Exhibit message

Sound vibrations can be felt in the body as well as being detected in the ear.

Quick Fact

Tones with frequencies below 20 hertz (Hz) can not be heard by humans, but can be felt. These frequencies are classed as **'infrasound'**. Experiments have shown that exposure to such low frequency, infrasonic tones (17 Hz) during a concert increase the **emotional impact of the music**. During such studies, concert-goers reported higher emotional states during the times the infrasound was presented. It has been suggested that this could be why pipe organ music, which produces very low notes, can elicit such powerful emotions in people.

Graphic panel text

Can you FEEL the music?

The ear isn't the only part of the body to experience sound. We also **feel sound vibrations** in other parts of our bodies.

Bass on the bottom

Heavy bass as low as 2 hertz (which is way below the threshold of human hearing) can be felt in our legs and whole body. **Higher frequencies** are better felt in our upper body, like our hands and arms. So, you can feel the deep bass notes on your bottom and the melody on your fingers!

Not all in the ear

People with hearing impairments can still detect and enjoy music by **feeling** the vibrations. In fact, research shows that people born deaf process sound vibrations in the same part of the brain that is normally used only for hearing.

Want to know more about how our ears and bodies sense vibrations?

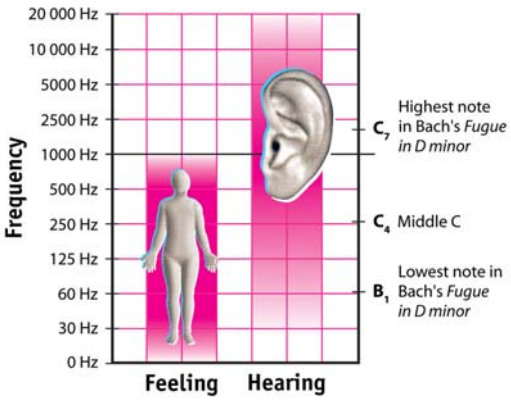
The ear detects vibrations and interprets them as sound, but the ear isn't the only part of the body to experience sound vibrations. We are also able to feel the vibrations caused by sound waves in other parts of our bodies. We can even feel sounds that are too low for our ears to hear.

Hearing a sound and feeling a vibration is essentially the same thing. The ear is a very sensitive instrument for **feeling** sound wave vibrations. '**Hearing**' is the brain's interpretation of the vibrations felt by the ear.

The ear is our most sensitive organ for detecting sound wave vibrations, but when it comes to **infrasonic** vibrations (vibrations lower than 20 hertz (Hz)), our bodies are able to feel what our ears cannot hear.

The threshold of feeling crosses the threshold of hearing at 20 Hz, therefore, we **feel** rather than **hear** sounds below this frequency.

Humans can **feel** frequencies from around 1000 Hz to as low as 1 Hz.



Thresholds of human hearing and feeling

The human body is not equally sensitive to all frequencies of vibration. Certain frequencies are better detected in some parts of our bodies than others. Low frequencies are generally detected best in larger areas of our bodies while higher frequencies are usually better detected in smaller areas.

For example, heavy bass as low as 2 Hz (which is way below the threshold of human hearing) can be felt in our legs and whole body, while higher frequencies are better felt in our upper body, like our hands and arms.

Extra for experts

Each part of the body has a different range of frequencies to which it is most sensitive. In other words, different parts of the body **resonate** at different frequencies.

When a part of the human body is excited at its **natural frequency**, it will resonate over a range of frequencies instead of a single frequency. Response to vibrations is dependent upon the **direction** in which the vibration is applied and the **strength** or volume of the vibration.

When measuring **whole-body vibration**, the body is most sensitive to 4–8 Hz in the head-to-toe (longitudinal) direction. In the front-to-back or side-to-side (lateral or transverse) directions, the greatest response is from 1–2 Hz. When measuring **hand-arm vibration**, the maximum sensitivity range for all directions is 12–16 Hz.

There are also different sensitivities in areas such as the eyeball and socket, the head, shoulder girdle, chest wall, spinal column and abdominal mass. The natural resonances of areas are also affected by whether a person is **seated or standing**.

For a **seated** person, with flexed knees, the legs are most sensitive to frequencies of 2 Hz, the arms to 5–10 Hz and the hands to 30–50 Hz. For a **standing** or rigid person, the legs are most sensitive to frequencies around 20 Hz and the lower arms to 16–30 Hz.

Deaf people are more sensitive than hearing people to minute changes in vibration frequency. People with hearing impairments can still detect and enjoy music solely by feeling the vibrations through their bodies.

The experience deaf people have when 'feeling' music is similar to the experience other people have when 'hearing' music.

In fact, research shows that people born deaf process sound vibrations in the **auditory cortex**, which is the same part of the brain that is used solely for hearing in hearing people.

The auditory cortex in the brain where hearing is processed.

When exposed to sound vibrations on their hands only, people with congenital deafness showed brain activity in the auditory cortex, while people with normal hearing did not.

In deaf subjects, areas of the auditory cortex were able to detect differences in vibrational frequencies between 180 Hz and 250 Hz, which is similar to that of sound discrimination in normal hearing subjects.

The auditory system is well suited for the processing of **vibrotactile** information (vibrations felt rather than perceived by the ear) as vibratory and auditory stimuli have essentially similar temporal patterns. These studies provide the first direct support for the notion that a deprived sensory region of the brain can take over the role of another sense.

Sensory regions of the brain receive input from several senses during development, but the irrelevant ones are usually masked by information from the 'main' sense. For

instance, in people with normal hearing, information from the ear masks information from vibrotactile stimuli.

This is not the case in sensory-deprived areas of the brain in which competition from the 'main' sense is absent, such as the auditory cortices of congenitally deaf people. In this instance, information that normally ceases to reach the brain after development, such as the vibrations from vibrotactile stimulation, continues to do so.

Hence, the 'hearing areas' of the brains of deaf people rewire to process vibrations in the absence of sound. This suggests that, contrary to some popular views, it is good to expose deaf children to music early in life in order to develop 'music centres'.

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.

Hearing: The perception and interpretation by the brain of sound waves detected by the ear.

Hertz: A unit of frequency; abbreviated as Hz. One hertz (Hz) is one complete wave cycle or one vibration per second.

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.

Sound: The brain's interpretation of sound waves detected by the ear.

Vibration: A single object or particle moving backwards and forwards (or up and down) rapidly.

Vibrotactile: Vibrations felt in the hands or body rather than perceived by the ear.

Further information

We would like to thank James Kearney for providing us with information relating to his experience as a musician with a profound hearing impairment.

- *Brains of deaf people rewire to hear music*. W Leary, 2001. EurekaAlert. http://www.eurekalert.org/pub_releases/2001-11/uow-bod111901.php
- Feel the music. E Klarreich, *Nature*, 27 November 2001.
- Seen and heard. E Lawrence, *Nature – Science update*, 21 January 1999.
- *Hearing the vibrations*. Helen Phillips, 1998. news@nature.com, News 13 Aug.
- Vibration-induced auditory-cortex activation in a congenitally deaf adult
- S Levänen, V Jousmäki and R Hari, 1998. *Current Biology*, vol. 8, pp. 869-872.
- *This one goes to eleven*. Philip Ball, 2000. news@nature.com; News 7 Jan.
- Vestibular responses to loud dance music: A physiological basis of the 'rock and roll threshold'? NP McAngusTodd and FW Cody, 2000. *JASA*, vol. 107, pp. 496-500.
- Feeling vibrations: enhanced tactile sensitivity in congenitally deaf humans. S Levanen and D Hamdorf, 2001. *Neuroscience Letter*; Vol 301 (1), pp 75-77.
- *Human Vibration*. Bruel & Kjaer, Choayang University of Technology. http://www.cyut.edu.tw/~hcchen/downdata/human%20vibration.doc