Recoding speech for the deaf and hard of hearing. A status report

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III. AIDS FOR THE DEAF

A. RECODING SPEECH FOR THE DEAF AND HARD OF HEARING. A STATUS REPORT.

A. Risberg

For some time a group within the laboratory has been working with the problem of developing new aids for deaf and hard of hearing persons. The philosophy behind this work is that it is possible to abstract the information bearing elements in speech from the acoustic signals. These elements can then be changed, recoded, to new acoustic, tactual, or visual signals and after training it might be possible for the deaf or hard of hearing subject to perceive the recoded speech or to use the recoded information as a complement to the visual signals from the speaker’s lips.

This work is supported by the Swedish Technical Research Council, the Swedish Council for Social Science Research, and the National Swedish Board of Education. Those who are working with this project are at present the following:

Arne Risberg, part-time
Karoly Galyas
Ove Frånzen
János Mártony, part-time
Bo Jacobsson
Karl Erik Spens, part-time

The project is aiming at a general study of the problem of extracting and recoding the information bearing elements of speech both to acoustical, tactual, and visual signals. The work within the group can be seen as an attempt to use the accumulated knowledge about the acoustics of speech in new aids for the deaf and hard of hearing. The analyzing problems are in many cases equivalent to the problems we meet in the work with vocoders, spectrum analyzers, and other instruments for the study of the acoustic speech signal.

The more special problems we meet are concerned with optimizing of the information transmission. Our present knowledge of the tactual sense as a channel for transmitting information is far from complete and the same is true for a defective hearing.

These problems have now been studied within the group by O. Frånzen, who has a training in psychology. The work within the group has up till now mainly been concerned with the following up of
what has been done previously in this field and with the development
of equipment and techniques to study the information transmission in
the tactual and auditory channels. Some practical equipments have
also been built and tested. The following is a brief summary of our
present view on those problems and a brief summary of present projects.
The projects have been divided after the channel of information trans-
mission.

1. General problem

Bibliography

Published work on the recoding of speech for the deaf and
hard of hearing has been followed up.
Status: The bibliography is published in this report.

Instrumentation for psychophysical measurements

A set of gates, time-delay units, amplifiers, and signal
generators have been built. With a combination of these a test signal
varying in any dimension or combination of dimensions can be produced.
A randomized program can be recorded on one channel of a dual channel
tape-recorder. The program allows for five dimensions and eight posi-
tions on each dimension. The subject answers by pressing the appro-
priate button and the answers are registered on counters. In experi-
ments using speech a stimuli the speech signal (syllables, words, or
sentences) can be recorded on the other channel of the tape-recorder
and the program signal can be used to give a visual presentation of
the correct answer. The equipment can thus be used in training experi-
ments in for example tests with tactual recording of speech.
Status: Completed. The programming unit will be described in a
following GFSR.

2. Auditory recoding

Two different approaches to auditory recording of speech
have been reported on in the literature, both intended to improve com-
munication in the case of pronounced high-frequency hearing loss. One
approach is to compress the whole frequency spectrum of speech with
the aid of a tape-recorder with rotating heads (3) or by using a
vocoder with analysis in the normal frequency range of speech and
synthesis in narrower range. In the second type of approach the speech within the subjects' useful hearing range is transmitted undistorted but to this signal are added the transposed high-frequency sounds, that is, high-frequency sounds are transposed to lower frequencies. Various techniques are available for spectral transposition.

Coding dimension for auditory signals

It is probable that a hearing loss must be viewed not only as a filtering process but also as a change in the time, amplitude, and waveform analyzing capacities of the auditory system. An experiment has been started to study these aspects of signal transmission in different types of hearing impairments. These tests are complicated by the necessity of training the subjects until an optimum performance is reached, which is especially apparent when children are used as subjects.

**Status:** Test equipment is under construction.

**Auditory recoding with frequency transposition of high-frequency sounds**

Experiments with recoding strategies based essentially on the ideas of B. Johansson (Department of Technical Audiology, Karolinska Institutet, Stockholm) have been started. Many different variations in the recoding strategy are possible and the experiments are aimed at a study of some of these and to gain general experience from auditory recoding.

**Status:** Three different experiment equipments have been built and preliminary tests have been made.

3. Tactual recoding

The experiments with tactual recoding are essentially a continuation of the work started in 1955, at the latest tested in the experiments made by Pickett. The same type of equipment is used, that is, the speech signals are analyzed with 10 band-pass

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*Johansson\,\(^{(1)}\) uses a modulator and an oscillator tuned to a suitable frequency and König and Eichler probably used some type of frequency-dividing technique. Johansson has tested his equipment for some years and results from these tests will soon be published (personal communication).*
filters covering the frequency range of speech. The output of the band-pass filters controls the amplitude of vibration of ten bone conduction transducers, one on each finger-tip.

Tactual speech transmission is mostly viewed as a possible complement to lip-reading and the number of vibrators can probably for this purpose be reduced so that only one hand need to be used.

Coding dimensions for tactual signals

A series of experiments has been started to investigate the information transmission properties of the finger-tips for tactual signals. Special attention is paid to masking and fatigue.

Status: In progress. Results will be published in the following QPSRs.

Optimizing the present system for tactual speech transmission

The aim is to optimize the time constants in the compression amplifier and to make experiment with different types of modulators. The experiments are made with normal hearing subjects and the test material is syllables and words.

Status: In progress.

Experiments with hearing impaired

An experiment has been made to compare the possibility to identify some sound classes with the aid of only lip-reading, lip-reading and amplified sound, and lip-reading plus tactual recoding.

Status: Completed. The results will be published in a following QPSR.

Experiments with a deaf and blind subject

A pilot experiment has been started with a deaf and blind subject, aged about forty, and deaf from birth and almost blind since five years. In this case an attempt is made to transmit speech only by means of tactual signals but normal speaking tempo is not essential.

Status: In progress.

4. Visual speech transmission

Our experiments with visual recoding of speech or speech elements are only aimed at the development of aids for speech training. No experiments are planned for use of visual signals for speech transmission equivalent to the experiments at the Bell Telephone Laboratories (7).
The advantage of visual recoding of speech elements is that a more direct feedback than the approval or disapproval of the teacher can be obtained and that the instruments can be designed for self-instructed training. The last point is probably very important and does not seem to have been considered in most of the previous experiments within this field.

Design of visual spectrum indicators

Experiments with visual spectrum indicators have been going on since 1955 within the laboratory. In STL-QPSR 4/1963 an instrument of this type was briefly described. Two instruments have been built and have been tested in two schools for the deaf. The results are good but an increase in the dynamic range seems to be needed.

Status: Development work on two new spectrum indicators is started. The first uses a cathode-ray tube as indicator and the second is an attempt to build a very simple equipment for more limited use. Prototypes of both types are ready.

Intonation indicator

The voice fundamental is extracted by means of a larynx microphone and a simple peak-picking circuit. A time-frequency pattern is presented on a cathode-ray oscilloscope with long persistence screen.

Status: Completed. Described in STL-QPSR 3/1964. Tests have been started at the State School for the Deaf at Manilla, Stockholm.

Rhythm indicators

An intensity-time pattern is displayed on an oscilloscope. With the aid of different microphones it is possible to display either only voiced sounds (larynx microphone), unvoiced sounds (airborne sound with high-pass filtering), or nasal sounds (nasal probe microphone). By means of a chopper two signals can be displayed simultaneously.

Status: Completed. Tests will start this spring.

References, see next page.
References:


