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Changes in the quality of infant sounds as a function of social and nonsocial stimulation*

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ABSTRACT

The vocalizations of eight infants were recorded longitudinally in relation to different social and nonsocial contexts. The infants were observed bi-weekly from 3 to 25 weeks. At each visit they were presented with their mother, a female stranger and a doll, who were alternately active and passive. The results showed that by 7 weeks the infant vocalizations could be categorized from the social perception of adults into relatively long sounds containing variable pitch contours (melodic); short, nasal-like sounds containing uniform pitch (vocalic); and sounds such as crying, laughing and fussing (emotional). The infants modulated these sounds depending on the context. They produced significantly more melodic sounds when the women conversed with them than in any other context, and significantly more vocalic sounds when the adults were unresponsive. Overall the emotional sounds were produced significantly more to people than to objects. The results indicated that the various sounds served different purposes for the infants since they were used differentially in the social and nonsocial contexts.

By two months of age, infants have a variety of vocalizations in their repertoire (Oller 1981, Stark 1978). Until recently, these vocalizations were thought to be produced at random (Jacobson 1972), or evoked by different endogenous stimuli (Ostwald & Peltzman 1974, Rosenhouse

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1977, Stark 1978, Stark, Rose & McLagen 1975). Present evidence suggests that the infants have some control over their vocal productions since they are able to vocalize selectively (Bloom, Russell & Wassenberg 1987, Delack & Fowlow 1978, D'Odorico 1984, Oller 1981, M. Papousek 1989, M. Papousek & Papousek 1989).

For instance, Delack & Fowlow (1978) demonstrated by spectrographic analyses that when young infants are facing people and objects some of the supra-segmental features of their vocalizations change consistently in relation to the social or nonsocial context. In another objectively analysed study, D'Odorico (1984) found that, within the social context alone, the vocal sounds of 4-to-6-month-old infants could be classifed into at least three different sound patterns. Request sounds were characterized by uniform as well as rising pitch contours that tended to occur when the baby was alone and would cease when mother returned. Call sounds had a higher percentage of falling contours and included infant cries that were found to occur when mothers were leaving their infants. Discomfort sounds were characterized by uniform and falling pitch contours and were produced when the infants became irritated by either the social or nonsocial object conditions.

The finding that such young infants are capable of modifying their vocalizations to suit physical and social settings is contrary to theories of cognitive development proposing that at least during the first half of the year the infant's responses are reflexive rather than accomodative to external stimuli (Piaget 1952). They confirm research suggesting that early infant behaviours are a manifestation of 'an active intelligent approach to vocalization' (Oller, 1981: 87). For instance, 3-to-4-month old infants are capable of switching from cooing to pure vowels under the influence of selective imitation (Kuhl & Meltzoff 1988, Legerstee 1990), and 3- to 6-month-old infants will reproduce high-pitched and low-pitched vowels when stimulated alternately by a tone or a human model producing these sounds (Kessen, Levine & Wendrich 1979).

To evaluate the adaptive significance of the quality of infant sounds during natural interactions, it becomes important to ask how listeners perceive these vocalizations. Although ancedotal reports (e.g. Tonkova-Yampol'skaya 1978) suggest that the audible intonational nuances of the various sound combinations in speech of three-month-old infants are readily noted by parents and nursery attendants, few studies have been reported examining the changing quality of infant sounds from a social-perceptual perspective in a systematic fashion. Instead, researchers have parents and coders categorize the vocalizations of young infants as belonging to positive or negative hedonic states (Keller & Scholmerich 1987). Relying on parental judgements to determine the meaningfulness of early infant

vocalizations induces a bias in the decision-making process (Crystal 1979, Furrow, Podrouzek & Moore 1990, Papousek 1989). Caretakers respond primarily on the basis of the infants' overall state (Fogel & Hannan 1985, Kaye & Fogel 1980). Rather than listening to the infants' changing prosodic pattern to infer meaning, the adults may use the hand, arm and facial expressions to classify the infants' vocalizations (Legerstee, Corter & Kienapple 1990).

There is recent evidence to suggest that adult listeners can reliably infer communicative intent from infant vocalizations in the absence of other behavioural cues. Adults listening to tape-recordings of three-month-old babies found that when infants were facing people who responded contingently to the babies' sounds, the ratio of 'speechlike' vocalizations (relatively long vocal responses containing varied pitch contours) increased. When the infants were presented with people who spoke at random, the speechlike vocalizations decreased and non-speechlike vocalizations (short, nasal-like sounds, containing uniform pitch) predominated (Bloom, Russell & Wassenberg 1987). Thus when adults conversed with the infants they not only experienced more vocal output, but a changing 'acoustic topography in a manner that had relevance for early communication' (Bloom *et al.* 1987: 213).

The categorization of infant sounds solely from the social perceptions of adults is an important step in clarifying the social significance of differential vocalizations in early infancy. Although objective analyses of infant vocalizations have provided invaluable information about the acoustic and phonetic properties of infant sounds, it is the caretakers' perception of these vocalizations as revealing communicative intent that ultimately has developmental implications. The development of communication is a guided process. Words evolve out of the infants' sensorimotor experiences, in particular those interactions that are supported by adults (Bruner 1983, Lock 1980), and that involve reciprocal vocalizing (Bloom *et al.* 1987, Delack & Fowlow 1978). If parents and caretakers perceive the infant vocalizations as 'speechlike' (Oller 1981), rather than as random vocalizations, then they may treat their infants as 'partners' in social interactions and thereby promote linguistic development (Bruner 1983, Legerstee & Bowman 1989, Newson 1979).

Taken together, the above studies provide grounds for hypothesizing that prior to the onset of language, infants vary the quality of their vocal sounds to express communicative intent. These vocalizations are readily identifiable with the use of instrumentation (Delack & Fowlow 1978, D'Odorico 1984, Fernald, Taschner, Dunn, Papousek & de Boysson-Bardies 1989). Only recently has research indicated that the infant vocalizations can be perceived socially. Given the importance of parental understanding of their infants'

communicative bids for the development of more appropriate vocal behaviour the social perception of infants' vocal sounds needs further investigation.

The purpose of the present study was twofold. Firstly, it wished to determine whether the infant vocalizations could be categorized solely from the social perceptions of adults into short nasal-like sounds containing uniform pitch contours (vocalic sounds or 'non-speechlike'), and relatively longer units of sounds, having oral resonance and variable pitch contours (melodic or 'speechlike sounds'). Since the usage of sounds, independent of their phonetic speech parameter (e.g. pitch, resonance, etc.), is also relevant for the development of speech (cf. Oller 1981), cries, laughs and fusses were also coded under the category 'emotional sounds'.

Secondly, the study wanted to add to current knowledge of infants' use of supra-segmental features by examining whether infants were able to use these features selectively. Accordingly, the infants were presented alternatively with communicative adults, and a graspable doll that moved and sounded when they looked at it. Making the nonsocial stimulus move contingently is a necessary control since adults communicating with infants naturally respond in a contingent fashion to the eye contact of their infants (Legerstee, Kienapple & Walsh 1989, Watson 1972). Similarly, since a noncontingent social stimulus seems to elicit particular vocalizations in babies (Bloom *et al.* 1987), the infants were presented with conditions in which the adults remained unresponsive and with a noncontingent (passive) doll.

By studying the infants under these conditions, we may, in addition to providing a developmental description of the infants' vocalizations, be able to trace the development of these sounds in relation to the adult's vocalizations, as well as in the context of objects. Apart for the Delack & Fowlow (1978) study which analysed the infants' vocalizations in objective terms, no such studies have been conducted of the infants' vocal behaviour using this experimental paradigm, despite the importance such research would have in relation to the development of language and speech from a communicative-cognitive point of view (cf. Delack 1976, D'Odorico 1984, Dore 1975, Halliday 1975).

METHOD

Subjects

Eight infants (5 boys and 3 girls) and their mothers, participated in this longitudinal study. Seven babies were 3 weeks old at the beginning of the study, and one girl was 7 weeks old. All infants participated until they were 25 weeks old. They were healthy, full-term babies, with high Apgar ratings,

and weighed approximately 3060g at birth. They were from middle-income French-Canadian families. The mothers, who were all in their mid-twenties (range = 24–27), were contacted at the maternity hospital and were informed of the nature of the filming sessions and the duration of the study. They were originally recruited as part of a longitudinal study of interactions between babies and their mothers, strangers and objects during the first year of life (Legerstee, Pomerleau, Malcuit & Feider 1987). They were seen bi-weekly until six months of age and monthly thereafter. Only tapes of the first six months were used since they comprised the full sample of eight infants, whereas the group in the last six months of the year was comprised of only five infants.

Apparatus

The infants were videotaped in a laboratory setting resembling an infant's room. Infants were placed in a specially constructed infant seat, which comfortably supported their head and trunk, and permitted free movement of arms and legs. Minimal physical restrictions seemed most conducive to infant vocalizations (Lewis & Freedle 1973). The seat was tilted at a 45° angle, to promote easy interaction with the stimuli. Sessions were filmed using two video cameras that were positioned out of the infants' line of vision, and 1.8m from the subjects. Using these cameras and a split-screen generator, the infants' and adults' behaviours were simultaneously recorded on to videotape. A date-time generator recorded the date and duration of each session.

Procedure

The infants were filmed bi-weekly when they were content and alert. In the social condition, the women sat in front of the infant at no more than a 50cm distance. In the *active* condition they were asked to talk to their infants as they normally do but not to touch the babies. In the *passive* condition they were asked to remain silent, to keep a 'friendly' face, and again not to touch the baby. In the nonsocial conditions, a doll was suspended in front of the baby at a reachable distance (not more than 50cm). This toy, a 40cm long, stuffed doll with a smiling face and big black eyes, had been chosen because it had on previous occasions attracted sustained attention in very young infants. In the active condition, the experimenter made the doll, which had bells attached, dance and sound each time the infant looked at it. In the passive condition the doll remained immobile.

Since the attention span of very young infants is short, each of the six conditions lasted 45 seconds during the 3, 5 and 7 week periods and 60 seconds thereafter. The conditions were presented at random order to

control for effect of presentation. If infants became distressed during the sessions they were comforted until they were again in an alert and content state (State 4; Wolff 1966). Due to experimental error, fatigue, or persistent crying, not all sessions were completed for some babies. The amount of missed stimulus presentations represents 14% of the total number of presentations for all infants.

Analysis of vocalizations

The vocal categories were developed from the studies by Bloom *et al.* (1987), Keller & Scholmerich (1987) and Tonkova-Yampol'skaya (1978). The techniques of these studies had been used since they had allowed a categorization of the various infants' sounds from the social perceptions of adults, and had indicated a link between communicative context and prosodic features during the first six months of life. The vocal categories were: (1) *melodic sounds*; these sounds contained varied pitch contours, were produced relaxed and in relatively long units (longer than ½ sec.), were syllable-like, often called cooing or babbling, and contained oral resonance; (2) *vocalic sounds*; the vocalizations were produced somewhat forced or with effort, they were relatively short (approx ½ sec), and were often series of vowel-like sounds, somewhat nasal with uniform pitch; and (3) *emotional sounds*, such as laughing, crying and fussing. Each discrete measure of occurrence was separated from another by a noticeable pause (0.3 sec. or longer, e.g. Stern, Spieker, Barnett, & MacKain 1984). Physiological sounds, such as sneezes, hiccups, coughs, grunts etc. were not included in the anlyses.

Transcription of videotapes

The audio-videotapes were coded by a phonetically-trained coder. Only the audio portion of the tape was played so that she would not be influenced by the affective facial expressions of the participants. Although the coder was able to hear the mother and stranger talk and the object sound during the active conditions, she was naïve to the nature of the experimental hypothesis, and it was therefore unlikely that she would influence the results of this study in one way or another. To prevent the coder from being influenced by the names of the vocal definitions (e.g. melodic, or 'speechlike'), the sounds were identified by the metaphonological characteristics (e.g., pitch, durations, resonance pattern), that identified the sounds as 'melodic' or 'speechlike' and as 'vocalic or non-speechlike'. The common components which were responsible for the adults distinction of 'melodic', 'vocalic and 'emotional' sounds were then given names of the letters of the alphabet (e.g., a, b, and c).

Whenever an infant vocalization occurred, it was classified according to

the features of each sound category listed above by the coder who was trained by a phonetician to recognize the particular sounds from 20% of the infant tapes at the various ages studied. Inter-observer reliability using Pearson's correlation coefficients was 0.97 for emotional sounds, 0.91 for vocalic sounds, 0.89 for melodic sounds and 0.86 for the total number of vocalizations. The coder's intra-rater reliability at the beginning of the study and after 50% of the data had been coded was between 0.86 and 0.92. These measures indicated that our coding scheme could be applied reliably.

RESULTS

In order to account for the varying durations of the sessions, the total frequencies of the responses emitted during the 3, 5 and 7 week periods were divided by the length of the session to give a proportion which was multiplied by 60 to obtain rate per minute. These adjusted frequencies were used in the subsequent analyses. To determine whether the type of vocalization was affected by the social and nonsocial contexts, the three infant behaviours – melodic, vocalic and emotional sounds – were submitted to randomized block ANOVAs with two within-subject variables (weeks and trials). Post-hoc group comparisons were conducted using Tukey's procedure (alpha = < 0.05). Table 1 presents the means for each vocal category.

Melodic Sounds. The ANOVA indicated a main effect for Age $F(11,77) = 6.75$, $p < 0.000$. Tukey's tests showed that the infants produced significantly more melodic vocalizations at 7, 9, 11, 13, 15, 17, 19 and 21 weeks than at 3, 5, 23 and 25 weeks. More importantly, there was also a significant main effect for Condition $F(5,35) = 21.10$, $p < 0.000$. Subsequent group comparisons indicated that infants produced significantly more melodic vocalizations to the active mother (am) condition than to all other conditions. Vocalizations decreased significantly in the following order: the active stranger (as) condition produced more melodic vocalizations than the passive mother (pm) and passive stranger (ps), which differed significantly from the two object conditions [active (ao) and passive (po)] which did not differ from each other (see Fig. 1).

The Age x Condition interaction was also significant $F(55,385) = 5,02$, $p < 0.001$). The Condition effects described previously were larger at 7, 9, 11, 13, 15, 17, 19 and 21 weeks and smaller at 3, 5, 23 and 25 weeks.

Although there was great variation in the overall amount of melodic sounds produced by each infant, as can be seen in Fig. 2, there were few individual differences in the way the melodic sounds were used to differentiate between the various conditions.

TABLE 1. *Mean frequencies of (a) melodic sounds, (b) vocalic sounds, and (c) emotional sounds*

	Weeks	active mother	passive mother	active stranger	passive stranger	active object	passive object
a)	3	1.06	0.00	0.00	0.00	0.35	0.35
	5	1.06	1.06	0.00	0.00	0.35	0.00
	7	5.84	0.00	2.32	0.46	0.00	1.40
	9	6.06	2.05	3.15	1.18	0.35	0.00
	11	4.70	1.18	1.95	0.75	0.00	0.35
	13	4.59	1.80	6.17	0.74	0.35	0.00
	15	9.11	1.83	2.43	0.92	0.35	0.35
	17	4.09	1.18	3.05	0.35	0.00	0.35
	19	3.05	0.35	2.64	1.35	0.35	0.35
	21	4.53	1.24	0.35	1.06	0.35	0.35
	23	3.74	1.19	0.52	1.19	0.70	0.35
	25	1.85	0.35	1.12	0.46	0.00	0.35
b)	3	1.69	2.18	3.66	1.35	0.70	1.69
	5	2.39	4.89	1.45	1.35	1.06	2.82
	7	2.55	6.32	4.94	4.65	4.86	4.83
	9	3.31	3.70	2.58	4.74	1.51	3.01
	11	1.77	4.43	2.96	4.68	1.06	1.88
	13	1.16	5.12	2.71	2.76	1.38	3.10
	15	2.49	6.46	3.37	4.14	5.77	4.23
	17	1.06	2.42	3.02	1.40	4.91	5.68
	19	1.39	3.38	1.90	5.31	1.50	3.07
	21	2.70	7.00	1.35	8.00	1.12	2.25
	23	1.67	9.71	2.26	7.02	7.62	2.47
	25	0.83	3.16	2.10	3.95	1.92	2.55
c)	3	4.14	4.06	10.15	10.43	1.95	1.60
	5	5.57	3.42	10.40	8.28	1.60	2.41
	7	6.48	2.41	4.15	11.33	3.46	1.18
	9	3.10	4.84	2.05	3.22	1.18	2.64
	11	3.90	7.81	3.13	6.66	3.11	2.50
	13	1.75	12.27	2.91	4.71	4.86	1.35
	15	1.76	4.35	2.00	9.44	1.16	2.13
	17	3.50	10.97	7.20	6.43	1.90	1.38
	19	5.43	8.46	3.46	10.54	0.70	2.82
	21	1.75	7.13	2.13	8.78	1.41	1.99
	23	1.03	2.47	0.74	1.72	1.06	1.06
	25	0.99	5.90	1.80	2.00	1.41	1.76

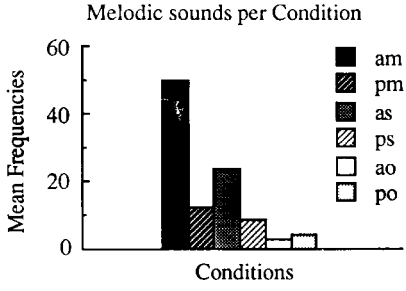

Fig. 1 Melodic sounds per Condition

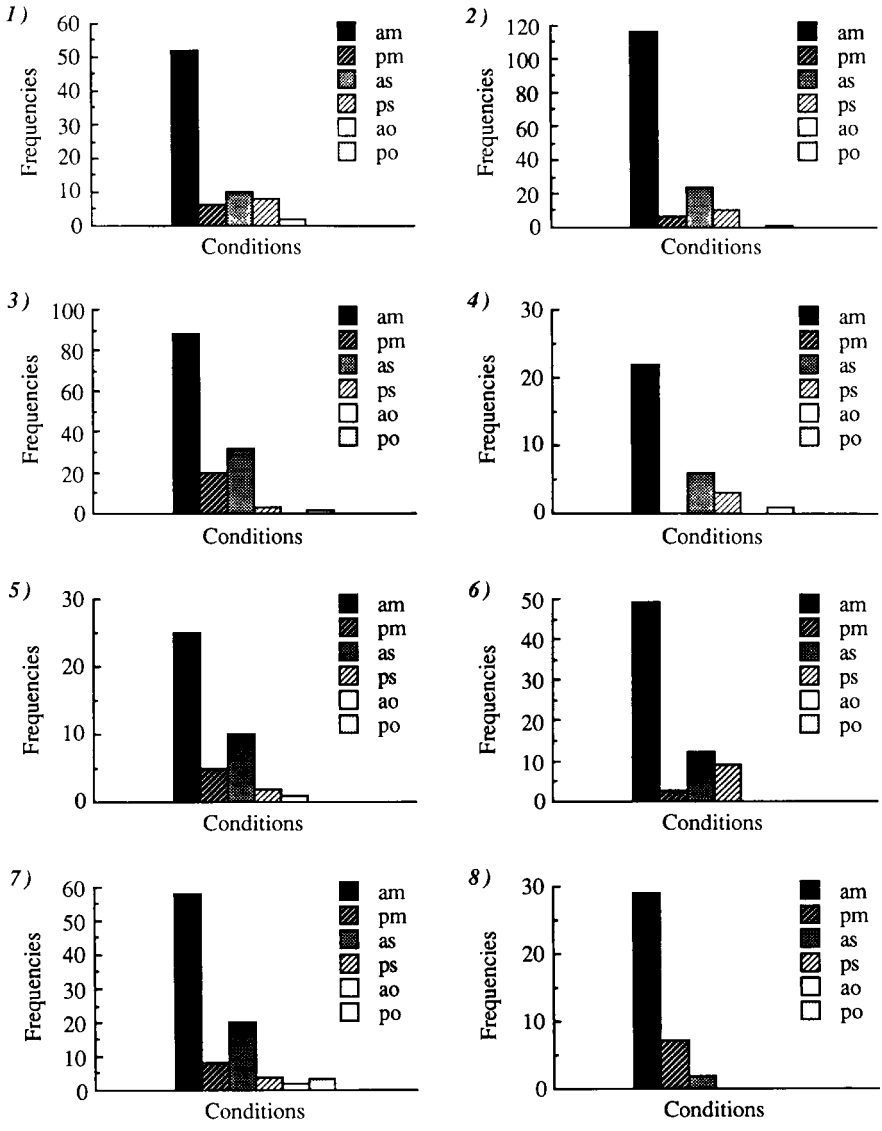

Fig. 2 Melodic sounds per Condition for each infant

Vocalic Sounds. The ANOVA showed a significant main effect for Condition for vocalic sounds F (5,35) = 6.39, p = < 0.000. Subsequent group comparisons suggested that the infants produced significantly more vocalic sounds to the passive mother (pm) and passive stranger (ps) than to all other conditions (see Fig. 3). No other differences were noted.

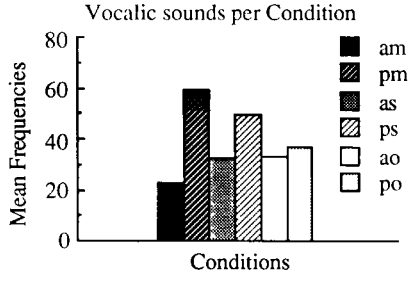

Fig. 3 Vocalic sounds per Condition

Although there were again large differences in the overall amount of vocalic sounds produced by each infant, Fig. 4 indicates that the pattern of responding among the individual infants was similar, except for infant 6, who produced most of the vocalic sounds to the passive mother (pm) only rather than to both passive adults.

Emotional sounds. There was a significant effect for Condition *F (5,35) = 10,96, p* < 0.001. As shown in Fig. 5, and supported by Tukey's tests, the infants produced significantly more cries, fusses and laughter to the passive mother (pm) and passive stranger (ps) conditions than to the active stranger (as) and active mother (am) conditions. The latter three conditions yielded significantly higher mean frequencies of emotional sounds that the objects [active (ao) and passive (po)]. No other significant differences were found.

In summary, by 7 weeks, the infant sounds could be reliably categorized into melodic, vocalic and emotional sounds. These vocalizations served different purposes for the infants since they were used differentially in various social and nonsocial contexts. Melodic sounds were produced more to people than to objects, in particular when people were communicating with the infants. Vocalic sounds were distributed evenly throughout the various conditions, except during the passive mother and stranger conditions when these vocalizations increased significantly. The emotional sounds were also produced more to people than to objects. These sounds increased particularly when the mother and stranger were unresponsive to the infants.

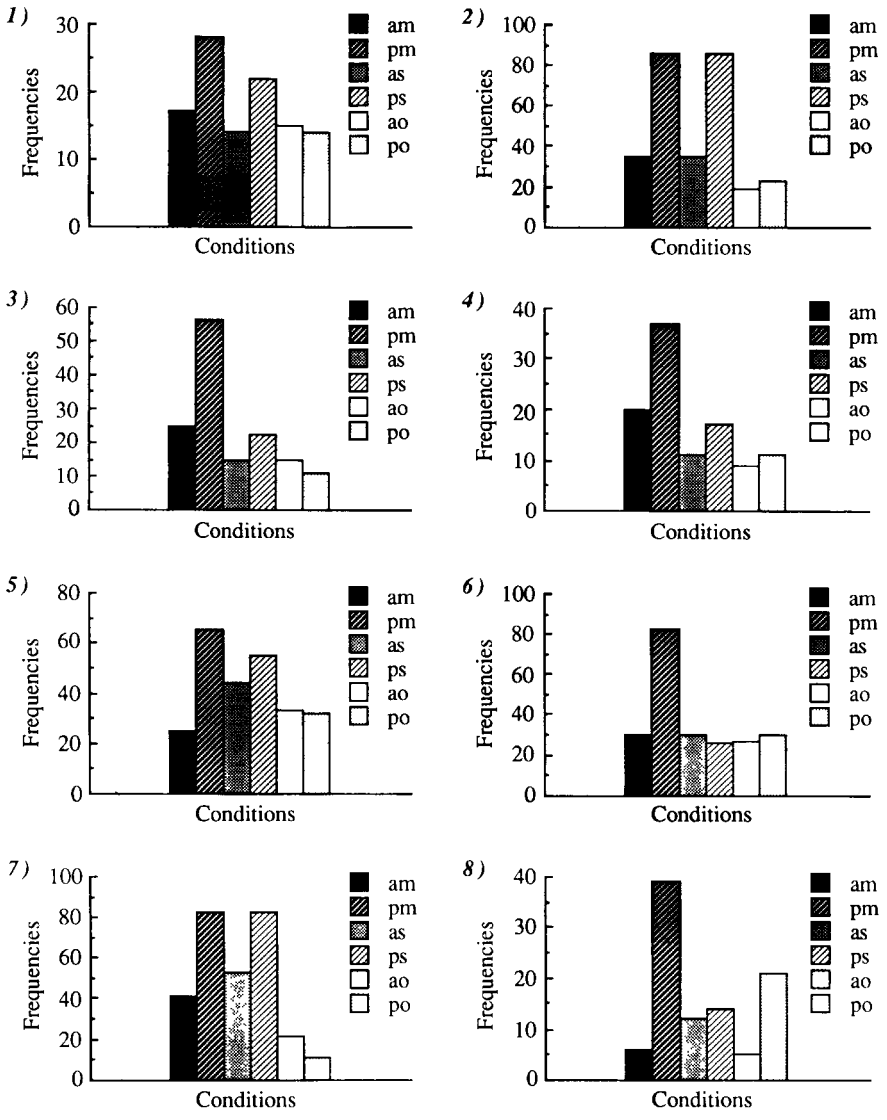

Fig. 4 Vocalic sounds per Condition for each Infant

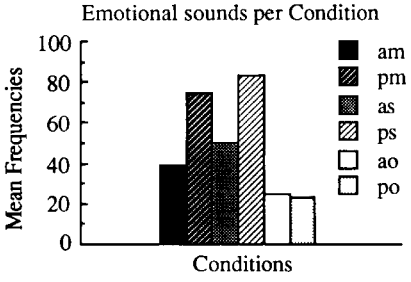

Fig. 5 Emotional sounds per Condition

DISCUSSION

Although generalizations must be limited due to the small sample size, the present study has shown that by two months of age the infant vocalizations can be reliably categorized by listeners into melodic, vocalic and emotional sounds.

This research has further indicated that two-month-old infants modulate the quality of their sound depending on environmental context. This effect is noticed even when no adult interpretation of the selectivity of the infant vocalizations is involved. In this study, selectivity was controlled by context. As suggested earlier, adult judgements are not made independently of prosodic contrastivity. By studying the infants in a variety of contexts, it has become possible to ascertain that a differentiation in the infants' vocal production, going beyond the simple discrimination between positive and negative vocalizations, is possible. The identification of such speech production skills supports the notion that early in development infants are motivated to produce sounds that have phonological relevance for later language (Locke 1989, Oller 1981, Stoel-Gammon 1989).

That infants vocally differentiate social and nonsocial events has been suggested in another longitudinal study with the use of spectrographic analysis (Delack & Fowlow 1978). The findings are consistent with studies indicating differential responsiveness to people and objects in young infants (Field 1979, Klein & Jennings 1979, Legerstee 1991, Legerstee & Bowman 1989, Legerstee *et al.* 1990, Legerstee *et al.* 1987).

A major implication of this research is that adult listeners were able to perceive differences in the quality of infant sounds in the social and nonsocial contexts studied. As suggested earlier, the emergence of communication depends both on developmental changes in the infants'

behaviour and the interpretability of their vocal productions (Nelson 1981). Thus both partners contribute to the effectiveness of the communicative exchange. Support for this contention comes from studies examining the vocal interactions of caretakers and atypical infants. Parents interacting with Down syndrome infants who exhibit less vocal behaviours to facilitate the responses of their partners experience more difficulty in maintaining turn-taking with their atypical infants than caretakers of normal infants (Berger & Cunningham 1983, Velleman, Mangipudi & Locke 1989). Contingent caretaker's responsiveness is one of the means to establish a dialogue-type of communication, in the course of which infant and mother can develop mutual understandings (Newson 1979). The establishment of this early reciprocal-affective phase between infant and caretaker lays the foundation for the subsequent acquisition of more appropriate vocal behaviour (Legerstee & Bowman 1989, Mundy, Sigman, Kasari & Yirmiya 1988).

The melodic sounds were distinguished from other sounds by their varied pitch contour and longer durations. In the literature such qualities are often referred to as the 'speechiness' of infant sounds (Oller 1981) and speech development in children is often thought to begin with the development of intonation (Tonkova-Yampol'skaya 1978). Our data provides support for such interpretations. Although it was difficult to discern audible differences in the vocalizations during the first month of life, by 7 weeks these melodic vocalizations began to be produced primarily in a 'conversational' context. As Fig. 6 shows, when people communicate, the infants reciprocated with 'speechlike' vocalizations. Few melodic sounds were produced to the passive adults.

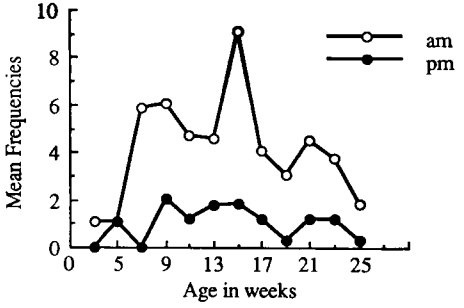

Fig. 6 Melodic sounds to active and passive mother

Whereas adult communication increased melodic sounds in the infants, it decreased vocalic sounds. These short utterances, with uniform pitch increased to the passive people instead. Thus, the unresponsive nature of

the adults changed the quality of the infant sounds. This finding seems to support the results by Bloom *et al.* (1987) indicating that when adults maintained a give-and-take pattern the infants produced a higher ratio of 'speechlike' vocalizations than when they responded in a random fashion to the vocalizations of the infants.

The infants also produced more emotional sounds to people than to objects. Thus as early as two months, babies laugh, cry and fuss more in the presence of people than when confronted with a brightly coloured doll that makes sounds when the infants look at it. Although laughing, crying and fussing may remain phonetically distant from speech, 'it's occurrence in front of people rather than objects has other features in common with speech, it's social responsiveness' (Oller 1981: 21).

GENERAL CONCLUSION

The results of the present study indicated that infants during the first six months of life consistently change the quality of their sounds when in various social and nonsocial contexts. These sounds can be identified by adult listeners by their changing supra-segmental features. Although these changing structures may not have a linguistic sense, the infants appear to use these sounds as purposeful behaviours. The exclusive use of melodic sounds in front of the conversing adults suggest that precanonical infants recognize their ability to have adults repeat their prosodic behaviour by repeating their own vocalizations (cf. Bretherton, McNew, Beeghly-Smith 1981). In contrast, when confronted with the unresponsive person, the infants actively increase short nasal-like, vocalic sounds, without the prosodic contour that gives it its speechlike quality, as if to signal protest (Carpenter, Mastergeorge & Coggins 1983). Both exemplars qualify as expressive behaviour designed to influence other persons, but not quite as intentional communication (e.g. making reference to another person or object within the conversation (Bates, Camaioni & Volterra 1975). Thus, as early as two months the infants use different supra-segmental features to convey different types of messages.

This research indicates that the analysis of non-segmental features is a valuable way of obtaining interesting descriptions of the vocalizations of precanonical infants. The findings further support hypotheses concerning the continuity between prelinguistic and linguistic production put forth by theorists who traced the existence of sound-meaning regularities during these periods (Blake & Fink 1987, Bruner 1983, Delack & Fowlow 1978, Dore 1975). Whereas truly intentional use of sound may not appear until the latter half of the first year when infants become motivated to vocally communicate to another person to achieve a goal, (e.g. Bates 1976,

Harding & Golinkoff 1979), this capacity appears prefigured in the infants prior developing understanding that sound conveys meaning.

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