

A comparative acoustic study on speech of glossectomy patients and normal subjects

Xinhui Zhou, Carol Y. Espy-Wilson

Department of Electrical Engineering, University of Maryland, College Park, USA

Maureen Stone

Departments of Neural and Pain Sciences and Orthodontics, University of Maryland Dental School, Baltimore, USA

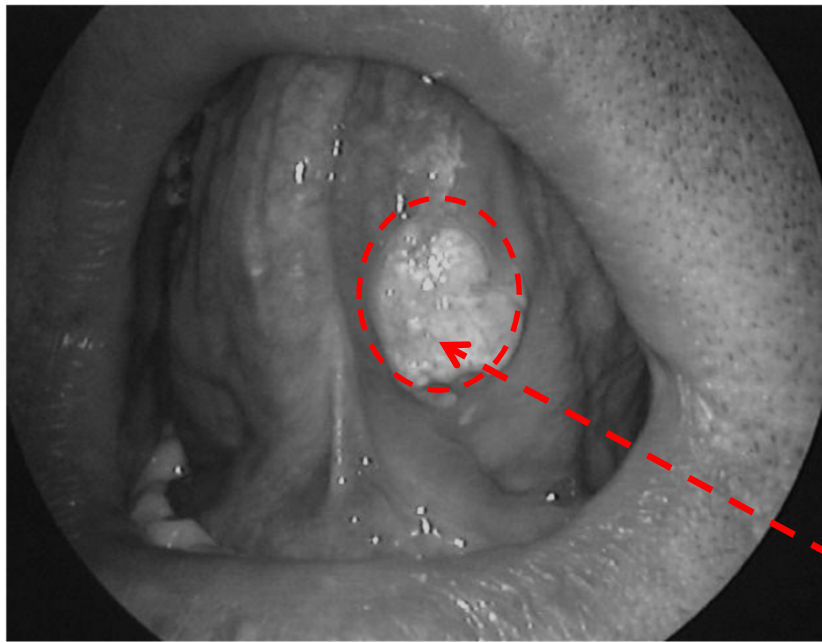
INTERSPEECH 2011

Aug. 29th, 2011, Florence, Italy

Introduction

- Oral, head and neck cancer represents 3% of all cancers in the United States (about 36,000 cases in 2010), the 6th most common cancer worldwide. (American Cancer Society, 2010)
- Most of the cancer in oral cavity are related to the tongue.
- Increase in tongue cancer is 5-fold among young men and 6-fold among young women, based on tumor registry data of four European countries from 1960 to 1994 (Annertz et al., 2002)
- Tongue cancer patients often are treated by glossectomy, a surgery to remove the tumor (T1: ≤ 2 cm in the largest dimension, T2: 2-4 cm, T3: > 4 cm, T4: invades adjacent structures)

A glossectomy patient before surgery (T1 tumor)

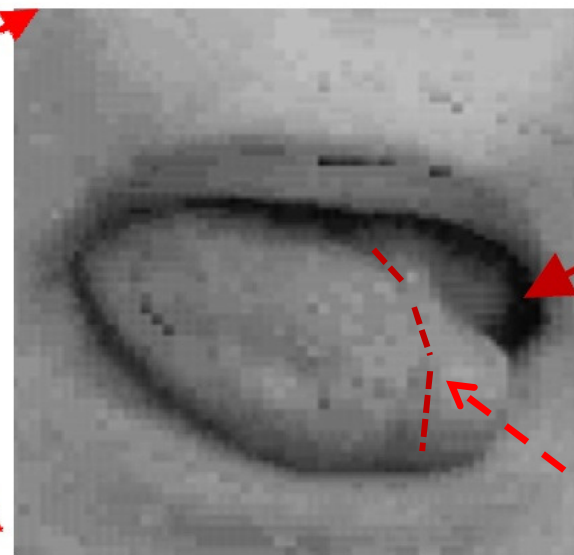
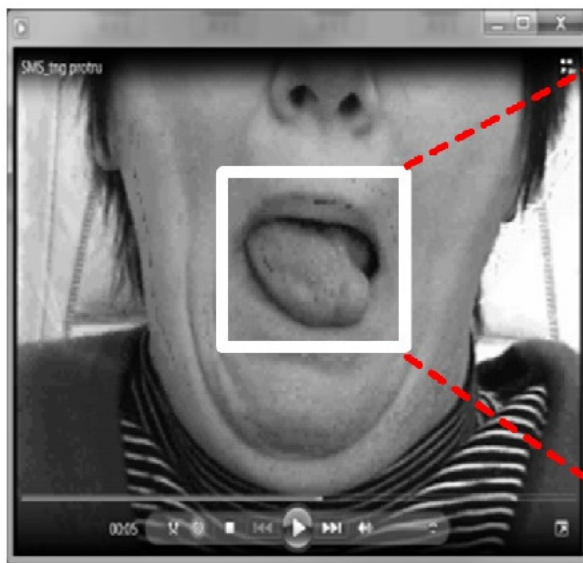


T1 tumor

Ref:

http://www.entusa.com/oral_pictures_htm/tongue_cancer_2.htm

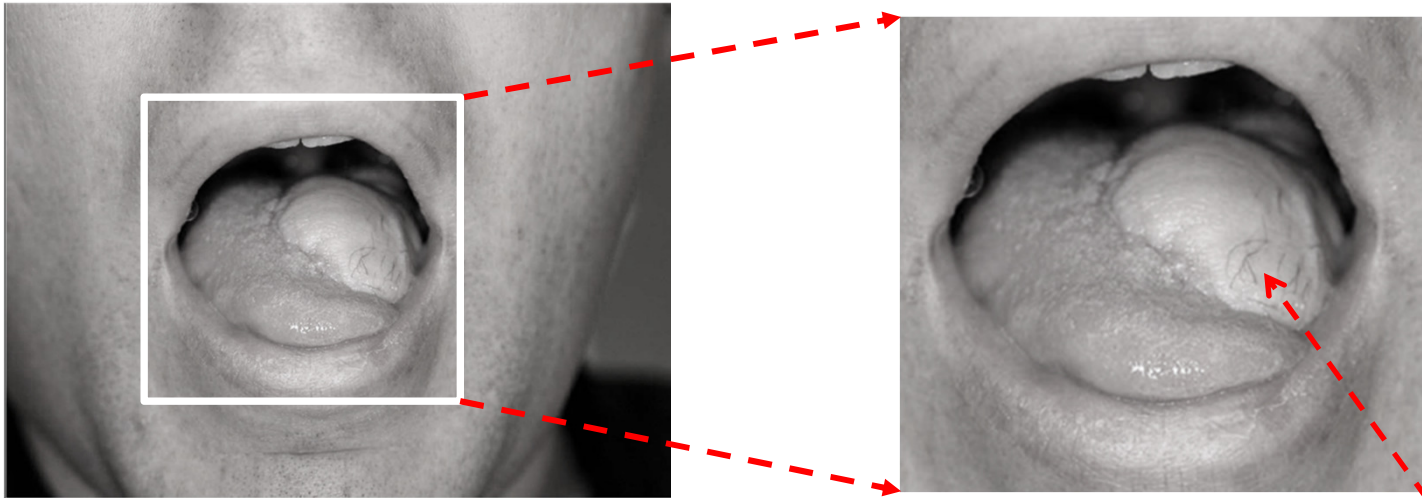
A glossectomy patient (T1) with primary closure



Location of resection

Midline of the tongue

A glossectomy patient (T2) with a flap



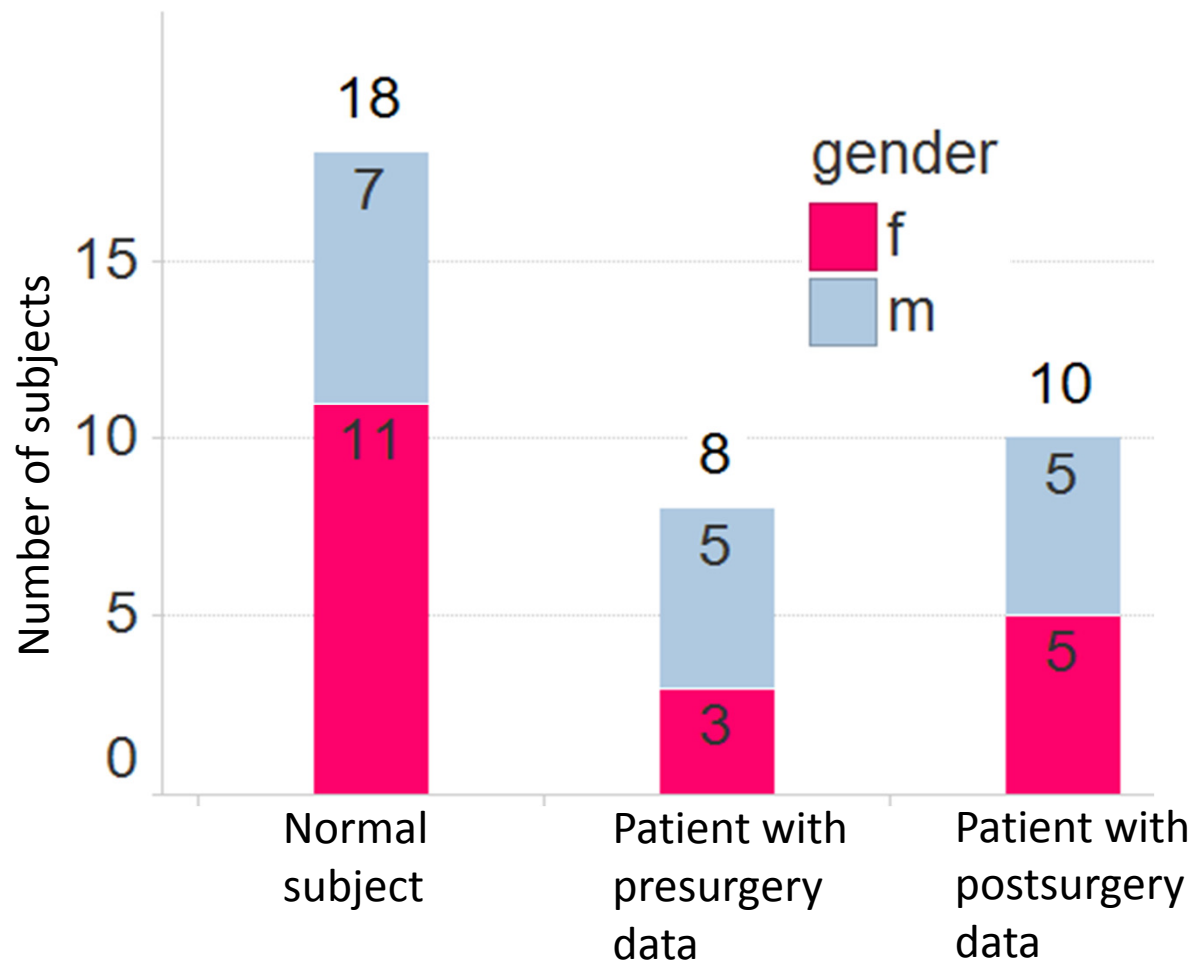
Flap

Objectives

- To assess how the speech signal is changed as a result of the differences in speech production between normal subjects and pre- and post-glossectomy patients.
- To model the vocal tract acoustics of the glossectomy patients.
- To couple this study with the larger ongoing project -- aimed at understanding the tongue muscle mechanics and tongue motion patterns of glossectomy patients – to provide clinical guidance.

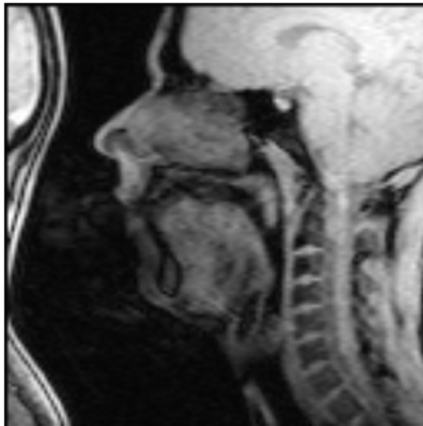
Database

- 18 normals , and 16 patients with T1 or T2 tumor on lateral part of the tongue.



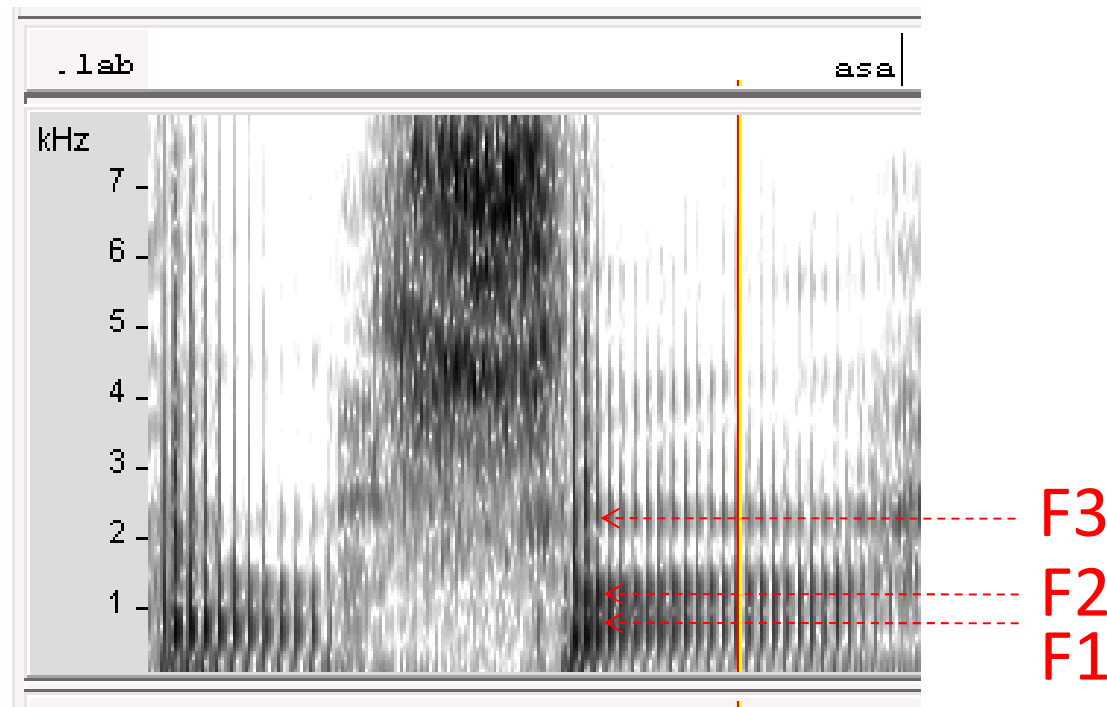
Database

- Speech data
 - Vowel-consonant-vowel (VCV) words (e.g., “isi”, “ishi”...)
 - Vowels: /iy/, /ah/, /uw/, /eh/.
 - Consonants: /s/, /sh/, /g/, /l/.
 - Each word repeated at least 3 times.
- Cine-MRI image data for the tongue shape



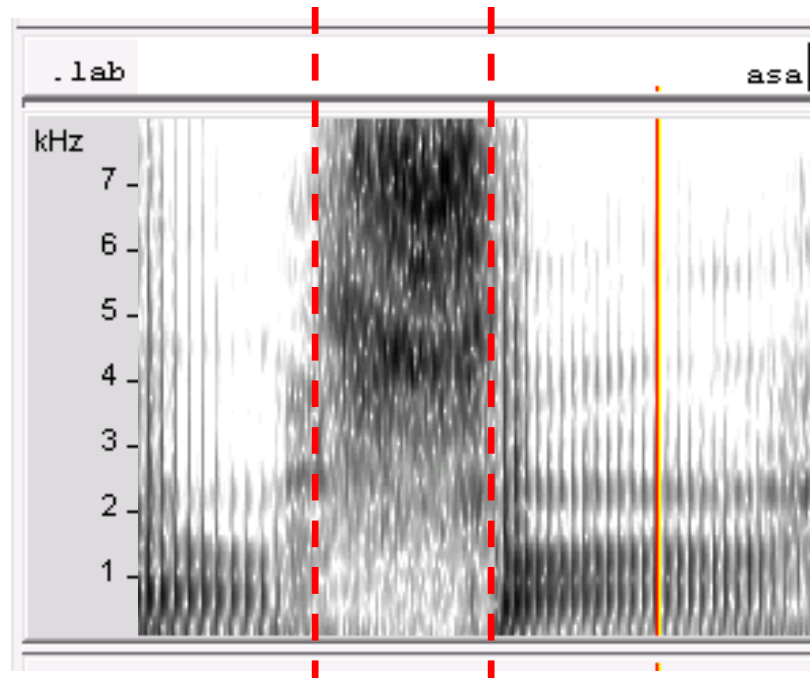
Acoustic measurement of vowels (F1-F3 of /uw/, /eh/, /iy/, /ah/)

/ah/ in “asa”



Acoustic measurement of fricatives (/s/ and /sh/)

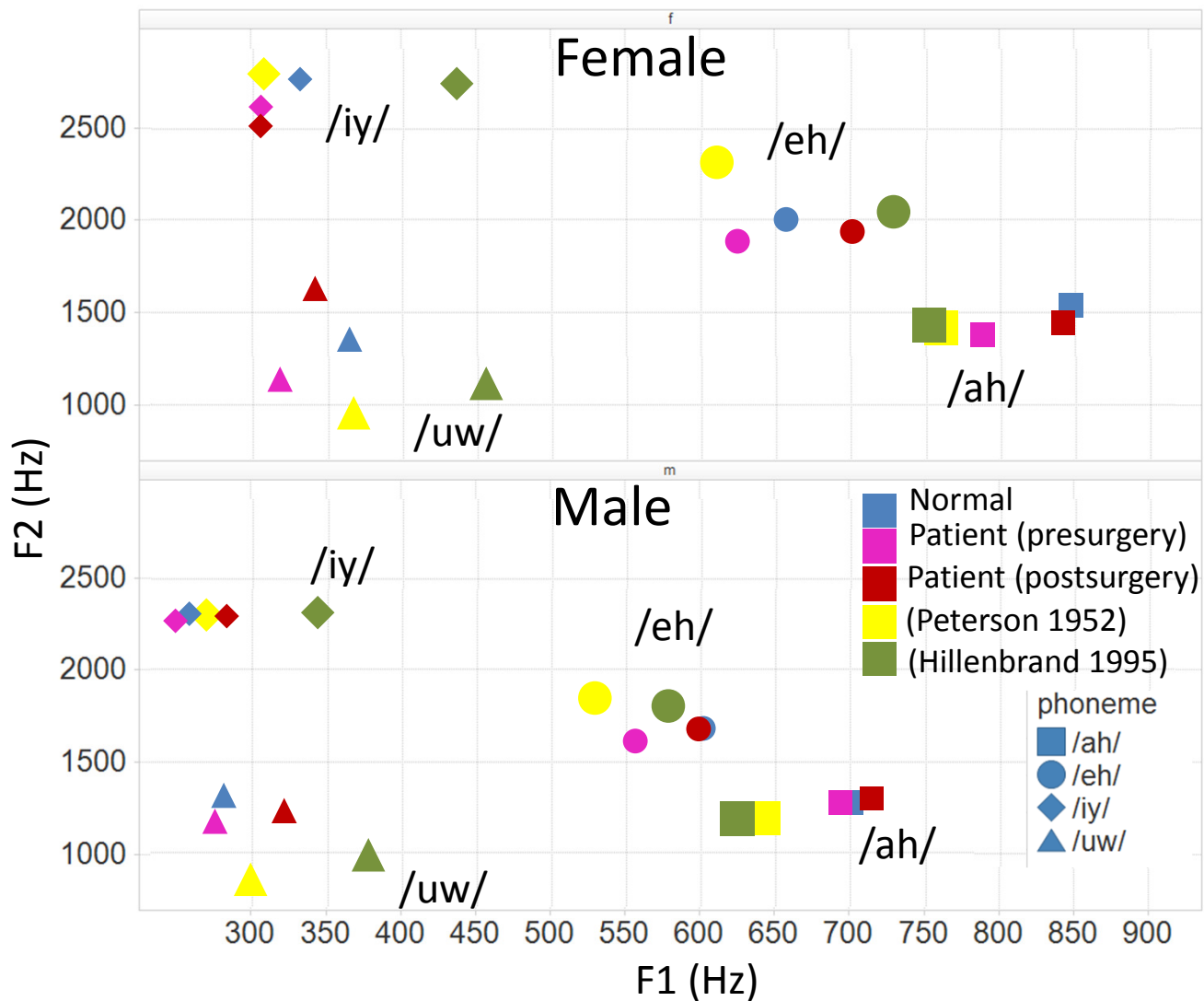
/s/ in “asa”



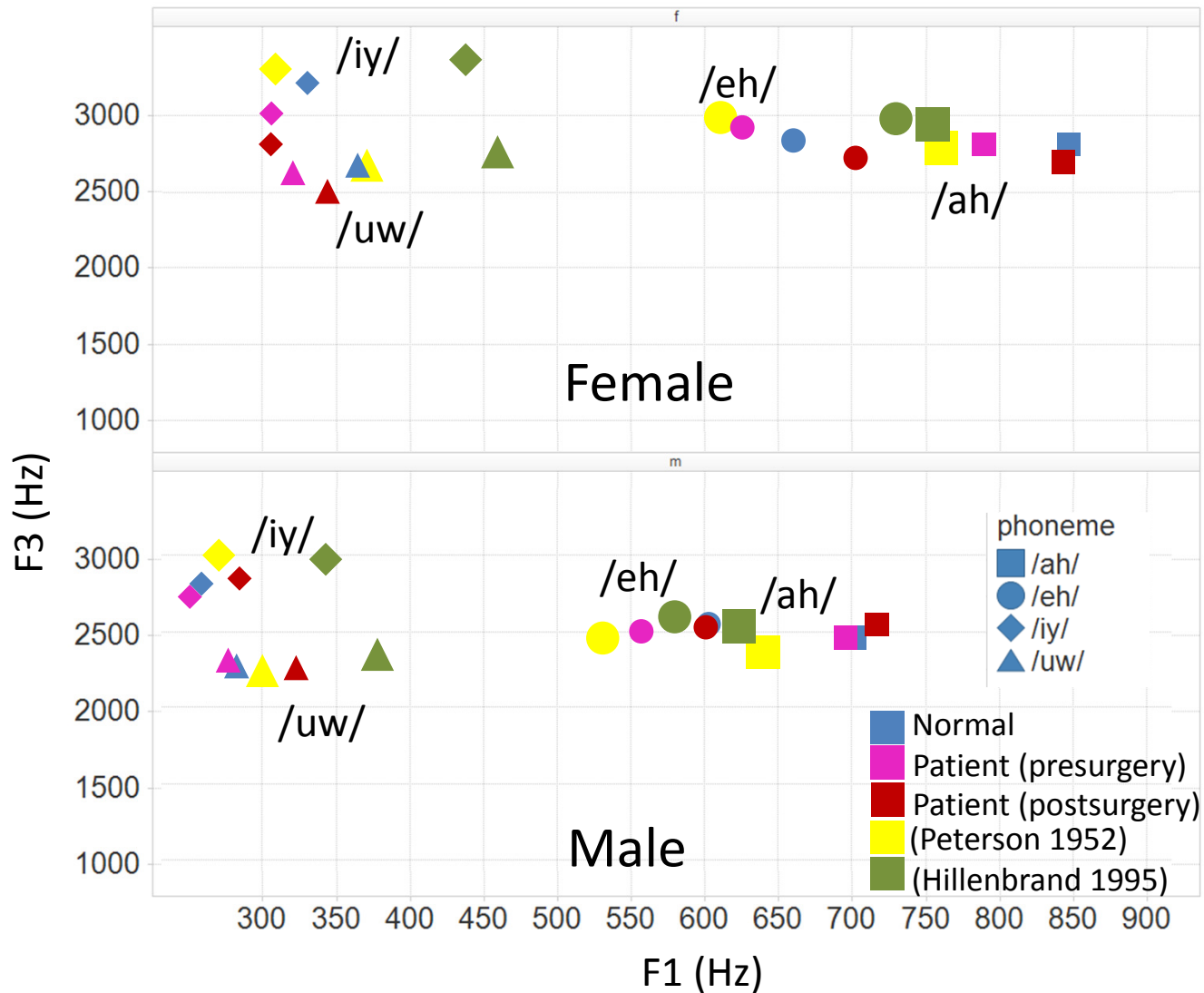
- Center of gravity $f_0 = \int_0^\infty f |S(f)|^2 df / \int_0^\infty |S(f)|^2 df$

- Skewness $\int_0^\infty (f - f_0)^3 |S(f)|^2 df / ((f - f_0)^2 \int_0^\infty |S(f)|^2 df)^{1.5}$

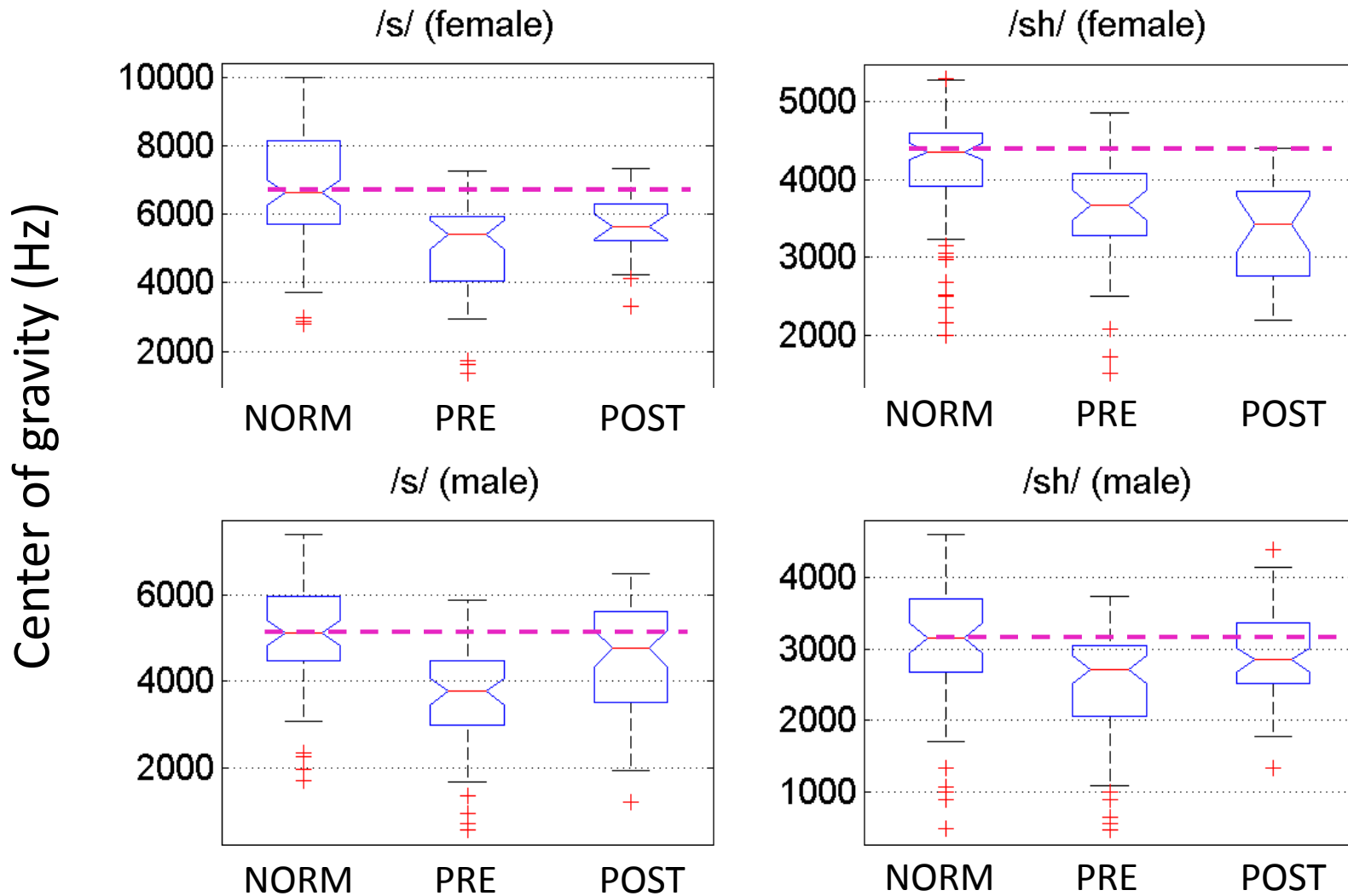
F1 and F2 of vowels (/uw/, /eh/, /iy/, /ah/)



F1 and F3 of vowels (/uw/, /eh/, /iy/, /ah/)

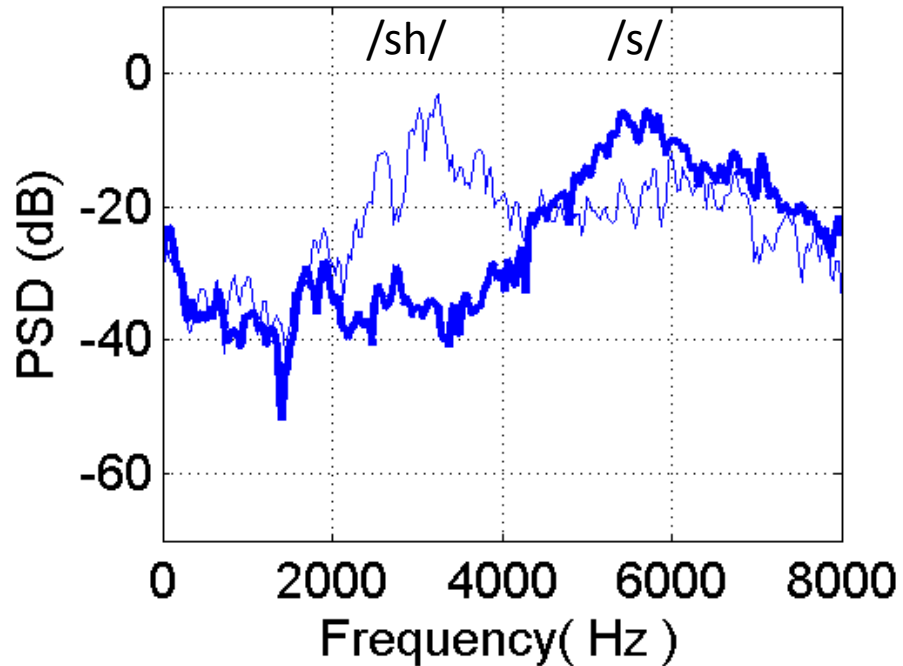


Center of gravity for fricatives /s/ and /sh/

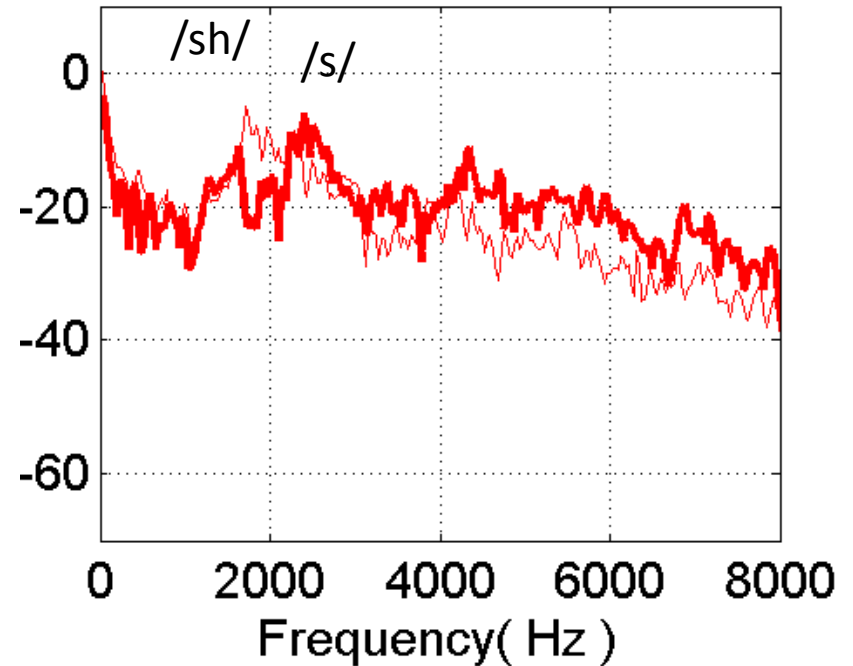


Example spectra of /s/ and /sh/

Normal
(SPH)



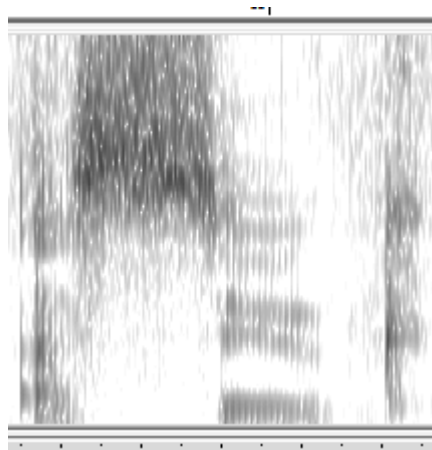
Patient
(WCS)



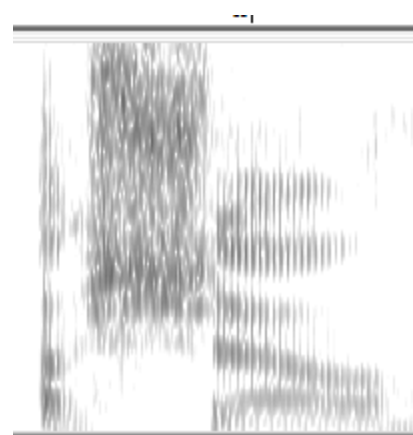
Example spectrogram of /s/ and /sh/

Normal (SPH)

“A souk”



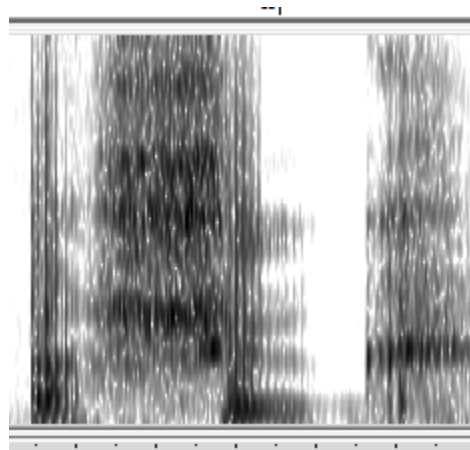
“A shell”



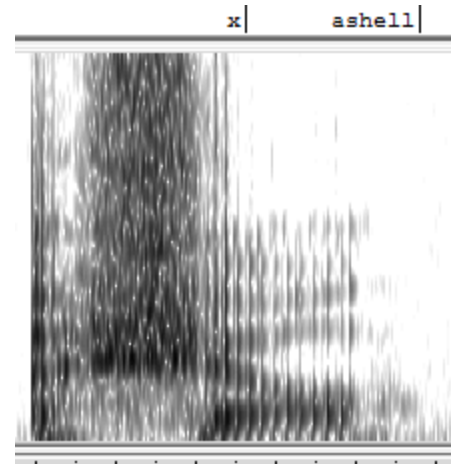
Example spectrogram of /s/ and /sh/

Patient (WCS)

“A souk”



“A shell”



Midsagittal MR images of /s/ and /sh/

/s/ in “asouk”

/sh/ in “ashell”

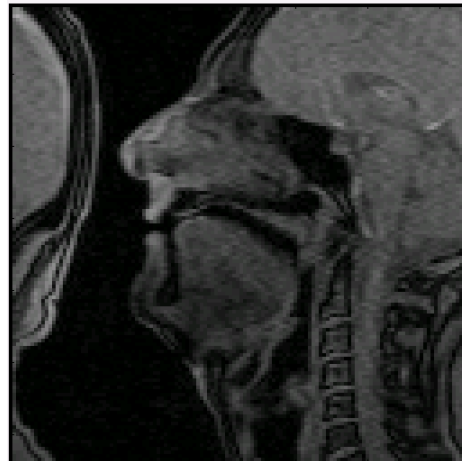
Normal
(SPH)



/s/ in “asouk”

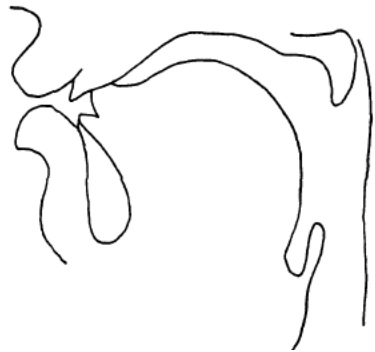
/sh/ in “ashell”

Patient
(WCS)



/s/ production (apical vs. laminal)

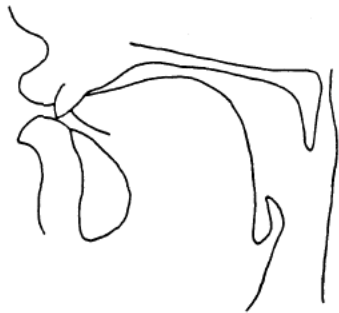
Apical



Apicolaminal



Upper apical



Laminal



(Dart 1991)

/s/ production statistics in our database

Normals (18)	Apical+	Laminal+
	Upper apical	Apicolaminal
	26	8
Patients (9)	Upper apical	Laminal+
		Apicolaminal
	6	11

Summary

- Compared four vowels (/iy/, /uw/, /eh/, and /ah/) and two fricatives (/s/ and /sh/) between normal subjects and partial glossectomy patients with T1 or T2 tumors.
- Average formants (F1- F3) for the four vowels between the normals and the patients are similar.
- Average center of gravity of fricatives for the patients is significantly lower than it is for the normals, probably due to the more posterior constrictions in patients and its resulting longer front cavity.

Thanks !