

The Production of Stops in VCV Sequences in Children with a Cleft Palate An Acoustic Study

Béchet¹ M., Ferbach-Hecker¹ V., Hirsch¹ F., Sock¹ R., Vaxelaire¹ B. & Stierlé² J.-L.

¹*Institut de Phonétique de Strasbourg & Composante Parole et Cognition, E.A. 1339
Linguistique, Langues et Parole (LiLPa) France*

²*Centre Hospitalier Universitaire de Strasbourg – Hautepierre
Department of ENT and Head & Neck Surgery, UH, 1 av. Molière, F-67000 Strasbourg
France*

E-mail : marionbechet@yahoo.fr

Abstract

The present investigation was conducted to examine characteristic features of speech production in children with repaired cleft palate. Acoustic recordings were obtained from 8 ten year old children, characterized by a unilateral posterior (4) or a total (4) cleft palate. Their data were compared with that of 4 healthy speakers of the same age. All subjects produced six French plosives embedded in carrier sentences several times. Stops are difficult to produce for speakers with a cleft lip and/or a cleft palate. Research investigations carried out on this question have revealed that speakers with a cleft palate will use compensatory articulations [1], [2], [3]. Indeed, they use glottal insertions and nasal consonants, since intra-oral pressure is less important [1], [4], [5]. Perceptually, such insertions have characteristics (closure, burst) similar to those of plosives.

Our results reveal significantly longer VOT values for the pathological subjects, especially for children with a posterior cleft palate, regardless of the place of articulation of the consonant. Furthermore, at the qualitative level, it is noted for all pathological subjects that voiceless stops usually present irregular voicing pulses during the supposedly silent phase and a presence of frication during the consonantal hold of the voiced stops.

1 Introduction

The cause of cleft lip and cleft palate formation can be genetic in nature. They are morphological accidents which appear in the second embryonic month. During the first six to eight weeks of pregnancy, the shape of the embryo's head is formed. Five tissues grow; if these tissues fail to

meet, a gap appears where the tissues should have joined [6] [7]. Many different forms of this pathology exist; it can be only lip or cleft palate, or both, unilateral or bilateral. It can vary in size and location.

There are six oral stops in French [p t k] and [b d g]. To produce them, the speaker must temporarily keep the air in the oral cavity before releasing it abruptly. Such sounds could be difficult to produce for speakers with a cleft lip and/or a cleft palate because of problems in obtaining occlusions that are sufficiently tight (lip-lip contact and tongue-palate contacts). It is usually reported in the literature (as in the present study) that the burst of the plosive is not clearly present, and that plosives may have the aspect of a fricative. Such a disability in controlling the closure of the plosive thus affects the nature of the burst-release and, consequently, Voice Onset Time or VOT.

Speakers with a cleft palate will use compensatory articulations [1], [2], [3]. As shown by Powers [8], Lawrence and Phillips [9] or Trost [3], several strategies are deployed by speakers to compensate to their problems. Some may even block sub-glottal air as early as at the glottis, or in the pharyngeal region. Such compensatory articulations allow speakers to create the necessary pressure for the consonant sounds.

Another characteristic of the speech of children with a cleft palate is in the temporal domain; consonantal durations are usually longer than those of the productions of pilot children. A study undertaken by Ha, Sim, Minje and Kuehn [10] testify these findings.

The most persistent problem for speakers with a repaired cleft palate is hyper-nasality due to a short

velum or hypotension of the velum. Consequently, it cannot sufficiently rise to perfectly close the velopharyngeal port. The present acoustic study looks only at the temporal characteristics of oral consonants and is therefore not capable of verifying this hyper nasality phenomenon.

Lindblom [11] described the plasticity of articulatory gestures as being highly malleable and adaptable. He underlines the speaker's ability to reorganize a constrained speech. Speakers adapt thus, acquiring compensatory articulations necessary to the production of the desired sound. This assumption will be verified here, since our speakers are forced to readjust their strategies because of the pathology. Such a problem was also studied by Gibbon and Crampin [12], who noted, using Electropalatography, the use of middorsum palatal stops in speakers with repaired cleft palate (the place of articulation for the [t] and the [k] is neutralised). These authors also showed [13] the use of a labial-lingual double articulation in these speakers when the intended sounds were bilabials.

The productions of these children are also intelligible, but it can be noted from the acoustics, that their productions are not optimal, due to the articulatory strategies.

2 Hypotheses

It is hypothesised that:

- (1) due to problems in obtaining occlusions that are sufficiently tight, lingual plosives, studied here, would have the properties of *fricatives*;
- (2) the corollary to this deficit in tongue-palate occlusions, *Voice Termination Time* (see below) will be longer for pathologic children, as the voicing buzz, after approximate lingual contact, would take a *much longer time to decay*;
- (3) also related to disability in controlling the closure of the plosive, and consequently subsequent release, the *noisy burst-release* would affect the *following vowel*, thus delaying the appearance of a clear formant structure and as a result *an increase in VOT* values;
- (4) the difficulty in controlling occlusions would be reflected, *quantitatively* also, in the acoustic *closure duration*.

3 Method

Acoustic recordings were carried out for ten twelve year old *children*. Four were characterized by a

unilateral posterior cleft palate (named Julie, Frederic, Grégoire and Safia), four by a unilateral total cleft palate (Berfin, Lucas, Elliott, and Tiago). All pathological speakers had been operated (cleft surgery) at the age of 6 months. Their data were compared with that of four healthy speakers of the same age (Laure, Clara, Pierre and Emilie). This gives us three different sub-groups of children, but two main groups, pathological *vs.* control subjects. All subjects produced six French plosives, embedded in carrier words, at least ten times. Here is an example of the *corpus*: “le bâtiment” [ati]; “le radis cru” [adi]; “la cicatrice” [ika]; “la cigale” [iga]; “l'Italie” [ita], etc. Thus in these V¹CV² sequences, vowel context was varied [i] *vs.* [a] and [a] *vs.* [i]; so was voicing contrast [t] *vs.* [d] and [k] *vs.* [g].

Recordings of the pathological subjects were carried out in a quiet room at Hautepierre University Hospital in Strasbourg, using a good quality tape recorder (Fostex FR-2™) and a directive microphone. Data acquisition for the normal group took place in a soundproof room at the Phonetics Institute of Strasbourg for the pilot children. The data examined here were extracted from our cleft palate database which comprises (to day) 54 subjects, from three to eighteen years old.

For each occurrence, overall consonant duration was *measured* as the interval between offset and onset of a clear vowel formant structure of the flanking vowels. Within this consonant hold, two other measures were taken: Voice Termination Time (VTT), which is the delay, after offset of the formant structure of V¹, for voicing decay during the closure of the voiceless stop. VOT was also measured as the interval between burst-release and onset of a clear formant structure for V². Finally, V² was measured.

Analyses are based on absolute and relative values. Relative values served to normalise temporal differences between subject groups, *i.e.*: % of VTT and VOT in the consonantal closure; % of consonantal closure in the VCV sequence; % of V² in the VCV sequence.

4 Main results

All results reported here are based on absolute and relative values. When differences are mentioned, they are significant at $p < .05$. In general, our results provide evidence for the 4 speakers from a given group follow the same tendencies. This finding thus authorised us to compare the results of the different groups.

The apical context

In the apical [t] context, we note that VTT is longer in speech production for speakers with a cleft palate, compared to the healthy speakers. In the [d] context, VTT is longer for speakers with a total cleft palate and shorter for speakers with a posterior cleft palate. In some instances, however, VTT values were similar between cleft palate children and control children ($p=ns$).

In this apical context, VOT values for speakers with a posterior cleft palate are close to those of healthy speakers, contrasting with results obtained for speakers with a total cleft palate: VOT is systematically shorter for speakers with a total cleft palate. This finding suggests that speakers with a total cleft palate find it more difficult to control occlusion duration and the subsequent release (Fig. 3 & 5).

The velar context

The 2 groups of pathological speakers have longer VTT values than control speakers; surprisingly there are the speakers with a posterior cleft palate who show the longest values. At this stage of our analyses, we are unable to account for this finding.

VOT is longer for both pathological groups compared with healthy speakers, in absolute and relative terms. However, only speakers with a posterior cleft palate have significantly superior VOT values (Fig. 4 & 6). Here also, this finding needs further investigations.

Vowel durational values (V^1 and V^2) did not reveal clear-cut results in all consonantal contexts.

Consonantal durations are either longer for cleft palate subjects, compared to control subjects, or both groups reveal similar values, regardless of vowel context ($p=ns$).

5 Conclusions

Blakeley and Brockman [14] have shown that a child with repaired cleft palate will have a normal oral production as well as perfect correct hearing abilities as of the age of 5. In a recent article, Hardin-Jones and Jones [15] affirm, that in spite of immense progress made at the surgical and speech therapy levels, children continue to show weaknesses in the production of speech sounds, requiring particular rehabilitation. Our investigations are related to productions of children who have received speech therapy. If their productions are fairly comprehensible, traces in the acoustic signal, however, indicate residuals of perturbed productions of certain sounds.

Qualitatively, the acoustic signal contains more fricative noise in cleft palate children than in control subjects, for plosives, be they voiced or voiceless (Fig. 1 & 2). This corroborates *hypothesis n°1*.

Quantitatively, VTT and VOT reveal higher values for pathological children (especially the speakers with a posterior cleft palate). In line with *hypotheses 2 and 3* respectively, such results confirm the difficulty in obtaining tight apical and velar closures. However, V^2 was not affected, in durational terms, by the remarkable burst-release specific to cleft palate children, as expected in *hypothesis 3*. This means that VOT takes up a higher proportion in the consonantal hold.

Differences in consonantal closures show *tendencies* for longer durations in cleft palate subjects, thus partially confirming *hypothesis 4*.

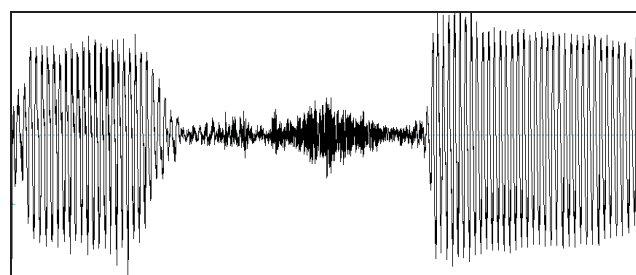


Figure 1: acoustic signal from the speaker Elliott (with a total cleft palate) for [ati] in "le bâtiment"

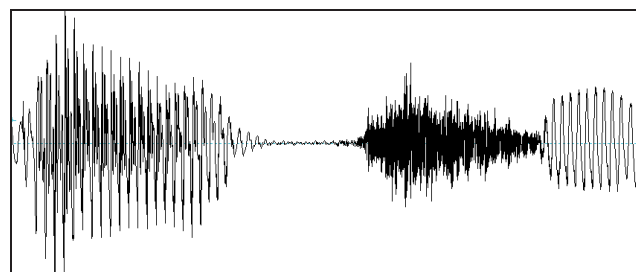


Figure 2: acoustic signal from the speaker Pierre (healthy speaker) for [ati] in "le bâtiment"

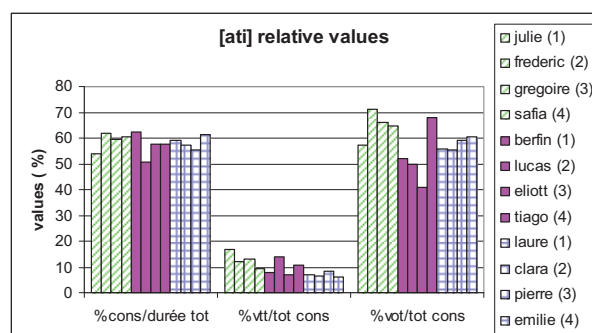


Figure 3: Absolute values for the sequence [ati] in "le bâtiment" for the 3 groups of speakers (children with a posterior cleft palate, with a total cleft palate and non pathological children)

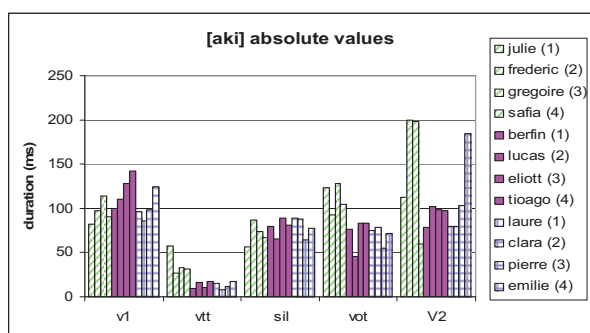


Figure 4: Absolute values for the sequence [aki] in "c'est à qui ça" for the 3 groups of speakers (children with a posterior cleft palate, with a total cleft palate and non pathological children)

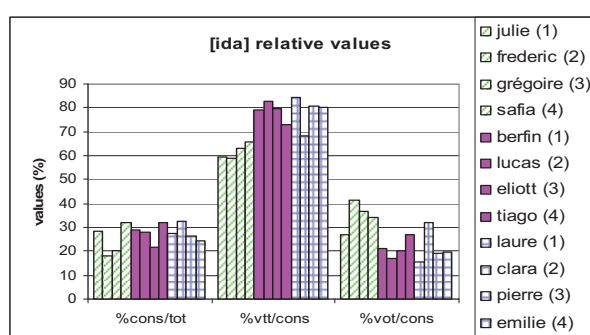


Figure 5: Absolute values for the sequence [ida] in "formidable" for the 3 groups of speakers (children with a posterior cleft palate, with a total cleft palate and non pathological children)

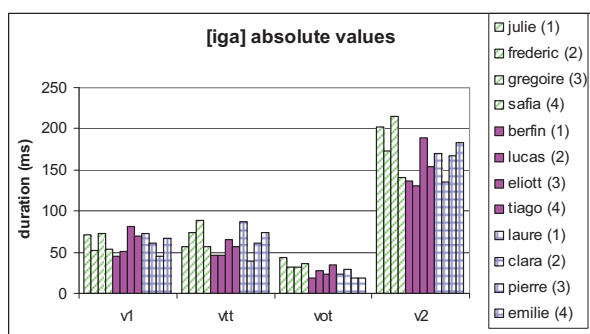


Figure 6: Absolute values for the sequence [iga] in "la cigale" for the 3 groups of speakers (children with a posterior cleft palate, with a total cleft palate and non pathological children)

6 References

- [1] Mc Williams B.J., Morris H., Shelton R., *Cleft Palate Speech*, Philadelphia: BC Decker, 1990
 [2] Gibbon F., Ellis L., Crampin L, Articulatory placement for /t/, /d/, /k/ and /g/ targets in school age children with speech disorders associated with cleft palate. *Clin. Linguist Phon.*, 18(6-8): 391-404, 2004

- [3] Trost J., Articulatory additions to the classical description of persons with cleft palate, *Cleft Palate Journal*, vol. 18, 230-239, 1981
 [4] Chapman Kathy L., Phonologic Processes in children with cleft palate, in *Cleft palate-Craniofacial Journal*, vol.30, n. 1, 64-72, 1993
 [5] Russell J, Grunwell P. Speech development in children with cleft lip and palate. In: Grunwell P, ed. *Analysing Cleft Palate Speech*. London: Whurr Publishing: 19-47, 1993
 [6] Thibault C., Vernel-Bonneau F, Les fentes faciales, Masson ed., collection orthophonie, 1999
 [7] Stemmelin M., L'insuffisance vélaire dans le cadre des fentes palatines: aspect orthophonique, mémoire d'orthophonie, Strasbourg, 1996
 [8] Powers G., Cinefluorographic investigation of articulatory movements of selected individuals with cleft palate, *Journal of speech and hearing disorders*, vol 40, 106-114, 1962
 [9] Lawrence C., Phillips BJ., A telefluoroscopic study of lingual contacts made by persons with cleft palate defects, *Cleft Palate Journal*, vol 12, 84-94, 1975
 [10] Seunghee H., Hyunsub S., Minje Z., and Kuehn P.D., An acoustic Study of the Temporal Characteristics of Nasalization in Children with and without Cleft Palate, *Cleft Palate-Craniofacial Journal*, vol.41, n°5, 535-543, 2003
 [11] Lindblom B., The Status of Phonetic Gesture. In *Modularity and the Motor Theory of Speech Perception* ed. by Mattingly, Ignatus M. and Michael Studdert-Kennedy, 7-24, 1991
 [12] Gibbon F.E., Crampin L., An Electropalatographic Investigation of Middlesum Palatal Stops in an Adult With Repaired Cleft Palate, *Cleft Palate-craniofacial Journal*, 2001, vol 38., n°2, 96-105
 [13] Gibbon F.E., Crampin L., Labial-Lingual Double Articulation in Speakers With Cleft Palate, *Cleft Palate-craniofacial Journal*, 2006, vol 39., n°1, 40-49
 [14] Blakeley R.W., Brockman J.H., Normal speech and hearing by age 5 as a goal for children with cleft palate: a demonstration project, *Am J. Speech Language Pathol*, vol 4, 25-32, 1995
 [15] Hardin-Jones M.A., Jones D.L., Speech Production of Preschoolers With Cleft Palate, *Cleft Palate-craniofacial Journal*, Vol 42, n°1, 2005

Acknowledgements: This research was supported by grants from the Maison Interuniversitaire des Sciences de l'Homme-Alsace (MISHA), 2005-2008 (ACM) and AN-07-CORP-018-01-DOCVACIM, 2008 – 2012. Funds also came from the Région d'Alsace.