Basic Study on the Mechanism of Earphone Hearing loss - Results of ear age measurement experiment conducted in 2021 -

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ABSTRACT

In our laboratory, in order to help prevent earphone deafness from young people, modeling its mechanism based on engineering ideas has been trying. The correlation between the ear age and the actual age of subject, and the sound energy which the subject has been exposed to so far, are important information for the purpose. Various collection methods have been tried but it may be that the best method has not been reached yet. The method should be developed, especially questioning methods for estimating sound energy with high accuracy. Ear age measurement has produced some success with the current method in which subjects listen to the sounds of 1000Hz to 21000Hz in order. Lectures are held, in which data are collected from the general public. 46 subjects were obtained at a lecture held in the summer of 2021. Ear ages of Males tend to be worse than those of females. In addition, while the ear age of the elderly is not bad, there are many young people with bad ear age.

Keywords: Questions and Answers, Female and Male, Younger person and elder person, Correlation diagram, Pure tone.

1. INTRODUCTION

In our laboratory, since WHO [1,2] warned that "young people are at risk of earphone deafness", the attempt to try to model its mechanism based on engineering ideas [3,4] has been continued. While various state variables, functions, the characteristics values of music [5-7] and the subject are unknown, the aim is to realize high-precision modeling as much as possible.

The ear age and real age [3] of the subject are also important information. On the other hand, since these are personal information, it is not easy to collect the data of healthy people. In our laboratory, the authors hold events such as lectures and laboratory open to the public, where data from the general public have steadily been collected [3,8]. A method using the Internet is also being tried so that data collection can be continued even in the current state of the epidemic of the new coronavirus.

The present paper reports new data of the correlation between the ear age and the real age collected during a lecture held in the summer of 2021 in Kamakura City under the auspices of the Board of Education. In addition, improvement of the ear age data collection method will be examined including the method of utilizing the Internet.

2. HISTORY TO DEVELOP EAR AGE MEASUREMENT METHOD

Earphone Usage Survey
The reason why our laboratory started the research on earphone hearing loss was that in 2010, a student belonging to our laboratory complained of earphone hearing loss. While exchanging information with the otolaryngology department of the Medical University, the usage of earphones by Japanese people was investigated [9]. In addition, in the survey, the subjects were asked to subjectively answer whether there was a problem with hearing. They were asked to write down their age, gender and occupation. With the cooperation of several local governments and boards of education, data for 8 elementary and junior high schools were also available. It was confirmed that the earphone usage rate increased and the age at which the earphones started to be used decreased year by year. Some subjects were worried that they might have deafness.

Checking Sound Source
In the next step, the survey was accompanied by a question

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asking what was being heard through the earphones, that is, the content of the sound information. First, a method of writing in words was adopted, but it is not currently implemented. It is because that it was troublesome for the subjects and it was difficult to get a polite answer. In addition, it was not possible to quantitatively evaluate how much the earphones were listening to the sound from words. Trial and error has been continued in an attempt to find a question which is easy to obtain an answer enough to easily evaluate quantitatively.

Numerical Answer Style
Currently, the following method is adopted as one of the best method. Ask to choose or write what kind of music, genre, piece title, composer, or performer they like. Ask to write how many hours they used / use their earphones on average per day / week. Ask to write how many years they have used / have used their earphones. There are various causes of deafness other than earphones, such as being in a noisy environment or commuting on the subway. It is hopefully that the information could be obtain, but the proper questioning method cannot be known. In general, the more detailed the answer, the more troublesome the subjects were to answer, the more incorrect and blank answers.

3. PRESENT EAR AGE MEASUREMENT METHOD

Present Method
Since 2014, the ear age measurement method that asks subjects to listen to pure tones from 1000Hz to 21000Hz and to answer whether they can hear them, has been adopted. From this result, the ear age can be estimated based on the audiogram. It totally takes about 15 minutes to distribute the answer sheet, explain how to do it, test the hearing, write the results and collect the answer sheet.

The advantage of this method is that the required time is short and it can be carried out to large number of subjects all at once. The measurement session with the largest number of subjects was held in a large classroom at the university with 240 people.

Disadvantages
On the contrary, the disadvantage is that the sound quality changes depending on the speaker, so the question remains whether the results of different locations can be treated equally. Depending on the location, it cannot be denied that the place where the subject sits may affect their hearing. When using the Internet, the subject uses his or her own speaker. It is said that whether or not the pitch can be heard is not affected much by the influence of noise and volume, it may be expected that the results of the survey so far are not significantly wrong. On the other hand, the errors caused by the effect of different speakers on the results should be evaluated.

Although the method of declaring whether or not it could be heard is a simple method which does not require a device, the subject may mistakenly hear another sound or tinnitus as that sound in the method. Coincidentally, the ear age of the elderly is unusually well reported. It may be due to an incorrect answer. Such bizarre data should be investigated in detail.

In addition, the audiogram used to estimate the ear age uniformly uses the average value of Japanese data. Audiograms often vary significantly depending on the investigator. The estimation error of ear age is currently studied in parallel

Utilization of the Internet
The authors created a Web site [10] to measure ear age on the Internet. The purpose is to have an unspecified number of persons become the subjects. However, in order for the general public to find the site, the site needs to be a useful for the general public. Advertising is not easy to do with less cost. In addition, the Web site was created so that answers are automatically added to the prepared Excel data using special commands, but it is not working well.. The reason is also that no solid management system for it. People who come to the site can hear the sound and can know their ear age, but the data cannot be recorded.

Currently, the site is not a tool for collecting data from the general public, but is only used as a reference when introducing research to subjects in remote areas. It is presumed that the use of the Internet will become more important in the future due to, for an example, the spread of the new coronavirus. The explanation in the site is presently written in Japanese, but it would widely be accepted if it can be displayed in another language such as English in the future. It is necessary to improve the management and the operation methods so that they can be available at an early stage.

4. EAR AGE MEARCUREMENT IN 2021

Overview
Since it is not easy to collect subjects, various opportunities for measuring ear ages are devised. For example, students are voluntarily gathered after their class. Visitors are free to take measurements at special occasions such as university festivals and laboratory exhibitions. Outside the university, subjects are recruited when the lecture is held. Although it is for the health of the ears of young people, it is not permissible to collect data taking at random from the general public. In our laboratory, data is steadily collected from as many subjects as possible.

In Kamakura City, a lecture on hearing loss is held once a year with the cooperation of the city, and at that time, visitors are asked to voluntarily measure their ear age. After various trials and errors, the program of this lecture currently consists of the following three:

1st session) Lecture on hearing loss
2nd session) Measurement of ear age
3rd session) Ear-friendly mini piano concert

A total of 46 subjects were obtained at the lecture held on July 27, 2021.

Also, from 2021, similar lectures began to be held on a trial basis in Fujisawa City. On August 21, 2021, in Fujisawa City, the authors facilitated a similar course sponsored by the city. For Fujisawa City which operates it, this first attempt presented various future issues such as how to publicize and where to implement it.

Questions
The following questions were asked in paper to the audience. All were voluntarily answered.

Sex: The subject chose and checked make or female. The option "other" should have been provided, but everyone happened to choose male or female this time.

Real age: Thy fill in the numbers. 39 subjects responded and 7 did not.

Occupation: They fill it in words. 31 subjects responded and 15 did not.

Results of ear age: They indicate whether they heard pure tones from 1000Hz to 21000Hz. 35 subjects responded and 11 did not.

Environment, whether they are in an environment where they listen to loud sounds on a daily basis: They fill it in words. 7 subjects responded and 39 did not.

Earphone use, Earphone and headphone usage time: They fill in the number how many hours they do / did use these on average per week, and how many years they continue / continued to use them. 13 subjects responded and 33 did not.

Fig. 1: Results of ear age measurement in 2021 in Kamakura City.

Subject					Answer or not		Impression				Favorite sound source genre										
No.	Ear age	Real Age	*F*	Sex	Environment	Earphone use	C	D	B	H	1	2	3	4	5	6	7	8	9	10	others
1	57	70	-0.186	F	non	non	1		2				V				V		V		
2	57	75	-0.24	M	non	non								V	V		V		V		
3				F	non	non															
4				F	non	non															
5	52	56	-0.071	F	non	non	2	2	2	2							V				
6	52	35	0.4857	M	answer	non											V				
7		80		M	non	non															
8				M	non	non															
9	70	80	-0.125	M	non	non															
10	59	80	-0.263	M	non	non													V		
11	66	73	-0.096	M	answer	non		1	2	2							V	V			
12	57	73	-0.219	F	non	answer															
13	59	77	-0.234	F	non	non	2	2	2		V					V	V				
14	70	85	-0.176	M	non	non	2	2	2	2											
15	60	83	-0.277	F	non	non			2	2							V				
16	56	73	-0.233	M	non	non			1								V				
17	59	71	-0.169	F	non	non					V										
18	59	77	-0.234	F	non	non															
19	52	58	-0.103	F	answer	answer	2	2	2	2	V						V		V	V	
20		81		F	non	non															
21		59		M	non	non															
22	57	58	-0.017	F	non	answer	1	2	2	1	V					V	V			V	
23	70	77	-0.091	M	non	non	1	1	2	2							V	V			
24	60	77	-0.221	F	non	non	1	1	1	1											
25	61	72	-0.153	F	non	non		1	1					V							
26				F	non	non															
27	61	75	-0.187	M	non	non	2	1	2	2							V	V			
28	70	86	-0.186	F	non	non	2	2	2	2											
29				F	non	non															
30	48	61	-0.213	F	answer	non	2	2	1	1							V				
31	57	72	-0.208	M	answer	answer			1												
32	61	74	-0.176	F	non	answer	2	2	2	2	V							V			
33				M	non	non															
34	29	15	0.9333	F	non	answer	2	2	2	2	V						V				
35	21	15	0.4	F	non	answer	1	1	2	1	V						V				
36	26	17	0.5294	F	answer	answer	2	2	2	2	V										
37		16		F	non	non															
38	14	17	-0.176	F	non	non	1	1	1	1	V										
39	44	16	1.75	F	answer	answer	2	1	2	1	V					V					
40	21	17	0.2353	F	non	non	1	1	1	1	V										
41	21	16.5	0.2727	F	answer	answer	1	1	1	1	V										
42	16	16.5	-0.03	F	non	answer															
43	14	16.5	-0.152	F	non	answer					V						V				
44	14	16.5	-0.152	F	non	non															
45	14	16.5	-0.152	F	non	answer					V						V				
46	14	16.5	-0.152	F	non	non					V						V				

* Subject No.41 to 46 did not answer their real age but should be 16 or 17 year old.

Favorite sound source genre: Sound information is classified as shown in Table 1 in the previous paper [3]. They checked any number of choices from 11 prepared choices, 1 to 10 and "other". 30 subjects responded and 16 did not.

Impression, whether they feel the four pieces played at the concert on that day were good: They double-check the prepared choices, the titles of the four pieces if they feel they are very good, and they single-check them if they feel they are good. 24 subjects responded and 22 did not.

Results

The answers are listed in Table 1. Ear ages AE were converted by the authors [3]. In addition, the ear degradation indices F were calculated based on Eq.2 defined in the previous report [3]. Table 2 shows the pieces played at the concert. Table 1 shows the impressions of each pieces which they answered, where 2 means being very good and 1 being good.

Table 2: List of pieces played in mini-concert in 2021.

symbol	composer	piece name
C	Chopin	Aeolian Harp
D	Debussy	Arabesque No.1
B	Beethoven	Moonlight (Sonata No.14 1st Mov.)
H	Hammerstein II	Edelweiss (arranged by K. Hishida)

Overall, the response rate was the worst ever. In Table 1, blanks and "non" indicate that no answer was given. The reason why there were few answers may be that the usage of the venue changed and the operation was not smooth under the prevalence of the new coronavirus, and that there was not enough time during and after the lecture as a results. Questions “Environment” and “Earphone use” are information which infers how much load is applied to the ears. Since they are indispensable for considering the modeling of the earphone deafness mechanism, it is necessary to improve the question and answer method.

Ear Ages and Real Ages

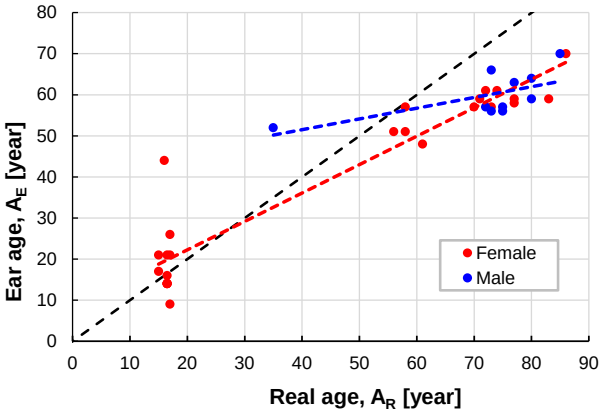
Fig. 1 a) shows the measurement results of ear age obtained in the lecture held in Kamakura City in 2021. Female tends to have better ear age than male. One of the 11 female high school students was significantly hurt in her ears, while the other 10 had a decent ear ages. Probabilistically, about 10% of girls are accelerating deafness.

5. DISCUSSIONS

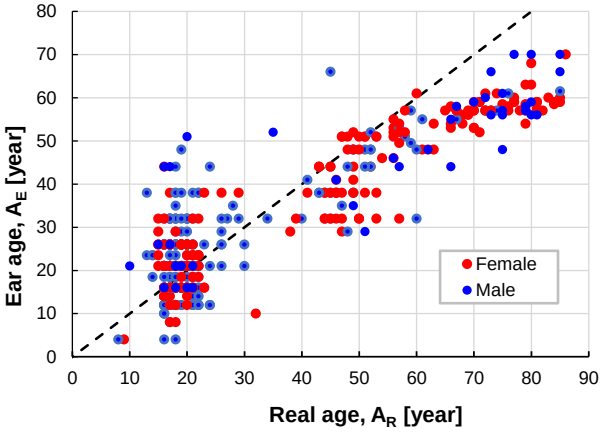
This result is added to the measurement results obtained in the past and is shown in Fig. 1 b). The present result is no different from the results obtained previously. A few subjects attend the lecture in Kamakura City every year to continue providing data, but the majority attended just only once.

The hearing of young people is much more variable than that of older people. That is, it is inferred that the ears of many young people are worse than their age. In addition, men tend to hurt their ears more than women, regardless of age. The boundary between young people with bad ears and older people with good ears is between the ages of 40 and 50. Data for people under 15 and 30 to 40 are missing and are expected to be collected them in the future.

In the preset paper, the correlation between the use of earphones and the degree of deafness was not discussed. Questions were prepared to ask a subject what he /she has been listening to and how long he / she has been listening with earphones. However, many subjects did not write sufficient answers. It turned out that there may be no answer if a subject actually used a considerable amount of earphones. Also, it may be that there are several wrong answers in reality. People do not remember how much they have used earphones in the past. Especially for the elderly and busy people, it may not be easy to answer accurately in a short response time. It suffices if the device or earphone which reproduces the sound would have a function to record the time history of the spectrum of the heard sound. The method must be developed in the future.



a) Data of Kamakura event in 2021



b) All data obtained up to now

Fig. 1: Result of correlation between ear age and real age.

6. CONCLUSIONS

Correlation data between ear age and actual age and data on how much sound energy the subject has been exposed to so far are necessary for earphone deafness prevention studies. In our laboratory, such data has been tried to be collected on various occasions. The data collected at the lecture held in Kamakura City in July 2021 was organized and the following views were obtained:

1) We reached the method to measure ear age to some extent. In order to measure via the Internet in the future, it is

necessary to confirm the influence of the speaker.

2) Male is more likely to have deafness than female. With the boundary about the age of 40 to 50, younger people were more likely to have deafness, and older people were not bad at ear age. These trends are consistent with previous data and medical experience.
3) The response rate of the questions prepared to determine the usage time of the earphones and the cumulative energy reached to the ears, was the lowest overall so far. Subjects may not necessarily remember their previous use. It is necessary to continue improving the answer method in the future.

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