VOICE QUALITY JUDGEMENTS AND PHYSIOLOGICAL MEASUREMENTS IN ESOPHAGEAL SPEAKERS WITH AND WITHOUT A GRONINGEN BUTTON.

G.L.J. Nieboer

H.K. Schutte, M.D., Ph.D.

T. de Graaf, Ph.D.
Institute of Phonetic Sciences, State University, Groningen, The Netherlands.

ABSTRACT.
Physiological measurements have been performed on 26 esophageal speakers, both with and without a Groningen Button. The measured variables are: intra-thoracic, sub- and supra- pseudoglottic pressure, trans-pseudoglottic flow and sound pressure level. Of the same set of speakers, tape recordings were made in view of a perceptual evaluation by a group of 85 judges. The evaluations were done on 13 bipolar semantic scales. The results of both parallel experiments are presented in this contribution, as well as the first results of correlation computations.

1 INTRODUCTION.

The measurement of physiological characteristics of esophageal voice has had a lot of attention during the last years. Part of this interest is due to the development of tracheo- esophageal valve prostheses (1). Besides the advantages of these prostheses, a few disadvantages emerged too: the need to use one hand to close off the tracheostoma, the need for cleaning and exchanging the device, and the fact that relatively much effort is needed to phonate.

One more circumstance that leads to an interest from our side in this type of speech is the fact that in the Groningen ENT Clinic both injection- and button- esophageal voice are taught as a rule to the laryngectomees: this offers the opportunity to compare both types of speech on a physiological as well as on an evaluative level.

In the experiment reported on here this effort is assessed by measuring simultaneously the intra-thoracic, sub- and supra- pseudoglottic pressure, the trans- pseudoglottic flow, and the resulting sound pressure level. Furthermore, attention is paid to the pressure loss caused by the button, with the simultaneously measured air flow rate. The efficiency of voice production was measured, but it will not be reported on here. In fact, due to the relatively high intra-thoracic and sub- pseudoglottic pressures we encountered, these pressures will say as much about the effort of phonation as the efficiency.

The same speakers were asked to read a number of standard sentences. This speech material was judged by a group of 85 listeners, both native judges and speech therapy students. The last group happened to consist of 86% female judges. Correlational computations have been made to relate these judgements to the physiological data of the same patients.

2 PHYSIOLOGICAL MEASUREMENTS.

In total, 1357 measurements were done in the phonations of 31 esophageal speakers. Not all variables were measured in every measuring point: during injection- esophageal phonation, we did not register the intra-tracheal pressure. The flow was measured in only 4% of the 1357 cases; this was done because the sound pressure level is influenced by the flow mask. The supra-pseudoglottic pressure data have not been processed so far.

The intra-thoracic pressure was measured with an open catheter, held by the patient himself in the trachea, under the thumb closing off the tracheostoma. The sub- and supra-pseudoglottic pressures were measured by means of micro pressure transducers, mounted on a catheter which has a diameter of 1.65 mm in the 6 cm of it between the two sensors. It was introduced through the nose into the esophagus, about 40 centimeters, and then gently pulled back again during phonation. By monitoring the signal on a scope, evidence could be attained as to the position of the proximal sensor. When this sensor stops showing up pressure offset during phonation, it means that it is situated in the supersupra-pseudoglottic pharynx. Minor adjustments are sometimes needed in order to be sure that the distal sensor is situated in the air-filled sub- pseudoglottic room. The simultaneous registration of both sub- and supra- pseudoglottic pressure with high frequency sensors will enable us to investigate the acoustic phenomena occurring just below and above the pseudoglottis.

The spread in the data is quite high (see Table 1), especially in the sub- pseudoglottic pressure and the flow. The sound pressure level, on the other hand, has a rather small standard deviation, due to the generally small dynamic potential of these speakers.

When we consider the mean sub- pseudoglottic pressure, flow and SPL of our speakers it becomes clear which variables are able to differentiate between the two groups of injection- and button- esophageal speakers. The sub- pseudoglottic pressure seems to do that quite well. The means differ by 1.4 kPa. Four of the five patients where measurements were done during both types of phonation, showed a higher sub- pseudoglottic pressure (see Table 2). On the right hand side, you see the P-values from a comparison of the means with a t-test.

Table 1: Mean sub-pseudoglottic pressure values of 5 variable speakers group and the injection group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1 (button)</th>
<th>Group 2 (injection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psub (kPa)</td>
<td>3.3</td>
<td>4.1</td>
</tr>
<tr>
<td>(S.D.)</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Flow (ml/s)</td>
<td>100</td>
<td>55</td>
</tr>
<tr>
<td>(S.D.)</td>
<td>93</td>
<td>112</td>
</tr>
<tr>
<td>SPL (dB(A))</td>
<td>66.6</td>
<td>66.2</td>
</tr>
<tr>
<td>(S.D.)</td>
<td>9.5</td>
<td>9.4</td>
</tr>
</tbody>
</table>

* These differences ask for a physiological explanation. The question is: what will cause one and the same speaker to sustain two different pressures in order to vibrate one and the same sound source. In the first place the pressure build-up possibilities of the respiratory mechanism are responsible, although the pressure in the lungs and that in the sub- pseudoglottic room are not directly 1 to 1 related because the prosthesis is situated in between, and because the sub- pseudoglottic space is lying outside the thorax, hardly affected by the intrathoracic pressure.

The flow values too differentiate between both types of speech. The mean registered value was 108 ml/s. Again, a significant difference was found between the two groups. Although we know from Schutte's data (2) that, for laryngeal voices, mean flow values are not very useful predictors of voice performance, the found differences might possibly be related to another voice variable: voice quality.

SPL did not discriminate between both voice types: both reached about 67 dB at 30 cm.

We measured a rather high in vivo trans-button pressure. These measurements were done without a selection based on the age of the devices. The mean age was about 11 weeks, so more than two and a half months; also, at the time we made our registrations (end 1985), no patients had anti-fungus medication (3). The high trans-button pressures, with respect to the in vitro values we measured, must be attributed to the deterioration of the devices by fungal growth: it makes the material stiffer, resulting in a higher flow resistance (3). Consequently,...
research is going on at this moment to reduce the flow opposition of the prostheses.

3) PERCEPTUAL EVALUATION

Speech material of the same speakers was subjected to a perceptual evaluation by 85 listeners. It was done by scoring one minute speech of each speaker on 13 semantic 7-points scales. The one could be expected. The scales 6, 7 and 11 formed one factor which one could call "quality." Another large factor can be considered to represent the voice appreciation; it comprises the scales 1, 2, 3, 4, 8, 9, 10 and 12. A third factor emerged as a pitch factor: scales 5 and 10.

This last factor showed a remarkable thing. As you see, the scales have been arranged in such a way that the more positive side is on the right. Now in the case of scale 5 it appeared that left and right should be changed. Normally, especially with male voices, the term "deep" would be more positive than "shrill." In the case of our set of esophageal speakers the reverse was the case. When the scale is turned around it correlates well with scale 13: "low - high," indicating that in fact "shrill" was considered a more positive attribute of the usually low pitched esophageal voices than "deep."

Tables 3 a, b: Multiple correlations computed with the speaker mean values on the 13 scales and the mean values of three (or five in the case of button- esophageal speakers) parameters from the physiological measurements. Flow is the mean flow, SPL the mean sound pressure level, Psbl the mean sub- pseudoglottic pressure, Ptra the mean intrathoracic pressure, and dPblw the mean pressure difference over the buttons. The figures in italics point at statistically significant correlations (p < .05) as found during the multiple correlation steps. As soon as one or more of the three physiological parameters are in the equation, the other figures in the row point to correlations of the rest-variance. In rows without italics figures, Pearson product moment correlations are printed. The figures in italics of the last column (between brackets) are the squared correlations of the injection group. In the figures of Tables 3 a and b the tendencies are somewhat different. The intrathoracic and trans- button pressures correlate well with the "tempo" factor, and the "pitch" factor shows no important correlations at all.

One of the most striking things is that in all tables the mean flow shows relatively high correlations with the "quality" and "tempo" scales, and that the sub- pseudoglottic pressure hardly shows any correlation with the scales. We have no explanation as yet for this phenomenon, as one might expect this sub- pseudoglottic pressure to be an important determinant of voice quality; in any case, it is "closer to the voice" than e.g. the intrathoracic pressure (see Table 3 b), but the latter has more to do with quality in the Tables 3 a and b.

REFERENCES

