

## Developmental Studies of Voicing in Stops\*

We have been conducting some research on the acquisition of the voiced-voiceless distinction in stop consonants occurring in initial position as found in the vocalizations of children during the second year of life. This age range was selected since some preliminary work suggested that this was a fruitful period for observation. To accomplish these aims, we have gathered longitudinal data from six Baltimore children starting around one year of life and continuing until about 100 weeks of age. Tape recordings of five of these children were made on a monthly or biweekly basis depending on the mother's ability to bring the child to the laboratory. The sixth child (started at 29 weeks) has come to the laboratory on a weekly schedule. In addition we have also collected some vocalization data from ten Lebanese Arab children about one year of age and from some deaf children of American parents. Mireille Bertrand of the Faculté de Médecine de Paris has also collected some similar data from some French children aged 10 to 24 months which she is going to place in our hands shortly.

The procedure for analyzing these data first involves a transcription of the child's vocalizations. Following transcription, wide-band spectrograms are made of any vocalizations that were transcribed as stops in initial position and which were also judged as stops by another listener. From the spectrograms, measurements of voice onset time (VOT) are taken

to the nearest 10 msec for each stop. VOT is a measure of the time interval between the release of air pressure which follows the period of occlusion, and the onset of voicing. Research at Haskins Laboratories with adult speakers has shown that VOT is a useful measure for sorting word initial stop-consonants into phonemic categories (/b/, /d/, /g/ vs. /p/, /t/, /k/).

A preliminary analysis of the data from the Baltimore children about one year of age suggests that children at that age produce apical stops with VOT values ranging for the most part between 0 and 30 msec, voicing lagging the release of air pressure. Most of these vocalizations would be classified as starting with a /d/ by American listeners. In addition, analysis of some of the Lebanese children shows essentially the same results. The cross-language comparison is particularly interesting since the Arabic language does not utilize voicing lag greater than about 40 to 50 msec for apical stops. Arabic /d/ is characterized by voicing lead (voicing preceding the release) while the range of VOT values for Arabic /t/ corresponds roughly to the range for English /d/. The results for the deaf children before obtaining a hearing aid show relatively few stops of any kind. Those that are found are likely to be labials with varying amounts of voicing lead. After the hearing aid, labials with long voicing lead usually appear after several weeks or months. Deaf children appear to progress at a slower rate than normal-hearing children but follow similar growth patterns.

During the past year we have begun to analyze the longitudinal data from the Baltimore children. Although there remains a considerable amount yet to be analyzed, the results (based on three of the six normal-hearing children) indicate the following trends:

- (1) Labials are usually produced with voicing lead around one year of age. Voicing lags of greater than 10 msec have yet to be found. By about two, the child begins to approximate the adult distributions for VOT. The spread to the VOT range for /p/ appears to be gradual with some stops falling in the range separating /b/ from /p/, that is 10 to 20 msec voicing lag.
- (2) Apicals at one year of age fall mainly in the VOT range for /d/ although lags as great as 40 msec are occasionally noted. By the age two, distributions are more like those observed for adults. Again, the spread from /d/ to /t/ appears to be gradual with some stops falling in the range between /d/ and /t/ (20 to 30 msec lag).
- (3) Velars at one year of age fall mainly between 0 and 50 or 60 msec voicing lag. They appear to encompass the /g/ category with some spread to the region separating /g/ from /k/ (30 to 50 msec lag). Not enough data for the older ages is analyzed to make any statement about growth trends for velars.
- (4) The children do not all progress at the same rate. One child appears to proceed at a slower rate than the other two on the growth pattern for apical stops.
- (5) During the period studied, the children's communicative skills increased markedly, i.e., from short repetitive sounds at one year to brief sentences at two. Acquisition of the abilities to produce labials and apicals with long lag occurs within the context of this growth.

We hope to have the major portion of analysis done within the next two months. A paper for presentation at the Acoustical Society meetings in the Spring of 1969 will report these data in final form.

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