A METHOD FOR TRACING NASALITY

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ABSTRACT

This paper aims to present a method of tracing nasality in speech with a very convenient device also accessible to researchers with only restricted lab facilities. The basic idea lies in using the spectral information represented by the formant pattern in a signal, recorded with a contact microphone attached to the nose.

INTRODUCTION

Due to its difficult accessibility, the description of the movements of the velum has demanded quite some imagination and technology to find appropriate methods for this purpose. Such methods vary from nasal airflow measurements, fiberoptic endoscope [1], velotrace [2], cineradiographic techniques [3] and X-ray microbeam [4] to the description of spectral events in the spectrogram of the speech signal [5, 6 & 7]. However, these methods are either invasive and/or demand valuable and expensive equipment to be effective. Furthermore, some of these devices do not permit an undisturbed simultaneous recording of the speech signal. The use of a contact microphone attached to the outer part of the nose has also been introduced [8]. With the help of such an accelerator microphone, the increase of vibration of the skin at the outer part of the nose, which is due to nasal airflow, can be measured. Interference from the oral signal, however, seems to be an obstacle which makes it difficult to determine whether a certain increase in amplitude of the signal recorded at the nose is related to nasal airflow or whether it originates from the oral signal. Making use of the intensity curve of the nasal signal has been its usual way of analysis: diverging directions of the aligned intensity curves of both the nasal and the oral signal were judged to be an indication of absence of any interference on the nasal signal by the oral signal.

In this paper an additional method will be presented, which makes use of the spectral information of the signal obtained with a contact microphone. Such a method does not give a physiological explanation about the exact behaviour of the velar movements and its relationship to other articulators, as do some of the devices mentioned above, but it aims to provide phoneticians and speech pathologists with a reasonably priced tool to detect onset and offset of nasality in undistorted speech. The analysis procedure of the nasal signal is related to the traditional - visual, auditory and manual - spectrogram analysis of the standard speech signal. Recorded French speech, containing CV, CṼ and CVN sequences, was used to evaluate this method.

PROCEDURE

With a two channel DAT-recorder, the oral and the nasal signal of French speech, spoken by a native male speaker, were recorded, using the contact microphone for the nasal signal. The recorded material contained sequentially read words of French, including CV, CṼ and CVN sequences. Some of those words were e.g. dos, dent, donne, etc.

During the recording procedure, the contact microphone was attached to the upper part of the nose on one side, where the lateral nasal cartilage is found (Figure 1). This location was discovered to be the most appropriate one for achieving a suitable nasal signal [9]. The contact microphone is a lightweight accelerometer named *Hot Spot* made by *K&K Sound Systems.* It consists of a small metallic disc which has a diameter of 12mm and is 0.7mm thick. It is attached to either the nose or - as originally intended - to acoustic musical instruments with an adhesive strip. The frequency response goes from 20-15000Hz. Unfortunately, the producer of the microphone did not provide us with more detailed information about the frequency response of the microphone. It has been reported though, that "any other accelerometer sensitive to vibrations in the frequency region 100-1500Hz could be used to detect nasalization" [9]. However, this microphone is also sensitive above the frequency region of 1500Hz. No preamplifying is needed with this microphone. Such a microphone costs about US$35.

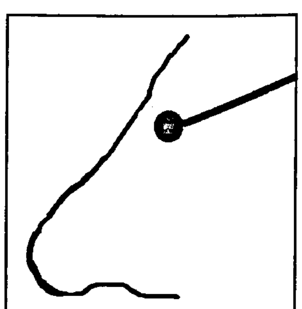

Figure 1. Placement of the contact microphone.

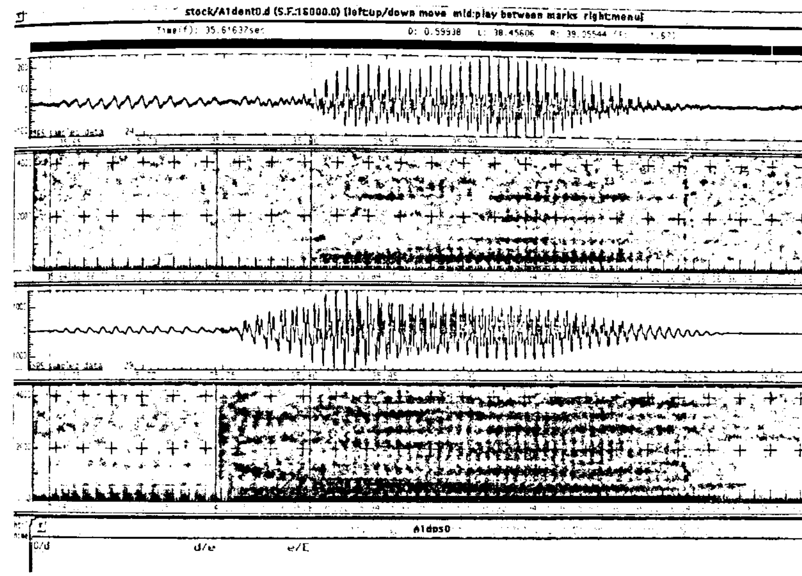

Figure 2. Nasal signal and speech signal representation of the waveforms and the spectrograms and the phonetic labels of the French word dent, in IPA-transcription [dã].

The signals of both channels and their spectra were analysed and displayed in the ESPS/Waves+ environment, and auditory and manual labelling was carried out.

OBSERVATIONS

Figures 2 to 4 present the French words *dent* , *dos* and *donne* in five windows, where the upper one shows the waveform of the nasal channel recorded with the accelerator microphone. In the next window below, the spectrogram of the nasal waveform is displayed. The third window shows the waveform of the general speech signal and its spectrogram follows in the window underneath. In the bottom window, the labels are marked. Here, the vowels should be read as follows, since the ESPS/Waves+ tool does not provide any IPA-font: |o| reads as [o], |e| as [a], |O| as [õ] and |E| reads as [ã].

In the second window of Figure 2, which presents the spectrogram of the nasal signal of the word *dent*, formant structure for the nasal vowel [ã] can be observed. However, the nasalization - presented by such a formant pattern - does not start right from the beginning of the vowel after the release of the voiced stop [d]. This is also audible, when listening to the speech signal. Figure 3, which presents the French word *dos* , does not show any formant structure in the second window at all. This utterance does not contain any nasal vowel or consonant. In Figure 4, however, presenting the word *donne*, formant structure can be observed in the second

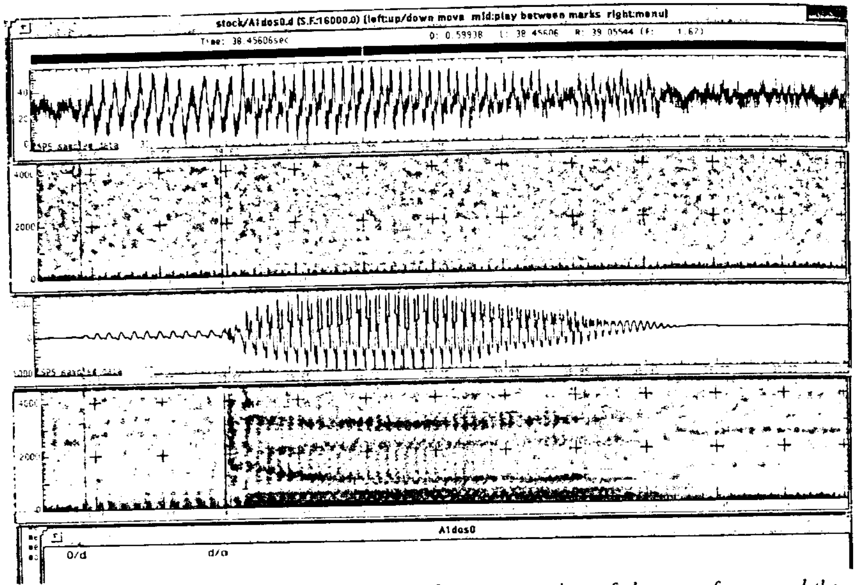

Figure 3. Nasal signal and speech signal representation of the waveforms and the spectrograms and the phonetic labels of the French word dos, in IPA-transcription [do].

window not only during the production of the nasal consonant [n], but also at the end of the phonologically non-nasalized vowel /o/ preceding the nasal consonant. When listening to the speech signal, this portion of the vowel clearly can be heard as being nasalized. Very faint formant structure can be found in the vowel already earlier on (labelled *N*), which also does not start until only later after the release of the voiced stop [d]. This kind of nasal activity is not observable when listening to the speech signal. It could however reflect anticipatory activity of the velum being lowered. Although using the same intensity/grey relationship for the display of the spectrogram of the nasal signal across the utterances, even such faint formant structure does not show up in the complete non-nasal environment (Figure 3).

The use of the spectral information of the nasal signal has its advantages over the use of the intensity curve or the waveform only. Even though one should notice that the amplitude scaling for the nasal signal varies across the utterances, one could be mislead in that periodicity in the waveform with greater amplitude would reflect a lowered velum positioning and therefore a certain degree of nasality. It has been reported in earlier work, that interference with the fundamental frequency and the signal obtained with the accelerometer microphone at the nose is most likely to occur. Using the spectral information of a nasal signal could thus extract such obstacles.

As presented earlier [10], the values of the formants observed in the spectrogram of the nasal signal correspond to the formant values found in the speech signal. The second formant shows a lower bandwidth which denotes a sharper peak correlated with higher ener-gy for the signal obtained at the nose in contrast to the usual speech signal.

CONCLUDING REMARKS

A method of measuring nasality was suggested above by making use of the spectrogram of a signal obtained with a contact microphone attached to the nose. Clear formant structure is visible here in the case of the production of nasal consonants, nasal vowels and at a certain period of time during the production of phonologically non-nasal vowels in the vicinity of nasals. In analogy to the traditional way of spectral analysis this low cost tool is a very convenient in-

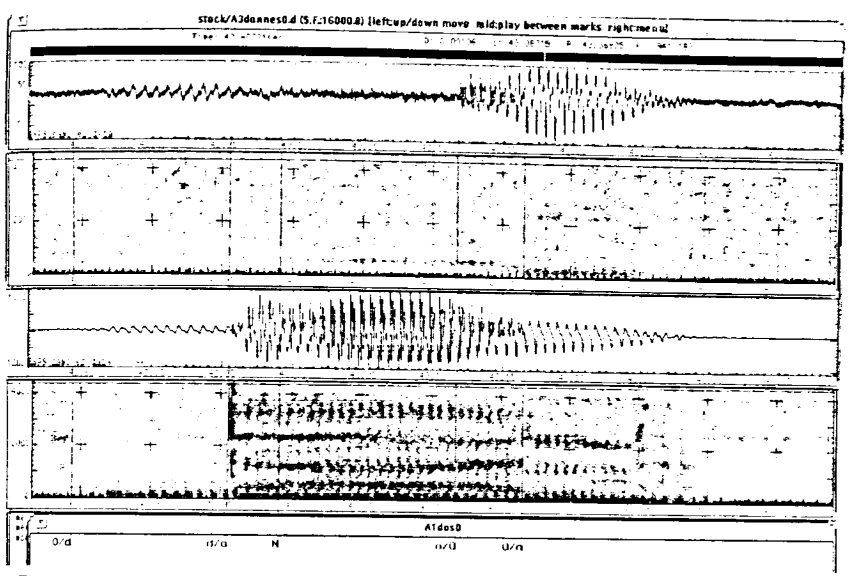

Figure 4. Nasal signal and speech signal representation of the waveforms and the spectrograms and the phonetic labels of the French word donne, in IPA-transcription [dɔn].

strument for phoneticians and speech pathologists who have only limited lab facilities, but have access to spectral analysis tools. For the sake of orientation and alignment, a two channel display showing the nasal signal and the speech signal simultaneously would be preferable.

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