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

Fagniart S.1, Delvaux V.1,2, Kuet H.1, Piccaluga M.1 & Harmenegies B.1,
1Language Research Institute, University of Mons, Belgium (UMONS), Belgium - Fonds National de la Recherche Scientifique (FNRS), Belgium
Contact: sophie.fagniart@umons.ac.be

Context

Written language assessment of a 11-year-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 ➔ devolving of the voiced stops – especially in clusters (CCV) context

Questions: Phonological or phonetic nature of the voice difficulties?
- Errors more frequent in a complex phonetical context (CCV)… Phonetic trouble impeding the function of the audiophony loop during grapho-phonemic conversions (reading) and phono-graphematic conversions (writing)?

Aim of the study:
- Understanding the nature of the difficulties of the voice production
- Using acoustical analyses: Objective observations and measures of the speech productions ➔ greater comprehension of the articulatory-phonetic production mechanisms and/or conceptual-phonetic 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 specific language level and little affected by his difficulties, little/no autocorrection behaviors ➔ therapy using biofeedback techniques

Data collection method

Pre-, during- & post-treatment

<table>
<thead>
<tr>
<th>Training session</th>
<th>Time period</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment data</td>
<td>t1</td>
<td>3 months</td>
</tr>
<tr>
<td>During-treatment data</td>
<td>t2</td>
<td>2 months</td>
</tr>
<tr>
<td>Post-treatment data</td>
<td>t3</td>
<td>2 months</td>
</tr>
</tbody>
</table>

Task

Picture naming – target words including clusters with voiced/unvoiced stops (C1C2 – /n/; /kn/, /br/, /bl/, /kl/, /pl/, /gl/, /fl/; /kl/, /gl/, /fl/, /kl/, /gl/, /fl/, /kl/, /gl/, /fl/)

Acoustical analyses

Quantification of the voiced-unvoiced stops distinction:
- Voice Onset Time: time between the release of the articulation (duration) and the beginning of the vocal cords vibrations (Lisker & Abramson, 1964)

Quantification of the nasality of the productions:
- Nasalance: ratio between the nasal cavity energy and the oral cavity energy

Results

Phonetic disorder:
- Voiced/unvoiced production characterization... Not that easy!
- « Immediate » productions: Unvoiced – voiced?
- ... despite the presence of a voicing bar!
- ... but outdating a voicing stop
- Imperceivable articulatory gestures?

Aim of the remediation:
- To improve the perception of voicing among the subjects
- To improve the production of voicing in the children

Compensatory strategies:
- Nasalance: Facilitate the initiation/maintain of the voicing?
- Velopharyngeal opening ➔ vocal pressure 1 ➔ vocal cords vibrations (Lisker & Abramson, 1964)
- Can explain the difficulties in CCV context? Initial voiced stop ➔ velopharyngeal opening ➔ median falcicule ➔ approximation between base of tongue and uvula

T1: 56% CR
T2: 77% CR
T3: 82% CR
Significant progression during the tests (F(1) = 147; p<0.002)

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

References:

Discussion and perspectives

The use of acoustical measures in clinical evaluation and remediation:
- Greater understanding of the nature and the mechanisms of the difficulties
- Help to personalize the training program and provide an objective measure of progress
- The speech production collection is non invasive, inexpensive

A training based on visual and vibrotactile biofeedback can improve the perception/production of the voice:
- Improvement of the habiliy to produce CV and CCV voiced segments
- Possibility to transfer the spoken space 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?

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

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 (SoS™)

Pictures from the UMONS Phonic Laboratory