

# The Effect of Helium on the Human Voice: A Laboratory Activity 1,2

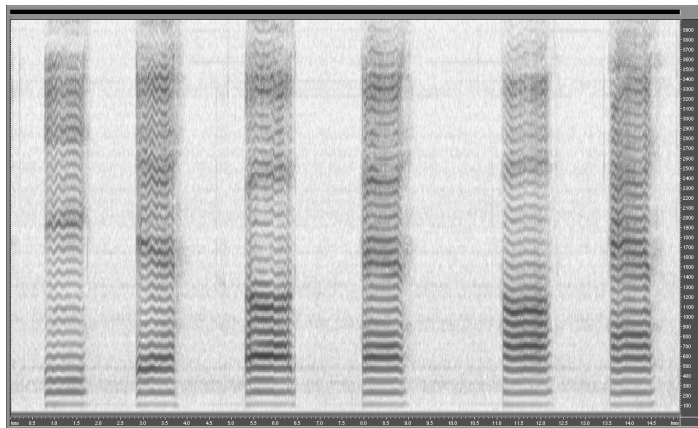
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(1) Support provided by NSF DUE grants 0088780 and 0088712.

(2) Humanizing Physics Project co-PIs: Robert G. Fuller and Vicki L. Plano Clark, University of Nebraska - Lincoln, Nancy L. Beverly, Mercy College, and Beth Ann Thacker, Texas Tech University.

## Characterizing the Normal Voice:

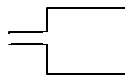
- Subject records normal vowel sounds
  - used computer-based sound editing software: Cool Edit 2000
  - maintained constant pitch
  - created a wav file
- Use the sound editing software to generate a sound spectrogram
- Identify lowest two formants (resonant frequencies of the vocal tract).



[i] [I] [u] [E] [a] [æ]  
 heed hid hood head hod had

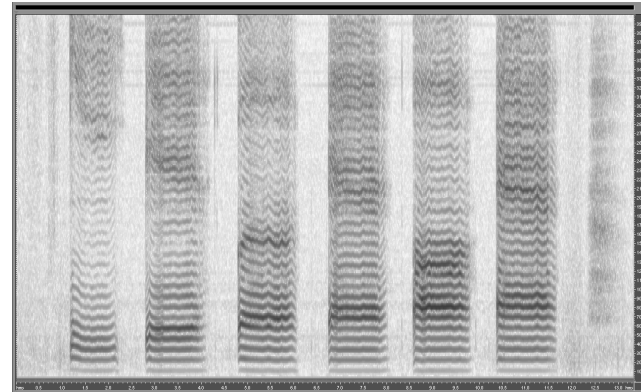
Figure 1. Sound spectrogram of normal voice produced by Cool Edit 2000. The vowel sound is indicated underneath the appropriate section.

- Calculate vocal tract lengths using 2 tube model.
  - Each formant is the lowest resonant frequency in the tube.
  - Assume quarter wavelength standing waves.  $L = \frac{v}{4f}$
- $v$  = speed of sound  $L$  = tube length  $f$  = frequency of standing wave



## Characterizing the Helium Voice:

- Subject exhales, inhales helium, listens to pitch of the normal voice recording and repeats the vowel sounds at the same pitch.
- The rest of the procedure is the same as for the normal voice.



[i] [I] [u] [E] [a] [æ]  
 heed hid hood head hod had

Figure 2. Sound spectrogram of helium affected voice produced by Cool Edit 2000. The vowel sound is indicated underneath the appropriate section.

Vowel	First Formant [Hz]	Calc. Column Length [m]	Second Formant [Hz]	Calc. Column Length [m]
[i] heed	320	0.26	1940	0.04
[I] hid	540	0.16	1640	0.05
[u] hood	600	0.14	1140	0.07
[E] head	640	0.13	1610	0.05
[a] hod	690	0.12	1080	0.08
[æ] had	750	0.11	1700	0.05

Table 1. Formant frequencies of vowel sounds determined visually from the spectrogram. Normal voice. Uncertainty is approximately 50 [Hz]. Column lengths based on 2 tube model.

Vowel	First Formant [Hz]	Second Formant [Hz]
[i] heed	430	2650
[I] hid	610	2350
[u] hood	690	1550
[E] head	780	2040
[a] hod	840	1290
[æ] had	880	2090

Table 2. Formant frequencies of vowel sounds determined visually from the spectrogram. Helium affected voice. Uncertainty is approximately 50 [Hz].

## Analysis:

- Fundamental frequency and harmonics are determined by vibration of vocal folds – independent of gas in the vocal tract
- Tube lengths should be the same for normal and helium -filled vocal tract.
- Speed of sound will change with introduction of helium: 340 [m/s] -> 972 [m/s]
- $f = \frac{v}{4L}$  implies increase in formant frequencies
- The data shows an increase in formant frequencies but not as large as would be predicted (~2.86 times)
- Vocal tract may not be filled with pure helium

Note: this activity can be done without the sound analysis softw are by using print outs of the spectrogram. These are available on the HPP web site. Go to web site, select "Module Summaries", se lect "Trial Acitivities", select "Modeling Human Speech".

Curriculum materials and multimedia available at project website :  
[www.doane.edu/hpp/](http://www.doane.edu/hpp/)