A longitudinal acoustic study of a phonetic disorder affecting the production of voiced stops

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Context

Written language assessment of a 11-years old boy:

- Sublexical route deficit in reading and writing : **Graphemic substitutions (voiced phonemes → unvoiced phonemes) during reading and orthographic transcription tasks**
- Compensation of the lexical route: formal errors (« guessing » behavior)
- Spoken language: deficit in a repetition of words and nonwords task → **devoicing of the voiced stops** – especially in clusters (**CCV) context**

Questions : **Phonological** or **phonetic** nature of the voicing difficulties?
➔ Errors in both spoken and written language … Problem with the central phonological representations?
➔ Errors more frequent in a complex phonetical context (CCV)… Phonetic trouble impeding the function of the audiophonatory loop during grapho-phonemic conversions (reading) and phono-graphemic conversions (writing)?

Aim of the study :

- **Understanding the nature of the difficulties of the voicing production**

→ **Using acoustical analyses:** Objective observations and measures of the speech productions→ greater comprehension of the articulatory-phonetic production mechanisms and/or conceptual-phonologic mechanisms?

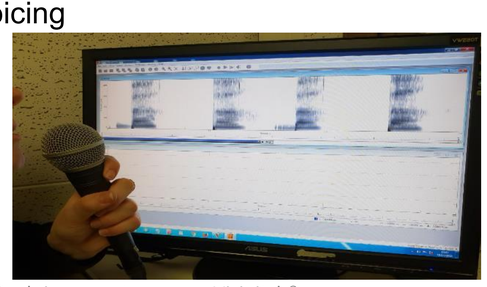
- **Helping the subject to produce (and perceive?) correctly the voiced stops**

→ **Set up of a remediation program:** Establish a correct articulatory gesture/phonemic selection – « old » subject with an excellent spoken language level and little affected by his difficulties, little/none autocorrection behaviors → therapy using biofeedback techniques

Remediation

Training to perceive et product correctly the voiced and unvoiced segments with the use of visual and vibrotactile biofeedback tools.

Phase 1 : listening and repeating voiced /unvoiced words and nonwords with a real-time spectrogram visualization → visual biofeedbacks of the presence/absence of the voicing



« Real time spectrogram » Visipitch®

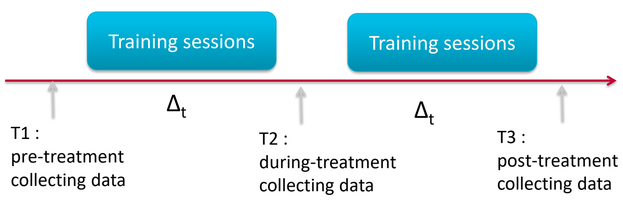
Phase 2 : discrimination and repetition of voiced/unvoiced words and nonwords only with the vibratory sensations perceived with the fingers → vibrotactile biofeedbacks of the presence/absence of the voicing

Oral production vibratory amplification and transmission device (Suvag®)
Pictures from the UMONS Phonetic Laboratory

Data collection method

Pre-, during- & post-treatment

Δ_t = 3 months

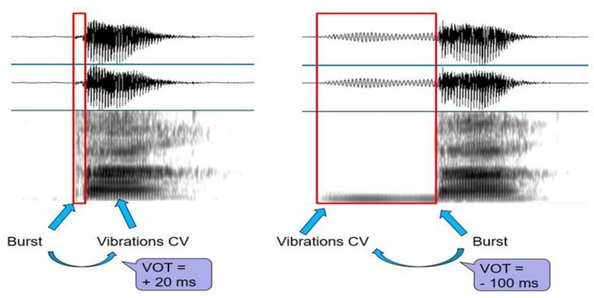


Task

Picture naming – target words including clusters with voiced/unvoiced stops (C1C2 : /tʁ/, (/dʁ/, (/pʁ/, /bʁ/, /pl/, /bl/, /kʁ/, /gʁ/, /kl/, /gl/, /fʁ/, /vʁ/)

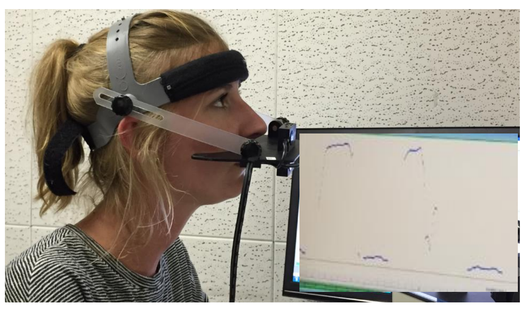
Acoustical analyses

➢ **Quantification of the voiced-unvoiced stops distinction:**
Voice Onset Time = time between the release of the occlusion (burst) and the beginning of the vocal cords vibrations (Lisker & Abramson, 1964)



➔Via Praat (Boersma & Weenink, 2009)

➢ **Quantification of the nazalisation of the productions :**
Nasalance = ratio between the nasal cavity energy and the oral cavity energy



➔Via Nasometer II (KayPentax®)

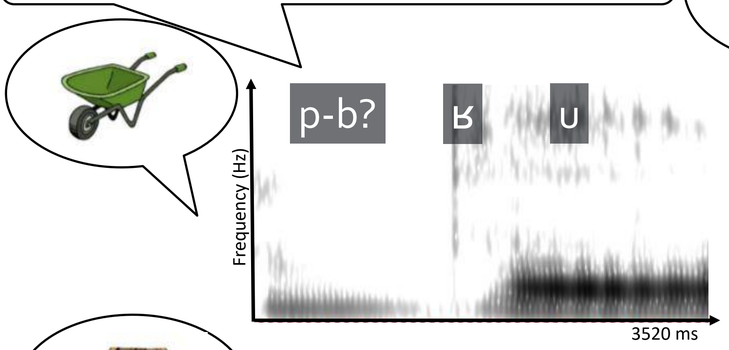
Results

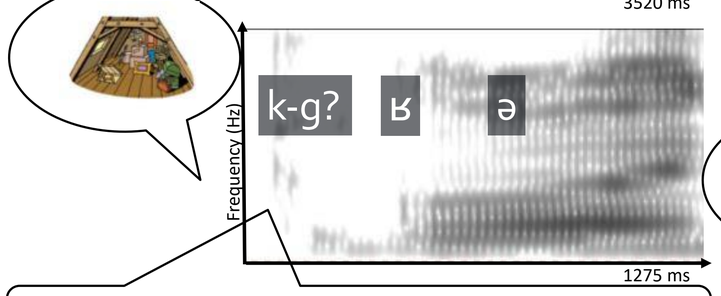
Phonetic disorder ?

Voiced/unvoiced production characterization … Not that easy!

➢ **« Intermediate » productions :** Unvoiced – voiced ?

… despite the presence of a voicing bar!
❑ …but preceding a voicing stop



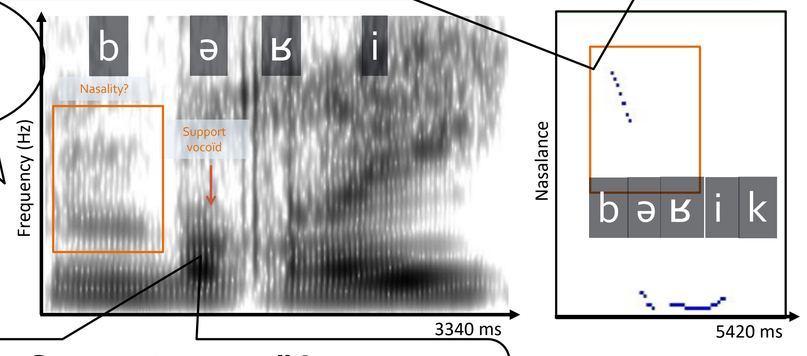


… despite the absence of the voicing bar !
❑ …but preceding a voiced fricative segment

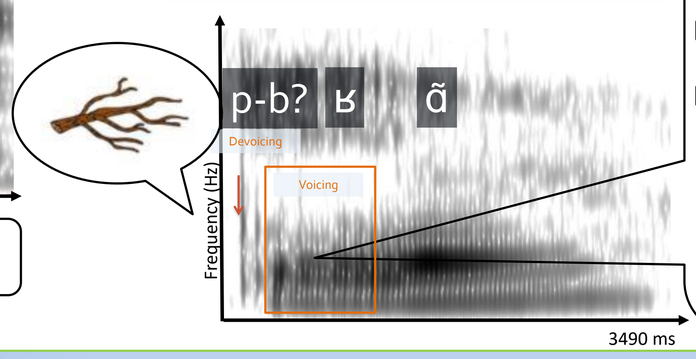
→ **Imprecise articulatory gestures?**

➢ **Compensatory strategies?**

Nasalization : Facilitate the initiation/maintain of the voicing?
❑ Velopharyngeal opening = ↓oral pressure = ↑ vocal cords vibrations (Solé, Sprouse & Ohala, 2008)
❑ Can explain des difficulties in CCV context? : initial voiced stop = velopharyngeal opening >< median fricative /ʁ/ = apposition between base of tongue and uvula

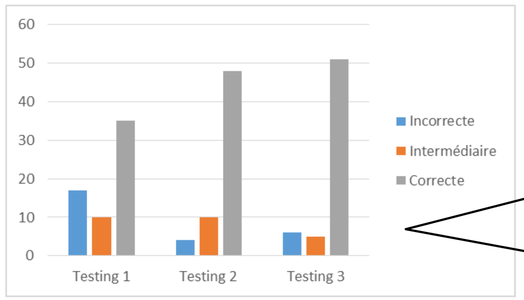


« Support » vocoïd
❑ Simplify the coordination of glottic and supraglottic gestures?



Voicing of the C2 fricative segment
❑ … while C1 is unvoiced!
❑ … attempt of « marking » the voicing despite the difficultlties to produce an initial voiced occlusive stop?

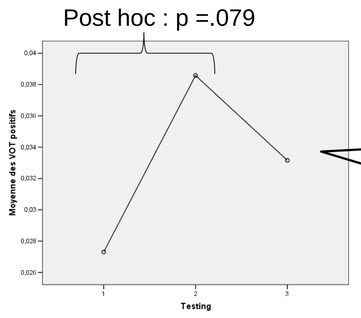
Treatment effects



Subject performances during the three testings

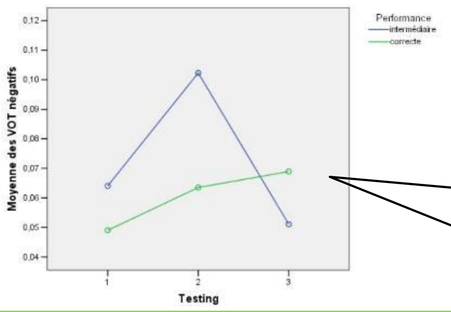
❑ T1 : 56% CR –
T2 : 77% CR –
T3 : 82% CR
→ Significative progression during the testings (F(1) = 1,47 ; p=.002)

VOT values evolution



Means of the positive VOT values (on top) and negative VOT values (above) during the three testings, depending on the type of performance.

❑ Significative extension of the positive VOT values during the testings (27 → 33ms)
❑ (F(2) = 2,687 ; p=.082)



❑ Non significative variations of the negative values during the testings

Discussion and perspectives

The use of acoustical measures in clinical evaluation and remediation

- Greater understanding of the nature and the mecanisms of the difficulties
- Help to personalize the training program and provide an objective measure of the training effectiveness
- The speech production collection is non invasive, inexpensive

A training based on visual and vibrotactile biofeedback can improve the perception/production of the voicing

- Improvement of the hability to produce CV and CCV voiced segments
- Possibility to transfer the spoken language improvement in the written language (normalization of the results obtained by our subject in the written language assessment)

Unvoiced/voiced distinction

- Not that easy!
- Not only cued by the VOT values!
- « Intermediate » productions : what status do they have in clinical evaluation?
- Unnormative productions : are they normal coarticulation effects or real compensatory strategies?

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