Modelling the Speech Production Mechanism

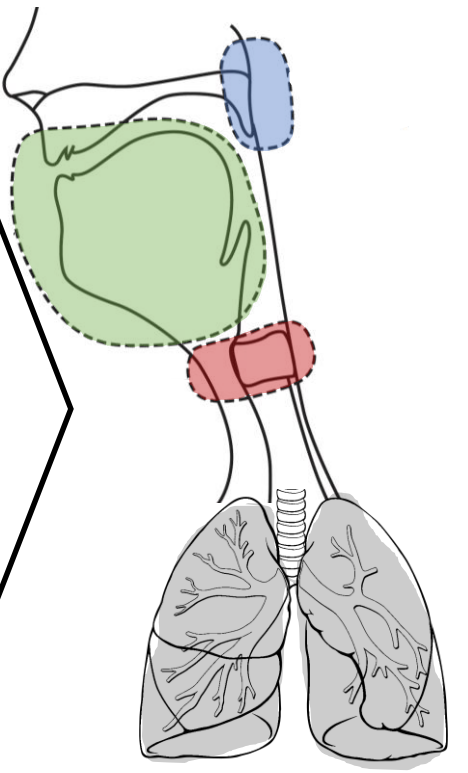
Speech Mechanism

AIRSTREAM PROCESS
Air is pushed from the lungs (usually) to provide the initial energy for the sound.

PHONATION PROCESS
The vocal folds in the larynx modify the air flow, making the sound voiced or unvoiced.

ARTICULATION PROCESS
Movements of the tongue and lips modify the sound.

ORO-NASAL PROCESS
It determines whether air escapes through the nose or the mouth.

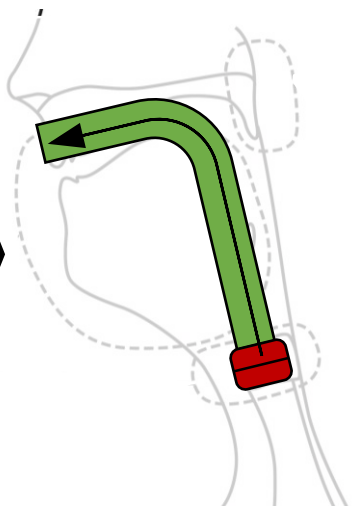


Source and Filter

The speech production mechanisms can be described in terms of a source and filter.

SOURCE
Voice source is produced as air passes through the vocal folds.

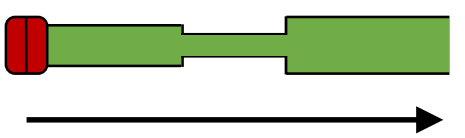
FILTER
The sound is filtered as it passes through the vocal tract.



The source of the speech (the voice) is produced in the larynx, while the vocal tract filters the sound.

Tubes Model

The complex shape of the vocal tract can also be simplified and imagined as series of connected tubes.



Roles of source and filter in speech

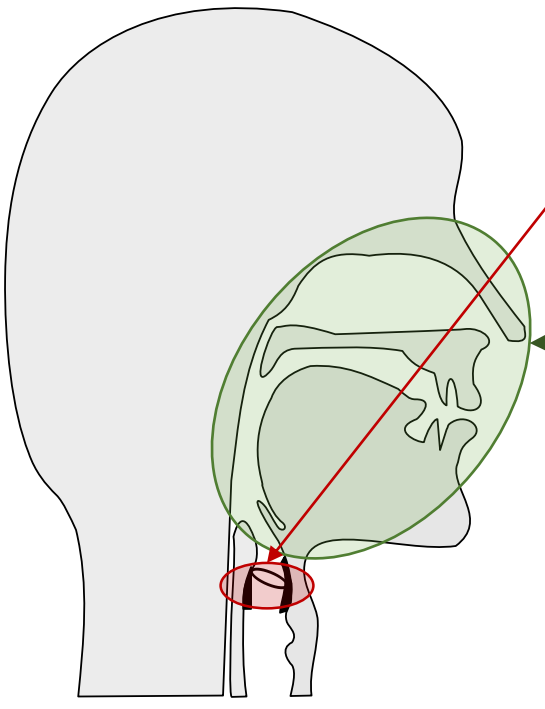
VOICE SOURCE

The larynx – your voice box – is responsible for creating ***voiced and unvoiced sounds***.

Hold your fingers against your voice box and say “ssssss” and then “zzzzzz” to feel the difference.

The larynx is also the source of what we hear as ***pitch*** – both in singing and the natural melody of speech.

It is also responsible for some characteristics of ***voice quality*** – such as the more harsh or breathy quality of some people’s voices.



VOCAL TRACT FILTER

As the source sound passes through the vocal tract filter we alter it by the changing the shape our tongue, lips, and jaw.

We also change the shape of the sound by letting it pass through our nasal cavity.

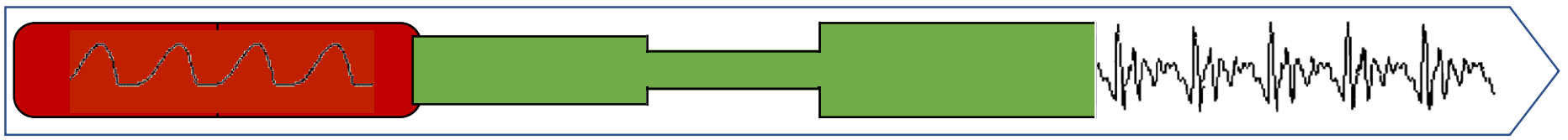
PRODUCING DIFFERENT SOUNDS

Together, the source and filter control the individual sounds we make – we change the behaviour of our larynx and the shape of our vocal tract very rapidly in order to produce the range of sounds we use in speech.

Try saying the following words and pay attention how you use your voice box and vocal tract to produce the different sounds:

Nan	***Dad***	***tat***	***lass***
noon	***dude***	***toot***	***loose***

Acoustics of Source, Filter, & Speech



The vibrations of the vocal folds alter the flow of air through the glottis & create a voiced ***source waveform***.

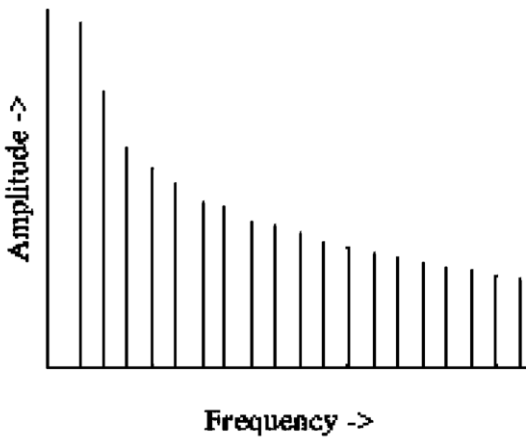
The shape of the waveform is modified by the configuration of the ***filter*** (and as it radiates out past the lips).

The ***speech waveform*** is a combination of the source, filter, and lip radiation.

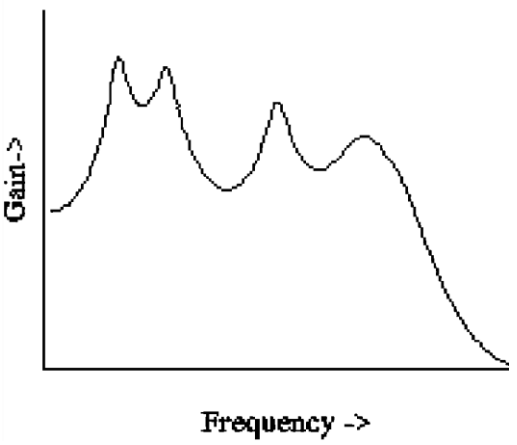
The waveform can also be described in terms of all the different frequencies across the sound spectrum that it carries.

Depending on how it is configured, the vocal tract filter boosts and lowers certain of these frequencies.

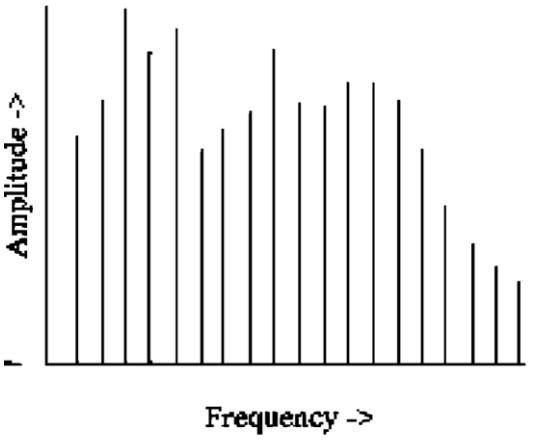
Over all, if the vocal tract is longer, it will tend to boost lower frequencies than a shorter vocal tract.



Frequency spectrum of source



Vocal Tract Filter



Frequency spectrum of speech output

SOURCE, FILTER, AND CARDBOARD TUBES

Use the cardboard tubes and the elastic bands as examples of source and filter. When you strum the elastic band, it acts as a source and the tube acts as the filter. Compare the sounds from the long and short tubes.

You should hear a deeper more resonant sound coming out the longer tubes even if you produce the same basic pitch with the elastic band. This is because of the filtering effect of the tube. The longer tubes will start boosting frequencies lower in the sound spectrum , while the shorter tubes will start boosting at higher frequencies.

Waveform and frequency spectra from http://www.jimelwood.net/students/temple/psychLL/readings/source-filter.pdf

How to read your voice

This tells you about your overall ***voice quality***.

The solid lines are crude averages, and the dotted lines are trends. The flatter the trend, it is more likely that your voice sounds quite harsh. If the solid line decreases very sharply at the beginning, your voice might have been more breathy or lax. If the solid line rises at the end, this might be due to breathiness.

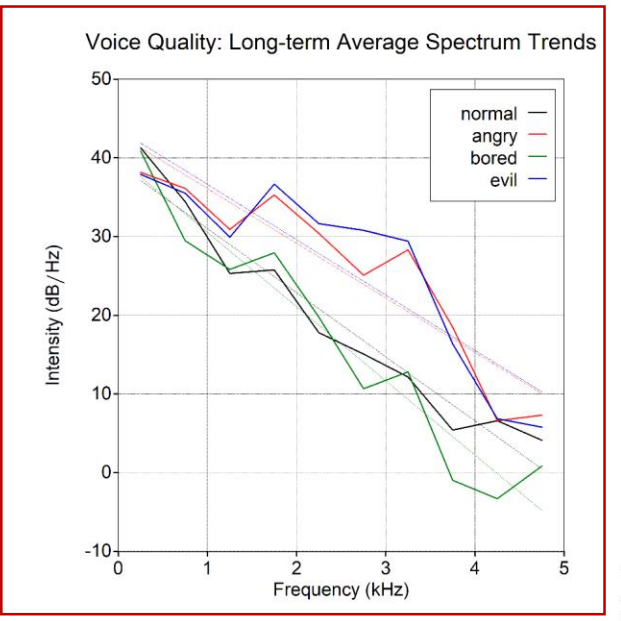
This tells you about the overall ***pitch**** of your voice (in Hertz).

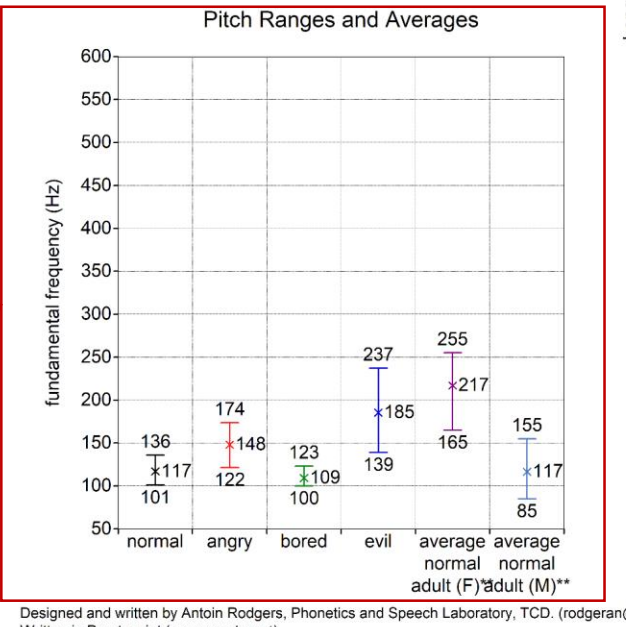
The bottom line is the lowest pitch and the top line is the highest pitch you reached. The x marks your average pitch. You can compare your results with the average adult male and female speakers in the last columns.

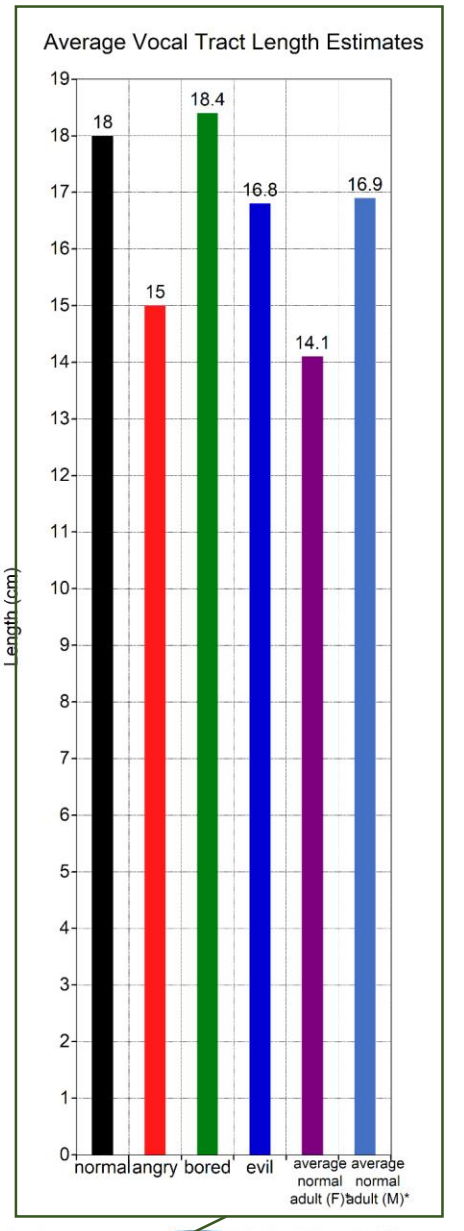
*Technically, it is fundamental frequency rather than pitch, but let's not get into that here.

Have a look at your different voices!

The measurements and estimates below were calculated from audio of your speech recorded at the Dublin Language Garden at the Hub, TCD on September 22nd, 2017.
You can see how your voice and vocal tract look difference depending on how you speak.
Compare your results with other people.
Do remember there may be errors since the recordings were very short.







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Written in Praat script (www.praat.org/)

*Goldstein, Ursula, 1980. *An articulatory Model for the Vocal Tracts of Growing Children*, MIT. Ph.D. Thesis
**Fitch, J., & Holbrook, A., 1970. Modal Fundamental Frequency of Young Adults. *Archives of Otolaryngology*, 92, pp.379–381

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This is an estimate of your ***average vocal tract length*** (in centimetres). It uses information in the speech signal created by your vocal tract filter to make the estimation.

If you spoke with a very tense voice, this might lower the estimated length. If you spoke with a very breathy voice, this might artificially boost the apparent length of your vocal tract.

You can compare your results with the average adult male and female speakers in the last columns, but as the technique is not always reliable, I wouldn't take it too seriously!

The **Vocal Track** was designed & developed by Antoin Rodgers from the Phonetics & Speech Lab at Trinity College Dublin.

Many many thanks to Vicky Garnett for her great suggestions and feed back – and for making the cardboard & elastic tube models. Many thanks to Neasa Ní Chairáin, Andy Murphy, and Eoin Rodgers for lending their voices to test the software. And finally thanks to Jim Regan, Emily Barnes, Mícheál Ó Meachair, & my mum for the comments & feedback on the posters.