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Analysis of Contact Point between Audio Equipment and Concha Cavity

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Abstract: In the fine field of audio equipment design, the contact range between the ear cavity and the audio equipment has become a crucial human-computer interaction interface. The analysis of the contact range between the audio equipment and the ear cavity is not only related to the optimization of acoustic performance, but also profoundly affects the user 's comfort, wearing stability and adaptability. The market audio equipment is divided into conventional headphones, hearing aids and professional ear return. These three types of audio equipment have different functional distinctions, but they are roughly the same in appearance design. Based on the physiological structure of the ear, this paper compares the characteristic points of the ear cavity defined by various experts and scholars, analyzes the contact range between three different audio devices and the ear cavity on the market, summarizes the rules, and provides a new idea for the design method of audio equipment.

Keywords: Ear Cavity Feature Points; Ergonomics; Audio Frequency Apparatus.

1. Introduction

The adaptive modeling design of audio frequency apparatus is closely related to the feature points of cavity of auricular concha. Due to the diversity of types of audio frequency apparatus, different types of audio frequency apparatus have different modeling design methods in order to meet the requirements of comfort level and comfort level. This paper will analyze the man-machine contact range of audio frequency apparatus, so as to study the relationship between audio frequency apparatus and the feature points of cavity of auricular concha.

2. Characteristic Points of Human Outer Ear

2.1. Bioanatomical Structure of Human Ear

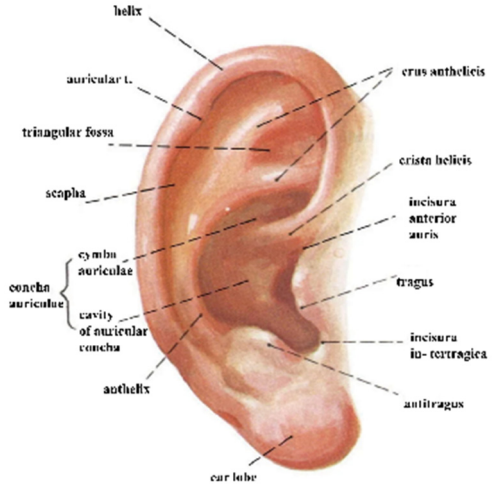


Figure 1. Physiological structure of human ear

According to the biological anatomy of the human ear, the human ear consists of three parts: the outer ear, the middle ear and the inner ear.[1] The research in this paper mainly focuses on the external ear, so only the structure of the external ear is introduced below. The part of the human ear exposed to the outside is called the external ear, which is mainly composed of skin soft tissue and cartilage, including 13 parts defined in biological anatomy, as shown in Figure 1: ear wheel, triangular fossa, navicular fossa, ear wheel, ear wheel foot, ear boat, ear wheel foot, ear cavity, tragus, tragus, intertragus notch, earlobe and external auditory canal opening. [2]

2.1.1. External Ear Feature Points

Due to the need of measurement and clustering, according to the previous research summary of external ear measurement and anatomy, combined with the expert suggestion of human factor engineering design and the expert group discussion of earphone designer [3], 37 key feature points and 46 feature sizes of the external ear are obtained, as shown in Table 1 and Figure 2.

2.2. Audio Equipment Man-machine Relationship

The human-machine contact range of conventional audio equipment is shown in the figure. The head beam part of the headset is in contact with the top of the user 's head, and the contact area is between feature points 1-8 and 13-23. The main contact areas of the in-ear headphones and the half-in-ear headphones are in the concha cavity and the external auditory canal, that is, the contact area is between the feature points 16-26 ; the contact area of the earphone is the concha cavity, the external auditory canal and the contour line behind the ear, and the contact area is between the points of 9-10,12,1-2,16-24 ; the contact area of the crescent headset is in the concha, concha cavity and external auditory canal, and the contact area is between the feature points 14-21 and 24. The contact area of the earbud headset is between the ear wheel and the tragus, and the contact area is between the feature points 15-16 and 16-26.

Table 1. Definition of external ear feature points

Ear partition	Serial number	Name of Special Outer Ear Clinic	Serial number	Name of Special Outer Ear Clinic
Auricle	1	The anterior point of the auricle	2	Ear attachment points
	3	Top point of auricle	4	The last point of the auricle
	5	Last point of earlobe	6	Bottom point of auricle
	7	Attachment point under ear	8	Earlobe front point
	9	Post-ear attachment points	10	mastoideale
	11	Ear screen base point	12	The anterior point of mastoid
Cavity of auricular concha	13	The front point of the ear boat	14	Top point of earnail boat
	15	Last point of concha cavity	16	The interaction point between the helix angle and the concha cavity
	17	on the ear screen	18	Cut marks between ear screens
	19	The lowest point of the lower edge of the ear screen	20	Ear Screen Point (Ear)
	21	The last point of preauricular notch	22	Top point of concha cavity
	23	The center point of the ear wheel angle	24	Midpoint of concha cavity
	25	Center point of concha cavity	26	Wheel screen notch point
Antrum auris	28	The top point of the ear canal	29	The lowest point of the ear canal mouth
	30	The front point of the ear canal mouth	31	The last point of the ear canal
	32	The top point of the first bend	33	The bottom point of the first bend
	34	The front point of the first bend	35	The last point of the first bend
	36	Central point of ear canal opening	37	The center point of the first bend

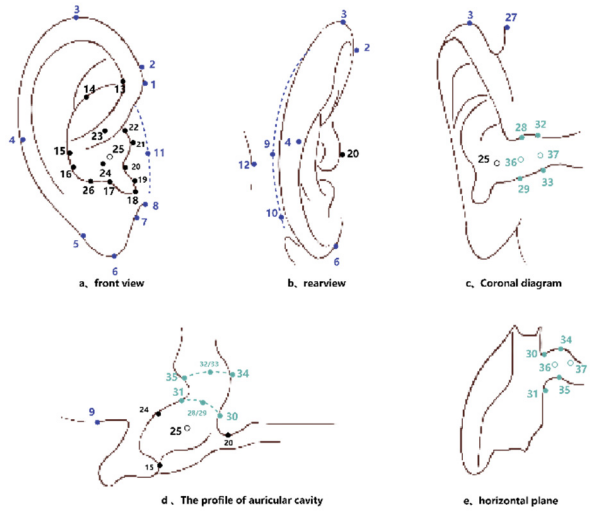


Figure 2. Human ear feature points

The following research takes the above feature points as a reference for subsequent man-machine analysis.

The four types of human-machine contact range of the hearing aid are as shown in Table 2. The ear-back type is in contact with the outer auricle, the concha cavity and the concha boat. The contact characteristic points are between 1-3,16-22, and 24-25; the intra-auricular type is mainly in contact with the concha cavity, external auditory canal and concha boat, and the contact feature points are between 14-26 and 28-37. The ear canal type contacts with the auricular cavity and the external auditory canal, and the contact feature points are between 17-25 and 28-37. The deep ear canal type is mainly in contact with the external auditory canal, and the contact characteristic points are between 28 and 37. [4]

From the table, it can be seen that the contact range between different audio devices and the ear cavity is different. Through these contact ranges, it can be concluded that there are 9 points commonly used in market audio devices, which are 16, 26, 17, 19, 20, 21, 23, 24 and 25 respectively. If the audio device is designed to meet these nine points in the design, a more pertinent audio product can be designed to meet the needs of most users.

3. Conclusion

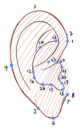
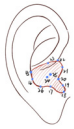
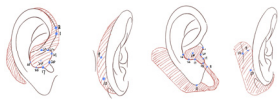
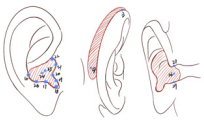
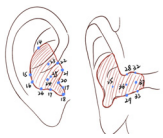
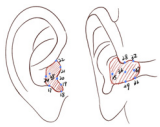
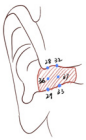
These meticulous human-machine contact points, as an indispensable consideration in the design process, can profoundly affect and optimize the overall design and user experience of future audio equipment. They are not only related to the physical form, material selection and layout arrangement of the device, but also touch every subtle feeling when the user interacts with the device. The optimization design of these key contact points can significantly improve the ease of use and user satisfaction of the device.

The contact point between the concha cavity and the audio equipment can also be disassembled and utilized through the intervention of other disciplines.

In the field of acoustics, the design of contact points directly affects the transmission efficiency and sound quality of sound. A good contact interface can reduce the loss of sound during transmission and improve the overall resolution and clarity of audio equipment. Therefore, designers need to comprehensively consider the transmission mechanism of sound, the diffusion characteristics of sound waves and the acoustic effects of the ear cavity. Through accurate modeling and simulation analysis, the shape, structure and material of the contact point are optimized to achieve the best acoustic performance.

In addition, from the perspective of ergonomics, the design of the contact point between the ear cavity and the audio device also needs to pay attention to the user 's operational convenience and cognitive load.

Table 2. Headset-human ear man-machine contact range

Name	Type	Pyramic area	Contact characteristic point position
Conventional headphones	Head-mounted audio		1-8, 13-23
	Half-in-ear audio		15-26
	In-ear audio		15-26, 28-31, 36
	Ear-hung audio		9-10, 12, 1-2, 16-24
	Crescent audio		14-21, 24
	Ear clip audio		15-16, between 16 and 26
hearing aid	earette		1-3, 16-22, 24-25
	hearing aids		14-26, 28-37
	Ear canal hearing aid		17-25, 28-37
	Deep ear canal style		28-37

In summary, the design of the contact point between the ear cavity and the audio equipment is an interdisciplinary and complex problem, involving biomechanics, acoustics, material science, ergonomics and other fields. Through in-depth academic research and practical exploration, we can not only improve the overall performance and user experience of audio equipment, but also provide useful reference for design innovation in related fields.

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