DIRECT AND INDIRECT MEASUREMENTS OF SUBGLOTTIC PRESSURE

D. Demolin[1], A. Giovanni[4], S. Hassid[3], C. Heim[4], V. Lecuit[2], A. Soquet[2]

Universite Libre de Bruxelles,
[1]Department of Linguistics, [2]Lab. of Experimental Phonetics, [3]O.R.L. Unit Hopital Erasme,
[4]O.R.L. Unit Hopital de la Timone Marseille.

RESUME

Nous présentons ici une expérience de mesure simultanée de pression sous-glottique et intra-orale au moyen d'une perforation trachéale. Le but de cet expérience est d'observer les relations entre la pression sous-glottique et intra-orale lors de la production des occlusives du français.

INTRODUCTION

Direct measurement of subglottal pressure can be done through invasive techniques: miniature pressure transducer catheters introduced into the trachea (Kitzing et al. 1975), tracheal puncture (Netsell 1969, Löfqvist 1975, Löfqvist et al. 1982, Hertegard et al. 1995). These techniques being particularly invasive they can only be used in selected experiments with an experienced staff.

The measure of subglottal pressure is necessary in order to measure glottal resistance. Interpolation methods are used to derive subglottal pressure measurements from intraoral pressure measurements (Rothenberg 1982, Löfqvist et al. 1982, Hertegard et al. 1995). In this experiment we use tracheal puncture to obtain direct measurement of subglottal pressure in order to observe the relationship between intraoral pressure and subglottal pressure during phonation of french logatomes.

METHOD

The subject, native speaker of french, was a 43-year old-man with a normal larynx and no voice problems. A simultaneous recording was made of intraoral and subglottic pressures as well as oral and nasal airflows. Recordings were made at the O.R.L. Unit of the Hopital Erasme, University of Brussels. A small fexible plastic tube (ID 2 mm) was inserted through the nasal cavity to the oropharynx, for the measurement of intraoral pressure. A needle (ID 2 mm) was inserted between the cricoid and thyroid cartilages, for the measurement of subglottal pressure. The needle was placed after local anesthesia with 2% Xylocaine, including the subglottal mucosa. The tip of the needle was inserted about 1 cm below the level of the vocal folds. A plastic tube (ID 2 mm) linked to a pressure transducer was connected to the needle. Oral airflow was measured with a flexible silicone rubber mouthpiece. Nasal airflow was measured through an olive inserted in one nostril. The olive was connected to a 0.5 cm platic tube. The tubes and rubber mouthpiece were connected to a Physiologia workstation (Teston and Galindo 1990, 1995) consisting in a PC computer and an acquisition system equipped with various transducers and the signal editing and processing software Phonedit. The subject task was to pronounce and repeat 5 time each of the six stops found in French [p, t, k, b, d, g] first associated to the vowel [a] in isolated logatomes and second in a carrying sentence 'dis CaCa encore'. Phonations were produced with a normal voice quality at a normal speech rate. There were no special instructions for the speaker to control the pitch of the phonations.

RESULTS AND DISCUSSION

Direct measurements

Figure 1 shows the data obtained for one utterance of each of the six logatomes CaCa. The subglottal pressure is superimposed on the

intraoral pressure. The corresponding sound signal is also displayed. For voiceless stops, the subglottal pressure matches the intraoral pressure at peak intraoral pressure. This is not the case for voiced stops, subglottal pressure being higher than intraoral pressure for the whole duration of the logatome.

Figure 2 displays plots of subglottic pressure versus intraoral pressure at peak intraoral pressure for the three voiceless stops. Black dots represent data from isolated logatomes, white dots represent data from carrying sentence. There is no significant difference between isolated logatomes and logatomes in carrying sentence. The systematic shift from diagonal observed may be due to error in captor calibration or measurements.

Indirect measurements

As in Löfqvist et al. 1982, the subglottic pressure was interpolated from the measure of the intraoral pressure in the middle of the vowel. The interpolation is computed from the following measurements: (i) at peak oral pressure from the first stop and (ii) after the first fast initial rise in oral pressure from the second stop. Figure 3 shows the results obtained for both voiced and voiceless stops. The black dots represent the data from isolated logatomes, the white dots represent the data from the carrying sentence. Table 1 and table 2 contain the error in subglottal pressure estimation for voiceless and voiced stops respectively. As expected from Figure 1, the interpolation is not valid for voiced stops. In the case of voiceless stops, the best results are obtained with the logatome [papa].

CONCLUSION

Direct measurement of subglottal pressure provides important information about stop production.
The results of the present experiment indicate that indirect measurement of subglottal pressure in the middle of the vowel between two voiceless stops is valid for our subject in both isolated and carrying sentence context. This may provide an alternative when direct measurement is not possible.

REFERENCES

Hertegard S, Gauffin J, Lindestad P-A, A comparison of subglottal and intraoral pressure measurements during phonation. J. of Voice 1995;9:149-55

Kitajima K, Fujita F. Estimates of subglottal pressure with intraoral pressure. Acta Otolaryngol (Stockh) 1990;109:473-8.

Kitzing P, Löfqvist A. Subglottal and oral air pressures during phonation-preliminary investigation using a miniature transducer system. Med Biol Eng 1975; Sept:644-8.

Koike Y. Sub- and supraglottal pressure variations during phonation In: Stevens K, Hirano M, eds. Vocal Fold Physiology. Tokyo: University of Tokyo Press, 1981:181-91.

Löfqvist A. A study of subglottal pressure during the production of Swedish stops,. J. of Phonetics 1975;3:175-89.

Löfqvist A, Kitzing P, Carlborg A. Initial validation of an indirect measure of subglottal pressure during voicing. J. Acoust Soc Am 1982;72:633-5.

Netsell R. Subglottal and intraoral air pressures during the intervocalic contrast of /t/ and /d/. Phonetica 1969; 20:68-73.

Rothenberg M. Interpolating subglottal pressure from oral pressure. J Speech Hear Res 1982;47:218-24.

Teston B., and Galindo B., Design and development of a work station for speech procuction and analysis. Proc. VERBA 90. International Conference on Speech Technologies. Rome 1990; 400-8.

Teston B., and Galindo B., A diagnostic and rehabilitation aid workstation for speech and voice pathologies. Eurospeech 95, Madrid.

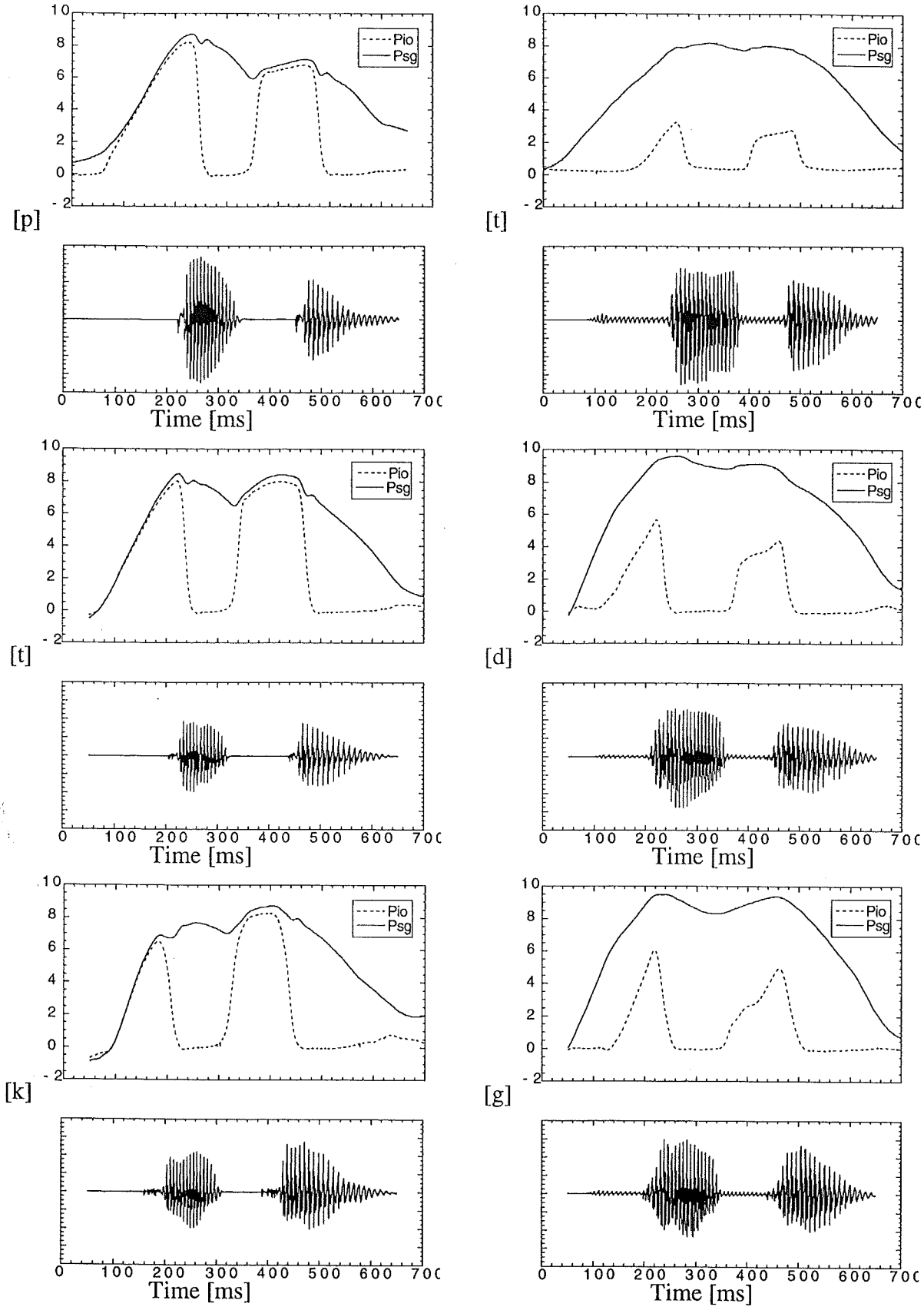

Figure 1: Subglottal (Psg), intraoral pressure (Pio) and sound signal for one utterance of each of the six logatomes CaCa, where C is one stop among [p, t, k, b, d, g].

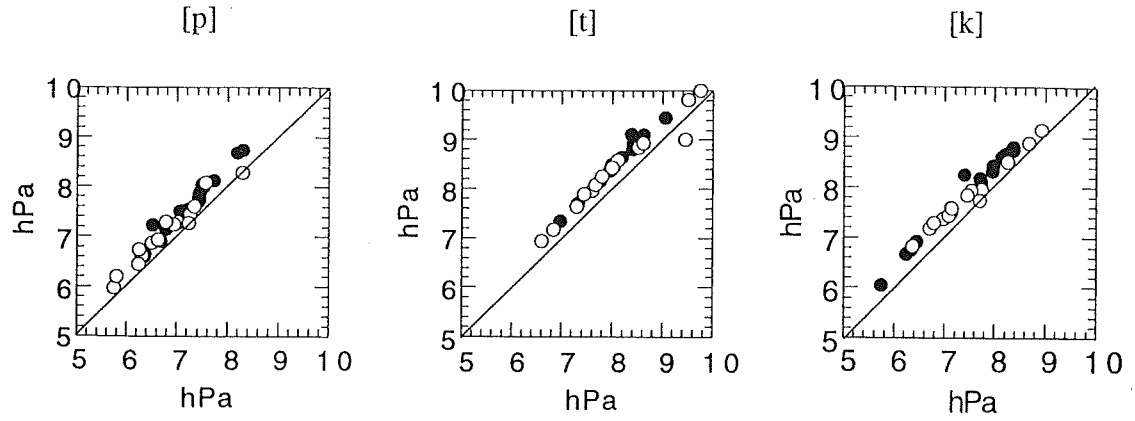

Figure 2: Subglottal preasure versus intraoral pressure in CaCa logatomes (where C is a stop consonant): subglottal pressure on the vertical axis and intraoral pressure on the horizontal axis.

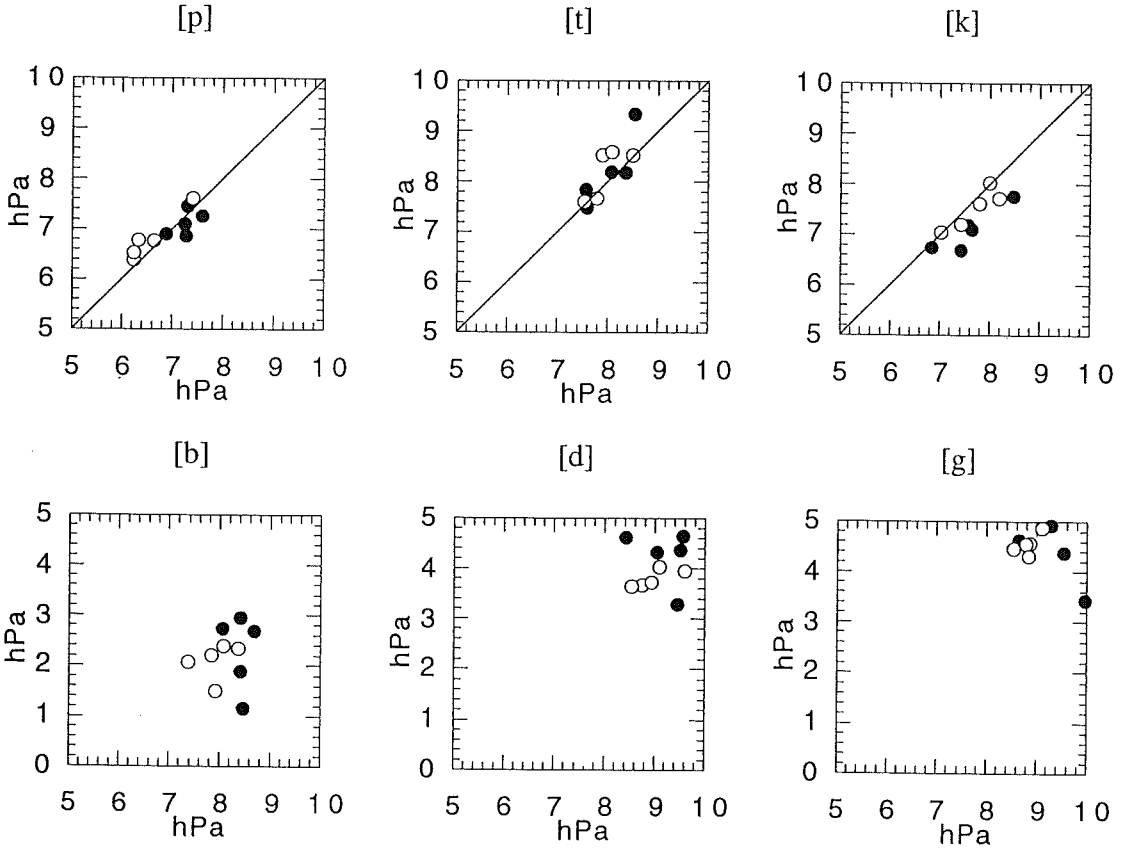

Figure 3: Subglottal preasure estimation for vowel [a] in CaCa logatomes (where C is a stop consonant): estimations on the vertical axis and measures on the horizontal axis.

Table 1: Subglottal preasure estimation error for vowel [a] in CaCa logatomes (where C is is a voiceless stop).

Error [hPa]	[p]	[t]	[k]
mean	0.054	0.204	-0.328
std. dev.	0.276	0.338	0.280

Table 2 Subglottal preasure estimation error for vowel [a] in CaCa logatomes (where C is is a voiced stop).

Error [hPa]	[b]	[d]	[g]
mean	-5.974	-5.070	-4.579
std. dev.	0.638	0.609	0.749