Speech, Hearing & Phonetic Sciences, UCL

ˈspiːtʃ prəˈdʌkʃən
www.phon.ucl.ac.uk

Science of Talking

Week 1 – Voice

Learning Objectives

You should be able to:

- describe the four main functions of the larynx in speech production
- describe the vibration cycle in normal phonation
- describe how phonation is started and stopped
- describe how changes in pitch are obtained
- describe how breathy voice and creaky voice differ from normal phonation

Overview

1. Structure of Larynx
   1.1. Position: sits on top of trachea, hangs down from hyoid bone
   1.2. Construction: rings of cartilage outside, inside has vocal folds, false vocal folds and epiglottis, cartilage elements are jointed and can be moved by muscles
   1.3. Thyroid Cartilage: large structure at front of larynx, visible (at least on men) as Adam's apple, front ends of vocal folds attached to thyroid cartilage, as thyroid cartilage rocks forwards, stretches vocal folds
   1.4. Arytenoid Cartilages: small mobile cartilage elements at rear of larynx, rear ends of vocal folds each attach to one arytenoid, as arytenoids swivel, they brings vocal folds together (adduct) and apart (abduct), can also help change vocal fold tension
   1.5. False vocal folds don't normally take part in voice
   1.6. Epiglottis used to help direct food into oesophagus and away from path to lungs
   1.7. Vocal folds, false vocal folds and epiglottis form system designed to protect lungs from food/drink and seal chest cavity. Use of vocal folds in speech actually secondary function!
2. Laryngograph
   2.1. Electrical means for monitoring vocal fold vibration, two surface electrodes on either side of larynx, monitor resistance of neck to current flow, less resistance when vocal folds touching.
   2.2. Get graph of vocal fold contact area against time (=Laryngograph waveform, Lx)
   2.3. Analyse the Lx waveform to get repetition frequency of vocal fold vibration (=Fundamental frequency, Fx)
3. Larynx Functions
   3.1. Source of Sound: voice is the raw sound shaped by vocal tract to make different vowels. Note vocal fold vibration cycle: vocal folds brought together, vocal folds blown apart, increase in air flow between them, pressure drop between folds due to Bernoulli effect, vocal folds snap together, pressure builds up below folds, cycle repeats.
   3.2. Voice Quality: changes in breathiness and creakiness indicate physiological state/mood/style. Note: Breathy voice: additional "whisper" in voice caused by turbulence from air rushing through incompletely adducted folds, Creaky voice: additional "irregularity" in voice caused by low vocal fold tension and greater medial compression of folds.

3.3. Voicing Contrast: presence/absence of voice signals contrast between some pairs of pronunciation units. Note: phonation is turned on by adduction (pushing folds together), phonation is turned off by abduction (pulling folds apart). Used in speech to signal: vowels from silence, voicing contrast e.g. /s/ from /z/ and /p/ from /b/.
3.4. Intonation: changes in voice pitch used to indicate different utterance functions. Note: caused by changes in repetition frequency of vocal fold vibration through utterance, caused by changes in length and degree of tension in vocal folds. Changes performed mainly by rocking forward of thyroid and swivelling of arytenoids

Reading

Chapter 2 of "Introducing Phonetic Science", by M.Ashby & J.Maidment, Cambridge University Press, 2005.

Reflections

1. What anatomical structures are involved in changing the pitch of your voice?
2. What is the Bernoulli effect? Why is it important in voice?
3. How do you change the loudness of your voice?
4. How would you describe the voice quality characteristics of “hoarseness”?
5. What is meant by “losing one’s voice”?
6. What is a “frog in the throat”?
7. Why do boys’ voices “break”?
8. How is singing different from talking?
9. What is whisper? Does whisper have pitch or intonation?
10. What problems would someone with no larynx have?

Larynx Anatomy

Fig 1. Front/Back Views of Larynx

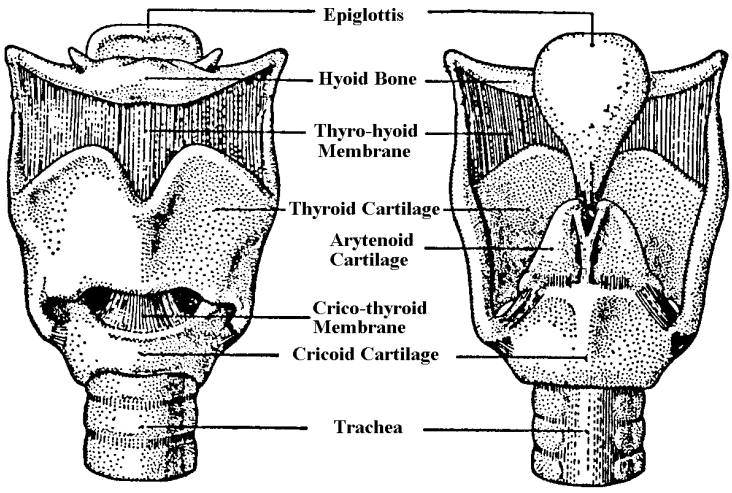


Fig 2. Superior View

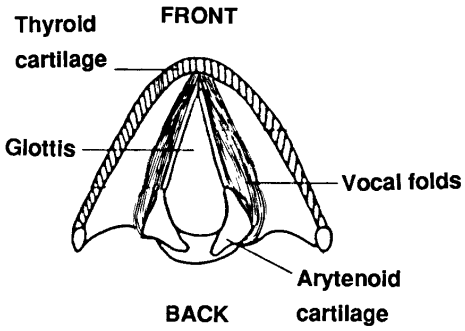
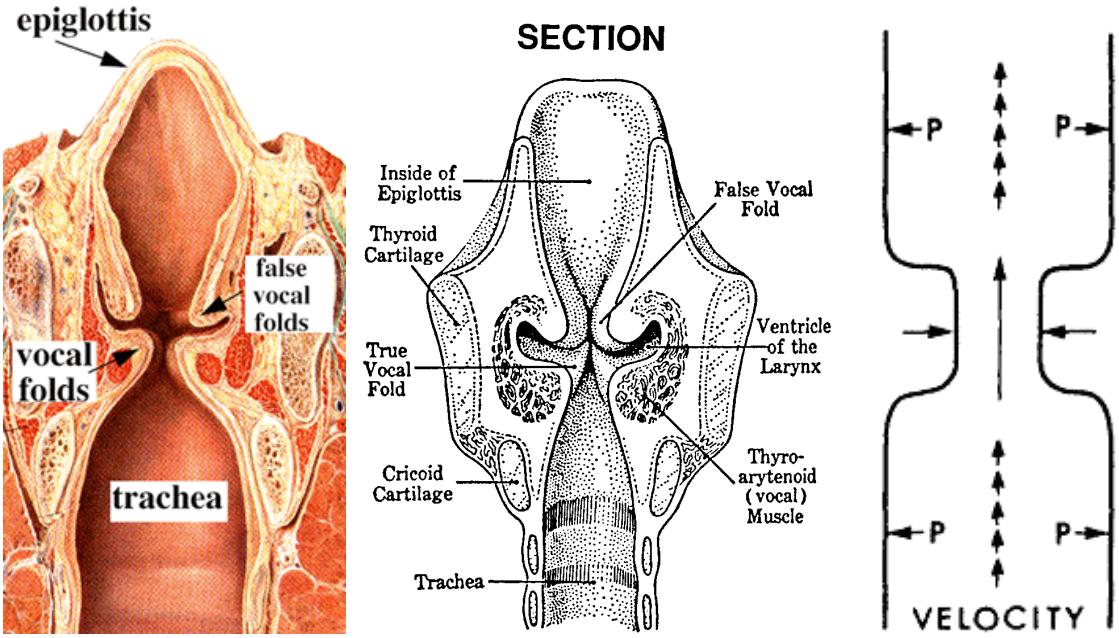


Fig 3. Vertical coronal section and air-flow schematic



Laryngography

Fig 4. Current Flow between Electrodes

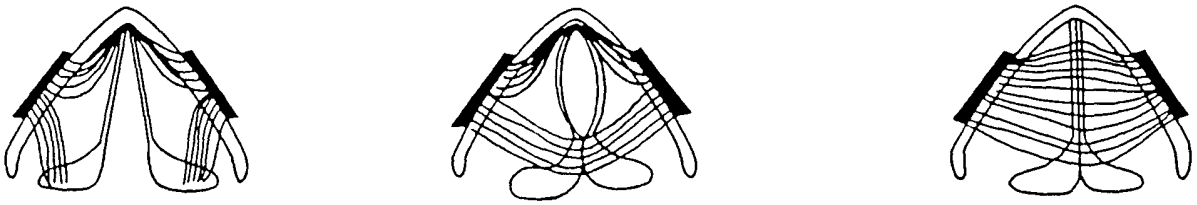


Fig 5. Stages in cycle of Vocal Fold Vibration

Fig 6. The Laryngograph current flow waveform

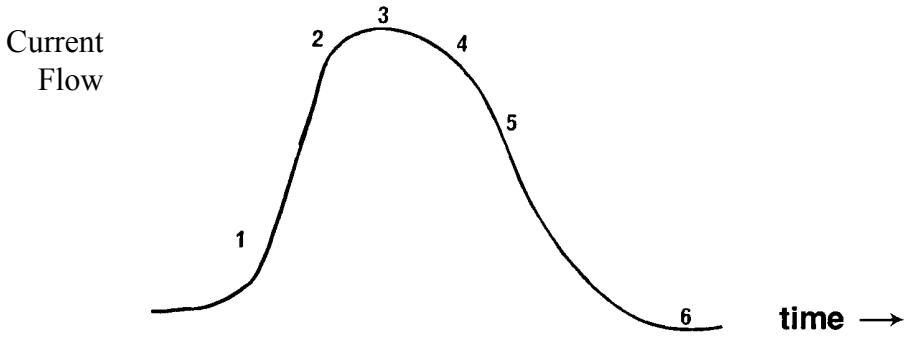
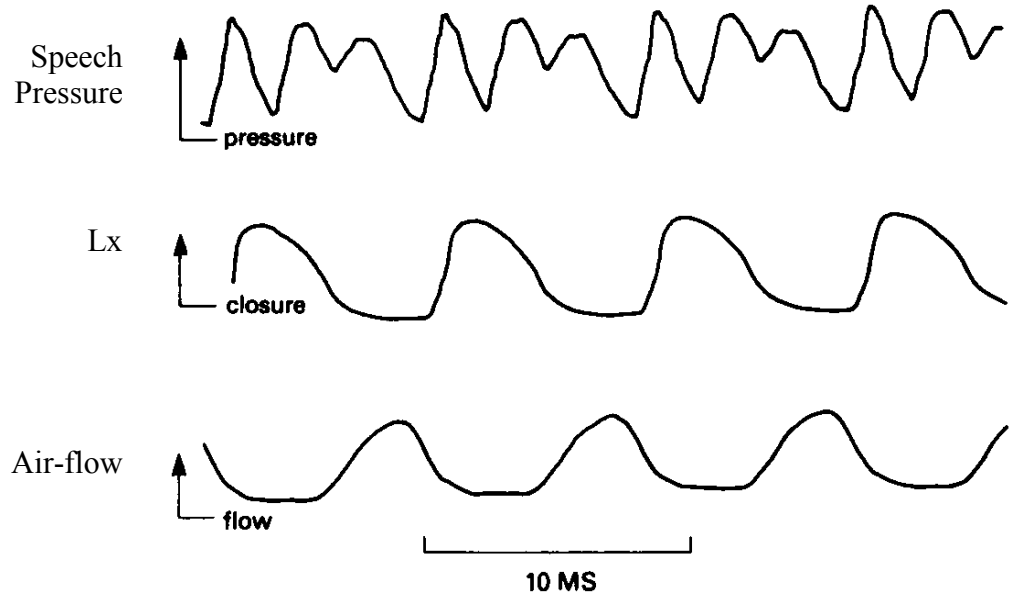


Fig 7. Speech Pressure, Lx and Flow Waveforms compared



Lab: Measuring the Voice

Introduction

The Laryngograph provides an electrical means for monitoring vocal fold vibration. The output of the Laryngograph is a measure of vocal fold contact area, and we can study this to gain information about the *repetition frequency*, the *regularity* and the *closed quotient* of vocal fold vibration. These parameters may be correlated with voice pitch and voice quality.

In this experiment you will use the Laryngograph to look at how vocal fold vibration varies with the intonation of speech and among normal, breathy and creaky voice qualities.

Scientific Objectives

- to determine how the properties of vocal fold vibration vary across changes in voice pitch and in voice quality.

Learning Objectives

- to gain experience of one method used to assess and monitor voice (the Laryngograph).
- to understand how the repetition frequency of vocal fold vibration defines voice pitch
- to understand how regularity is changed in creaky voice.
- to understand how open quotient is changed in breathy voice.
- to understand how repetition frequency, regularity and closed quotient may be quantified.
- to experience how these measures vary across a group of speakers

Apparatus

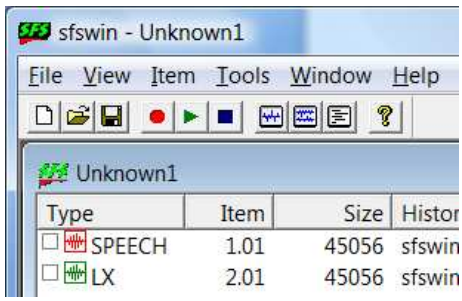
The Lab PCs will be set up to acquire a laryngograph signal using the SFS software (http://www.phon.ucl.ac.uk/resource/sfs/).

The Laryngograph is described at: http://www.laryngograph.com/pr_procs.htm.

Methods

A. To make a joint Speech and Laryngograph recording

1. Switch on the Laryngograph and fit the electrodes such that they are on either side of the "Adam's apple". Ensure they are making good electrical contact with the skin. The neckband should be quite tight. Position the microphone close to the mouth but out of the airstream.
2. Start the SFSWin program (in the Lab Tools folder on the desktop). Request a "New" file.



3. Press the Record button on the toolbar. Choose options "Speech & Lx" at 44100 samples/sec:

4. Click on "Test Levels" and adjust the level controls on the Laryngograph processor so that the recording level bars come about half way across the screen when you say "ar" at normal volume. Press "Stop".
5. Click on "Record" and say the utterance to be recorded. Press "Stop", then press "Done".
6. You can display/replay/print the recorded utterance using "Item | Display All".
7. If the recording is OK, save it to a file in "C:\tmp" using the "File | Save As" command in SFSWin.

B. To analyse a joint Speech and Laryngograph recording

1. Make and save the recording as in Method A.
2. Start the EFxHist program (in the Lab Tools folder on the desktop).
3. Open the recording with "File | Open".
4. Choose "View | Waveforms Display" and then select the part of the signal you want to analyse by placing the start cursor with the left mouse button and the end cursor with the right mouse button.
5. Choose "View | Analyses Display" and then ensure the following display option is selected: "Analysis Table (Vowel)"
6. From the Statistics table, record the "Fx Mean", "Close Quotient Mean" and "Jitter" statistics.

Observations

A. Low pitched modal voice

1. Display and print the Sp & Lx for 100ms of an /ɑ:/ vowel on a relatively low pitch, using Method A.

2. Measure the duration of one cycle (you might do this by measuring the duration of 5 cycles and dividing by 5). What is the average pitch period?

_____

3. What is the fundamental frequency (repetition frequency) related to this pitch period?

_____

4. Use Method B to get statistics on this voice quality:

_____

5. In which part of the waveform are the vocal folds together?

_____

6. Why do the vocal folds close more rapidly than they open?

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B. High pitched modal voice

1. Display and print the Sp & Lx for 100ms of an /ɑː/ vowel on a pitch towards the top of your normal speaking range, using Method A. (N.B. don't sing, or use falsetto)

2. Use Method B to get statistics on this voice quality:

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3. How does the repetition frequency (Fx) compare with the low-pitched vowel in A.

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4. What changes in the larynx are the cause of this change in repetition frequency?

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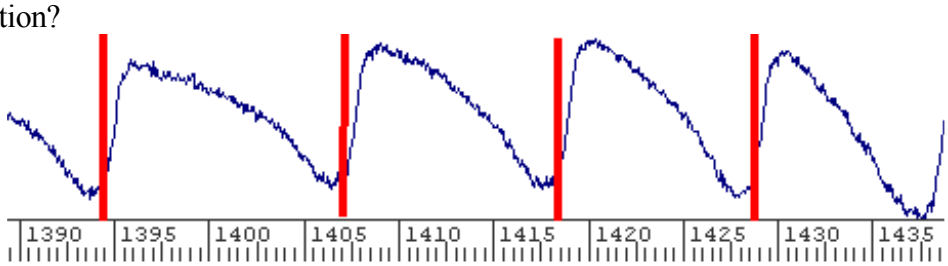
C. Measuring some voice qualities: creaky voice

1. Display and print the Sp & Lx of 100ms of an /ɑː/ vowel with a creaky voice quality, using Method A. You may find creaky voice easier to produce at the low end of your pitch range.
2. Measure the duration of three or four separate larynx cycles. Do all cycles have the same duration?



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3. Use Method B to get statistics on this voice quality:

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4. Compare statistics with the modal quality - what are the key differences?

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5. What changes in the larynx cause these variations in cycle-to-cycle period?

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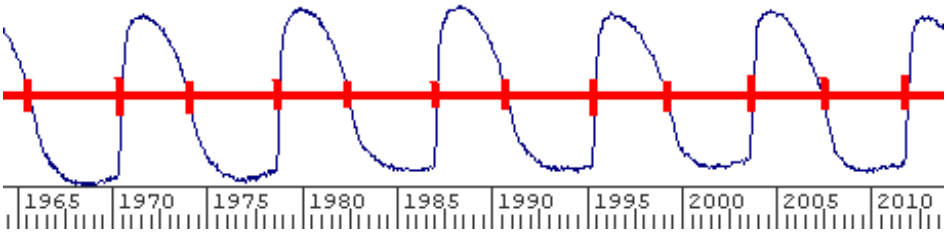
D. Measuring some voice qualities: breathy voice

1. Display and print the Sp & Lx of 100ms of an /ɑː/ vowel with a breathy voice quality, using Method A.

2. Estimate what fraction of each larynx cycle is spent closed (the *closed quotient*). Compare the closed quotient for breathy voice with the closed quotient for normal voice. What do you notice?



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3. Use Method B to get statistics on this voice quality:

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4. Compare statistics with the modal quality - what are the key differences?

_____

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5. What changes in the larynx cause the variations in closed quotient?

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