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A Study on the Self Partial Hearing Test for Voice Sub-band

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Abstract:

Hearing ability does not recover once damaged. Therefore, in order to live a happy life, care must be taken to avoid hearing loss. Hearing loss due to the noise environment can cause partial hearing loss, in which the specific frequency band is damaged first. However, hearing loss is painless and difficult to detect at an early stage. In this study, we proposed a method to measure partial hearing loss by voice sub-band. As in Chapter 4, this method is used to discriminate partial hearing loss by listening to nine pure tones of different frequencies in the voice sub-band. As a result of Chapter 5, one out of twelve experiment participants was identified as suspected partial hearing loss. In addition, when the proposed participant described the proposed partial hearing test method, all the experiment participants discriminated themselves for partial hearing loss. These experiments confirmed that the proposed method is indeed a suitable method for partial hearing self test.

Keyword: Hearing ability, Noise environment, Partial hearing loss, Voice sub-band, Discrimination

1. INTRODUCTION

In order to live a happy life, humans must not only have no disease but also have to enjoy the fun by enriching the five senses. However, humans live on average 18.5 years of ill life until their aging functions die at an average age of 83.5 years. In order to live a happy life, periodic health check-ups will require early detection and treatment of unhealthy areas. Hearing ability also ages with age. In particular, hearing loss accelerates in the thirties. However, the actual age of discomfort due to hearing loss is about 40 to 60 years old. This is because, despite the fact that words are heard smaller and smaller, they have not had a problem in understanding the other person's words as they have become accustomed to not hearing well over time. Also, it is difficult to know whether or not hearing ability is due to the fact that it gradually worsens and adapts before hearing loss is recognized. For this reason, if the conversation is a difficult situation and visited the hospital, the hearing ability is already very bad [1-3].

Modern man is exposed to an environment where hearing ability is easily damaged. Traffic noise, factory noise, construction noise as well as various noises due to the development of media threaten hearing ability. In particular, the noise deafness of teenagers due to excessive use of earphones is a serious social problem, and the noise of wind power generators in the renewable energy field has also emerged as a new social problem. In this threat of noise, hearing ability once deteriorated is not restored. Hearing ability generally worsens from the high frequency band as the body ages. However, since the energy is concentrated in a specific frequency band in the case of our surrounding noise, there is a high possibility of partial hearing loss in the case of noise deafness. Even though hearing ability is impaired, since the conversation is qualitatively possible, a partial hearing test method for each frequency on the voice sub-band that is most frequently used for the conversation is needed to prevent neglect of hearing ability management. In particular, most hearing loss is difficult to recognize, and a measuring method is needed so that anyone can easily check their hearing ability [4-7].

In this study, we propose a self partial hearing test method for voice sub-bands that can detect partial hearing loss without being examined in a hospital. This aims to create a living environment that protects hearing ability by allowing anyone to easily measure partial hearing loss. Chapter 2 describes auditory system and sound signal, and Chapter 3 describes existing hearing test method. Chapter 4 describes the proposed method for self partial hearing test for voice sub-band. Chapter 5 describes the experiment and results, and Chapter 6 concludes.

2. AUDITORY SYSTEM & VOICE SIGNAL

2.1 Auditory system

The auditory system have the ability to detects and recognizes sound in our body. Sound from outside is collected through the earflap and vibrates the tympanic membrane through an external auditory meatus called the auditory pit. The vibration of the tympanic membrane is amplified by the auditory ossicle and transmitted to the cochlea. The cochlea analyzes the transmitted vibrations and delivers them to the brain. Cochlea recognizes high frequencies from the inlet and low frequencies toward the back. The auditory system is a delicate sensory organ that detects and analyzes the motion of several micrometers of the tympanic membrane. Very loud noises can therefore damage the auditory cell. Figure 1 shows the auditory system and cochlea, and Figure 2 shows the distribution of resonance frequencies along the length of the cochlea, ie the distance of the basilar membrane [8-9].

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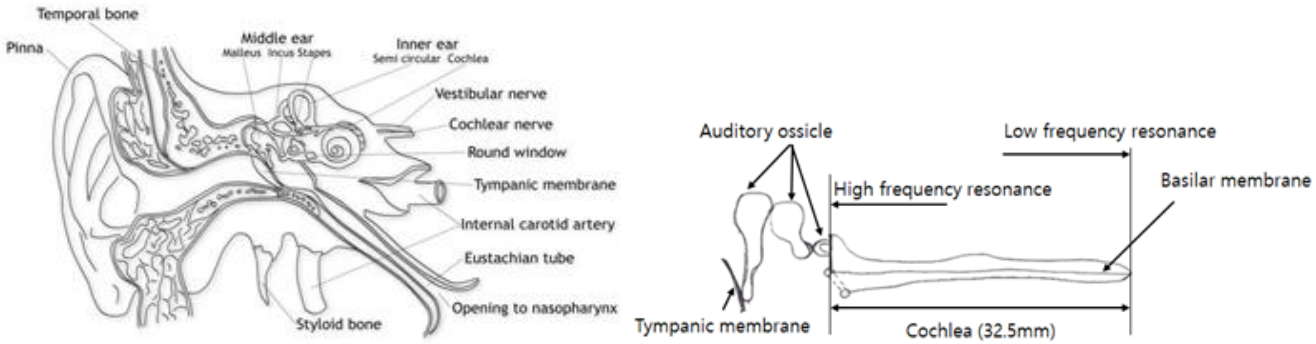

Fig 1. Auditory system & cochlea model [9]

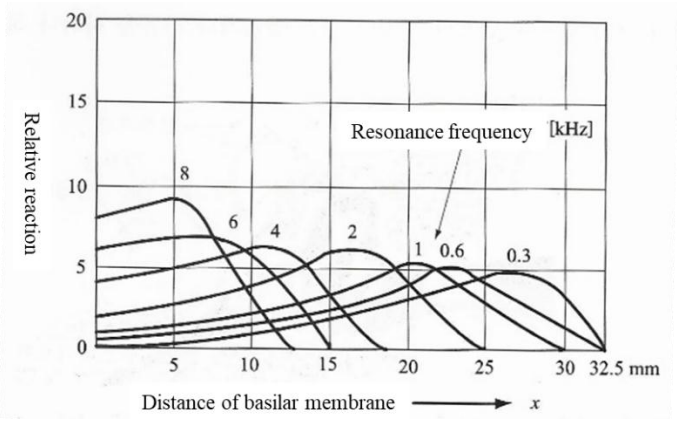

Fig 2. Distribution of resonant frequencies with distance of basilar membrane [9]

2.2 Voice signal

Human audio frequency is known as 20 ~ 20,000Hz. But the human voice is about 8000 Hz or less. Generally speaking, human words are expressed in frequency components of 200 to 8000 Hz. Human vocal cords are driven by air pushed out of the lungs and controlled by the tension of the vocal cords. The speed at which vocal cords tremble is called the fundamental frequency. The fundamental frequency is between 50 and 250 Hz for males and between 120 and 500 Hz for females. The fundamental frequency varies depending on physical structure and lifestyle, and changes depending on emotions and various situations [10-11].

Tremors caused by vocal cords have multiple resonance frequencies depending on the structure and movement of the vocalization organ. In particular, the vocalization organ moves according to the words to be expressed, and various types of resonance frequency distribution occur. The distribution of these frequency components is recognized by the auditory system as words. Figure 3 shows the voice signal in the time domain, and Figure 4 shows the distribution of frequency components in the frequency domain for the voice signal in Figure 3 [10-11].

Fig 3. Voice signal in time domain

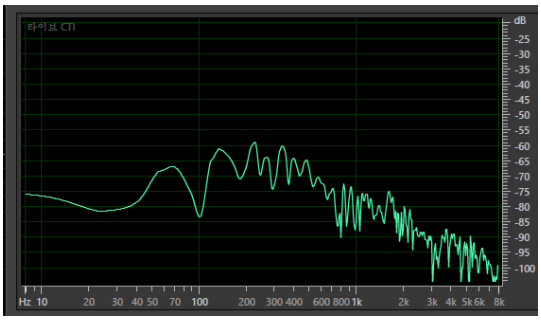

Fig 4. Voice signal in frequency domain

3. TRADITIONAL HEARING TEST METHOD

The hearing test methods include pure tone hearing test, immittance audiometry, speech audiometry, and infants audiometry. The most common of these are the pure tone hearing test. The pure tone hearing test is a method of measuring the pure tone for each frequency and measuring whether each pure tone is heard for the 250 ~ 8KHz sound that is commonly used in daily conversation. At this time, the hearing ability of each frequency component is judged by listening several times while adjusting the amplitude of the pure tone. This pure tone hearing test is a very effective measurement method to confirm hearing ability of various frequency components [10] [12].

However, not only does not a hearing test be conducted in a hospital in a normal conversation state, but most hospitals judge that the hearing ability is normal even if the hearing ability is measured. In the case of detailed measurement of partial hearing loss in a hospital, a very long time is taken in consideration of the hearing threshold by age group [13-14].

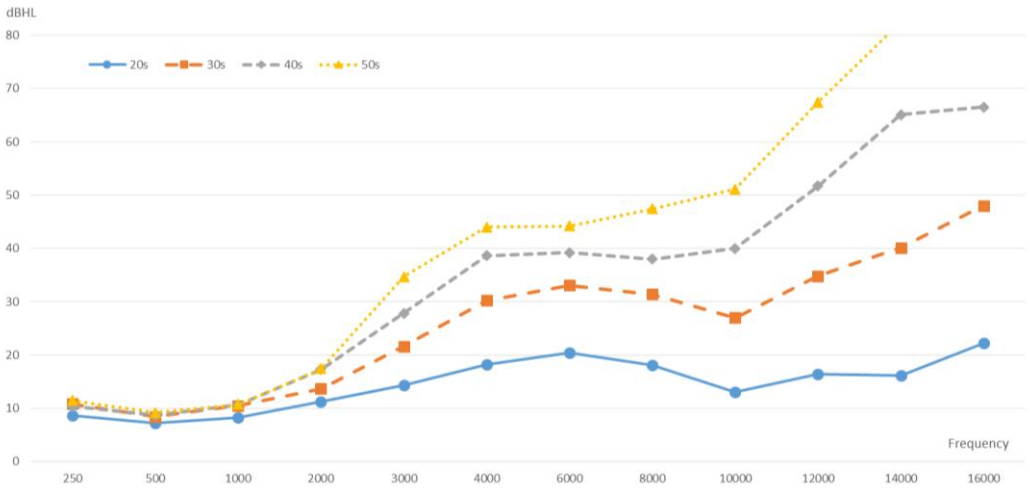

Fig 5. Average hearing threshold by age group

4. PROPOSED METHOD FOR SELF PARTIAL HEARING TEST FOR VOICE SUB-BAND

In this paper, we propose a self partial hearing test method for voice sub-bands using the pure tone hearing test method used in hospitals. Figure 5, which shows the hearing thresholds by age group, shows that hearing loss due to aging occurs first at high frequencies. In other words, as people get older, they are less likely to hear high frequency bands, and relatively low frequency bands can be heard to some extent. Figure 6 shows the expectation that can recognize pure tone according to age group in voice sub-band. Figure 6 shows the pure tone that can be heard because the sound level is higher than the hearing threshold for each age group [13-14].

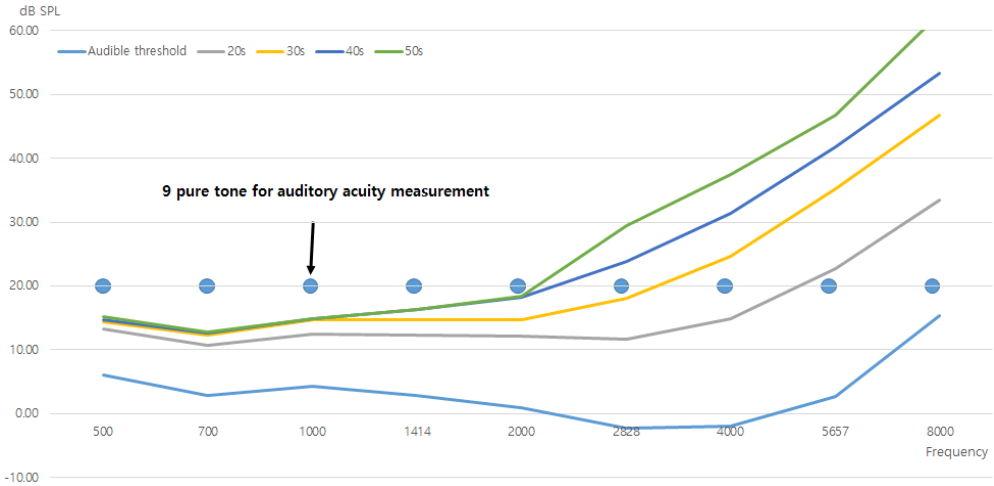

Fig 6. Expected pure tone by voice sub-band that can be heard by age group

In Figure 6, a teenager can hear nine sounds when listening to a pure tone of about 20dB, while the fifties hear only five sounds. However, a teenager with partial hearing loss at 4000 Hz due to noise may raise the hearing threshold at 4000 Hz, allowing only a total of eight pure tones to be heard. In order to identify such partial hearing loss, a method of discriminating sounds and counting the number of sounds heard is applied as shown in Table 1. The sound source heard at this time is nine pure tones with the frequency increased by Mel scale from 500 to 8000Hz.

Table 1. Proposed pure tone array for Voice sub-band

Sound source		500Hz	700Hz	1000Hz	1414Hz	2000Hz	2828Hz	4000Hz	5657Hz	8KHz
Total		O	O	O	O	O	O	O	O	O
Play by 1/2	A			O		O		O		O
	B		O		O		O		O	
Play by 1/2	C			O			O			O
	D		O			O			O	
	E	O			O			O		

If the 20s with normal hearing and 20s with 2KHz partial hearing loss are sounded with 20dB pure tones as shown in Table 1, they are expected to recognize the sound as shown in Table 2.

Table 2. Estimated number of times to hear 20s

Sound source		20s with normal hearing	20s with partial auditory disturbance at 3KHz
Play by 1/2	A	3	2
	B	3	3
Play by 1/2	C	2	2
	D	2	1
	E	3	3

As shown in Table 2, people with normal hearing and those with partial hearing loss can be distinguished according to the number of sounds perceived for each sound source. A≤B and C≤D≤E can be judged as normal hearing. However, as in the case of A> B or C <D> E, if the number of sounds perceived in the source that was first heard by someone is more than the number of sounds perceived in later sources, the person is suspected a partial hearing loss.

5. EXPERIMENTS AND RESULTS

The self partial hearing test method for the voice sub-band proposed in Chapter 4 was conducted on 12 men and women in their teens to 40s. Experimental participants are people who think they have no problems with their hearing because they do not have any communication problems. The experiment participant listened to nine pure tones ranging from 500 to 8 kHz as shown in Table 1. At this time, the audio volume was adjusted to 3 levels of 8%, 4%, and 2% using the LG Notebook 15U480. Nine pure tones were generated at -15dBFS using Audition CC. However, in the case where four pure tones were heard in A and B, the measurement of listening to C, D and E was omitted. The experiment was conducted by selecting a general space that anyone can measure, such as a general office or a university classroom. Table 3 shows the age, sex and measurement results of each experiment participant.

Table 3. Measurement result

Index	Age	Sex	Volume (%)	The number of hearing times for each sound source					Judgment on partial hearing loss
				A	B	C	D	E	
1	15	Woman	8	4	4				
			4	4	4				
			2	4	4				
2	14	Woman	8	4	4				
			4	4	4				
			2	4	4				
3	12	Woman	8	4	4				
			4	4	4				
			2	4	4				
4	12	Woman	8	4	4				
			4	4	4				
			2	4	4				
5	28	Man	8	4	4				
			4	4	4				
			2	4	4				
6	27	Man	8	4	4				
			4	4	4				
			2	4	4				
7	46	Man	8	4	4				
			4	3	4	2	3	3	
			2	3	3	2	2	3	
8	43	Man	8	4	4				
			4	3	3	2	3	2	suspected partial hearing loss
			2	3	2	2	2	2	suspected partial hearing loss
9	45	Woman	8	4	4				
			4	4	4				
			2	4	4				
10	45	Woman	8	4	4				
			4	4	4				
			2	4	4				
11	23	Man	8	4	4				
			4	4	4				
			2	4	4				
12	22	Man	8	4	4				
			4	4	4				
			2	3	4	2	3	3	

In the results of Table 3, 11 of 12 experiment participants were judged normal hearing and one suspected partial hearing loss. Due to the nature of the hearing threshold by age group, it is more likely to be heard when the frequency is lower than when the frequency is high. However, when the partial hearing loss is suspected, a higher number of sounds are heard even though the pure tones in the relatively low frequency range are heard. Experimental participants explained the purpose and discrimination method for the self partial hearing test method for the proposed voice sub-band. They then asked for a partial hearing loss judgment on their results, and everyone was able to judge the same results as the partial hearing loss judgment.

6. CONCLUSION

With the development of medical technology, we have entered the “Homo Hundred”, where humans live to 100 years of age. To be happy by the age of 100, five senses must be enriched. However, hearing ability declined rapidly from the age of 30, and by the age of 40 to 60, the conversation became uncomfortable. Since hearing ability does not recover once damaged, care must be taken from good health to avoid damaging hearing ability. Hearing loss due to aging occurs from the high frequency band. However, due to noise environment, partial hearing loss may occur, which is damaged first in a specific frequency band.

In this study, we proposed a method of discriminating partial hearing loss by itself to cope with hearing loss at the early stage of damage in voice sub-band. The proposed method is to listen to nine pure tones with increasing frequency on mel scale in voice sub-band of 500 ~ 8000hz in the arrangement as shown in Table 1 and discriminate partial hearing loss by itself. As a result of Chapter 5, one person was suspected of partial hearing loss in a 12-person experiment. Experimental participants were described with a self partial hearing test for the proposed voice sub-band. As a result of discriminating partial hearing loss on the experimental results, all 12 experiment participants discriminated the same as the partial hearing loss judgment in Table 3. From these results, we confirmed that the proposed method is actually suitable for self partial hearing test for voice sub-band.

It is hoped that the proliferation of self partial hearing test methods for voice sub-bands will help to lead a healthy life.

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