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AURAL CHARACTERISTIC OF THE BONE CONDUCTION SPEAKER ON THE CHEEK BONE

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Abstract

Recently, various products using bone conduction speakers have been developed. When such products are used, bone conduction speakers are placed on the cheekbone. This gives the advantage of hearing the bone conduction sound while using an ear protector in a noise environment. It also gives the advantage of hearing the sound of air conduction and bone conduction at the same time. Aural characteristics of the bone conduction speaker on the cheek bone were measured. Specifically, this study investigated the equivalent sound of the air conduction to the bone conduction sound. It was shown that the relation between the vibration of the bone conduction and the sound pressure of air conduction is linear. In addition, a listening test of Japanese words was conducted. It was shown that the subjects had clearly recognized them.

1. INTRODUCTION

Recently, various applications using bone conduction speakers have been proposed [1-4]. If the bone conduction speaker is used, a surrounding sound can be heard because the ear is not closed. As an application to the teleconference, the participant can hear to the remote place and the surrounding voice by air conduction while listening to the interpreted voice by the bone conduction. Because it doesn't use the loudspeaker, it gives the advantage of not using the acoustic echo canceller. The use of the ear protector such as earplugs might be necessary in construction sites, jet plane maintenance and noise environments. If the bone conduction speaker is used, an ear protector can be used because it only has to attach the bone conduction speaker somewhere of the head.

In this paper, we showed the experiment results for the future application of the bone conduction speaker. One was an experiment result that investigated the relationship between the volume of the bone conduction speaker on subject's cheek and the volume of the headphone.

The other was a result of investigated the word listening test. The bone conduction speaker was placed not on the mastoid bone but on the cheekbone because an earmuff was used.

2. MEASUREMENT EXPERIMENT OF BONE CONDUCTION SOUND

The sound was presented from the bone conduction speaker, and an equivalent air conduction sound to the bone conduction sound was examined. The bone conduction speaker was held to subject's right cheek by 3.5N. Because the position of the bone conduction speaker was a cheekbone, utilizing earmuff became possible. The subject put the earplug to a right ear, and, in addition, put on the headphone of the soundproofing level 30 dB. The compared sounds were presented only to a left ear with this headphone. The sounds presented from the bone conduction speaker were Japanese words because it had aimed at the speech communication. The sound of one word was first presented in the right, the sound of one word would be presented in the left in one second, and this was repeated. The subject has equally adjusted the felt bone conduction loudness and the loudness of the headphone. Figure 1 shows the block diagram of this measurement. After the adjustment was finished, the vibration force of the bone conduction speaker and the sound pressure level of the headphone were measured. The vibration force of the bone conduction speaker calculated in mass (10g) of the bone conduction speaker and the measured vibration acceleration. It differed from the bone conduction audiometry, that is, non-examining ear was not masked.

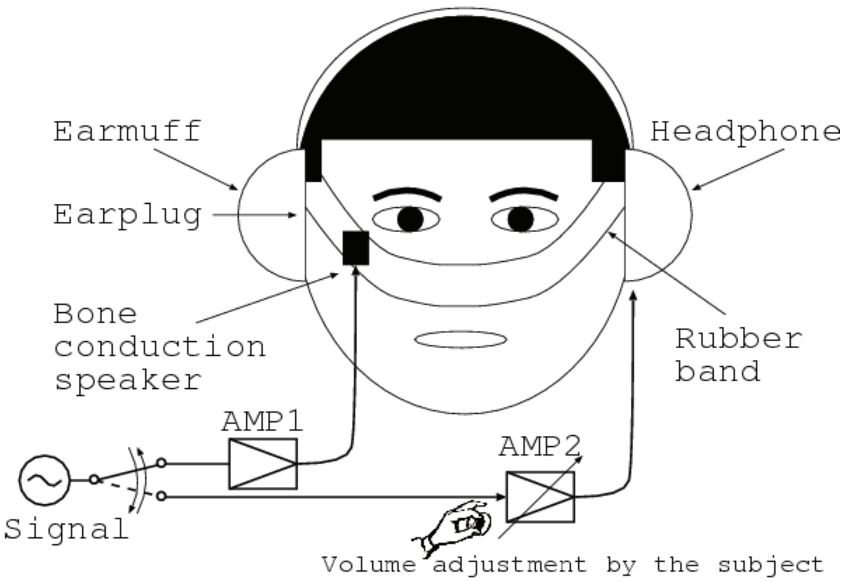

Figure 1 Block diagram for acoustic characteristic measurement of the bone conduction speaker on the cheekbone.

Next, the reproducing characteristic of the bone conduction speaker and the headphone was measured. In addition, the word listening examination with this bone conduction speaker was conducted. This examination was a validity of 50 words that inserts the no sound district section of three seconds between words. These results were shown in the next chapter. The measuring assemblies used here and conditions are as follows.

- Bone conduction speaker: NEC Tokin, KD-02
- Amplifier of bone conduction speaker: YAMAHA RP-U200
- Vibration acceleration sensor: Rion PV-90B
- Amplifier of vibration acceleration sensor (AMP1): Rion UV-06A.
- Headphone: Sennheiser, HD280pro.
- Headphone amplifier (AMP2): YAMAHA AX-500.
- Measuring instrument of sound pressure of headphone: B&K Head torso simulator Type 4100D.
- FFT analyser: Ono Sokki, CF-5220, Sampling point 4096, Sampling frequency 25.6kHz, Hanning window, Average 50 times.
- Voice signal: NTT-AT, Familiarity-controlled Word-lists 2003 (FW03), Man speaker's signals.

3. MEASUREMENT RESULTS

To get the characteristic of the acoustic characteristic of the bone conduction speaker, three experiments were conducted. First, it is a measurement of the vibration characteristic. The signal of 25 word voices was input to the headphone and the bone conduction speaker. Figure 2 shows the spectrum that averages the output of the headphone at this time. Because frequency characteristic of the headphone was flat, it was the same as the characteristic of the input voice. Figure 3 shows the spectrum that averages the vibration of the bone conduction speaker at this time. Because the bone conduction speaker was a piezoelectric element, the vibration of the low frequency was small, and had the resonance in high frequency.

Next, the word voice was input, and the volumes of the bone conduction speaker and the headphone were compared. At this time, frequency characteristic of the bone conduction speaker was not considered. Subjects are 17 people in his/her twenties. Figure 4 shows the relation between the air conduction sound and the bone conduction sound, and vibration force and the sound pressure were linear. It was estimated that the vibration force of the sound pressure 0dB was 36μN. This value was approximated in the case of the mastoid bone.

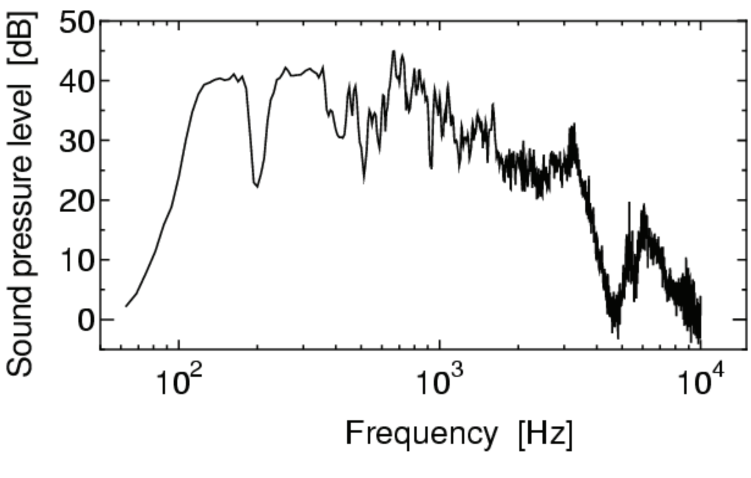

Figure 2 Spectrum of headphone output of voice.

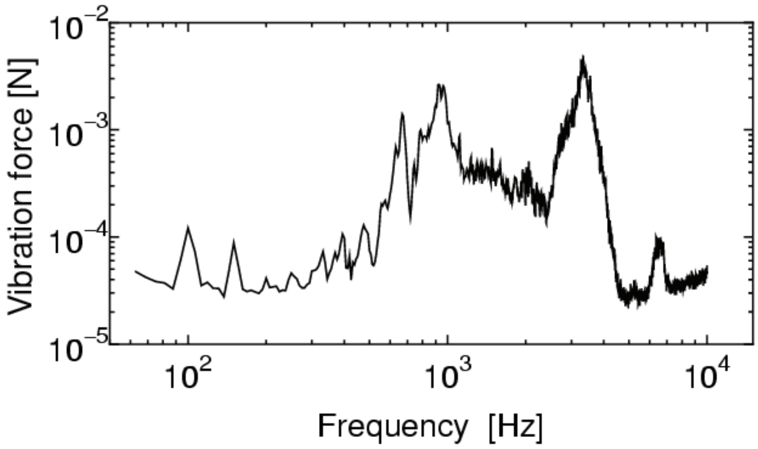

Figure3 Spectrum of vibration of bone conduction speaker of voice.

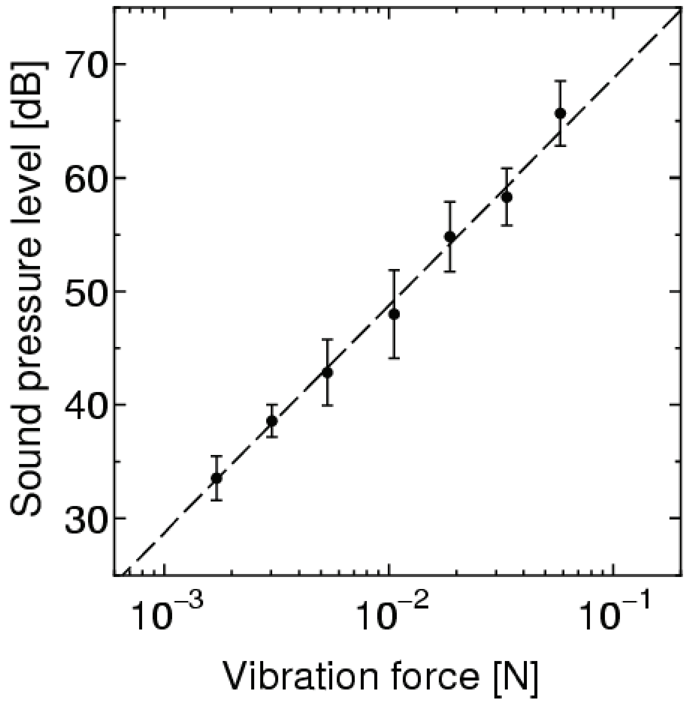

Figure 4 Relation between the vibration of bone conduction speaker on cheekbone and the sound pressure of headphone and the confidence interval 95%.

In addition, the listening test of the word voice was conducted. The familiarities of two levels of the word voices were used. The bone conduction speaker drove the aural signal that corresponded to 60dB of air conduction sound. Subjects were ten people in his/her twenties. Figure 5 shows the result of the listening test with the bone conduction speaker. The correct answer percentage at words with a high familiarity was 97.0%, and the correct answer percentage at words with a low familiarity was 84.6%. Both excellent results were obtained though there was statistical significance by the familiarity of the word. It is thought that catching the first formant influenced because the vibration spectrum of the bone conduction speaker was not flat. The frequency correction is necessary for the improvement of the consent to the bone conduction sound that uses the piezoelectric element.

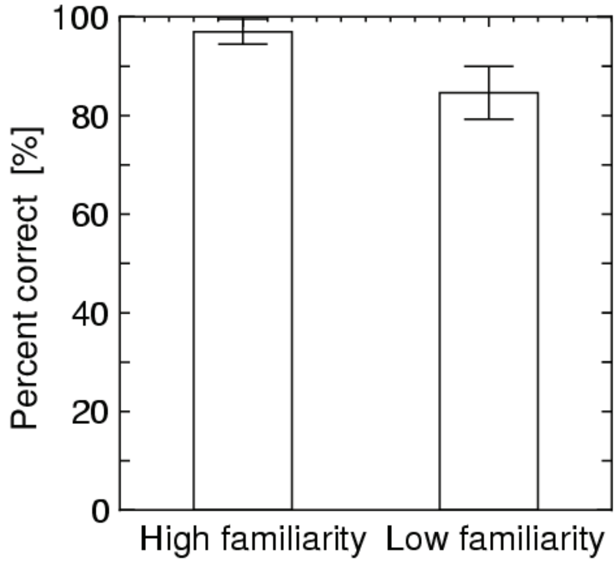

Figure5 Percent of correct answer of word by difference of familiarity of word and the confidence interval 95%.

4. CONCLUSIONS

The experiment that compared the bone conduction sound and the air conduction sound was conducted. The linearity of the relation between the bone conduction sound and the air conduction sound was confirmed. The reproducing characteristic of the bone conduction speaker and percent correct of the word were measured. It became clear that though the frequency response function was not flat because the piezoelectric element was used, there was no obstacle in the voice transmission.

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