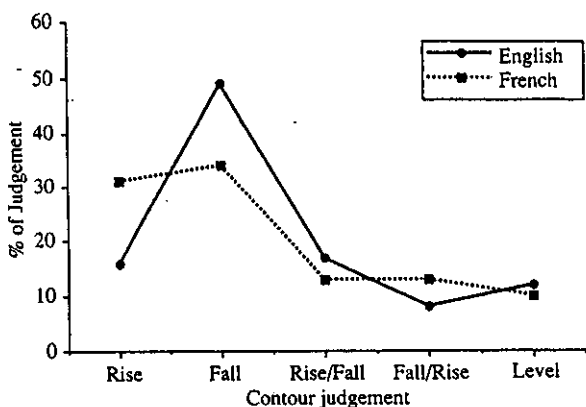


Fig. 1 Percentage of listener judgements for each of the five intonation contours. Each function represents the total for the utterances from the five children learning each language (French and English).

Thus the rise-fall was coded as 1, and the rise as 2, while the fall-rise was coded as -1 and the fall as -2. The four listeners and their two judgements per stimulus were treated as within-factors for the 156 utterances, which were grouped by the between-factors of language environment and number of syllables.

Language environment, confirming the obvious patterns in Fig. 1, was a significant factor ($F(1, 152) = 5.53, p < 0.05$). The number of syllables did not affect the intonation judgements ($F(1, 152) < 1.0$, n.s.). In the coding scheme, the difference between level and rise-fall (the only difference noted in the percentages of judgements) was a small one and so did not contribute much to the variance accounted for by this factor. The interaction of these two factors was not significant.

Despite the sizable agreement among listeners, there were still significant differences among them ($F(3, 456) = 2.88, p < 0.05$), and some differences for the listeners' judgements on the two languages ($F(3, 456) = 3.58, p < 0.05$). Although all four listeners had more falling (i.e. negative) responses for the English than for the French stimuli, they differed in the degree of disparity between the two languages. No other interactions with this factor were significant, nor were any involving the difference between the two repetitions.

II ACOUSTIC ANALYSIS

DATA REDUCTION AND ANALYSIS

The focus of our acoustic analysis was fundamental frequency, which, though not the only determinant of prosody, is the major one (Cruttenden, 1986: 2-3). F_0 values for each syllable of the 156 stimuli were obtained for comparison with the perceptual judgements. For the analysis, the medians of the values for each third of the syllable were obtained. While such a selection has the drawback of ignoring duration differences between syllables, it has the advantage that there are the same number of measurements for each syllable. Each of the utterances was analysed with the API command of the Interactive Laboratory System package. Once the values were obtained, they were compared with an auditory judgement of the closeness of fit. In many cases, the value reported is actually one half or one third the true value. In these cases, the numbers obtained were simply multiplied by an appropriate amount. In some cases, no pitch was detected where there clearly was some. In these cases, an average measurement was obtained by hand-delimiting ten pitch periods and finding the average F_0 . Such changes and replacements were done for 30% of the syllables in the corpus.

RESULTS

Before computing intonation contours based solely on the F_0 pattern, we determined the fit between the listener judgements and the computed F_0 pattern. For this analysis, the utterances were divided according to the category that received at least half of the listener judgements. Ninety-one % of the utterances had such a majority judgement, and the other 9% were classified as 'Indeterminate'. Pseudo-contours were obtained by averaging the mean of the logs of the three F_0 values per syllable. Logs of the values in Hz were used to make the changes in F_0 more equivalent across the range of F_0 s. Other researchers have used semitones to analyse F_0 ranges. Since the semitone conversion requires a baseline, we used the more independent log scale. The semitone scale is logarithmic in nature, and gives identical statistical results for the analysis of variance.

CHILD LANGUAGE

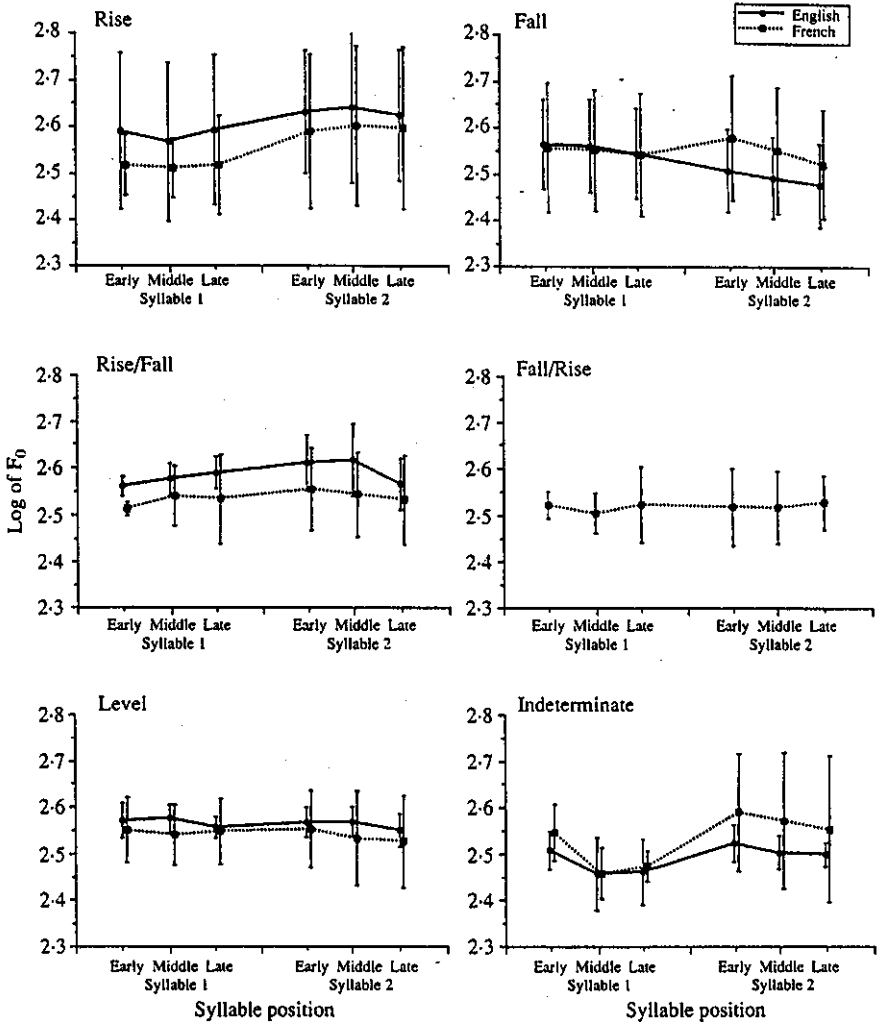


Fig. 2 F_0 patterns of the two-syllable utterances, categorized by the majority judgement made by the four listeners. The F_0 s are in averaged logHz of the median F_0 for each third of each syllable. The error bars represent one s.d. above and below that mean. The error bars for the French infants are always to the right of those for the English; if there are no error bars, the pattern represents only one utterance; there were no English-learning infant utterances which received a fall-rise majority. The log values for the tick marks from 2.3 to 2.8 corresponds to 200, 251, 316, 398, 501, and 631 Hz.

Fig. 2 shows the F_0 pseudo-contours for the two-syllable utterances, and Fig. 3, for the three-syllable ones. The rise and fall categories, which made up a large percentage of judgements for both languages, are clearly supported by the F_0 contours. The only contour which is somewhat surprising is the two-syllable fall pattern for the French-learning infants (Fig. 2, top right). The second syllable starts high enough for it to be tempting, on the basis of visual evidence to label this pattern a rise-fall. For the two-syllable complex patterns (middle panels of Fig. 2), there does not appear to be enough change visible to base the judgement on. The three-syllable complex patterns, on the other hand, seem much easier to see. The level patterns are truly flat (though there is only one per language in the three-syllable case). The Indeterminate patterns seem, for the most part, to have conflicting directions in the F_0 changes, leading different listeners (indeed, the same listener on different occasions) to focus on one aspect or the other. In the two-syllable Indeterminate utterances, there is sizable variability, though not any larger than for some of the other categories. (The low variability in the three-syllable examples is due to low sample size.)

The F_0 patterns support the listener judgements to a large degree, and most of the discrepancies can be attributed to differences in the analysis procedures. Our listeners were necessarily making prosody judgements, not F_0 judgements, since the contribution of such factors as duration and amplitude cannot be avoided perceptually (Lehiste, 1970). Only three F_0 measurements were taken per syllable, so some differences between syllables could have been lost. Some of those syllables might have been longer and therefore more important to the listener, but our analysis would be forced to ignore such a result. In the course of obtaining these medians, however, we did not feel that there were any instances of a contour within a syllable which was eliminated by being reduced to one number. Rather, the largest F_0 excursions were reduced due to selection within a contour.

Another interesting perceptual effect that accompanied a few utterances was that of a large change in amplitude. While there were not enough such instances to study further, we discovered for them that a large decrement in amplitude was perceived as a drop in pitch, even when the acoustic analysis did not show a change in F_0 . Given that lower amplitude correlates well with decreased air flow, which in turn correlates with lower F_0 , this perception seems reasonable. Rossi (1979) has found just this correlation in the perception of steady-state vowels. It was not, however, taken into account in our acoustic analysis, and did not occur often enough to change the results.

Further analysis of the acoustic data was performed without regard to the perceptual results. We treated the F_0 measurements within syllables and within utterances as repeated measures for the following analyses: comparisons of the first two syllables of all utterances; comparisons of the last two syllables of all utterances; and comparisons for the two- and three-syllable

CHILD LANGUAGE

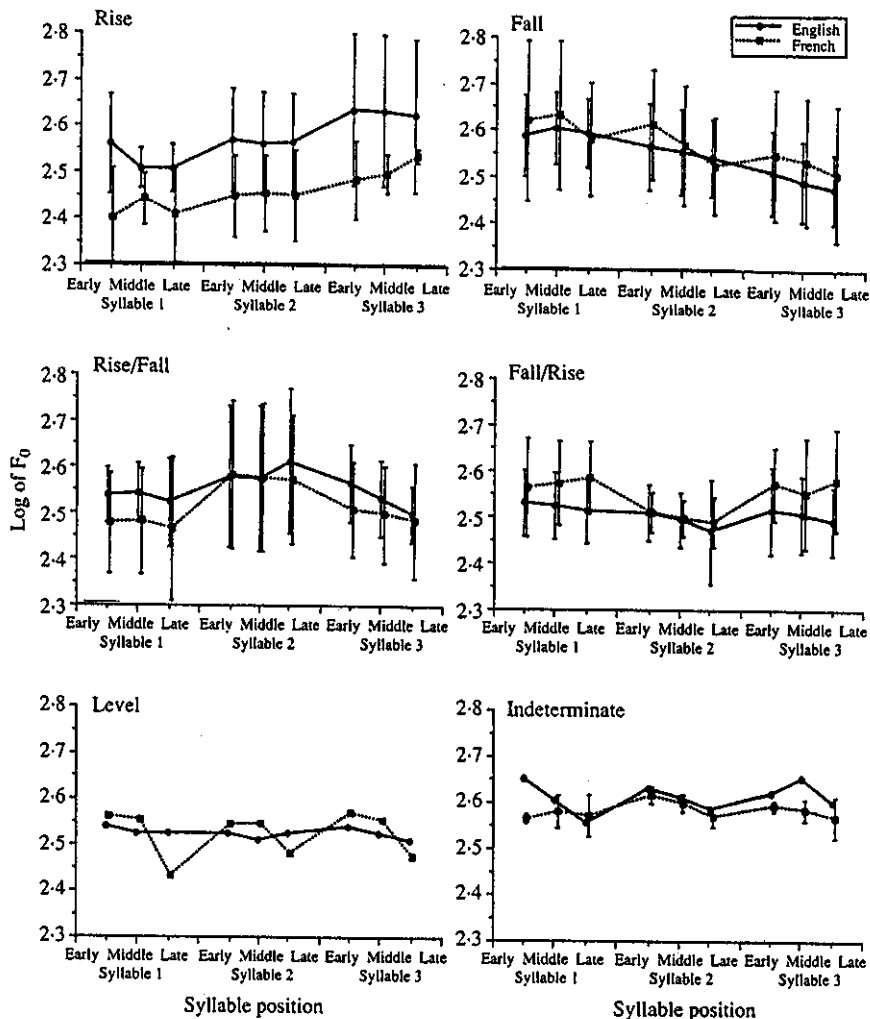


Fig. 3 F_0 patterns of the three-syllable utterances, categorized by the majority judgement made by the four listeners. See Fig. 2 for further details.

utterances separately of all the syllables in those utterances. Since it was not possible to combine the two- and three-syllable utterances directly, we compared syllables in the same relative position to the entire utterance in the first two subsets. These analyses showed language effects primarily in the interactions of Language with Syllable.

In the analysis of the first two syllables of all utterances, the between-factor of language, and within-factors of syllable (first or second) and location

within syllable (early, middle, late) were used. There was no main effect of language or of syllable (for both, $F(1, 154) < 1$, n.s.), but a significant interaction between the two factors ($F(1, 154) = 6.91$, $p < 0.01$). The English infants had higher F_0 s in the first syllable and lower in the second than the French, though the average of the two syllables was almost identical. Within syllables (location), there was a consistent tendency for the F_0 to drop ($F(2, 308) = 17.94$, $p < 0.001$). The interactions of location with the other two factors were not significant, showing that both syllables and both languages had the same tendency.

In the analysis of the last two syllables of all utterances, there was again no main effect of language or syllable ($F(1, 154) < 1$, n.s.), but a significant interaction of language with syllable ($F(1, 154) = 7.66$, $p < 0.01$). The English infants had higher F_0 s in the first syllable and lower in the second than the French, with the French two-syllable utterances with rising intonation contributing a great deal to that figure. The tendency for the F_0 to drop within syllables was present as well in a significant location effect ($F(2, 308) = 26.03$, $p < 0.001$). The interactions of location with the other two factors again were not significant.

The analysis of the two syllables of the two-syllable utterances revealed largely the same pattern. The language and syllable factors did not approach significance, but the syllable by language interaction was significant ($F(1, 96) = 8.44$, $p < 0.01$). Location was also significant ($F(2, 192) = 12.63$, $p < 0.001$). In this case, the syllable by location interaction was significant ($F(2, 192) = 3.07$, $p < 0.05$), due to the second syllable's larger drop in value.

The analysis of the three syllables of the three-syllable utterances revealed a somewhat different pattern from that of the two-syllable utterances. The language factor was again not significant, though the syllable factor did approach significance ($F(2, 112) = 2.60$, $p < 0.10$). The syllable by language interaction was not significant for this analysis ($F(2, 112) < 1$, n.s.). The location changes were significant ($F(2, 112) = 10.47$, $p < 0.001$). Not only was the syllable by location interaction significant ($F(4, 224) = 2.46$, $p < 0.05$), but the three way interaction of language, syllable and location was significant ($F(4, 224) = 3.27$, $p < 0.05$). Each syllable had falling F_0 s, but the French utterances fell more steeply within each syllable, while the English utterances fell very little in the first syllable, but more steeply across the last two.

DISCUSSION

Reduplicative babbles from five infants from a monolingual English environment and five from monolingual French environment were analysed for differences in intonation contour. The French children used significantly more rising intonation and less falling intonation than the English children,

at least in the two-syllable utterances. This pattern reflects the relative distributions of F_0 contours in the two adult languages (Delattre, 1961). It also supports the findings of de Boysson-Bardies *et al.* (1984) that the language environment is discernable in the babbling of very young children.

The language-specific differences we have found could be confounded with the children's differential use of F_0 for communication. D'Odorico (1984) found that even very young children (0;4-0;9) use different F_0 contours in different proportions depending on their emotional state. Since we did not obtain detailed information on the context of each utterance, it was not possible to categorize the babbling on the basis of the child's presumed intent. Nonetheless, the recording situation excluded two of D'Odorico's three situations: CALL and DISCOMFORT were not relevant, since the parent was already present, and the children were recorded at the times they were least likely to be fussy. Even the number of REQUESTS (D'Odorico's third category) was likely to be small, since the parent was to interact with the child only when s/he stopped babbling. In another study of the communicative use of intonation contours, Marcos (1987) found that French children older than those studied here were likely to use rising contours for requests, and falling contours for labelling. However, the children in her study who were less than 1;6 did not show this effect. Similar age ranges for the emergence of the communicative use of intonation has been found for English (Halliday, 1975; Menn, 1976). Thus it seems likely that the differences we found did not indicate that the French children were, by chance, making more requests. Rather, some aspect of the language environment seems to be responsible.

If the child learning a language is more influenced by the speech directed to him or her than by speech in the environment at large, then the differences in Infant Directed Talk (IDT) are of more direct concern than differences in the adult language. Despite the well-established increase in pitch changes in IDT relative to ADT (Adult Directed Talk) (e.g. Garnica, 1977), there is very little research examining pitch contours *per se*. For language directed at much younger infants, German appears to have a majority of rising intonation (Fernald & Simon, 1984). For Mandarin, there is a majority of falling contours (Grieser & Kuhl, 1988), though the infants in that study were much younger (0;2). The most extensive cross-linguistic study of IDT for children near the ages of the ones in this study does not report contours (Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies & Fukui, 1989). Fernald *et al.* do mention a common 'tag vocalization' (1989: 492) which has a steeply rising F_0 for all the languages. At this point, we can only say that it is possible that the intonation that children between 0;5 and 1;1 hear is different in F_0 pattern from the standard adult language, but a more detailed account must wait for further measurements. If the intonational differences are primarily present in the adult language rather than the more universal

IDT, then the presence of intonational differences in babbling would signal an attunement to more than just IDT. Alternatively, such differences might make us examine cross-linguistic differences in IDT more closely, in particular, the F_0 contours. This is particularly important given the changes that occur in IDT as the child develops (Stern, Spieker, Barnett & MacKain, 1983; Bernstein Ratner, 1984, 1986).

An apparently discrepant result in the literature is that of Allen (1983), who found that older French children (two-year-olds) had preponderantly falling intonation on their two- and three-syllable utterances. Allen's stimuli, however, were elicited by the presentation of a picture, which the child was supposed to name. Each utterance, then, was a complete statement of a sort, and as such would be expected, even in French, to have falling intonation. It is the rising intonation signalling continuation that is most different from English (Delattre, 1961), which tends rather to have a fall-rise.

Very little of the perceptually salient pitch change was present within single syllables. The two-syllable utterances received many fewer judgements of the complex patterns (rise-fall of fall-rise) than did the three-syllable ones. Other studies of children learning English have found a higher proportion of complex patterns (Kent & Murray, 1982; Robb, Saxman & Grant, 1989). In support of the present results, these earlier studies of English-learning children show a lack of rising contours similar to that found here. The difference in the percentage of complex patterns may be in part due to the way the contours were measured. The earlier studies used classifications of the F_0 pattern based on visual estimation of the F_0 s from automatic pitch extraction. Since automatic pitch extraction algorithms make most of their mistakes at the boundaries between voiceless (or silent) and voiced segments, these systematic errors could introduce more apparent F_0 movements than is actually present. Further, it is not obvious which patterns that make a visual difference will be perceived as distinct contours auditorily. The present methodology is more sensitive to the perceptually relevant changes and may therefore be the more relevant measure.

Our focus on reduplicative babbling, which was guided by methodological considerations, may have made it more difficult for F_0 differences to emerge. Nonreduplicative babbling in the prelinguistic stage can contain long, continuous vocalizations with large changes in F_0 , but such utterances were deliberately excluded. The reduplicated babbling we examined is 'poorer in prosodic cues' (de Boysson-Bardies, Sagart & Durand, 1984: 10) than babbling as a whole. That significant differences in F_0 emerged nonetheless is even stronger evidence of the influence of the language environment.

One way in which languages differ is in whether F_0 changes signal a change in words, as in a tone language such as Mandarin, or not, as in English and French. Since tones are characteristic of single words, it may be that the child learning a tone language will need to attend to F_0 changes earlier than does

the non-tone language learner. Also, the one-word stage may force the language learner to use an appropriately sized unit for a tone contour, while using a sentential intonation contour on a single word may be more difficult. This may explain the apparent earliness of tone learning relative to phoneme learning (Li & Thompson, 1976). One study of Mandarin IDT (Grieser & Kuhl, 1988) showed that mothers increase the global changes in F_0 at the expense of tonal changes within the syllable, but the speech in that study was directed at two-month-old infants. Adults change their IDT as the infant changes (Bernstein Ratner, 1984, 1986), even in their range of F_0 (Best & McRoberts, 1988). For a non-tone language, the meanings associated with these patterns are necessarily intonational. As such, they may be reflected in reduplicative babbling, which may be equivalent to a sentential construct and thus a site where native intonation could reasonably be attached. Further comparisons of the contours of late reduplicative babbling with the contours on early words would be of great interest. It would also be interesting to see the intersection of tone and intonation (cf. Lin, 1989) at the one-word stage in a tone language.

The establishing of a difference in intonation between French and English sharpens the question of just what the language environment for the child is. It is clear that children prefer IDT to ADT (Fernald, 1985), but that does not indicate that IDT constitutes the major source of language exposure. If the contours used in IDT (or their relative frequency of occurrence) differ from those in the adult language, we would be able to determine somewhat better which style of language the child incorporates into his or her system. Similarly, it would be of interest to see if use of and sensitivity to F_0 changes become language-dependent before the well-established shifts in segmental perception (Werker & Tees, 1984; Werker, 1989). Further work needs to examine the relative amount of time that infants are exposed to various language styles. From the present work, it appears that children are sensitive to F_0 variation before they have a recognizable language system.

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