

Laryngeal level and pneumophonic coordination

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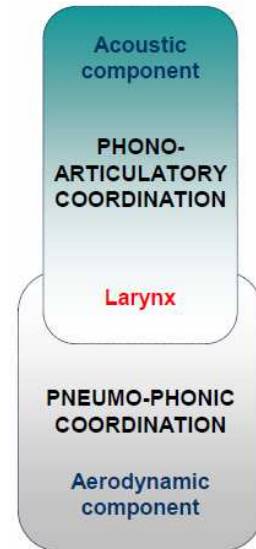
Speech production requires notably the adequate coordination between respiratory and laryngeal activities, namely the pneumo-
phonic coordination.

It is also needed to ensure a good coordination between the laryngeal and articulo-resonatory activities of the vocal tract



Laryngeal level and pneumophonic coordination

- The pneumophonic coordination plays a crucial role in the production of sound pressure level, which contributes largely to speech intelligibility.
- Thus, it appeared important to assess this aspect of speech in Parkinson's disease (PD) since one of the main deficits in hypokinetic dysarthria refers to the reduction of respiratory input (Jiang *et al.*, 1999, *J Voice* 13, 583-591).



Laryngeal level and pneumophonic coordination

- Moreover, effects of subthalamic nucleus (STN) stimulation on dysarthric speech in PD remain erratic and challenging for the clinician.
- Some aspects of dysarthric speech in PD might be responsive to STN stimulation (Pinto *et al.*, 2004, *Lancet Neurol*, 547-556). This modulation could be expected to be at least partially dependent on a deficit in pneumophonic coordination.

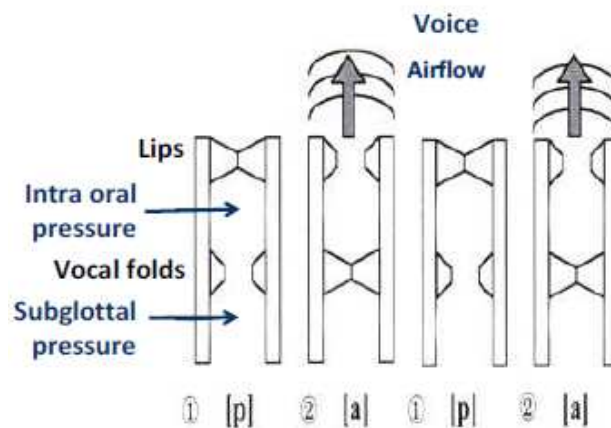


Subglottal pressure and Intraoral pressure

- Subglottal pressure and its temporal course within a sentence production is relevant for evaluating speech motor control, particularly pneumophonic coordination.
- If subglottal pressure is difficult to estimate non-invasively, several methods have been developed and are used to estimate indirectly this parameter (Bard *et al.*, 1992, *Ann Otol Rhinol Laryngol* 101, 578-582; Jiang *et al.*, 1999, *Laryngoscope*, 425- 432; Jiang *et al.*, 2006, *Laryngoscope*, 89-92).
- We decided to measure the intraoral pressure (IOP), which is known to be equivalent to the subglottal pressure during the occlusive consonants (Laukkanen *et al.*, 2006, *J Voice* 20, 25-37), just before voicing

AIM OF THE STUDY

To investigate and quantify the changes induced by STN stimulation on subglottal pressure within the course of a sentence production



PATIENTS AND SUBJECTS

- **50 patients with Parkinson's disease (PD)**
 - Off L-dopa (overnight washout > 12 hours)
 - On vs. Off subthalamic nucleus (STN) stimulation
- **UPDRS motor scores (on and off stimulation)**
- **50 age-matched control subjects**

ACOUSTIC AND AERODYNAMIC ANALYSIS

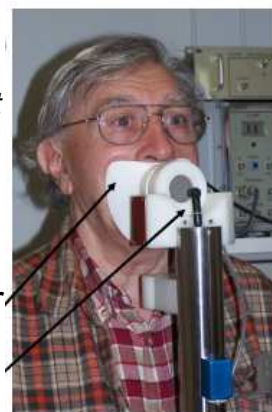
The **EVA** system (Teston & Galindo, 1995 Eurospeech 4, Conference proceedings, 1883-1886) was used for data recording; analysis was performed using the **Sesane** environment (Ghio *et al.*, 2004).



Aerodynamic sensor

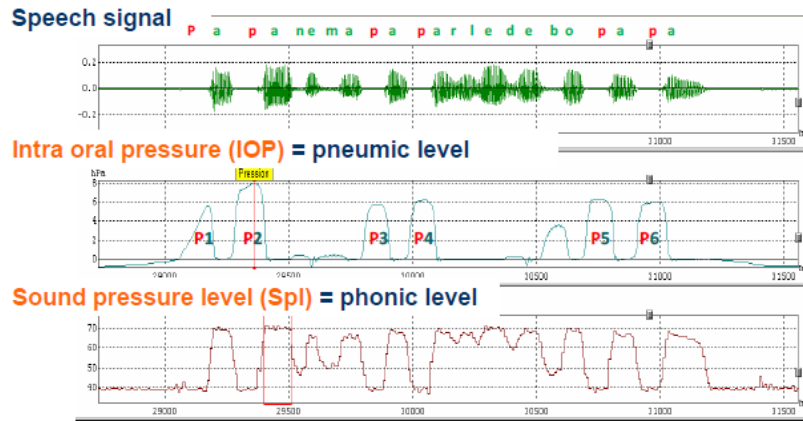
Intraoral tube

Microphone



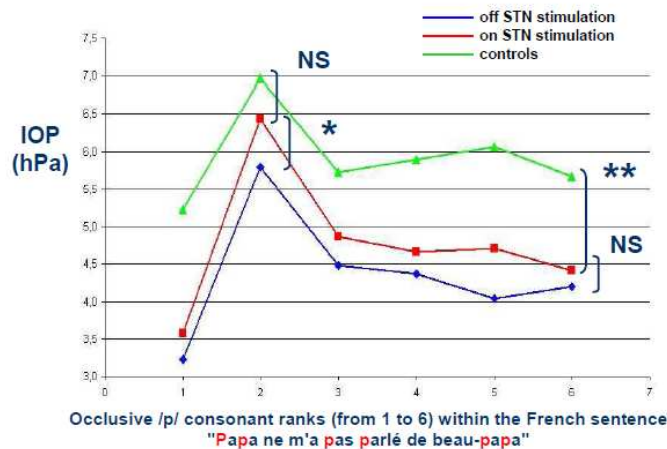
SPEECH PRODUCTION TASK

- Production of the following sentence in French « **PaPa** ne m'a **Pas** **Parlé** de beau-**PaPa** », within which measurements were made upon the 6 /p/ occlusive consonants (see figure below).
- **IOP (hPa)** = subglottal pressure during the occlusive consonant, just before voicing. Control oral airflow is at level 0.
- **Spl (dB)** = vocal intensity during the vowel following the occlusive consonant.



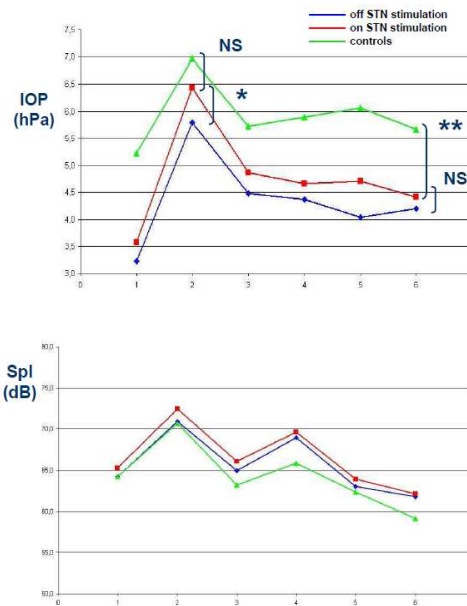
Results

<p>Mean UPDRS global motor scores</p> <p>44 (± 14) off stimulation</p> <p>19 (± 7) on stimulation</p>	<p>Mean UPDRS item 18 (speech)</p> <p>2 (± 0.6) off stimulation</p> <p>1 (± 0.7) on stimulation</p>
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Results

- **CONTROLS** Subglottal pressure needs to reach a threshold and be sustained within a functional window (4-10 hPa) to ensure vocal production.
- **PD OFF stimulation** Akinesia is responsible for an energizing deficit that may impair the ability to reach the IOP threshold and alter the functional window level maintenance. Regarding Spl, patients seem to compensate the IOP decrease.
- **PD ON stimulation** An increase of IOP is observed ON stimulation, compared with the OFF stimulation condition; this effect mimics the L-dopa one; this increase does not reach systematically normal values. Spl is also increased, without statistical significance neither compared with the OFF stimulation condition or the control state.



Discussion

- Does such an improvement of IOP refer to a real improvement of pneumophonic coordination? The pneumatic level argumentation
- **YES:** from a phonologic point of view, the sentence stress point (second consonant P2) reaches the IOP normal range and thus is restored with STN stimulation.
- **NO:** from a temporal point of view, STN stimulation is not able to improve the sentence starting (first consonant P1) and to sustain the adequate IOP level for the latter stages of the sentence production (from P3 to P6). Regarding the phonic level, patients seem to use a compensatory strategy to ensure vocal production with reduced IOP: no statistical differences in Spl have been found compared with the control state; a trend towards significance was however observed between the ON and OFF stimulation conditions.
- Speech intelligibility of PD patients may vary following STN stimulation according to the balance between Spl and IOP performances.

Conclusion

- **IOP appears to be a useful, non-invasive and relevant parameter to be measured in order to assess speech motor control deficits in PD.**
- **Speech production in PD seems to benefit from various motor compensation strategies, as observed for limb movements. However speech motor control, among which is pneumophonic coordination, does not seem to respond totally to STN stimulation; this may participate to the frequent negative modulation of speech intelligibility following the surgical treatment.**

Laryngeal resistance

- Laryngeal resistance (LR) is a parameter able to further document the laryngeal activity by linking two aerodynamic dimensions (Smitheran and Hixon, 1981, J Speech Hear Disord 46, 138-146): **LR** is the ratio between the estimated subglottal pressure (**ESGP**) and the oral airflow (**OAF**).
- As a matter of fact. it is important to consider laryngeal resistance - **LR** - as a means to assess globally and dynamically laryngeal dysfunction in Parkinson's disease (PD).

To determine the aerodynamic relevance of laryngeal resistance in Parkinsonian dysarthria

- **PATIENTS AND SUBJECTS**
- **51 patients with PD** off L-dopa (overnight washout > 12 hours)
- **50 age-matched control subjects**



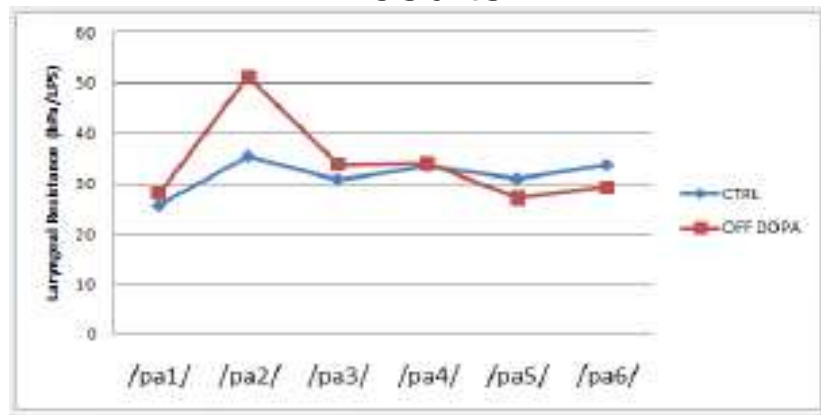
Results

ESGP (hPa) mean (SD)	P1	P2	P3	P4	P5	P6
OFF DOPA	3.84 (1.9)	6.22 (2.2)	4.46 (1.8)	4.7 (1.9)	4.49 (1.9)	4.26 (1.7)
CTRL	5.23 (2.00)	6.97 (2.15)	5.73 (1.90)	5.9 (1.93)	6.06 (1.98)	5.67 (2.00)

OAF (dm³/s) mean (SD)	P1	P2	P3	P4	P5	P6
OFF DOPA	0.2 (0.09)	0.16 (0.08)	0.17 (0.08)	0.17 (0.08)	0.19 (0.07)	0.2 (0.08)
CTRL	0.2 (0.08)	0.21 (0.07)	0.21 (0.07)	0.2 (0.08)	0.21 (0.06)	0.2 (0.06)

LR (hPa.s/dm³) mean (SD)	P1	P2	P3	P4	P5	P6
OFF DOPA	26.05 (20.50)	51.22 (40.14)	33.77 (23.10)	33.99 (21.97)	27.09 (16.27)	29.21 (26.74)
CTRL	25.75 (16.92)	36.38 (13.54)	30.81 (11.83)	33.40 (14.09)	30.84 (11.64)	33.64 (13.51)

Results



- The LR ratio, which displayed a striking increase specifically on the stressed syllable (second /pa/): this data is the result of a supplementary OAF decrease independent from the ESGP reduction possibly reflecting an “active” strained glottis.
- No significant difference was observed for the LR ratio concerning the latter syllables: as if the LR was progressively normalized, whereas the ESGP became stabilized thus resulting in a restored OAF.

Conclusion

- LR, as previously reported for ESGP (Sarr *et al.*, *Revue Neurol*, 2009), can thus be considered as a marker of altered aerodynamic mechanisms in PD dysarthria. It appears to be a useful, non-invasive and relevant parameter to be measured in order to assess speech motor control deficits in PD.
- Speech production in PD seems to benefit from various motor compensation strategies, as observed for limb movements. Vocal forcing may be one of these strategies, leading to an active control of laryngeal activity that have also to deal with the akinetic-rigid PD syndrom.