

THE DEVELOPMENT OF EARLY VOCALIZATIONS OF DEAF AND NORMALLY HEARING INFANTS IN THE FIRST EIGHT MONTHS OF LIFE

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ABSTRACT

To establish how and from which age onwards, speech perception influences the development of vocalizations in the first year of life, we studied the speech production of deaf and normally hearing infants longitudinally from 2.5 months until 7.5 months of age. Several differences between deaf and normally hearing infants were observed indicating that lack of auditory feedback influences speech production already at this early stage of speech development.

INTRODUCTION

Some recent studies suggest a deviant speech production of hearing impaired compared to normally hearing infants in the first year of age [e.g.1]. No canonical babbling was found in deaf infants before the age of eleven months while most hearing infants start babbling before that age [2]. In several studies differences were observed in consonantal features and phonetic repertoire size [e.g.3].

Until now - to our knowledge - no systematic study has been performed on the vocalizations of deaf infants starting within the first half year of life. The present study reports on longitudinal data of 6 deaf and 6 normally hearing infants between 2.5 and 7.5 months of age. The main question we address is: do hearing impaired infants differ from normally hearing infants with respect to number and type of vocalizations?

METHOD

Subjects

Twelve mother-infant pairs participated in this study; six infants profoundly hearing impaired (group HI) and six infants with normal hearing (group NH). All infants have normally hearing parents. By means of developmental tests performed when the infants were 12 and 18 months of age no clear cognitive or motor delays were found. The HI infants had an average hearing loss over 90 dB at the best ear, established by Auditory Brain

-stem Response audiometry (ABR) in the first six months of life. The profound hearing loss was confirmed by several pure-tone audiometric tests at later ages. Hearing aids were used by three subjects within the studied period. Two hearing impaired infants were raised with TC (Total Communication)/Dutch Sign Language, two infants by TC and two mainly by the Oral method.

The NH infants were matched with the HI infants on the following criteria: sex, birth order, duration of pregnancy, mother age, socio-economical status of the parents, and dialect of the parents. All NH infants were recorded from the age of 2.5 months onwards, two HI infants from the age of 2.5 months, two from 3.5 months and three from the age of 5.5 months onwards.

Data collection

Audio recordings, lasting about half an hour each, were made every two weeks. The mothers of the infants themselves made the recordings at home. The mothers were asked to talk with their children in a face-to-face situation while the children were sitting in an upright position.

Procedure of analyses

Of every monthly audio recording, the first 10 minutes were transcribed. Two trained phoneticians performed and verified the transcriptions. The inter-judge agreement based on all material (62 recordings) was 93% for the infant utterances. An infant utterance was defined as a sound production during one breath cycle starting with inspiration. Laughing, crying and vegetative sounds were not taken into account. The number of infant utterances during the first 10 minutes were counted.

Fifty infant utterances per recording were selected evenly out of the transcribed ten minutes. The total of 3100 utterances were digitized into a computer with a sample frequency of 48 kHz and stored for

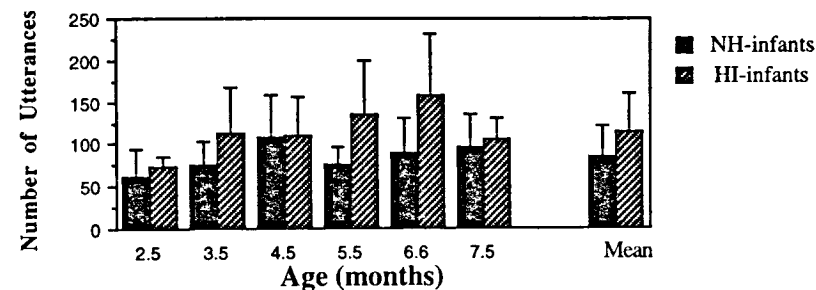


Figure 1. Mean number of utterances and standard deviations during ten minutes of interaction presented for the two groups of infants per month, as well as the mean number for the 6 months combined. (N is 6 in case of the NH infants at each age. N is 2, 3 and 3 at 2.5, 3.5 and 4.5 months resp. and 6 at 5.5, 6.5 and 7.5 months in case of the HI infants.)

further analysis.

Each utterance was classified in one of three possible types of articulation 1) no articulatory movement; 2) one articulatory movement (e.g. gooing); 3) two or more articulatory movements during two or more syllables, i.e. babbling. Furthermore, each utterance was classified according to one of five possible types of phonation: 1) uninterrupted phonation; 2) interrupted phonation 3) variegated phonation (variation in the intonation, pitch or loudness e.g. screaming and growling) 4) a combination of interrupted and variegated phonation 5) no phonation. Types 4 and 5 were rarely found and therefore left out of consideration in this paper. The classification was derived from an earlier study on infant speech development [4].

RESULTS

Number of utterances

Figure 1 represents the mean number of utterances in 10 minutes and their standard

deviations per age as well as the average number over 6 months for both groups.

It can be observed that the mean number of utterances for the combined 6 months is higher in case of the HI infants (115, $sd=45$) compared to the NH infants (85, $sd=37$). A t-test on the data of the combined 6 months indicates a significant difference between the groups ($t(60)=2.95$, $p \leq .005$, one-tailed). By separating the ages in two different age groups (from 2.5 to 4.5 months and from 5.5 to 7.5 months) we can get an indication of a developmental effect. By means of a Mann-Whitney U test no significant differences between the HI and NH infants are found at the early age. At the later age, a Mann-Whitney U test shows that HI infants produce significantly more utterances than their hearing peers ($U(18,18)=79$, $p \leq .005$).

Utterance duration

In figure 2 the mean utterance duration of the 50 selected utterances is presented

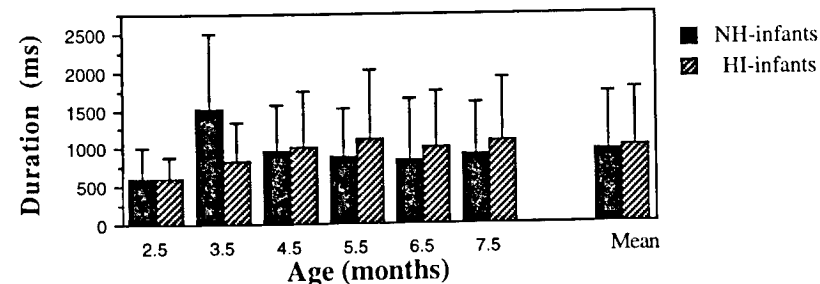


Figure 2. Mean utterance duration and standard deviations of the 50 selected utterances for the HI and the NH group per month, as well as the mean duration for the 6 months combined. (N is 300 at each age of the NH infants. N is 100, 150 and 150 at 2.5, 3.5 and 4.5 months resp. and 300 at 5.5, 6.5 and 7.5 months in case of the HI infants.)

per age, as well as the average duration over the 6 months for both groups. It can be observed that the mean utterance duration for the 6 months combined is somewhat longer for the HI infants (997 ms, $sd=761$) than for the NH infants (948 ms, $sd=761$). A z-test on the months combined shows a low significant difference ($z=1.77$, $p<.05$). A z-test performed on the utterance duration per month indicates that from 5.5 months to 7.5 months the HI infants produce longer utterances (5.5: $z=3.72$, $p<.0005$; 6.5: $z=2.65$, $p<.005$; 7.5: $z=2.63$, $p<.005$). At the age of 2.5 and 4.5 months no significant differences between the two groups are found. At the age of 3.5 months, however, the mean duration of the NH infants is longer than at any other age in the studied period. A z-test indicates that the NH infants produce significantly longer utterances at the age of 3.5 months than the HI infants ($z=9.45$, $p<.0005$).

Type of utterances

In figure 3 the "articulation types" are shown per age for both groups. A tendency can be observed that the HI infants produce fewer utterances with articulation movements than NH infants in the first months although this turned out to be not

significant according to a Mann-Whitney U test, nor in the later age period. Utterances with 2 or more articulation movements are produced more often by NH infants than by HI infants in the later 3 months ($U(18,18)=100.5$, $p<.05$). The total amount of this utterance type in the HI group is due to only one subject who started to babble at 7.5 months of age.

The "phonation types" are presented in figure 4. It can be seen that NH infants produce more interruptions in the airstream specially in the later months ($U(18,18)=85.5$, $p<.01$ for the data at 5.5, 6.5 and 7.5 months combined). Although a tendency for more variegated phonation can be observed by the HI infants, no significant differences are found.

DISCUSSION

In the present study it could be observed that, as a group, the HI infants produced more utterances than their hearing peers in the period between 2.5 and 7.5 months. This was found as well in a previous study on HI and NH infants between 5.5 and 9.5 months of age [5]. These studies support the suggestion of Locke [6] that deaf infants vocalize more than normally hearing infants, possibly due to extra effort HI infants expend to get auditory

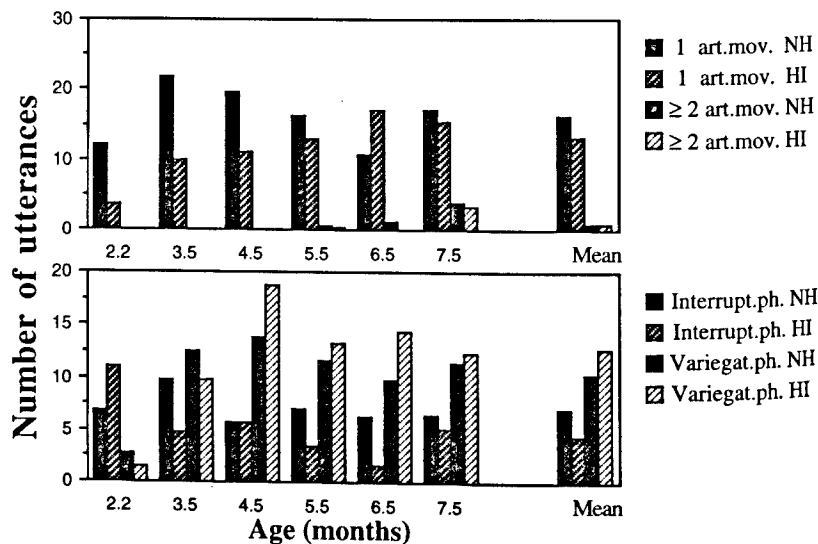


Figure 3 and 4. Mean number of utterances with 1 articulation movement or 2 (or more) articulation movements (fig.3) and interrupted or variegated phonation (fig. 4) for the NH and HI group per month, as well as the mean for the 6 months combined. (N: see fig. 2)

stimulation. It seems that the often reported reduction in number of utterances takes place after the period we studied, namely towards the end of the first year [e.g.7].

Furthermore, we found a longer utterance duration of the NH infants at age 3.5 months compared to the HI infants. After the 5th months the profile seems to be reversed; the HI produce longer utterances than the NH infants. The longer utterance duration might indicate - already in this early age - a tendency of HI children to prolong syllable duration as was found in a study on 6-to-10-year-old children [8].

In the phonation domain we found differences between the two groups in number of utterances with interrupted phonation, particularly in the later ages of the studied period. We did not find evidence for the finding of Stark [9] that the sound types which are characteristic of the "vocal play stage" (experimentation with squealing, growling, friction and other noises) are produced by HI infants to a limited extent only. A possible explanation for this difference in results might be that Stark studied the utterances of HI infants from 15 months onwards. Furthermore, the HI infants produced fewer babbling utterances within the studied age period than their NH peers.

In summary, it seems that already within the investigated period, i.e., between 2.5 and 7.5 months of age, several differences in the speech production between HI and NH infants can be observed. The differences become more clear from about 5.5 months onwards, with respect to number of utterances, utterance duration, interrupted phonation, and babbling. This may be due to lack of auditory feedback on the speech production from that age. In the first months fewer differences between the two groups can be observed. This may suggest a stronger influence of biologically determined factors (e.g. anatomical growth) on vocalizations in these first months compared to a later period.

CONCLUSION

Since the results of the present study are based on a small sample size, specially in the early months of age, caution should be taken when making any conclusion. In the period between 2.5 and 7.5 months, described in this paper, we observed a number of differences in the vocalizations

between 6 deaf and 6 hearing infants. These differences can be found both in a quantitative and in a qualitative sense. Our preliminary results suggest that a lack of auditory feedback influences the speech production already in this very early stage of development.

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