Proceedings of The Institute of Acoustics

ACQUISITION OF FRICATION BY HEARING-IMPAIRED CHILDREN: THE ROLE OF VISUAL FEEDBACK

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Introduction. The correct production of fricatives is mastered at a rather late stage in the development of speech, some children achieving it only about the age of eight, as they are the most difficult class of sounds for English-speaking children[1]. For the hearing-impaired, whose maximum hearing-loss is usually in the higher frequencies correct frication with its high-frequency spectrum is even harder to attain[2,3], which greatly impoverishes their communicative abilities.

In view of these difficulties, special training procedures would seem to be necessary[4]. At the same time, it is to be expected that visual aids would have a beneficial effect in the training of fricative production. A few such aids are currently available, among which is the V-S-F Indicator[5] and, on a more sophisticated level the Speech Spectragraphic Display, which presents frication and timing within a complete spectrogram[6]. This latter has been in experimental use with young adults only; it is not yet known whether children would be able to interpret the display for it to be of use in speech training.

Recently, an aid which gives information about frication and timing and displays it in a simple format suitable for teaching - the Fricative and Timing Aid (FTA) - was developed at Cambridge University Engineering Department. A pilot study was carried out to determine appropriate teaching procedures and to assess the results obtained after six months of teaching with it.

The Fricative and Timing Aid. The FTA displays in real-time the presence of frication, voicing and silence. It generates a picture on a domestic television set which shows a broad trace evolving from left to right with time. The trace is chequered for frication, white for voicing and black for silence allowing the user to perceive the occurrence and position of frication in a word (Fig.1). Two traces can appear on the screen: the target generated by the teacher and below the user's attempt. The user is therefore able to correct the speech error relative to the target. The FTA is currently available in the form of dedicated digital circuits and in the more complex form of a microprocessor-based system. Technical details about the FTA are presented in[7]. The microprocessor-based system was used for teaching in this study.

Method. Teaching was carried out by two speech therapists for about 6 months in various Partially Hearing Units attached to local schools in the Cambridge area. A group of 9 severely hearing-impaired subjects (Ss) aged between 10-17 years was selected on the basis of their hearing loss and speech ability, with particular reference to fricative production. The level of hearing loss was determined by pure-tone audiometry and the speech profile by the Edinburgh Articulation Test (EAT). The Ss were divided into three groups of three

Fig.1 Display of fricative and affricate sounds within words

ACQUISITION OF FRICATION BY HEARING-IMPAIRED CHILDREN

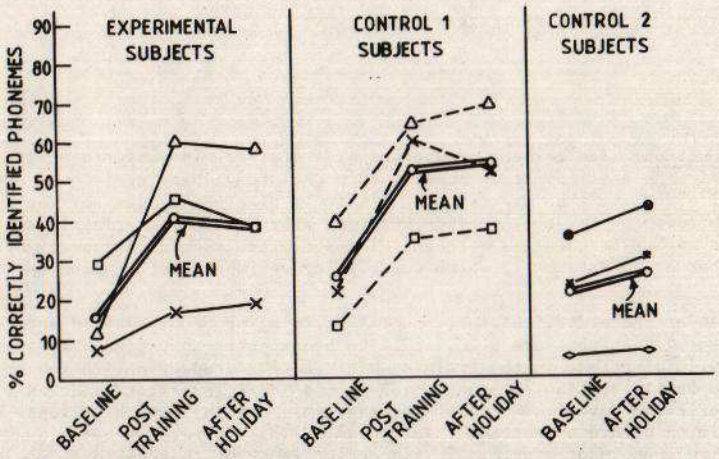

Fig.2 Changes with training in intelligibility and their retention after holiday in E, C1 and C2 subjects

three children each, broadly matched on the basis of hearing loss, EAT scores and age: experimental group (E) was taught with the FTA, control 1 (C1) was taught using conventional methods, and Control 2 (C2) was given no training by us. Mean hearing threshold level at 0.5, 1 and 2 kHz in the better ear was for E - 75 dB, ranging from 0.125 to 6 kHz, for C1 - 71 dB, ranging from 0.125 to 8 kHz and for C2 - 92 dB, ranging from 0.125 to 8 kHz. The mean EAT scores were respectively 25, 24 and 25.

E and C1 Ss were seen in their schools for 30 minutes daily. Teaching was based on words presented as minimal pairs which had been selected to highlight the contrast being taught, e.g. ship/chip, wash/watch to illustrate the fricative/affricate contrast, toe/sew, hit/hiss for the stop/fricative contrast. The visual cues for stop/fricative/affricate contrasts were the presence or absence of frication and silence. The order of teaching the contrasts was governed partly by the findings of initial speech assessment and there was a common programme for E and C1.

Each teaching session included ten minutes of auditory discrimination and a minimum of ten minutes speech production practice of the contrast being taught. Records were kept of numbers and sequences of correct/incorrect attempts and a criterion of 8 out 10 correct was applied to control progress from easier to more difficult tasks (e.g. the production of words already practised later being produced in phrases). For the children using the FTA, visual feedback was delayed when consistently good production had been achieved, by concealing the display until the subject had made a judgement about his production.

A number of tests were applied to ascertain whether progress had been achieved by our training programme. Here we only refer to the data yielded by an identification test (ID). For this test, the children's utterances were elicited by picture cards, each of which was designed to prompt a particular word, beginning or

ending in a fricative or affricate. These were tape-recorded before training, after training and two months after cessation of training. The recordings were edited and partially randomised with the proviso that neither the same word nor the same child occured twice in succession. The tapes were then played to panels of naive listeners instructed to write down what they understood, as words or parts of words. Scoring took into account the total number of correctly identified phonemes, either within words or in isolation.

Results. The global results of the ID test are presented in Fig.2. This shows the percentage of utterances in which the relevant phoneme was correctly identified before training, after training and after two months holiday, for each subject. It also shows the mean for the group (for C2 only baseline and after holiday results are presented since they were given no training). Each point is calculated from about 35 words judged by 5 listeners.

Three main features emerge: 1) there is a definite increase in intelligibility with training for E and C1, while only negligible changes occur in C2; 2) there is no change in the level of intelligibility after an interval of two months without practice; and 3) there are marked inter- and intra group differences in baseline intelligibility scores as well as in that of the subsequent learned material.

A further analysis of the data separating the fricatives and the affricates showed differences in intelligibility between E and C1 (Fig.3 and 4). Each column shows the mean baseline and the mean post-training intelligibility level for E, C1 and C2 groups, for fricatives (Fig.3) and affricates (Fig.4) in all positions, and separately in initial and final position. For fricatives, the mean is calculated from about 25 words, and for affricates from 10 words produced by each

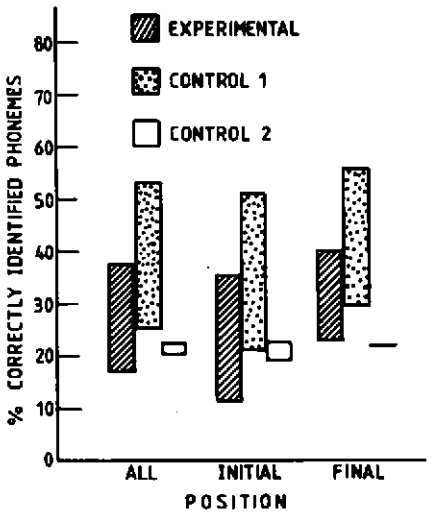

Fig.3 Changes in intelligibility of fricatives for E, C1 and C2 groups

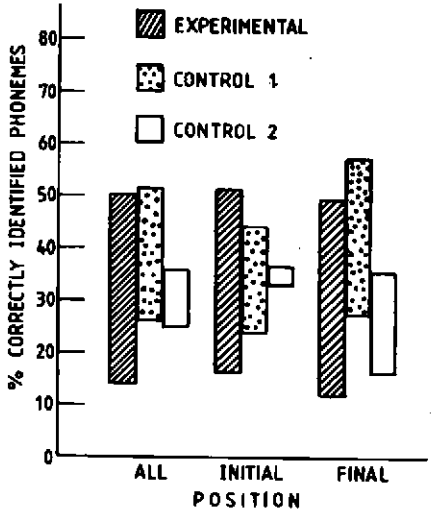

Fig.4 Changes in intelligibility of affricates for E, C1 and C2 groups

S, all judged by 5 listeners.

It can be seen that E start with lower intelligibility scores than C1 in the case of both fricatives and affricates. However, with training the intelligibility of affricates produced by E rises sharply while in the case of C1 the increase is smaller, in particular in initial position (Fig.4). This trend is not apparent in the intelligibility of fricatives, where the rise is practically the same for the two groups. In the cases of Ss in C2, who were given no training, hardly any change over time is observable (in this context the increase in intelligibility shown for final affricates is probably a chance effect).

Discussions and Conclusions. The results obtained in this study show that even extremely difficult features of speech like timing of frication and the fricative-affricate distinction can be acquired/improved in a short period of time and retained after a period of non-practice if appropriate speech training has been carried out. The degree of progress for each child is however variable, depending on the characteristics of the hearing-loss and previous speech ability. When intensive speech training is not carried out with deaf children, no spontaneous improvement in speech intelligibility can be detected.

Visual feedback as displayed by the FTA proved beneficial from several points of view. First, by displaying the distinctive pattern of fricative/affricate contrast - which is very difficult to convey without a visual model - it facilitated the learning of affricate production: the intelligibility of affricates in E Ss increased consistently more than that of C1 Ss. Secondly, the teaching itself was facilitated, by giving the children an indisputable criterion of success/failure and by making it easy to elicit a large number of repetitions in rapid succession. From the teachers' point of view it is time-efficient, i.e. it saves time otherwise spent in preparation of varied tasks required to maintain the children's interest in speech practice.

Although this study suggests that visual feedback is beneficial in teaching speech to deaf children, the advantages of using the FTA do not emerge to their full extent from the data presented. It is probable that, as was the case in a previous long-term study of vowel learning using the Computer Vowel Trainer[8], the differences between learning with or without a visual aid emerge at a later stage. In that study, the differences between experimental and control Ss were visible in their long term retention. The short duration of this study precludes such results.

The conclusions we can draw from this study are tentative because of its time-scale, the small number of Ss and their variability. It is assumed that a long-term assessment of learning of frications using the FTA will allow a better understanding of the strategies deaf children employ and provide evidence regarding its possible advantages for long-term retention and generalization into spontaneous speech.

Acknowledgement. This research was supported by the Medical Research Council.

References. 1. Ingram, D. (1976). E.Arnold, London; 2. Smith, C.R. (1975). J.S.H.R., 18, 795-811. 3. Bennett, C.W. (1978). J. comm. dis., 11, 433-442. 4. Ling, D. (1976), A.G. Bell Assn, Washington, D.C. 5. Mynders, J.M. (1979), H.A.J. 32, 28-29. 6. Steward, L.C., Larkin, W.D., Houde, R.H. (1976), IEEE ICASS Philadelphia. 7. Bate, E.M., Fallside, F., Gulian, E., Hinds, P. and Keiller, C. (1982)., Proc. ICASS, Paris. 8. Brooks, S., Fallside, F., Gulian, E., Hinds, P. (1981). Br. J. Audiol. 15, 151-163.