

Comparison of speech intelligibility between normal headsets and bone conduction hearing devices at call center

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ABSTRACT

The purpose of this paper is to clarify the difference of speech intelligibility between the normal headsets and the bone conduction hearing devices. From the research results of the assessment of noise exposure of call center operators with wearing the headsets, the risk of hearing damage in call centers has been found out. Also, it has been found that the bone conduction hearing devices is better equipment than normal headsets for prevention of hearing loss of call-center operators. But, the difference of speech intelligibility between normal headsets and bone conduction hearing devices does not clear exactly yet. In this paper, the comparison experiment of speech intelligibility between normal headsets and bone conduction hearing devices at call-center was carried out at the laboratory. It was clear that the speech intelligibility had almost the same between normal headsets and bone conduction hearing devices. It was also clear the bone conduction hearing devices are able to use instead of the normal headsets without hearing loss damages at the call center.

Keywords: Speech Intelligibility, Bone Conduction Devices, Headset I-INCE Classification of Subjects Number(s): 63.3

1. INTRODUCTION

Call centers are the rapid growth communication industries in the world. From the research results of the assessment of noise exposure of call center operators with wearing the headsets, the risk of hearing damage in call centers has been found out (1-5). And one paper suggested that, therefore, the risk for call center operators should be seriously assessed. Also, although the method of the prevention of Hand-Arm Vibration Syndrome has been proposed by a researcher (6), the realization of the devices does not yet. On the other hand, the bone conduction devices to hear the voice or music are developing by many industries. The usefulness of bone conduction devices to use at working under noisy high way and tunnel, production line at iron factory, production line at car manufacture, work at airfield have been reported. And also, the usefulness of the bone conduction devices has been reported for prevention of hearing loss (7). But, the performance of speech intelligibility between normal headsets and bone conduction hearing devices does not clear exactly yet.

The purpose of this paper is to clarify the performance of speech intelligibility between normal headsets and bone conduction hearing devices used at the operation of the call center by using the STI (Speech Transmission Index) (8) and the category judgment method (9).

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2 DIFFERENCES OF HEARING

2.1 Ordinary Hearing Process

As shown in Fig. 1, the humans are hearing the sounds through both our bones (bone-conducted or bone transmitted) and the eardrums (air-conducted or air-transmitted). Most of sounds are heard by the eardrums. The eardrum converts the sound waves to vibrations and transmits them to the cochlea (or inner ear).



Figure 1 - Ordinary hearing process

2.2 Bone Conduction Process

As shown in Fig. 2 of the bone conduction listening, the bone conduction devices decode sound waves and convert them into vibrations that can be received directly by cochlea so the eardrum is never involved. The sound reaches the eras as vibrations through the bones (or skull) and skin.



Figure 2 - Bone conduction process

3 EXPERIMENTS

3.1 Used ordinary headset and bone conduction headset at call centers

Fig.3 and Fig.4 show the headsets used in this experiment. Fig.3 is the ordinary headset at call center. This is widely using at call center in Japan.



Figure 3 - Example of ordinary headset at call centers

Fig.4 is the alternative headset such as the bone conduction headset used in this experiment. The frequency range of both headsets is almost the same frequency range between 100-3400 Hz.



Figure 4 - Example of bone conduction headset at call centers

3.2 Stimuli

The reading of the woman who had recorded from the frequency modulation broadcasting program of NHK (anthology "[Kaicyouon]. ") was chosen from the sound source of our hearing always as an original sound to make the examination sound. And, the PCM recording method to convert the audio signal in A/D because the tone quality when recording and reproducing was not decreased, and to memorize as a digital signal was adopted. The recording time is 11.6 seconds, and the speech rate is 5.3 characters/second. An original sound was processed adding the reverberation of two kinds of the condition directly electrically under 10 kinds of conditions by the combination of the sound by two mixing ratio kinds of, and the stimulus sound was produced. And the sound level controlled at 85 dBA by using the level controller of the personal computer. The 85dBA sound level is Occupational exposure limits for continuous or intermittent noise by A-weighted sound pressure level of Recommendation of Occupational Exposure Limits (2010–2011) of The Japan Society for Occupational Health (10). The level of the bone conduction headset was controlled by the equalization method (11).

In this paper, the conditions as shown in Table 1 used to get the performance of the speech intelligibility test between the normal headsets and bone conduction devices.

Stimulus No.	STI
1	1.00
2	0.68
3	0.61
4	0.48
5	0.36
6	1.00
7	0.55
8	0.53
9	0.40
10	0.28

Table 1 – STI conditions of used experiment.

In general, the relation between STI value and articulation is clarified as shown in figure in Fig.5 (8).



Figure 5 - Relation between STI value and Speech Intelligibility

Therefore, the value of STI is thought for the articulation (easiness to catch) to the range from 0.28 to 1.00 to become very, and to be able to clarify the difference of bone conduction headphone and normal headphone.

3.3 Subjects

The test subjects were 12 people (6 males and 6 females). Their ages were between 20 to 60 years old. These subjects confirmed an audiometry was done beforehand, and abnormality was not found in hearing. This experiment was approved by the experimental ethics committee, which consisted of members of Kinki University, medical doctors and commoners.

3.3 Experimental procedures

The category judgment method was used to obtain the performance of the speech intelligibility. The seven categories were used for the evaluation of speech intelligibility in this experiment.

- 7: Extremely easy
- 6 : Very easy
- 5 : Fairly easy
- 4 : Average
- 3 : Fairly difficult
- 2 : Very difficult
- 1 : Extremely difficult

The STI levels of the speech signals were varied over a range of 10 steps as shown in Table 1. These signals were each used five times, comprising a total of 50 stimuli applied in random order, as shown in Fig. 6, each applied for a duration of about 12 seconds with a five-second pause between stimuli for each subject in the experiment. 50 stimuli (10 conditions x 5 repetitions) were presented. The each stimulus level was assumed $L_Aeq=77.5\pm2.5dB$. The subjects got the stimulus sound from the normal headphone the bone conduction headphone shown in Fig.7 and Fig.8 one by one, and judged whether each stimulus speech belongs to the category of the judgment category of seven stages.



Figure 6 – Sequence of stimuli



Figure 7 – Normal headphone



Figure 8 – Bone conduction headphone

4 **RESULTS AND DISCUSSIONS**

The performance of the speech intellibility of a bone conduction headphone and a normal headphone was shown from Fig.9 in Fig.11. Fig.8 showed the mean value of all subject of the category judgment result.

It was clarified that there was no difference between a bone conduction headphone and a normal headphone from outcome of an experiment from the results of Fig.9 to Fig.11 for the speech intelligibility. However, it was clarified that the speech intelligibility of the bone conduction headphone was higher when examining it as the male and female divided the subject.

Generally, when the value of STI becomes 0.5 or less, it is clarified that the person of 50% or more passes the judgment "It is difficult to catch" to the speech. Moreover, the judgment that belongs from "Average" to "Fairly easy" is clarified when it is larger than 0.5. It is clear in both a bone conduction headphone and a normal headphone that speech intelligibility has divided on the boundary of STI=0.6 from Figure 8 to Figure 10 of this outcome of an experiment.



Figure 9 - Relationship between Category and STI of all subjects



Figure 10 - Relationship between Category and STI of male subjects



Figure 11 - Relationship between Category and STI of female subjects

5 CONCLUSIONS

The following was clarified by the current experiment.

- a. There were no difference of speech intelligibility between bone conduction headphone and normal headphone. However, it was clarified that the female speech intelligibility of the bone conduction headphone was higher than male subject results.
- b. The speech intelligibility of the boundary of "Average" was STI=0.6 in both a bone conduction headphone and a normal headphone.

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