Measuring nasality? A status report

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C. MEASURING NASALITY? A Status Report
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Abstract

In an attempt to assess nasality an acoustic measuring device has been developed. It is based on the comparison of the amount of energy radiating from the nose and the amount of energy emanating from the larynx. This was done with two contact microphones, one for the nose and the other for the larynx pickup. The two microphone signals are then processed and a ratio between the durations of the nose signal and the larynx signal is given in percent in a numerical display.

During the last year or so, we have been working with the analysis of speech in cleft-palate patients, and we have found that among other articulatory defects in their speech, nasality i.e., excessive nasality (hypernasality) is certainly the parameter that makes their speech more conspicuously deviant. This is due to the involuntary connection between the mouth and the nose cavities. This connection may be large or small depending on the type of Cleft. In the lesser case, i.e. the case of a cleft of the soft palate, this connection can be due to a short soft palate, an open one or a malfunction in its enervation. All these give an excessive nasal (hypernasal) quality to speech. Most of these cases can be helped nowadays by means of plastic surgery and eventually speech training. Somewhere along this procedure one is bound to ask: Was there an improvement in the speech quality after plastic surgery? After speech training? To answer this question (in what relates to the nasality in speech), one would need a method to measure nasality or at least some of its major components. This method should, to be effective, satisfy all of the following criteria or at least as many as possible:

1. Measuring nasality; have a high correlation to the perception of nasality.
2. Be reliable; measure always the same.
3. Be reproducible; give the same results for the same input over a long period of time.
4. Not interfere with speech; no part or as little as possible of the speech mechanism should be tampered with.
5. Be easy to use; no need for especially trained people.
6. Be easy to transport; so it can be taken anywhere.
7. Give a result or an answer in as near real time as possible.

Among other methods, two seemed to be the most appropriate, either because they have been used before or because they were related
to our own field. They are a) subjective assessment of nasality, through listening tests and b) an acoustic processing technique. Method a) compiles well with criteria (1) and (4), but poorly or not at all with the other criteria. Method (b) could potentially satisfy more or less all of the criteria. We have accordingly concentrated our efforts on the development of a simple and accurate acoustic method.

Method

We used two microphones, placing one on the right blade of the thyroid cartilage, and the other on the right cartilageneous part of the ala nasa (see Fig. II-C-1). These microphones are contact microphones sensitive to acceleration. They are built around a piezoelectrical crystal that is suitably damped. Their frequency response curve is straight up to their resonance frequency at 3 kHz where they have a top of ca 6 dB. The two signals (see Fig. II-C-2), one from the nose and the other from the larynx, are processed so that we get two DC signals of different polarities. The positive one is proportional to the larynx pickup, and the negative one proportional to the nose pickup. The positive signal goes directly to the positive threshold detector and to a time integrator. In the two integrators the time each signal is above a preset level is measured. We have in this way two measured time lengths:

\[ t_N \] - the time the weighted nasal signal is above a preset level;
\[ t_L \] - the time the larynx signal is above a preset level.

These time lengths are then computed in the following way:

\[ \%n = \frac{t_N \cdot 100}{t_L} \]

where \( \%n \) means percent nasal.

This measure is then A/D converted and shown on a two-digit display.

Results

A long series of tests has been started, in order to evaluate to what extent this meter satisfied the criteria we had at the beginning. Until now we have used normal speakers, either directly or through tape recordings, soon we will try it on cleft-palate patients.
Fig. II-C-1. The experimental setup with the nasality meter marked with an arrow.
Fig. II-C-2. Block diagram of the experimental setup.
A high degree of reproducibility has been obtained in these measurements. Interesting possibilities appear for grading the relative degree of nasalization of various phonetic elements in normal speech. Later we will run some listening tests to establish a correlation between the subjective and objective measures.

This nasality meter is still on the design stage and a further development in anticipated.