Experimental device for control of intonation with an artificial larynx. A status report

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D. EXPERIMENTAL DEVICE FOR CONTROL OF INTONATION WITH
AN ARTIFICIAL LARYNX. A status report
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Abstract
At the Department of Speech Communication a prototype of a manual
control for variation of F0 in electrolaryngeal speech has been developed.
The value of such a control, in terms of acceptability and intelligibility,
is to be investigated experimentally. For this purpose the system has
been made highly flexible, allowing for several parameters to be changed
independently. In addition to the prototype a carefully chosen speech
material, an oscilloscope and a repeat recorder will be used to conduct
learning experiments. The evaluation procedure will involve the use of
a listener group who will give their interpretation of the stimuli as well
as their judgment of naturalness.

1. Background
Laryngectomees are a group of people who experience a severe speech
handicap. Since they have had their larynges removed, the possibilities
for their acquiring normal-sounding speech are very limited. There are
two principally different ways of learning to speak again—a method of
oesophageal speech and the use of an artificial larynx (a vibrator).

The oesophageal speech has the advantage of being achieved with the
remaining muscular structures in the throat region. Thus, it is not
dependent on any external aids that need to be attended to and it leaves
the hands free. On the other hand, there is a need for the electronic
artificial larynx. A significant percentage of the laryngectomees never
learn to use oesophageal speech at all or very unsuccessfully. This is
true especially of the aged (Sindercore, 1962). There are certain other
groups of laryngectomees that are not able to or do not wish to use oeso-
phageal speech. However, the voice quality of the electronic artificial
larynx is not very pleasing, nor is it very intelligible to untrained lis-
teners. The sound is machine-like in quality and the pitch contour is
perfectly even. It has been suggested that a better situation might be
achieved by training listeners to perceive electrolaryngeal speech (Knox
& Anneberg, 1973) but a still better solution might be reached by improv-
ing the intelligibility and naturalness of the electrolarynx. In the literature
there are certain indications that prosodic patterns convey a great deal
of information in a listening situation—information about syntax, word
boundaries, emotional contents etc. (O'Connell et al., 1968; Blesser,
1969; Wingfield & Klein, 1971; Svensson, 1974). Therefore, the short-
comings of electrolaryngeal speech may be due in part to the lack of
variation in fundamental frequency. Thus, the possibility was con-
sidered of improving intelligibility as well as naturalness by adding a
continuous control to a vibrator.

These considerations led to the development of a manual control for
continuous monitoring of fundamental frequency (Bondelind, 1973) with
an experimental set-up. We intend to study man's ability to learn the
use of such a control device and to investigate the effect of intonation
control of the artificial larynx on the intelligibility and naturalness of
that speech.

2. Equipment

When starting the development work the following design objectives
have been identified:

-- a light-weight control unit, fitting well into one hand,
-- sensor for gripping and opening forces from the fingers,
-- a three-position switch for the thumb, and
-- flexible electronic circuitry, permitting alteration of parameters.

A laboratory prototype of a hand-held control unit has been developed
containing only a sensor for pushing and pulling forces from the fingers
and a three-state switch for the thumb, see Fig. II-D-1. The electronic
circuits are placed in a separate box and they consist of circuit blocks
which are easy to exchange. A number of parameters can be changed
such as:

-- pitch controlling sensitivity to changes in pushing or pulling force,
-- variable threshold on both sides on zero force which means that no
  change in pitch occurs until a preset value of force has been exceeded,
-- pitch frequency corresponding to zero force,
-- mode of pitch control, i.e. either a frequency change proportional to
  a change in force or the rate of a change in $F_o$ determined by the value
  of force (velocity steering).

In addition, sensitivity to opening force from the fingers has been made
about four times higher than to gripping because of the different strength
(in the fingers) of the different muscles.

For starting the phonation the three-state switch has to be pressed
until stop (state 2). At the end of the utterance a slowly ceasing amplitude
(with a duration of about 1 sec) can be achieved by releasing the switch.
LARYNX VIBRATOR WITH MANUAL CONTROL

Fig. II-D-1.
half-way (state 1). A complete release makes a fast stop in phonation.

In our experiments we are using a larynx vibrator that can be attached to the throat. It is named "Phonatron" and manufactured by Sama in Italy. The experimental set-up is completed with a repeat recorder, an $F_o$-meter and a large screen oscilloscope which makes possible repeated display of an intonation pattern. The time span of the screen is variable between 0.5 and 12 seconds.

Our present purpose is to conduct learning experiments in order to test the laboratory model. So far, a gross outline of the experimental design has been drawn up. In the typical experimental setting the subject will listen to a pre-recorded stimulus over earphones while looking at the corresponding $F_o$-pattern on the oscilloscope. With the manual control the subject tries to imitate the stimulus. As long as the "repeat" button is down, the same stimulus reappears over and over again, at intervals of 6 seconds, which gives the subject time to make his response in-between. With this method the subject is given both auditory and visual feedback, which ought to accelerate learning. When the subject is satisfied with his version of a particular stimulus, a recording of it can be made before feeding the next stimulus into the repeat cassette.

Since the goal of the investigation is to increase intelligibility as well as acceptability, there have to be two components in the evaluation procedure. It is planned to submit the recorded response to a group of listeners who will give their interpretations of what was being said, and who also will give their judgment of the naturalness of the utterances. The results, in terms of intelligibility and naturalness will be compared to results from an ordinary electrolarynx (without variable $F_o$). Furthermore, the rate of progress in learning to use the system will be investigated.

At this stage, test materials are being prepared, and the experimental design is being worked out in detail.

References:


