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B. TEACHING MACHINE FOR TRAINING EXPERIMENTS IN SPEECH PERCEPTION

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There is at present a great deal of interest in developing new technical aids for the deaf and hard of hearing in which the speech signal is analyzed and some important elements are extracted and then transmitted to the hearing impaired subject either as a new acoustic, tactual, or visual signal.* It is clear that the subject only can use these new signals after training.

Many different solutions are possible to the analyzing and presentation problems and it is necessary in the development of these aids to run a large number of training experiments. It is also necessary to standardize these tests so that the effect of different solutions can be easily compared. These considerations and also the need of reducing the amount of man power needed to run the experiments have resulted in the development of a teaching machine suitable for this purpose.

Description of the machine

It was decided to limit the maximum number of alternatives to 15 which means that a 4 bit binary code can be used. A block diagram of the teaching machine is shown in Fig. III-B-1. The code signal is stored on one track of the tape recorder and the stimuli on the other. As tape recorder Uher Universal 5000 was selected as this was the only tape recorder at a low price with provisions for electronic control of fast rewind. The rewind mechanism is also sturdy so that one can expect troublefree function. The rewind speed is five times the playback speed. The tape recorder is as a rule equipped with a mono head but this was changed to a stereo head.

The code signal is a four bit tone code using the frequencies 250, 1000, 1700, and 3000 Hz. Each code group starts with a 0.4 sec segment where all four frequencies are present. This segment starts the code-reading signal in the decoder and is then followed by a 0.4 sec long signal. The code group always precedes the stimulus.

* In June 1967 a conference with the title "Speech Analyzing Aids for the Deaf" was held at Gallaudet College, Washington, D.C. under the direction of Prof. J. M. Pickett.
Fig. III-B-1. Block diagram of the teaching machine.
The tape recorder automatically stops when it reaches the next code group, which means that the training is self paced. When the "REPEAT" button is used, see Figs. III-B-1 and III-B-2, the tape recorder will rewind until it senses a code group and then automatically reply the stimulus and stop.

In the decoder the code signal is converted to four binary signals and these signals are stored in a memory and also converted to control signals to the 15 lamps, see Fig. III-B-2.

The subjects answer on a set of fifteen pushbuttons. The signals from these are then converted to a binary code and compared with the code signal from the tape. The output signal from this comparison is fed to counters that indicate the number of answers and the number of correct answers but also to a program selector. Three different programs can be used.

1. **Prompting program.** The subject starts the tape recorder and is then informed about the next stimulus before this is heard, that is, the lamp corresponding to the stimulus will light up before the stimulus appears. The subject must answer by pushing down the button corresponding to the stimulus and can then proceed to the next stimulus by means of the "NEXT" button. Before answering he can also repeat the stimulus by pushing down the "REPEAT" button.

2. **Confirmation program.** The subject hears the stimulus and answers on the pushbuttons. He then receives the correct answer and if his answer was correct he can proceed to the next stimulus by means of the "NEXT" button. If his answer was wrong he has to repeat the stimulus by means of the "REPEAT" button and then give a correct answer before he can proceed to the next stimulus. He can also use the repeating function before giving any answer.

3. **Test program.** The subject hears the stimulus and gives his answer and then proceeds to the next stimulus by means of the "NEXT" button. Repetition is not possible.

The design of the two training programs was influenced by the discussion about the relative efficiency of prompting versus confirmation in paired-associate learning (3) and the importance of the stimulus-label overlap.

In all the three programs the number of answers and the number of correct answers are registered on counters.
Fig. III-B-2. The teaching machine.
Pilot study

To test the efficiency and the functioning of the teaching machine a program was prepared for training of normal hearing subjects with a simulated hearing loss in the identification of transposed fricative sounds. The transposing equipment used in the experiment can be seen as a part of a channel vocoder. By means of three band-pass filters the energy in three bands in the frequency region of normal fricatives, 1500-6000 Hz, is measured and this energy controls the noise energy in three band-pass filters with the center frequencies 300, 600, and 900 Hz, respectively. The analyzing filters were selected to give maximum resolution between the Swedish fricatives [s, c, f]. The training material consisted of the syllables [si:, sa:, su:, ci:, ca:, cu:, fi:, fa:, fu:]. Spectra of the synthesized fricatives are shown in Fig. III-B-3. Due to coarticulation there are marked differences between the same fricatives followed by different vowels.

Five lists of 60 syllables in random order were prepared and played through the transposing equipment followed by a steep low-pass filter with cutoff frequency 1500 Hz. White noise was added to give a signal to noise ratio of 20 dB. Finally, code signals were recorded on the other channel.

Four subjects tried to learn to identify the transposed fricatives. Each training session consisted of training with the confirmation program and then a test with the test program. The learning curves are shown in Fig. III-B-4. The subjects varied in degree of familiarity with the transposing equipment which explains the difference in starting level. Two subjects had no previous experience.

The training curves of Fig. III-B-4 can be compared with the result of a similar experiment in Fig. III-B-5. In this experiment the same tape recordings were used but in this case the original fricatives were recorded before the transposed one on the tape, which meant that the subject first heard the normal fricative and then the transposed. None of the three subjects had previous experience with the transposed fricatives. As can be seen from Fig. III-B-5 only one subject learnt to recognize some of the fricatives.

A detailed description of the transposing equipment and the learning experiment will be published in a following quarterly progress and status report.
Fig. III-B-3. Frequency spectra of the transposed fricatives used in the experiment
Fig. III-B-4. Learning curves for the four subjects that trained with the teaching machine.
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Figure II-B-5. Learning curves for three subjects trained with paired
listening to the original and the transposed recordings.
Conclusion

The teaching machine described seems to solve at least some of the problems of training in speech perception experiments. The number of alternatives is maximum 15 which means that tests with more items must be divided into parts but this does in most cases not seem to be a serious objection. The equipment can also be used in hearing training with hard of hearing children.

References: