Is the outer ear (the pinna) useless as Darwin believed? Its function revisited

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Darwin claimed that the pinna in humans served no function and he believed it was inherited from our putative ape ancestors. Research has documented that this claim is misleading. It actually has several functions, including to help determine the source of sounds and as a means of communication to other persons.

One of the most noticeable features of the human face is the external, visible part of the ear, called the pinna or the auricle (figure 1).[1] This outer ear consists primarily of elastic cartilage covered with skin. It is a critical organ that, in animals, can be moved to more accurately locate the source of sound and improve its reception, and also aid communication between conspecifics.[2] Darwin observed this fact and noted that humans could not move the pinna as can many animals. He opined the ear muscles in man are so degenerate that the ear cannot normally be moved.[3] For several reasons he wrote much about the pinna and what he concluded was its lack of function in modern humans.[4] Science journalist Rosie Mestel writes about Darwin's curt response to the pinna's function: "With a flick of his quill pen, Darwin shrugged off the pinna in *the Descent of Man*" as useless.[5] One reason Darwin gave for claiming the pinna lacked a function was "a study of a sailor who'd had one pinna cut off in a scuffle but could still hear just as well with that ear."[6]

Darwin believed that humans evolved from some unspecified lower-level primate that could move its pinna to direct sound waves into the ear canal.[7] As university Professor Robert Butler noted, Darwin argued "that our pinnae are small and we can't move them about as many animals can … our pinnae may have had a function earlier on in our evolution, but now they're [useless] vestiges."[6]

Some of Darwin's correspondents supported his conclusion that the human outer ear lacks a function. One example is Jena University Professor William Preyer, who concluded that the external ear has no physiological functions, only a decorative role. He wrote to Darwin:

> "I shall also, I hope soon, have the pleasure of sending you a paper on the physiological functions of the external ear, wh[ich] are nearly naught, contrary to what many physiologists believe. This result is in accordance with your remarks on the rudimentary nature of the concha. But how is it to be explained that only the human ear has an ear-lap? And the ears of the negroes have none."[8]

Darwin answered in a letter dated 30 April 1871 as follows:

> "I shall be particularly glad to see your paper on the external ear, as this will be very useful for any future corrected edition of my book. I was quite unaware of the inexplicable fact of the deficient ear-lap in negroes."[9]

After Darwin, the vestigial claim for the pinna was often uncritically repeated. A typical example is the claim by Rogers *et al*. that the outer

> "… ear is another part of the body that shows numerous vestigial features. The entire *outer ear* is so greatly reduced in size and so ineffective as a funnel for concentrating sound waves, compared to its development in many of the lower mammals, that it must itself be regarded as a vestigial organ."[10]

Since humans normally cannot move the pinna, as can many animals, Darwin considered it a functionless evolutionary remnant of a much larger functional pinna that our putative evolutionary ancestors possessed. Furthermore, Darwin claimed that the "whole external shell of the ear may be considered a rudiment, together with the various folds and prominences (helix and anti-helix, tragus, and anti-tragus)."[3] Historically,

> "… the shape of the external ear has attracted Man's attention from remote ages. In the traditional lore of Indo-China an ear with a long lobe is held to be a sign of great wisdom. Aristotle considered long ears indicated an outstanding memory. Darwin referred to the human ear as a rudimentary organ."[11]

In many societies older people were believed to have greater wisdom, and at least it appeared that they typically had longer, or larger, ears as well, possibly because aging affects the facial proportions.[12] This may be the source of this lore.

Claims that the pinna has no function disproved

The first problem with the notion of the pinna's vestigial nature is that Darwin's claim that one can hear just as well without it is not supported by research.[13] One summary of the research related that "the Taliban punished a group of Afghan truck drivers suspected of collaborating with U.S.-led troops by chopping off their ears."[14] In answer to the question of whether loss of the pinnae would affect their hearing, Baylor College of Medicine professor Dr John Oghalai and Advanced Ear, Nose & Throat Specialist Dr Madan Kandula indicated that it *would definitely* affect their hearing:

Figure 1. Adult human outer ear

> "The outer part of your ear, known as the pinna, funnels sound into your ear canal, like a megaphone in reverse. If someone cut it off, everything would sound quieter. (A wound that scabbed over would make the sound suppression more severe.) The pinnae also tell you where sounds are coming from: The ridges and grooves shape sound waves differently depending on where the sound originates. As a result, the brain learns to associate certain amplification patterns with certain directions. So, if you lost your ears, you might be able to tell what music you're hearing, but not where the speakers are."[14]

Research has supported this clinical observation,[15] noting that the pinna is required for both effective sound amplification and localization.[16]

Children born without pinnae—a deformity called microtia—have been studied in some detail. Such a deformity

> "… is a congenital anomaly, characterized by a small, abnormally shaped auricle (pinna). … The estimated prevalence of microtia is 0.8–4.2 per 10,000 births, and it is more common in men. Microtia can have a genetic or environmental predisposition. Mendelian hereditary forms of microtia with an autosomal dominant or recessive mode of inheritance, and some forms due to chromosomal aberrations have been reported. Several responsible genes have been identified, most of them being homeobox genes."[17]

The problems, such as social and communication issues, that result usually prompt an attempt to reconstruct the pinnae, not only for the sake of appearance, but also to improve hearing. Building a new pinna is a very complicated task; surgeons graft a section of cartilage from the ribs, carve it into the pinna shape, then implant it under the skin where the pinna would be. Then a skin graft is used to make the fake ear protrude. The process requires three or four operations, and can take up to two years to complete.

New research shows the pinna responds to sound direction

A recent study concluded that we make small movements of the pinna, which, the authors hypothesize, facilitates better hearing and improved sound localization. They write:

> "Many animals … move their ears to better focus their attention on a novel sound. That humans also have this capability was not known until now. A research team based in Saarland has demonstrated for the first time that we make minute, unconscious movements of our ears that are directed towards the sound we want to focus our attention on."[18]

The researchers recorded signals that control the minute movements of the pinna by surface electromyography (EMG). Sensors on the subject's skin detect electrical activity produced by the muscles that move the pinna or alter its shape.[19] To assess reflexive, stimulus-driven attention, the researchers presented novel sounds from speakers at four different lateral locations while participants silently read a text to distract them. To test voluntary, goal-directed attention, participants listened to a story coming from one of the speakers, while ignoring a competing story from the speaker on the opposite side. The fact that the neural networks function to slightly move the pinna indicates the pinna system does have a function which may improve hearing quality, especially directional hearing. The study concluded "that the direction of auditory attention is reflected in sustained electrical activity of muscles within the [claimed] vestigial auriculomotor system."[19]

These tiny movements appear to be part of a sensory system that triggers the gross muscle system to move the head toward the source of the sound of interest.[20] Another function is to improve the function of the pinna's role to amplify certain sounds, especially those sounds used to communicate with others. The best example of this effect is when a lecture in a classroom is recorded one notices it picks up many unwanted sounds, such as the ventilation system noise that those in the room are often not aware of. The reason is our hearing system is effective in reducing, or even eliminating, sounds outside of the normal human communication range, which is from 300 to 4,000 Hz. Conversely, most healthy humans can hear a range from 20 to 20,000 Hz. The finding also has possible clinical applications. For example:

> "These tiny movements could be used to develop

better hearing aids that sense the electrical activity in the ear muscles and amplify sounds the person is trying to focus on, while minimizing other sounds."[19]

Could these muscles be developed so that they have a small role in moving the pinna which may not be important in everyday life, but could be significant in certain occupations, such as a musician? As with other talents, the degree of their development depends on the genetics, interest, and the hours of practice of the person, a fact that could be part of the use and development of this muscle system. Are there persons that have developed this system to the degree that it aids their hearing? After all, we know the small internal and external grooves in the pinna play a significant role in amplifying the sounds of concern in hearing.[21] It may not take a very large movement to be of benefit in enhancing the effect. Perhaps the most important explanation for the purpose of the muscles that slightly move the ear is that they are intended to function as part of the total set of face musculature (43 face muscles plus the eight temporal and extrinsic human ear muscles), which set plays an important role in conveying a variety of emotions so important to effective human-to-human interactions.[22]

Lastly, an important role of the pinna is to pick up information about the details of the sound source, which then must be processed by the brain.[23] Specifically, sound localization, which is especially important in humans, is processed by a complex network including anterior and posterior regions of the temporal lobe, the posterior parietal cortex, the dorsolateral prefrontal cortex and the inferior frontal cortex.[24] And the design of the pinna is critical in obtaining the information required to accurately pinpoint the source of sound information, both in humans and other mammals.[25] Some of the research on sound location is on animals because the same research on humans would be unethical.

Conclusions

In conclusion, research has shown that, in contrast to Darwin's claim, the external ear is a well-designed structure that effectively collects and amplifies sound in the frequency ranges most important to humans for communication, which is from 300 to 4,000 Hz.

Furthermore, the slight muscle-induced movement of the ear, while it has little effect on moving the pinna, may be part of the sensory system, which facilitates the person moving their head toward the sound source. This is one reason that determining direction, detection, and sound localization in humans is so effective. Even if such slight ear movements are largely non-functional for hearing, it is still functional as an incidental effect of the role of the total musculature involved in the important role of emotional social interaction.

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