Fricative Spectra in Normal and Hearing Impaired Children with Cochlear Implant

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Introduction

- In this study, similar parameters to those proposed by Jesus and Shadle (2002) were used to compare the production of fricatives by the two groups of speakers.
- The parameters consist of measurements of spectral slope and are applied to the spectrum of the far field acoustic signal.
- Using a multitaper technique, 11ms windows were centred at mid fricative position to produce the spectra.

Introduction

- Two linear regression lines were fitted to the spectrum and the following parameters were extracted:
  - **S´p** for the low frequency slope (slope of the first regression line);
  - **Sp** for the higher frequency slope (up to 20 kHz) line fit.
- If we analyse the previous definitions and relate them with information regarding articulatory performance and acoustical parameters, several predictions can be made, as shown in Table 1 (Jesus and Shadle 2002).

Introduction

Phonetic class	Acoustic effects	Predictions
Sibilants (relative to non sibilants)	Localized source; Higher source strength.	S´p higher Sp lower
Posterior place (relative to more anterior place)	Longer front cavity	S´p higher Sp Same
Unvoiced	Higher source strenght	S´p higher Sp higher
Voiced	Lower source strenght	S´p lower Sp lower

Table 1. Predicted effects on various speech parameters.

Introduction

- The parameter ***Sp*** should be related to the source strength.
- The behaviour of parameter ***S´p*** should be correlated with place of articulation or source strength, i.e., an increase in ***S´p*** corresponds to a more posterior place or greater source strength (Jesus and Shadle 2002).

Introduction

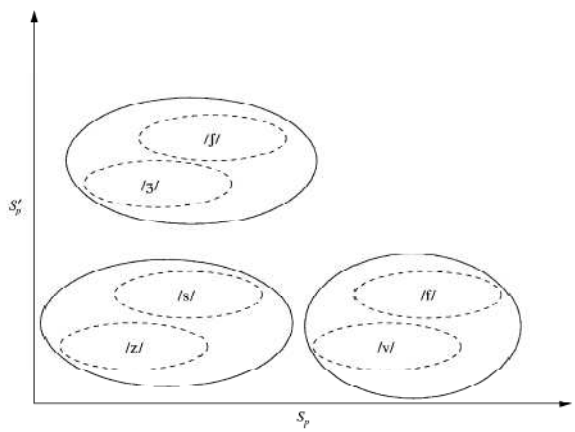

Figure 1. Predicted S´p vs. Sp relations for the fricatives. From Jesus and Shadle (2002).

Method

- The corpus used in this study included a total of 25 CVCV dissyllabic words, with fricatives in middle word position.
- Most target sounds (fricatives and vowels) were in an unstressed position.
- Acoustic and EGG signals were recorded simultaneously for the fricatives /f, s, S, v, z, Z/.
- The fricative spectral slope was investigated by fitting the spectra with two linear regression lines.

Method

- **Speakers**

Table 2: Demographic data of the children used in the study

Inf	Gen	Etiology	PTA	SD	AD	AI	CA	CI Exp	M.C.
TG	F	Congenital	85 dB	Pre-lingual	0;9	1;10	5;1	3;3	Oral
JB	F						4;10		
ML	F	Congenital	90 dB	Pre-lingual	0;9	2;1	6;3	4;2	Oral
MS	F						6;9		
MP	M	Bacterial Meningitis 16 M	95 dB	Pre-lingual	1;4	2;2	9;3	7;1	Oral
RV	M						9;9		
JC	M	Congenital	95 dB	Pre-lingual	0;8	2;3	11;2	8;9	Oral
JT	M						10;5		

Method

Recording :

- The speakers sat in front of a Behringer ECM8000, omnidirectional microphone, placed at a distance of 40 cm from the lips.
- An electroglotography (EGG) signal was also collected using an EGG processor (model EG2-PCX, Glottal Enterprises, USA), with 28 mm electrodes (paediatric size).
- The acoustic signal was recorded simultaneously with the EGG signal via an external sound card connected to a laptop computer (16 bits, 44.1 kHz sampling frequency).
- The recordings took place in an ABS-AUD.45.1 (Absorsor, Portugal) sound booth, with 45 dB sound reduction.

Method

- **Segmentation and Annotation**

The annotations consisted of (as shown Figure 2): preceding vowel start (1), fricative start (2), fricative middle (3), fricative end (4) and succeeding vowel end (5).

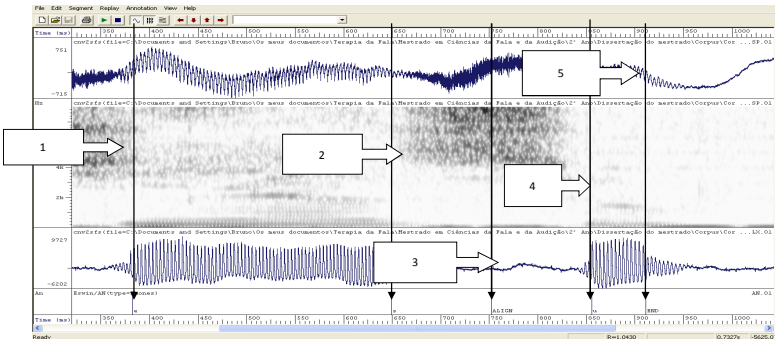

Figure 2. Annotation of the VCV sequence in the word ["Zesu].

Results

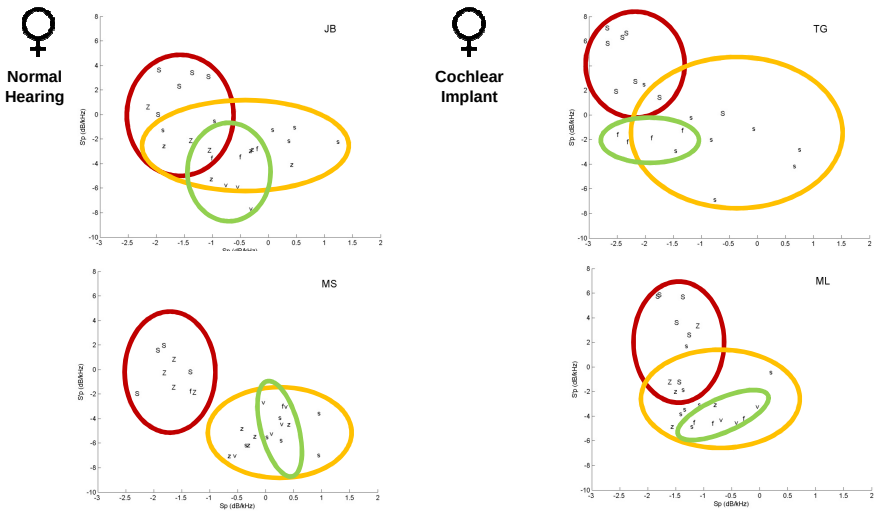

Figure 3: Low frequency (S'_p) slope versus high frequency (S_p) slope.

Results

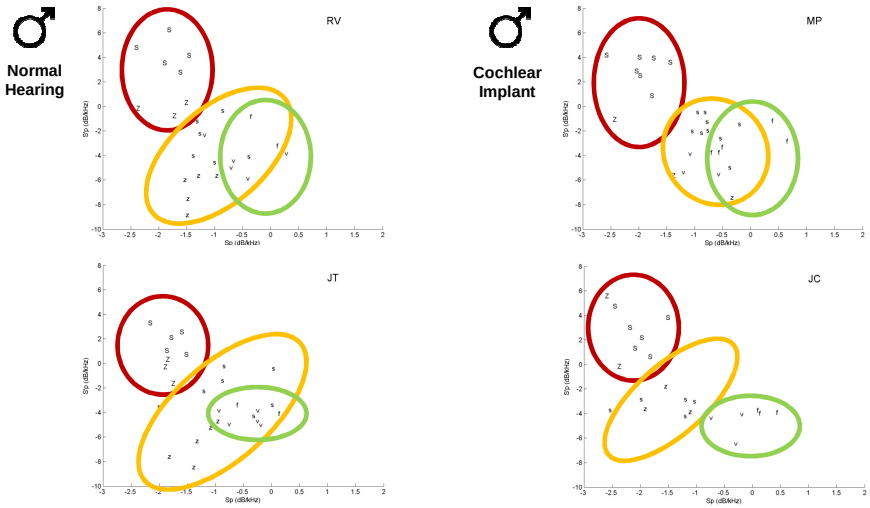

Figure 4: Low frequency (S'_p) slope versus high frequency (S_p) slope.

Results

- Spectral slope parameters behaved similarly for both groups regarding changes in place and sibilance.
- However, voicing predictions (unvoiced fricatives possess a more intense sound source and therefore have higher spectral slope values) were only present in normal hearing children.

Conclusions

- Results showed the individual capabilities of deaf children with cochlear implant to correctly produce place and sibilance, and deviant (regarding voicing mechanisms) voiced fricative production.

Acknowlegements

- This work was developed during the first author's M.Sc. in Speech and Hearing Sciences at the Universidade de Aveiro, Portugal.