

PREMEANINGFUL VOCALIZATIONS OF HEARING-IMPAIRED AND NORMALLY HEARING SUBJECTS

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ABSTRACT

The present study extends the work of Stoel-Gammon [3] by examining longitudinal samples of nonmeaningful vocalizations from 10 normally hearing subjects, aged 5-18 months, and 11 hearing-impaired subjects, aged 5-39 months. Consonantal phones in the samples were phonetically transcribed and analyzed in terms of proportional occurrence of place and manner classes. Developmental trends within each group were also examined. The results show clear group differences in both place and manner of articulation. The hearing-impaired subjects evidenced a higher proportion of labials, nasals, and syllabic consonants and a lower proportion of alveolars and supraglottal stops. Group differences increased between 8 and 22 months of age.

1. INTRODUCTION

Recent research has identified several differences between the prelinguistic development of normally hearing (NH) and hearing-impaired (HI) infants. In particular, it has been shown that the onset of canonical babbling, which typically occurs before 9 months in the hearing infant, does not occur until 12 months or later in HI subjects [2] and that the phonetic inventories of NH and HI differed in their size (HI inventories were smaller) and composition [3,4].

Stoel-Gammon's detailed comparison [3] of the consonantal inventories of 11 NH and 14 HI subjects showed group differences in both place and manner of articulation of consonantal phones. Specifically, the inventories of the HI subjects contained more continuant phones and more types of labial than alveolar consonants; by

comparison, the NH subjects tended to have more balanced repertoires with nearly equal numbers of labial and alveolar phones. In addition, the inventories of the HI subjects contained a higher proportion of syllabic consonants and a lower proportion of stops than the NH group. Since the study focused exclusively on consonantal inventories (i.e., on consonantal types), it provides only a partial picture of the phonetic characteristics of the prelinguistic vocalizations of the two groups.

The present study extends the work Stoel-Gammon [3] by analyzing the frequency of occurrence of each consonantal phone (i.e., analysis of consonantal tokens) and determining the proportional use of particular place and manner classes.

2. METHODS

The subjects and database for the present study are a subset of those used in the previous study by Stoel-Gammon [3]. Methodological procedures are briefly described in the following sections; for more complete descriptions, particularly of the HI subjects, readers are referred to the previous publication.

2.1 Subjects

The NH group consists of 10 subjects whose prelinguistic development was followed from around 5 months to the onset of meaningful speech, usually around 15-18 months. (These subjects are identified as N1-10 in the previous publication.) None of the NH subjects suffered from recurrent otitis media during the study.

The HI group consists of 11 subjects, aged 5-39 months, with moderate-severe sensorineural hearing loss. (These

subjects are identified as YH 1,2,5,6,7 and OH 1,2,4,5,6,7 in the previous study [3]. Details regarding hearing sensitivity, age at loss, age at identification of loss and amplification are provided in that reference.) The HI subjects varied in age at onset and age at identification of hearing loss; for five subjects, data are available in the 5-18 month age range corresponding to the period of data collection for the NH subjects. The remaining six subjects were 19 months or older at the time of data collection.

2.2 Data collection

Half-hour audio recordings were collected in a sound-treated room during which parents and experimenters used eye contact and vocalizations to stimulate vocal output. To be included for analysis, a sample had to contain at least 10 speechlike utterances with a minimum of 20 consonant tokens. The maximum number of speechlike vocalizations for any one sample was set at 60.

Samples were collected from the NH subjects at approximately 6-10 week intervals. The database for this group contains a total of 44 samples with the number of samples per subject ranging from 3-6. The database for the HI group consists of 28 samples. Longitudinal data are available for eight subjects; data for the remaining three consist of a single recorded sample. 12 of the HI samples are from subjects under 18.4 months and thus overlap with the age range of the hearing group.

2.3 Data Analysis

Speechlike vocalizations of each sample were transcribed by a team of trained transcribers who worked independently and then compared analyses. Transcriptions were not changed unless a transcriber felt he or she was mistaken after relistening to the samples. Comparison of 10% of the transcriptions showed that intertranscriber agreement for place, manner and voicing of consonants exceeded 90%. For the present study, the two transcriptions of each sample were analysed independently to determine the number of occurrences of each consonantal phone and the proportional occurrence of consonants according to traditional place and manner classes. The analysis of place of

articulation was based on four categories: (1) labial, including labiodental; (2) alveolar, including interdental and palatal; (3) velar, including uvular and pharyngeal; and (4) glottal. For manner of articulation, consonants were categorized as one of the following: (1) stop; (2) fricative; (3) affricate; (4) nasal; (5) glide; (6) liquid; and (7) flap or trill. The proportion of syllabic consonants, a category which overlapped with some of the manner categories identified above, was also determined. The percentages for each place and manner category obtained from analysis of the independent transcriptions were averaged to yield a single percentage for each place and manner class for each sample.

3. RESULTS AND DISCUSSION

To provide a general picture of the phonetic characteristics of the vocalizations of subjects in each group, the overall performances of NH and HI subjects were compared. The samples were then grouped by age in order to examine developmental trends within each subject population.

3.1 General comparisons

Previous studies [2,4] suggested that the vocalizations of HI subjects evidence of higher proportion of glottal consonants than those of NH subjects and this was supported by the findings of the present study. Across all samples, the mean proportion of glottals for the NH group was 24.1% (SD 14.8) compared with 36.6% (SD 28.3) for the HI group. As shown by the large standard deviations, there was a good deal of variance across samples; in fact, although the mean percentage for the HI samples was just over 36%, one sample contained no supraglottal tokens.

Although the proportional use of glottals was higher for the HI subjects, differences in place and manner of articulation of supraglottal consonants were of an even greater magnitude. Table 1 presents a comparison of key differences between the two groups in the use of supraglottal consonants. (Percentages in this table are based on an analysis of supraglottal consonants only, and thus represent a subset of the data.)

In terms of place of articulation, the suggestion by Stoel-Gammon [3] that HI

subjects produce relatively more labial consonants and fewer alveolar consonants is borne out by the frequency of occurrence data. In the HI samples, labial consonants accounted for a much higher proportion of the data, nearly 72% of the supraglottal consonants produced; in the NH samples, the mean proportion of labials was 42%. The figures for alveolars show the opposite trend with the proportional use by NH subjects nearly three times as high as for HI subjects (34.4% vs 12.1%). Here again, the standard deviations are quite high; part of the variance can be explained by developmental changes which are discussed below.

TABLE 1. Group comparisons: Mean occurrence of place and manner features as a proportion of supraglottal consonants.

	NH	HI
%Labial (SD)	42.0 (26.5)	71.7 (27.4)
%Alveolar (SD)	34.2 (23.6)	12.1 (15.9)
%Stop (SD)	34.4 (19.3)	14.4 (16.3)
%Nasal (SD)	24.9 (22.8)	50.5 (29.1)
%Syllabic (SD)	22.8 (23.4)	43.2 (28.4)

The comparison of manner features highlights three areas in which the group samples differed markedly: the HI samples contained a much higher proportion of nasal consonants and a much lower proportion of supraglottal stops. In addition, the HI subjects produced proportionally more syllabic consonants, many of which were nasals.

3.2 Developmental comparisons
The second type of group comparison focuses on changes in the proportional use of particular place and manner features as a function of age. NH samples were classified by age as Early (5.0-7.3 months), Mid (8.0-13.6 months) or Late (14.4 - 18.4 months). Table 2 presents a comparison of NH samples grouped by these age periods;

only those place and manner categories which showed a change with age are shown in the table. As in the previous table, the percentages represent the proportional occurrence of features of supraglottal consonants only.

TABLE 2. NH Subjects: Place and manner of supraglottal consonants by age.

age *	Early	Mid	Late
%Lab (SD)	58.9 (27.8)	36.7 (26.6)	32.3 (17.1)
%Alv (SD)	13.9 (14.7)	41.7 (25.2)	46.2 (13.6)
%Stop (SD)	18.0 (15.8)	40.0 (19.4)	43.0 (11.3)
%Syl (SD)	47.3 (24.1)	17.1 (16.1)	6.1 (2.9)

*Early: 5.0-7.3 months (13 samples)
Mid: 8.0-13.6 months (18 samples)
Late: 14.4-18.4 months (13 samples)

It can be seen that each of the features in question shows a linear increase or decrease as a function of age and that, the amount of variance for each feature tended to be highest in the Mid age range. For place of articulation, there is a marked decrease in the proportion of labial consonants and an increase in the proportion of alveolar consonants with age. In both cases, the degree of change between the Early and the Mid age range greatly exceeds the change between the Mid and Late age periods, though the standard deviation declines considerably in the latter period indicating more uniform performance.

For manner of articulation, the mean proportional occurrence of supraglottal stop consonants more than doubles between the Early and Mid age periods, rising from 18% to 40%, and then increasing slightly in the subsequent period to 43%. Here again, the amount of variance declines in the third period. The proportion of syllabic consonants decreases substantially with age, from nearly 50% of all supraglottal consonants in the Early period to about 6% in the Late period.

Table 3 presents a comparison, based on analysis of supraglottal consonants,

of HI samples grouped by three age periods: Early (5.0-12.0 months), Mid (15.0-21.2 months) and Late (22.7-39.4 months). It is evident from the table that the developmental patterns of the HI subjects do not follow the linear trends noted for the NH group; rather, they are better described as U-shaped patterns wherein the samples in the Mid age show a marked increase or decrease in the occurrence of a sound class and the samples in the Late age period show a reversal in the direction of change.

TABLE 3. HI Subjects: Place and manner of supraglottal consonants by age.

age *	Early	Mid	Late
%Lab (SD)	37.2 (20.3)	90.8 (7.6)	74.5 (24.3)
%Alv (SD)	23.8 (24.1)	3.8 (2.5)	12.4 (14.1)
%Stop (SD)	20.9 (11.7)	6.9 (6.9)	17.7 (21.2)
%Syl (SD)	50.0 (12.0)	57.5 (33.7)	29.5 (27.5)

*Early: 5.0-12.0 months (7 samples)
Mid: 15.0-21.2 months (9 samples)
Late: 22.7-39.4 months (12 samples)

The mean proportion of labial consonants, for example, increased sharply between the Early to the Mid age, from a mean of 37.2% to 90.8%; in the Late age period, the mean dropped to 74.5%. A similar pattern is seen in the occurrence of alveolars which decreased from, a mean of 23.8% in the Early period to 3.8% in the Mid period and then increased to 12.4% in the Late period. The proportional occurrence of supraglottal stops and syllabic consonants also showed reversals in their developmental patterns.

Comparison of Tables 2 and 3 reveals that the performance of the two subject groups was most similar in the samples from the youngest subjects and became increasing dissimilar with age, up to 22 months. It is not possible to make direct comparisons of HI and NH subjects over 22 months of age since the nonmeaningful vocalizations of the NH

subjects at this age were not analyzed. It is clear, however, that the U-shaped developmental curves in the HI samples make the productions of the Late period more similar to the NH patterns.

In sum, two major differences between the groups emerge from the analyses. First, the HI subjects produce a higher proportion of labial phones. This difference is most likely due to the fact that labials have a highly salient visual component and thus their articulation can be seen and imitated by babies who have little or no auditory input; alveolar consonants, by comparison, lack this visual component. Second, the HI subjects produce more nasals and syllabic consonants. It was hypothesized earlier [3] that this preference is due to the fact that these consonants provide more tactile and kinesthetic feedback than do stops which are characterized by rapid movements and short durations.

More research is needed, particularly with HI subjects at younger ages, before the hypotheses proposed here can be confirmed. By documenting phonetic patterns in one set of HI subjects, the present study provides a starting point for such research.

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