

## EMOTIONAL INFORMATION IN YOUNG INFANTS' VOCALIZATIONS

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### ABSTRACT

Developmental aspects of four infants' ability to express emotions through vocalizations were studied based on perceptual rating experiments against 9 reference words for 200 voice samples recorded at 2 months of age. Infants even at 2 months of age can produce vocal elements necessary to express emotional contrasts which are identifiable for adult listeners.

### INTRODUCTION

There is a hypothesis proposed that "infants begin to communicate through nonlinguistic aspects of voice rather than linguistic aspects at very early stage of their life"[1]. One way to test this hypothesis is to observe interaction scenes between the infant and the parent and collate the contents of such interaction with the infant's vocalization or expression. Several attempts to explore this field have been made so far[2]. Another way to test the hypothesis is to determine experimentally whether conditions necessary for communicating through nonlinguistic aspects of voice exist at an early stage of the infant's development. We adopted the latter method, defined "emotion" as "information communicated through nonlinguistic aspects of voice" and have conducted several experiments. The object of our study was to confirm some of the following conditions for communication through nonlinguistic aspects; (a) infants can produce vocalizations necessary for communication, (b) the parents as well as surrounding adults can interpret meanings contained in the infant's vocalizations with a certain degree of regularity, and (c) Infants can also interpret meanings contained in the vocalizations of other infants at some stage of their life.

Our previous reports suggested the following: (i) adults listeners can perceive a rich variety of emotional contrasts such as "pleasant vs.

discomfort" even in voices made by infants older than 6 months of age[3]; and (ii) there were significant consistency in adults attributions of infants' vocalizations, although significant differences due to the child-rearing experiences were also observed[4].

The purpose of the present study is to test (1) if 2 months age young infants can express emotions through vocalizations, and (2) if so, what acoustic aspects of voice convey such emotional information.

### METHOD

#### Recording

Totally 200 voice samples were recorded from four Japanese infants (three male, one female), during playing with their mothers at home, on the day when they were just 2 months of age. They were raised in households where standard Japanese was spoken. Through a questionnaire, it was confirmed that the infants showed normal development and behavior. The voice samples were presented in a random order repeating each sample five times.

#### Perceptual Rating

The listeners participated were 15 university students with normal hearing whose mother tongue was Japanese. They rated each voice sample using nine 9-point dipole scales related to emotions, listed in Table 1. Nine relatively independent items (happy, sad, laughing, pleased, frightened, demanding, rejecting, seeking affection, angry) were selected as the basic rating scales through preliminary experiments, and "calm", "surprising", "friendly" and "awful" were included to form dipole scales. Five terms representing the manner of vocalization, such as "speaking", "singing", "crying", "shout" and "secret talk" were added to study the relationships between voicing modes and emotional contents.

The experiments were conducted in a quiet room where voice samples

Table 1. Nine 9-point-rating dipole scales used in Experiment.

Happy	vs.	Sad
Laughing	vs.	Crying
Pleased	vs.	Frightened
Demanding	vs.	Rejecting
Seeking affection	vs.	Angry
Singing	vs.	Speaking
Secret talk	vs.	Shout
Calm	vs.	Surprising
Friendly	vs.	Awful

Happy + - - - - - + Sad  
-4 -3 -2 -1 0 1 2 3 4

Fig. 1. A dipole scale used in perceptual rating.

were presented via a loudspeaker at listeners' most comfortable level.

Obtained rating scores were analyzed by a principal factor analysis and analysis of variance.

#### Acoustic Analysis

Using an acoustic analysis system, ten acoustical parameters were extracted from the voice samples. For 60 voice samples which had a large positive or negative factor score on a factor extracted by the principal factor analysis, an analysis of variance was carried out to extract significant relationships between the acoustic parameters and the perceptual factor scores.

Table II. Acoustic parameters measured.

1:	Total length
2:	No. of segments
3:	Segment type
4:	Segment length
5:	Type of Fo pattern
6:	Initial value of Fo
7:	Final value of Fo
8:	Maximum Fo
9:	Minimum Fo
10:	Fo range

## RESULTS & DISCUSSION

### Perceptual Rating

A principal component analysis was carried out to extract a few essential components from the rating scores on the nine dipole scales. Three principal components were extracted. Their

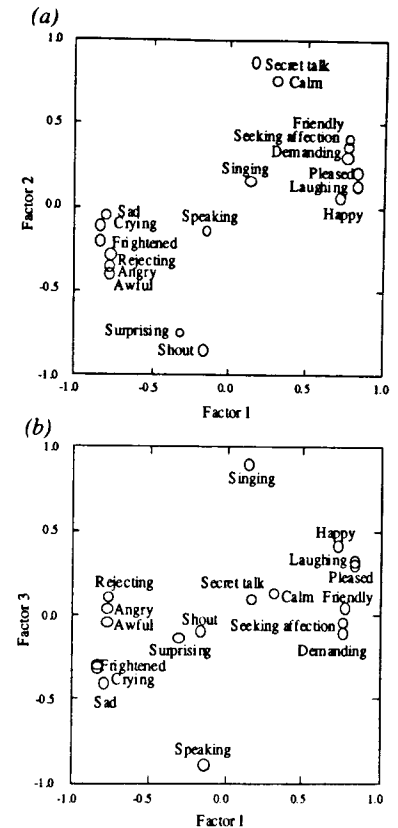


Fig. 2. Factors extracted from the rating scores given by the listeners. (a) Factor 1 vs. 2. (b) Factor 1 vs. 3.

accounting for rates in percentage were 56%, 11% and 8%, adding up to 75% in total.

Factor loading of the rating scales after Varimax orthogonal rotation is shown in Fig. 2. It can be seen that Factor 1 represents emotions relevant to "laughing vs. crying"(0.833), "pleased vs. frightened"(0.833), "happy vs. sad"(0.791), "friendly vs. awful"(0.775), "seeking affection vs. angry"(0.767) and "demanding vs. rejecting"(0.762) and that Factor 2 represents emotions relevant to "secret talk vs. shout"(0.861), "calm vs. surprising" (0.753). Factor 3 represents emotions relevant to "singing vs. speaking"(0.869).

The above results suggest the following; (1) Factor 1 can be

considered as information pertaining to "laughing / pleased / happy / friendly vs. crying / frightened / sad / awful"; "pleasant vs. discomfort" (2) Factor 2 can be considered as information pertaining to "secret talk / calm / vs. shout / surprising"; "calm vs. surprising" (3) Factor 3 can be considered as information pertaining to "singing vs. speaking."

The factor scores were analyzed by an ANOVA to test the significance of individual differences between infants. Differences between infants were significant with respect to all three factor scores ( $p < 0.0001$ ).

Figure 3 (a) shows the 90% confidence area of the factor scores on Factor 1 (F1) vs. Factor 2 (F2) for the four infants of 2 months of age, whereas Fig. 3 (b) the 90% confidence area of the factor scores for the six infants of 6 months of age. The later results were obtained from our previous report.

Although individual differences are observed as predicted by the analysis of variance, the 90% confidence areas of 2 months of age infants are narrower than those of the 6 months of age infants. The 90% confidence areas of the former group are restricted in the area representing emotional contrasts between "pleasant vs. discomfort," while those of the later group expand toward the area representing not only emotional contrasts between "pleasant vs. discomfort" but also "speaking" vs. "singing".

These results suggest that although even 2 months of age infants can produce vocalizations inducing significant infant-dependent differences in emotional contrasts, their ability to express emotional contrasts seems to develop with their age.

#### Acoustic Characteristics

Table III shows the relationships between the acoustic parameters and the perceptual factor scores.

For Factor 1 representing the emotional contrast between "pleasant vs. discomfort," only three acoustic parameters, length, No. of segments, and minimum Fo, had significant differences at 1% level. Voice samples perceived as "discomfort" had a longer length of

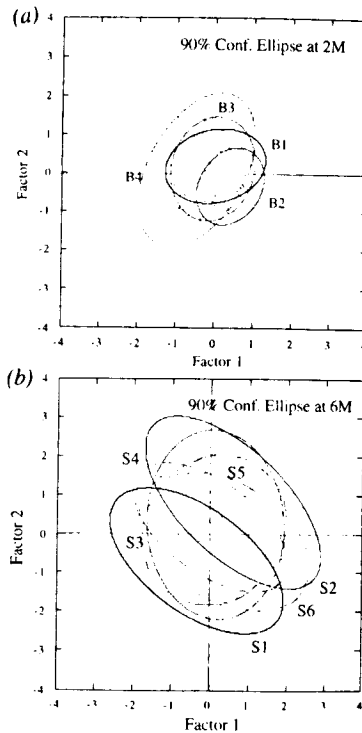


Figure 3. (a) Scatter diagram of the factor scores on F1 and F2 extracted from four 2 months of age infants. (b) Scatter diagram extracted from six 6 months of age infants.

vocalization with a less number of segments, and a lower minimum Fo than the ones perceived as "pleasant".

For Factor 2 representing "calm vs. surprising", two parameters were significant at 1% level and other two at 5% level. The voice samples perceived as "surprising" had a less number of segments with a higher and wider range of Fo than the others. Fo patterns of the "surprising" voice samples were more complex than the others.

Many acoustic parameters correlated with Factor 3 representing "speaking vs. singing." The voice samples perceived as "speaking" had a longer duration with more number of segments, and lower Fo with a narrow Fo range than the others. The voice samples perceived as "speaking" had rising-falling or falling-rising Fo

Table III. Relationships between the acoustic parameters and perceptual factors.

Factor	F1: Pleasant vs. Discomfort		F2: Calm vs. Surprise		F3: Singing vs. Speaking	
	short	long**	short	long	short	long**
Length	short	long**	short	long	short	long**
No. Seg.	many	less*	many	less**	less	many**
Init Fo	high	low	low	high	high	low**
Final Fo	high	low	low	high	high	low**
Max. Fo	high	low	low	high*	high	low**
Min. Fo	high	low**	high	low	high	low**
Fo Range	narrow	wide	narrow	wide*	wide	narrow
Fo Type	∩, -, /, ∖, complex, ∩∩	U	U, -, /, ∖, ∩, ∩∩, complex**	∩, /, ∖, ∩∩, complex	∩, /, ∖, ∩∩, complex	∩, U

patterns, while the ones perceived as "singing" had flat, rising, falling or complex Fo patterns.

These results suggest the following. (1) Infants even at 2 months of age can produce vocal/acoustical elements necessary to express emotional contrasts which are identifiable for adult listeners. These acoustical elements were estimated as Fo range, Fo pattern, minimum and maximum Fo values, vocalization length, and the number of segments. (2) Even 2 months of age infants can produce various voices which induce consistent interpretations or responses in adult listeners about the infants' emotional states. Even if the induced responses or interpretation of the emotional contents might not be the same as the infants' actual emotional state, surrounding people tend to interpret infants' vocalizations in a lawful way. This is important because people may induce infant's notice on the social meanings of his/her own vocalizations.

#### CONCLUSION

Developmental aspects of four infants' ability to express emotions through vocalizations were studied based on perceptual rating experiments against 9 reference words for 200 voice samples recorded at 2 months of age. By a factor analysis for perceptual rating scores, three factors representing emotional contrast of "pleased vs. discomfort", "calm vs. surprising," and "speaking vs. singing" were extracted. Acoustical analyses showed that these factors significantly correlate with the acoustical parameters such as F0 range,

F0 pattern, minimum and maximum F0 values, vocalization length, and the number of segments. These results suggest that infants even at 2 months of age can produce vocal elements necessary to express emotional contrasts which are identifiable for adult listeners.

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