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Acoustic Determinants of Infant Preference for Motherese Speech

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Three experiments investigated possible acoustic determinants of the infant listening preference for motherese speech found by Fernald (1985). To test the hypothesis that the intonation of motherese speech was sufficient to elicit this preference, it was necessary to eliminate lexical content and to isolate the three major acoustic correlates of intonation: (1) fundamental frequency (F_0), or pitch; (2) amplitude, correlated with loudness; and (3) duration, related to speech rhythm. Three sets of auditory reinforcers were computer-synthesized, derived from the F_0 (Experiment 1), amplitude (Experiment 2), and duration (Experiment 3) characteristics of the infant- and adult-directed natural speech samples used by Fernald (1985). Thus, each of these experiments focused on particular prosodic variables in the absence of segmental variation. Twenty 4-month-old infants were tested in an operant auditory preference procedure in each experiment. Infants showed a significant preference for the F_0-patterns of motherese speech, but not for the amplitude or duration patterns of motherese.

motherese intonation infant auditory preference
fundamental frequency language input auditory development

The primary emphasis in research on the structure and functions of motherese has been on linguistic variables and language outcome measures. Much less attention has been given to the *sound* of mothers' speech, and to the possible role of the exaggerated intonation typical of motherese in communicating affect and regulating infant attention, particularly with prelinguistic infants. In an auditory preference study, Fernald (1985) found that 4-month-old infants chose to listen more often to infant-directed speech than to adult-directed speech, a listening preference which could be accounted for by a number of perceptual as well as linguistic variables. The present study extends these find-

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ings to investigate possible acoustic determinants of the infant preference for motherese.

Numerous studies have shown that adult speech to infants and young children is simplified syntactically, semantically, and phonologically in comparison with normal adult conversation (see Snow, 1977, for a review). Adults typically use a simplified lexicon in motherese, consisting primarily of one- and two-syllable words, often with special words of affection (Ferguson, 1964). Another dramatic difference between adult-directed and infant-directed speech is in the intonation, or prosody, of motherese (Garnica, 1977; Menn & Boyce, 1982; Stern, Spieker, Barnett, & MacKain, 1983). Even with newborns, mothers use higher pitch, wider and smoother pitch excursions, longer pauses, shorter utterances, and more prosodic repetition when speaking to their infants than in conversation with adults (Fernald & Simon, 1984). Which of the numerous linguistic and prosodic features distinguishing adult-directed and infant-directed speech might make the motherese speech register more attractive to the young infant? It could be the characteristic lexical usage of parental speech, special words associated with caretaking and affection, that the infant finds familiar and appealing. Or perhaps some prosodic aspect of the speech signal, such as pitch contour, intensity modulation, or temporal patterning, accounts more directly for the infant listening preference for motherese.

Fernald (1984) has argued that the exaggerated pitch contours of motherese, in particular, are highly salient auditory stimuli for the infant. This claim for the special acoustic salience of motherese intonation is based on three different lines of evidence. First, psychoacoustic research with adults (e.g., Divenyi & Hirsh, 1978) suggests that the relatively simple pitch contours typical of motherese, considered as auditory patterns, may be processed and remembered more efficiently than the more complex and variable pitch contours of normal adult speech. Second, research on the vocal expression of emotion (e.g., Scherer, 1981) suggests that the exaggeration of pitch level and pitch range typical of motherese may enhance the communication of positive affect in speech to infants. Finally, observations of mother–infant interaction show that mothers use exaggerated prosodic contours to direct the infant's attention (Stern, Spieker, & MacKain, 1982), and to modulate the infant's arousal level (Fernald, Kermanschachi, & Lees, 1984).

To investigate the hypothesis that the intonation of motherese is sufficient to elicit the infant listening preference demonstrated by Fernald (1985), it was necessary to eliminate the lexical content from motherese speech and to isolate each of the three major acoustic correlates of intonation (Fry, 1968): (1) fundamental frequency (F_0), which correlates with pitch; (2) amplitude, which correlates with loudness; and (3) duration, which is related to speech rhythm. In the original study, infants were presented with recorded samples of natural infant-directed and adult-directed speech, each 8 s long, spoken by four unfamiliar women (see Figure 1). A conditioned head-turn (>30°) to one side was rewarded by one of the four motherese speech samples, while a head-turn

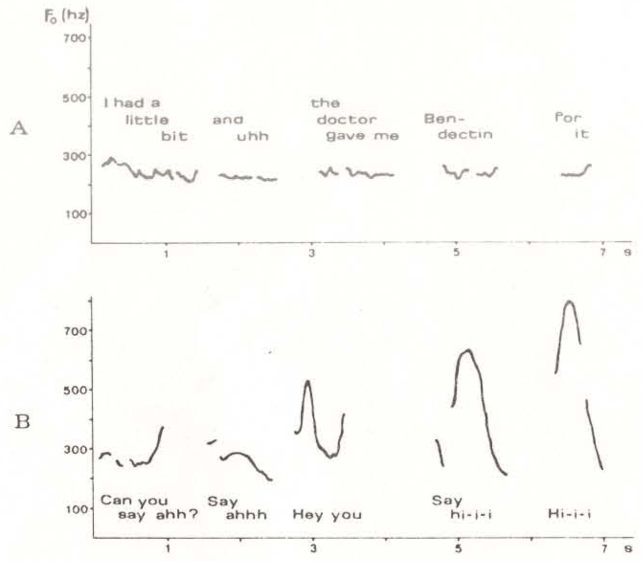

Figure 1. Intonation contours from one of four pairs of natural speech samples used as auditory reinforcers by Fernald (1985): (A) Adult-directed speech; (B) Infant-directed speech, or motherese.

to the other side produced one of the four samples of adult-directed speech. For the present study, three new sets of auditory reinforcers were computer-synthesized: derived from the fundamental frequency (Experiment 1), amplitude (Experiment 2), and duration (Experiment 3) characteristics of the infant-directed and adult-directed natural speech samples used by Fernald (1985), as shown in Figure 2. Thus each of these experiments focused on particular prosodic variables in the absence of segmental variation. The goal of these experiments was to determine if 4-month-old infants, when presented with the choice between listening to auditory signals derived either from the prosodic characteristics of infant-directed speech or from the prosodic characteristics of normal adult conversation, would demonstrate a listening preference for those signals derived from motherese.

EXPERIMENT 1

The purpose of Experiment 1 was to test the hypothesis that infants prefer the F_0-contours of motherese to the F_0 contours of adult-directed speech. Acoustic analysis of the natural speech samples used by Fernald (1985) revealed that the F_0-range extended from approximately 90 Hz to 300 Hz for the adult-directed speech samples, and from 90 Hz to 800 Hz for the infant-directed speech samples, consistent with F_0-range values observed by Fernald and Simon (1984). The auditory reinforcers used in Experiment 1 consisted of synthesized sine wave signals derived from the F_0-contours of the natural speech samples used in the original preference study, with amplitude held constant. These synthesized pitch contours did not, however, isolate fundamental frequency as the sole prosodic variable, because the temporal structure of the original speech samples was also preserved. These auditory signals thus reflected both the fundamental frequency and duration characteristics of infant-directed and adult-directed speech.

Method

Subjects. Twenty 4-month-old infants (M age = 123.6 days ± 5), 11 males and 9 females, participated in this study. An additional 9 infants (M age = 122.5 days ± 5), 6 males and 3 females, were tested but were excluded because of fussiness and failure to complete the requisite number of trials. All subjects were full-term infants with no history of hearing disorder or ear infection.

Stimuli. The eight natural speech samples used as auditory reinforcers by Fernald (1985) were digitized and stored in disk memory on a PDP 11/10 computer. A sampling rate of 20 kHz was used, with a maximum amplitude resolution of 8 bits within a ± 4-volt dynamic range. To reduce any noise introduced by the digitizing process, all signals were low-pass filtered at 8 kHz and conditioned with an autocorrelator noise-reduction device (Phase Linear 1000). The digitized speech signals were then acoustically analyzed on the PDP 11/10 to extract fundamental frequency and amplitude information as a function of time. The output of this analysis program was a list of F_0-values in hertz, and amplitude values in decibels, sampled every 2 ms for each of the eight natural speech samples. These values were then used in the synthesis of auditory reinforcers for Experiments 1, 2, and 3.

The signals used as auditory reinforcers in Experiment 1 were F_0-contours derived from the eight natural speech samples used by Fernald (1985) and synthesized on an 11/34 computer as frequency-modulated sine waves with no amplitude variation. A frequency value was specified every 2 ms and amplitude was held constant at 68 dB, with a rise- and fall-time of 40 ms at signal onset and offset (see Figure 2).

Design. This experiment employed a 2×2 factorial design, with side of presentation of motherese speech (left vs. right) and training order (motherese first vs. motherese last) as between-subject variables. The dependent measure was the number of trials, out of 15, in which the infant's head-turn was in the direction required to produce the signals derived from motherese speech. Five subjects were assigned randomly to each of the four groups, with the constraint that the distribution of male and female subjects was balanced throughout the groups.

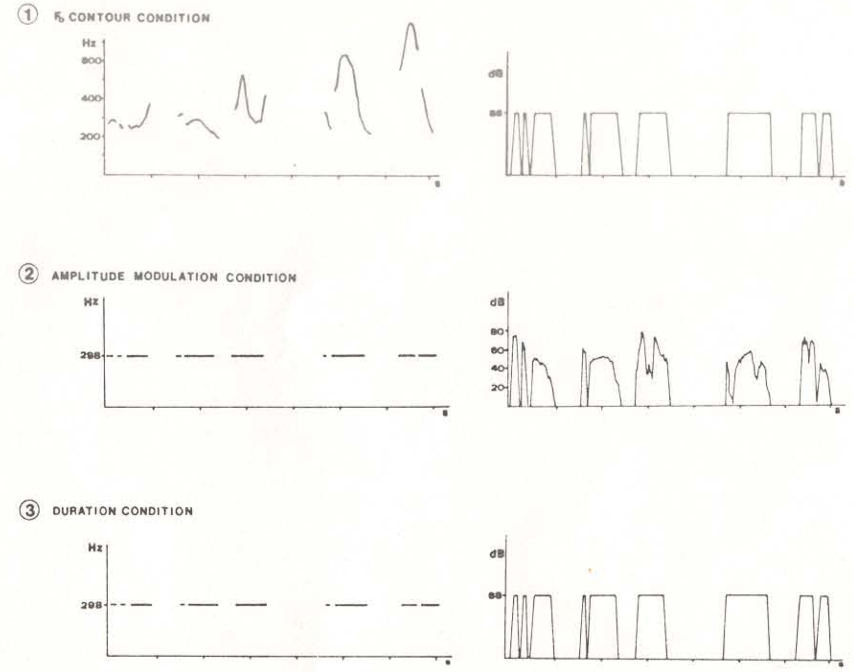

Figure 2. Example of auditory reinforcers used in Experiments 1–3, showing frequency contours, left, and amplitude envelopes, right, of three synthesized signals derived from one sample of natural speech: (1) Frequency modulation, constant amplitude (Experiment 1); (2) Amplitude modulation, constant frequency (Experiment 2); (3) Constant frequency, constant amplitude (Experiment 3).

Apparatus. Because the testing booth used in this experiment has been described in detail by Fernald (1985), only a brief description will be given here. The infant sat on the mother's lap in a three-sided testing booth, which was located in a sound-attenuated room with an adjacent control room. Symmetrically mounted on the left and right sides of the booth, at the level of the infant's eyes, were two loudspeakers and two red blinker lights. On the center panel at eye level was a green blinker light, and an opening for the lens of a video camera which was connected to a video monitor in the control room. In contrast to certain procedures described in the original auditory preference study, both the presentation of audio signals and the recording of infant response data were under the control of a PDP 11/34 computer, located in the control room. Audio signals were converted from digital to analog form by the computer and delivered on either of two channels, with a Mackintosh amplifier for each channel. The output of each of the two channels could be presented through either the left or right loudspeaker in the test booth, depending on the predetermined experimental condition. The blinker lights were also under computer control.

Procedure. The testing procedure described by Fernald (1985) was followed in this study, with certain modifications resulting from the fact that sound production and data collection were under computer control. Mother and infant were seated in the center of the test booth. The mother listened over headphones to recorded music in order to mask the sound of the audio signals presented to the infant. The infant's head position was observed on the video monitor by a judge, who was unaware of which set of audio signals was being presented on which side. The responsibilities of the judge were: (1) to judge when the infant's eyes were at midline, thus initiating a trial, and when the first criterion 30°-head-turn had occurred within a trial period; (2) to record these judgments by pressing appropriate keys on the computer keyboard; and (3) to decide, in case of infant fussiness, if the experiment should be terminated.

The experiment began with a training period in which the infant was familiarized with four of the different synthesized audio signals available on the two sides of the booth, according to a predetermined training order. The audio signals used during the training period were a subset of those used in the subsequent test trials. Sound was presented twice to each side, in alternating order, accompanied each time by the red light on the appropriate side. After each sound presentation, the red light was switched off and the green center light was turned on, until the infant's eyes were once again at midline, initiating a new training trial. During the training period, the mother was instructed to rotate her chair to the appropriate side if the infant did not spontaneously orient to the sound and light within a few seconds of presentation. After the four training trials, the mother was asked to keep her chair exactly centered in the test booth with the infant's legs oriented forward.

Following the four training trials, sound presentation was made contingent upon a 30°-head-turn by the infant. A test trial began when the infant's eyes were at midline. The first criterion head-turn to the left or right following trial onset was rewarded with presentation of one synthesized audio signal, accompanied by the red light, on the side to which the infant had turned. Auditory reinforcers were presented in random order, with the constraint that the same signal was not presented more than twice in succession. Each 8-s auditory reinforcer was played to completion, regardless of whether or not the infant turned away. The infant had to return to midline after each sound presentation in order to initiate the next trial. Completion of 15 test trials was required from each infant for inclusion in the study. Signals were presented at 68 dB, measured at the position of the infant's head with a Bruhl and Kjaer sound-level meter. Signal level was calibrated daily for the two channels on each of the two loudspeakers.

Results and Discussion

In Experiment 1, infants demonstrated a strong listening preference for the F_0-contours of motherese when given the choice between F_0-contours derived from infant-directed speech of from adult-directed speech. A t-test comparing the mean number of head-turns in the direction of motherese ($M=9.80$) with the expected chance-performance mean ($M=7.50$) revealed a significant difference, $t(19)=3.36$, $p<.01$. Sixteen of the 20 subjects in this experiment turned more often (i.e., >50% of the trials) toward the side of motherese. A binomial test showed this proportion to be significantly above chance, $p<.01$. A 2×2 analysis of variance revealed no significant main effects for side of presentation, $F(1, 16)=.37$, $p>.25$, or for training order, $F(1, 16)=.58$, $p>.25$. The interaction between these two factors was not significant.

The results of Experiment 1 suggest that the fundamental frequency characteristics of infant-directed speech may be critical acoustic determinants of the infant preference for motherese. Pitch may well be the prosodic parameter on which the two speech registers differ most dramatically. Although the natural speech samples of infant-directed and adult-directed speech used in the original preference study sounded characteristically distinct, they also shared perceptual similarities in their segmental structure. However, when segmental information and amplitude modulation were removed, as in the synthesized F_0-contours used in Experiment 1, the perceptual contrast between the motherese and normal adult speech registers was greatly enhanced, at least to the adult ear. The F_0-contours derived from adult speech sounded like low, continuous murmurs, whereas the motherese F_0-contours sounded more like highly distinctive musical glissandi. Because the infant-directed pitch contours were both higher in mean-F_0 and wider in F_0-range than the adult-directed contours, either or both of these F_0-characteristics could be influencing the infant listening preference. Several arguments for the relative contribution of F_0-level and F_0-modulation to the enhanced perceptual salience of motherese prosodic contours will be considered in the General Discussion.

Another perceptual phenomenon related to frequency, subjective loudness, should be considered here. Psychoacoustic research with adults shows that listeners perceive a pure tone signal at 500 Hz to be louder than a signal at 200 Hz, when intensity levels are held constant (Robinson & Dadson, 1956). Since infant-directed speech is higher in mean-F_0 than adult-directed speech, infants might perceive motherese as subjectively louder. In an effort to balance the subjective loudness of the two sets of natural speech stimuli used in the Fernald (1985) study, intensity levels were determined by asking adult subjects to make loudness-matching judgments. Even with this adjustment, infants chose more often to listen to motherese speech, suggesting that greater subjective loudness was not responsible for the preference. In any case, extrapolation from adult judgments to infant sensitivity must be regarded as speculative, since it is not known if infant equal-loudness functions are similar to those of adults. For this reason, and because of the parametric nature of the present experiments, it was decided to present all auditory signals at a constant level of intensity. Further research is necessary to investigate the contribution of subjective loudness to the enhanced salience of infant-directed speech.

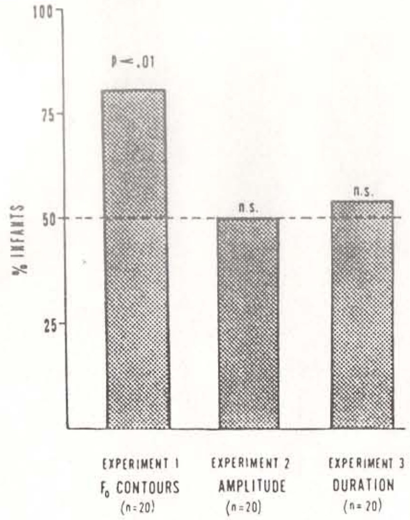

Figure 3. Percentage of infants turning more often in the direction of synthesized signals derived from infant-directed speech than in the direction of synthesized signals derived from adult-directed speech.

EXPERIMENT 2

The patterns of amplitude modulation, as well as frequency modulation, differ in infant-directed and adult-directed speech, although there appear to be no studies that have examined both parameters in motherese. The amplitude envelopes associated with normal adult speech are presumably more complex and variable than those associated with motherese, if only because the segmental density is greater in adult-directed speech (Fernald & Simon, 1984), and amplitude fluctuations tend to accompany segmental variation. The hypothesis tested in Experiment 2 was that infants would prefer the patterns of amplitude modulation of motherese to those of adult conversation. The auditory reinforcers used in this experiment consisted of four pairs of synthesized signals, derived from the amplitude characteristics of the natural speech samples of infant-directed and adult-directed speech samples used by Fernald (1985) with frequency held constant for each pair. As in Experiment 1, these signals did not isolate a sole prosodic variable, since the temporal structure of the original speech samples was again preserved. These synthesized signals thus reflected both the amplitude and duration characteristics of the natural speech samples.

Method

Subjects. Twenty 4-month-old infants (M age = 121.5 days ±5), 10 males and 10 females, participated as subjects in this experiment. An additional 18

infants (M age = 120.3 days ±4), 10 males and 8 females, were tested, but were excluded because of fussiness (12), equipment failure (4), and experimenter error (2). All subjects were full-term infants with no history of hearing disorder or ear infection.

Stimuli. The auditory reinforcers used in this experiment were synthesized as amplitude-modulated sine waves on the PDP 11/34 computer, using the amplitude values obtained by the acoustic analysis procedure described for Experiment 1. An amplitude value was specified in decibels every 2 ms with frequency held constant for each pair of infant-directed and adult-directed speech samples. The frequency value for each pair was determined by averaging the F_0-values across the two speech samples for each of the four talkers. For example, one woman spoke with a mean-F_0 of 230 Hz in her adult-directed speech sample, and 366 Hz in her infant-directed speech sample, with an average of 298 Hz. Thus, the amplitude-modulated sine waves derived from this particular pair of natural speech samples were all synthesized at a constant frequency of 298 Hz (see Figure 2).

Design, Apparatus and Procedure. The design for Experiment 2 was identical to that in Experiment 1. Experiment 2 used the same apparatus and procedure described for Experiment 1.

Results and Discussion

In Experiment 2, infants showed no reliable preference for the signals derived from the amplitude and duration characteristics of either motherese or adult-directed speech. A t-test comparing the mean number of head-turns in the direction of the motherese signals (M=8.15) with the expected chance performance mean (M=7.50) revealed no significant difference between the means. Ten of the 20 subjects turned more often towards the amplitude-modulated signals derived from motherese, consistent with chance.

A 2×2 analysis of variance revealed no significant main effects for side of presentation of the motherese signals, $F(1, 16) = .99$, $p > .25$, or training order, $F(1, 16) = 2.66$, $p > .10$. The interaction between the two factors was not significant, $F(1, 16) = .62$, $p > .25$.

The results of Experiment 2 suggest that the amplitude characteristics of infant-directed speech are not sufficient to elicit an infant preference for motherese. However, rejection of this hypothesis on the basis of these findings alone would be premature for at least two reasons. First, the full dynamic range typically used by mothers interacting with infants was not adequately represented here. Whispering, for example, did not occur in the speech samples used in this study, although Fernald and Simon (1984) found that whispering was very common in mothers' speech to newborns, used both playfully and in soothing the infant. A second limitation on the generalizability of these findings is that, although the amplitude-modulated signals derived from each natural speech sample accurately reflected the patterning of amplitude modulation within a given dynamic range, information about the absolute limits of that range was unfortunately lost. Each stage in the process of tape recording, dubbing, and digitizing required a gain adjustment on the input amplifier in order to utilize the full dynamic range of the device and achieve maximum amplitude resolution. Thus the speech samples were all effectively normalized to a 0–68 dB range. This procedure undoubtedly reduced the amount of contrast between the dynamic range characteristics of natural infant-directed and adult-directed speech. While it seems unlikely that the patterns of amplitude modulation typical of motherese are as distinctive as the patterns of F_0-modulation, they do differ from those of normal adult speech, and this difference was probably very conservatively represented in this experiment.

EXPERIMENT 3

The synthesized signals used in the two previous experiments preserved the temporal order of the natural speech samples from which they were derived. Thus in Experiment 1, duration was confounded with frequency, and in Experiment 2, duration was confounded with amplitude, as independent variables. Obviously, the modulation of both frequency and amplitude must occur over time, so that some form of temporal pattern is essential. Since temporal patterning could not be eliminated, it was decided to retain the original signal durations, rather than to alter them, in order to keep the synthesized signals in Experiments 1 and 2 as "natural" as possible. In order to dissociate duration from frequency and amplitude modulation, the durational characteristics of the infant-directed and adult-directed speech samples used by Fernald (1985) were presented separately in Experiment 3, with frequency and amplitude held constant. Given the negative results of Experiment 2, however, it was not predicted that infants would demonstrate a listening preference for the signals derived from the duration characteristics of motherese.

Method

Subjects. Twenty 4-month-old infants (M age = 125 days ± 3), 10 males and 10 females, participated as subjects in this experiment. An additional 7 infants (M age = 122.2 days ± 4), 3 males and 4 females, were also tested but were excluded because of fussiness (6) or experimenter error (1). All subjects were full-term infants with no history of hearing disorder or ear infection.

Stimuli. The auditory reinforcers used in Experiment 3 were synthesized on the PDP 11/34 computer using the signal duration values obtained by the acoustic analysis procedure described in Experiment 1. The amplitude of the signals synthesized for use in this experiment was held constant at 68 dB, with a rise- and fall-time of 40 ms at signal onset and offset. Each of the four pairs of signals was synthesized at a constant frequency, with the frequency value for each pair determined as in Experiment 2 (see Figure 2).

Design, Apparatus and Procedure. The design for this experiment was identical to that in Experiment 1. Experiment 3 used the same apparatus and procedure described for Experiment 1.

Results and Discussion

In Experiment 3, infants showed no preference for the signals derived from the duration characteristics of either motherese or adult-directed speech. A t-test comparing the mean number of head turns in the direction of the motherese signals ($M = 7.80$) with the expected chance-performance mean ($M = 7.50$) revealed no significant differences between the means. Twelve of the 20 subjects turned more often towards the signals derived from motherese, consistent with chance.

A 2×2 analysis of variance revealed no significant main effects for side of presentation, $F(1, 16) = 4.44$, $p > .05$, or training order, $F(1, 16) = .66$, $p > .25$. The interaction between the two factors was not significant, $F(1, 16) = .003$, $p > .25$.

The results of Experiment 3 show that the isolated temporal patterns of infant-directed speech are not sufficient to elicit an infant listening preference. The relatively low salience of speech rhythm found here should, however, be interpreted with caution. First, the distinctive temporal patterns of motherese were integral to the F_0-modulated signals used as auditory reinforcers in Experiment 1. The possibility that these typical speech rhythms are necessary, although not sufficient, to elicit the infant auditory preference for motherese needs to be addressed by further research. And second, natural observations of adults' playful interactions with young infants suggest that temporal patterning is indeed an important dynamic component in infant-directed speech, especially in ritualized games (see Stern, 1974). The motherese vocalizations used to derive the stimuli for this study did not include games and represent only a small sample of the potential rhythmic variation commonly used in speech to infants.

GENERAL DISCUSSION

These experiments used synthesized auditory stimuli devoid of linguistic content to focus on three prosodic characteristics of infant-directed and adult-directed speech: fundamental frequency modulation, amplitude modulation, and duration. We found that 4-month-old infants showed a strong listening preference for the F_0-patterns of motherese speech but not for the amplitude or duration patterns of motherese. These results suggest that the fundamental frequency characteristics of infant-directed speech are highly salient to the infant and may account for the listening preference for motherese shown in the Fernald (1985) study, in which natural speech samples were used as auditory reinforcers.

The finding that F_0-contours derived from motherese speech are sufficient to elicit an auditory preference in infants suggests that it is the widely reported "higher pitch" of mothers' speech (e.g., Ferguson, 1964) that is especially attractive to infants. However, the "higher pitch" commonly attributed to infant-directed speech usually refers to several different features of motherese intonation, including higher mean-F_0, wider F_0-excursions, and expanded F_0-range (see Fernald & Simon, 1984). While these F_0-characteristics of motherese do tend to co-occur in motherese, they are independent and could have distinct perceptual consequences for the infant. For this reason, it is important to differentiate between the possible contributions of pitch level and pitch movement to the heightened salience of motherese prosody.

It could be that high mean-F_0 per se accounts for the infant preference for motherese. Perhaps the greater auditory sensitivity of infants to pure tones in the region of 500 Hz than to tones in the region of 100 Hz (Schneider, Trehub, & Bull, 1979; Sinnot, Pisoni, & Aslin, 1983) is somehow related to their listening preference. However, the hypothesis that higher absolute pitch level is the most salient feature of motherese speech would lead to certain predictions that do not find support in the literature. One prediction is that infants should prefer women's to men's speech because of the higher mean-F_0 of the female voice. The few existing studies on infant selective responsiveness to male versus female speech do not suggest that women's voices are intrinsically more reinforcing to infants than men's voices (Bankiotes, Montgomery, & Bankiotes, 1972; Brown, 1979; Wolff, 1963). A second prediction is that speech spoken in a high-pitched monotone, higher in absolute F_0 than motherese speech but narrower in F_0-range, should be even more attractive to infants than typical infant-directed speech. However, it seems likely that infants would habituate more rapidly to a high-pitched monotone signal than to the richly modulated F_0-contours characteristic of motherese. Although no experimental research has investigated this possibility, there is substantial observational evidence indicating that experienced parents in many different cultures use exaggerated F_0-modulation rather than a high, narrow F_0-range, in their speech to infants (Fernald et al., 1986).

It therefore seems more plausible that it is the increase in F_0-modulation within an expanded range, rather than the higher absolute F_0-level, that makes motherese speech more interesting to infants than adult-directed speech. The pitch excursions of infant-directed speech provide the young infant with a dynamic form of auditory stimulation that is high in both perceptual contrast and perceptual coherence (see Fernald, 1984). The acoustic dimensions influencing infant auditory preferences have received very little attention (see Aslin, Pisoni, & Jusczyk, 1983) when compared with research on infant visual preferences (see Banks & Salapatek, 1983). However, in the auditory as well as the visual domain, infants are in general less responsive to static, monotonous forms of stimulation than to stimuli characterized by contrast and change (e.g., Eisenberg, 1976). Recent neurally-based theories of the development of visual perception (Haith, 1980; Karmel & Maisel, 1975), which argue that infant scanning is innately organized to maximize cortical firing, may have relevance to audition as well. Haith proposes that scanning visual stimuli which are high in contrast and contour density enhances neural activation in the newborn visual system. Although looking and listening are different in fundamental ways, neural activation in the infant auditory system may be maximized by the exaggerated frequency sweeps typical of infant-directed speech.

The distinctive F_0-contours of motherese may be attractive to infants not only because of their greater perceptual salience, but also because they communicate positive affect. Although the relation of specific patterns of fundamental frequency to the vocal expression of discrete emotions is not straightforward (see Scherer, 1986), there is substantial evidence for the association of high-F_0 and wide F_0-range with a high degree of emotional activation. It seems likely that the vitality and positive emotional tone of maternal vocalizations so frequently observed in studies of early mother–infant interaction (e.g., Papousek & Papousek, 1981; Stern, 1974) are to some extent mediated and amplified by the exaggerated F_0-modulation typical of infant-directed speech. The initial appeal of motherese may lie in its affective expressive power, especially in the early months before adult speech has become linguistically meaningful to the infant.

The results of this study suggest that it is the fundamental frequency characteristics of infant-directed speech that account for the infant listening preference for motherese. In interpreting these findings, however, it is important to keep the limitations of parametric research in mind. Although a parametric approach can shed light on the contribution of isolable prosodic features to the salience of motherese speech to the infant, the infant obviously never encounters these prosodic features in isolation under normal circumstances. In natural speech to infants, the exaggerated modulation of fundamental frequency inevitably covaries with distinctive patterns of intensity and rhythm. Furthermore, mothers typically coordinate facial expressions and other gestures with their vocalizations in affective interactions with infants (e.g., Stern, 1974, 1985). While exaggerated pitch may be a particularly compelling acoustic characteristic of motherese speech, its effectiveness is undoubtedly enhanced by the dynamic configuration of vocal and visual behaviors within which it naturally occurs.

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