Studies on the Development of Stop-Consonants in Children†

Research in this area has examined the way in which a child gains control over his vocal apparatus such that his vocalizations contain acoustic features critical for speech communication. The main target of investigation has been the development of the voiced-voiceless distinction. This particular feature has been selected since the underlying acoustic differentiator (voice onset time) can easily be measured from spectrograms and since preliminary studies indicated that stops in initial position occur early in the vocalizations of infants.

In pursuing these studies, samples of the vocalizations of children from three different groups have been tape-recorded or are in the process of being tape-recorded: (1) normal hearing children of American English speaking parents, (2) hearing impaired children who have acquired a hearing aid and who are being raised by American English parents, and (3) normal hearing children of Lebanese Arabic speaking parents.

Data collection for children in the first group was started at approximately one year of age and has continued until the child fully masters the voiced-voiceless distinction (about two years of age in most cases). These children have come to the Neurocommunications Laboratory at Johns Hopkins Hospital in Baltimore on a two to four week basis for recording sessions which last 30 to 60 minutes. Periodic interruptions in the schedules have occurred on occasion because the mothers could not come to the laboratory for reasons such as illness or

vacations. Data collection for children in the second group is also proceeding at the Neurocommunications Laboratory. These recordings are being made on a four to six week basis. Children in this group, all of whom have a severe to profound sensorineural loss, were referred by the Hearing and Speech Center at the hospital. They range in age at the start of recording between 72 and 128 weeks. Prior to the acquisition of a hearing aid these children produced few speech-like sounds. The vocalizations of the Arab children (ages 45-70 weeks) were collected in Beirut, Lebanon. Tape recordings were made at home in the quietest room available. The sessions lasted for about one hour and the recordings were made over a period of six weeks. Comparisons between the American and Arab infants are interesting because the adult models differ with respect to the voiced-voiceless distinction (see JASA[1] paper). Tables 1, 2 and 3 summarize data collection to date.

To analyze the data, rough phonetic transcriptions of each session are made. Sounds which appear to be stops in initial position are submitted to at least two other judges and spectrograms are made of those items which the judges agree are stops and on which there is no dispute on the place of articulation. Voice onset time is determined from the spectrograms and frequency distributions are made for each child for each session.

The JASA paper presents results for normal hearing children between 50 and 57 weeks of age and for hearing impaired children between 104 and 106 weeks (26-29 weeks after acquiring a hearing aid). The following points summarize the data analyzed so far.

Normal hearing children about one year of age produce unimodal distributions of voice onset time approximating the middle

category found in the speech of adults over a range of language. The vocalizations produced at this age do not appear to be communicative utterances in the sense of spoken words with specific referents. They occur largely in vocal play with the mother or in monologues of babbling.

There seems to be little difference between the distributions for American and Arab children. This is particularly evident for apical and velar stops, the places of closure for which most data is available. This occurs despite the fact that Lebanese children are exposed to stops with voicing lead while American children are exposed to stops with voicing lag in the 50 to 100 msec. range. Both groups of children, of course experience stops in the middle category (simultaneous voice onset and stop release).

With respect to labial stops, there is a tendency for both American and Arab children to show voicing lead. A possible explanation for this phenomenon might lie in the fact that lip closure makes available a larger cavity for the build up of air pressure thus increasing the likelihood of voicing lead.

Some data for the normal hearing American English children who have reached 96 weeks of age is currently being analyzed. While frequency distributions have not yet been made, the results for two of these subjects show clearly that some voiceless stops are being produced in syllable initial position; that is, children at this age have more or less effective control over the voicing lag that serves this phonetic distinction in English. The vocalizations obtained at 96 weeks, however, are obviously of a communicative nature. They consist mostly of words and short sentences. This suggests that the use of spoken words and the

acquisition of the voiced-voiceless distinction are closely related phenomena.

The older hearing-loss children show voice onset time distributions similar to the younger normal-hearing children although there is a tendency for voicing lead to occur more frequently on apical stops. It appears, then, that deaf children who acquire hearing aids may follow the same developmental sequence in learning to make the voiced-voiceless contrast in their speech.

Further analysis of the data already collected is underway to determine just how and when children develop the use of the voiced-voiceless distinction in words. The experiments thus far have succeeded in bracketing this important development, indicating that the phonetic basis for the voiced-voiceless distinction is not present at one year of age (or much later in deaf children) but is being used at two years of age in children with normal hearing.

Malcom Preston
Grace Yeni-Komshian

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1. Malcolm S. Preston. A study of Voicing in Initial Stops Found in the Pre-Linguistic Vocalizations of Infants from Different Language Environments. Given at the 73rd Meeting of the Acoustical Society of America, New York City, 19-22 April 1967. The text appears in Haskins Laboratories' Status Report on Speech Research, No. 10, April - June 1967.

Table 1

Group 1: Normal hearing American English

Longitudinal Subjects

	Sex	Age in weeks at start	Age in weeks at last session	Data Collection	Sessions
E1	M	33	82	finished	7
E2	F	57	109	finished	23
E3	M	44	101	finished	14
E4	F	47	84	continuing	9
E5	M	43	89	finished	13
E6	F	44	72	continuing	7

Subjects who were able to attend a few sessions only

	Sex	Age in weeks at recording	Sessions
ECS1	F	53-60	4
ECS2	M	48-49	2
ECS3	F	46-47	3
ECS4	M	56-57	2
ECS5	M	110	1
ECS6	F	70	1
ECS7	F	69	1
ECS8	M	72	1

Table 2

Group 2: Hearing impaired American English

Longitudinal subjects

	Sex	Age in weeks at start	Age in weeks at end of Sept. 67	Sessions
EHL1	M	78	159	18
EHL2	F	77	156	16
EHL3	M	78	153	16
EHL6	M	85	136	12
EHL8	F	128	160	8

Subjects who were able to attend a few sessions only

	Sex	Age in weeks at recording	Sessions
EHL4	F	72	2
EHL5	F	81	7
EHL7	F	95	2

Table 3

Group 3: Normal hearing Lebanese Arabic

	Sex	Age in weeks at recording	Sessions
A1	M	45	1
A2	F	55	1
A3	M	47-53	4
A4	M	47	1
A5	M	46-52	4
A6	F	54-60	4
A7	M	56-62	4
A8	M	46-52	4
A9	M	70-76	4
A10	M	53-59	4