Exhibit message

The shape of our vocal tract transforms raw sound from our vocal folds (vocal cords) into recognisable vowel sounds.

Quick Fact

Our vocal folds are found in the larynx, commonly known as the 'voice box'. The tension and length of the vocal folds determines the base pitch of a vocal sound. Longer folds produce deeper sounds.

Adult males have lower voices (~70–200 Hz for normal speech) than females (~140–400 Hz). In males, one of the nine cartilages of the larynx (the 'Adam's apple') increases in size during puberty. This elongates the ligaments of the vocal folds which then vibrate at a lower frequency making men's voices deeper than women's.

Graphic panel text

The vocal tract

Each vowel sound is formed by the **shape of the vocal tract**. Your vocal tract includes your throat, mouth and nose and is mainly controlled by the position of your lips, jaw and tongue.

Shaping vowels

Our **vocal folds** (vocal cords) vibrate to make the initial sounds of our vowels. (Here, the duck call represents the vocal folds.) **The shape of the vocal tract** then makes some of these sounds louder than others.

Each vowel has a **typical pattern** of sounds that is the same whether the vowel is sung as a high or low note.

Say "ah"

Vowels, like "ah", "oo" and "ee", are important in **singing** because these sounds are held for long periods in musical notes.

Want to know more about how your vocal tract forms vowel sounds?

Vowels (e.g., 'ah', 'oo' and 'ee'), are especially important in **singing** because these sounds are held for long periods in musical notes.

Each vowel sound is formed by the **shape of the vocal tract**. Your vocal tract is a hollow space that includes your mouth, nose and the space above the **vocal folds** (vocal cords) in your throat. The shape of the vocal tract is mainly controlled by the position of your lips, jaw and tongue.

Your **vocal folds** are found in your 'voice box' (larynx) in the middle of your throat. The vocal folds are two folds of tissue stretched across the windpipe (not cords, like a string). You can feel your vocal folds vibrate by putting your fingers lightly on your throat as you hum or speak.

To make **any** vocal sounds, we force air from our lungs through our vocal folds. This causes our vocal folds to **vibrate**.

When we speak or sing our voices have a particular frequency that determines the **pitch** we hear**.** This is called the **fundamental frequency**. It is the lowest and loudest frequency and determines whether the voice is high or low. The pitch of your voice is determined by how fast your vocal folds vibrate.

But our voices contain other frequencies as well. These are called **harmonics** and are higher than the fundamental frequency. In speech or singing, the different strengths of these higher frequencies determine what vowel is heard, while some contribute to our voice's individual character.

The **shape of the vocal tract** causes some harmonics to be louder than others. Each vowel sound has a typical pattern of loud harmonics that set it apart from others. The pattern of harmonics remains constant for a given vowel, even if we speak or sing a note at a different overall pitch.

Extra for experts

In 1828 English mathematician, archaeologist and amateur musician, Robert Wills, discovered that every vowel sound is connected with a particular frequency related to a **resonance** in the oral cavity. In 1860, Helmholtz showed that certain vowels were associated with two such resonances (later called 'formants') and in 1924, Richard Paget, proved that this was true for every vowel.

The **vocal tract** is like a closed pipe. It is closed at the vocal folds and open at the mouth, similar to an organ pipe, with natural frequencies or resonances according to the length of the pipe. The natural frequencies of a 17 cm long closed pipe (corresponding to the average length of an adult male vocal tract), are approximately 50 Hz, 1500 Hz, 2500 Hz, and so on.

Each resonance of the air column of the vocal tract corresponds to a standing wave; and changes in the width of the vocal tract tube at certain points changes the pattern of the standing wave and alters the resonant frequencies.

Formants are frequency ranges that are central to the recognition of vowels in speech and song. These groups of frequencies are in the general vicinity of the natural (resonant) frequencies of the vocal tract and are boosted by the **vocal tract filter function**. That is, those frequencies from the vocal fold vibrations that match the natural frequencies of the vocal tract will come through more strongly than those that don't.

Formants remain the same, regardless of the overall pitch of a note. For example, for a male singing a note around 100 Hz (~G_2), the spectrum of frequencies produced will all be multiples of 100 Hz. The vocal tract filter function then boosts around 500 Hz, 1500 Hz, 2500 Hz, etc. which are around the natural frequencies of the 17 cm vocal tract. If the singer were to sing a note an octave higher (200 Hz), the spectrum would now include all multiples of 200 Hz, but would still be boosted around the natural frequencies. That is, the formants remain the same.

Female vocal tracts are approximately 20% shorter than men's (an average of 14 cm for women compared to 17 cm for men), and therefore produce formants that are ~20% higher for same articulations.

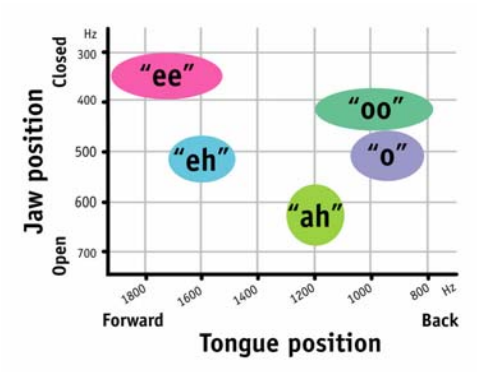
Men, women and children and individuals with different vocal tract lengths have different formant values corresponding to each vowel sound, but we automatically compensate when hearing these in relation to other vowels. That is, the brain recognises the relationship between formant patterns.

The brain of the listener recognises the locations of formant regions fairly independently of the initial frequencies from which they are composed.

While a number of formants are present, it is mainly the first two (F1 and F2) that are the used to identify vowels. For example, the corresponding formant ranges for the F1 (first formant) for the vowel sound 'uh' is 800 Hz and F2 is 1500 Hz.

The frequency of the first formant (F1) is determined largely by the height of the jaw and thus the mouth opening. Opening the mouth will increase the frequency F1.

The frequency F2 is more strongly determined by the position the tongue. The frequency is high when the tongue is forward and lower when it is further back in the mouth.



Source: Epps, J, Dowd, A, Smith, J and Wolfe, 1997.

Helpful terms

Frequency: The number of times a vibration occurs in one second (hertz or Hz). Fast vibrations have high frequencies and produce high notes or pitches.

Pitch: The perceptual phenomenon of how high or low a tone seems. The pitch of a tone corresponds to its frequency. High frequencies are perceived as high pitches while low frequencies are heard as low pitches.

Fundamental frequency: The lowest frequency present in a musical note.

Harmonic: An overtone that is a whole number multiple of the fundamental frequency. All harmonics are overtones, but not all overtones are harmonics.

Further information

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