

Frequency characteristics of oppressive and vibratory feeling to low-frequency sound

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ABSTRACT

Although experimental results on oppressive and vibratory feelings due to low-frequency sound are widely known, those studies were conducted about 40 years ago in Japan and some questions remain to be examined. For example, “oppressive feeling” and “vibratory feeling” are generally unfamiliar terms, but it is not clear how these terms were explained to or understood by participants. In the present study, an experiment was conducted using a method similar to the previously reported method, and the frequency characteristics of sound that induced oppressive and vibratory feelings were reviewed. Using one-third octave band noise with center frequencies ranging from 10 Hz to 630 Hz, a laboratory experiment was conducted to investigate the sound pressure level at which oppressive or vibratory feeling tended to appear for each frequency. Participants were divided into two groups. One was provided an explanation of the meaning of oppressive and vibratory feelings, and the other was provided no such explanation, and results were compared between the groups. The results suggest that sound pressure levels where these feelings tended to occur were slightly different between the two groups. Furthermore, the feelings appeared even in the higher frequency bands compared with previous studies.

Keywords: Low-frequency noise, oppressive feeling, vibratory feeling

1. INTRODUCTION

Much research has been conducted on the evaluation of impressions of low-frequency sound. Tokita et al. (1) reported the existence of oppressive feeling and vibratory feeling as sensations unique to low-frequency sound. Also, they showed the frequency characteristics of sound pressure levels that induced these feelings, finding that these feelings tended to occur prior to others. The results of that study have been cited in various works (2-4). However, the experiments were conducted over 40 years ago, and there appears to be room for improvement.

Given that “oppressive feeling” and “vibratory feeling” are generally unfamiliar terms, it is necessary to adequately explain the meaning of the feelings to participants in the experiment. To our knowledge, however, none of the previous studies has reported details of the instruction provided to the participants. According to a report written in Japanese (5), some participants misunderstood the meaning of the “vibratory feeling”. In addition, the experiment was conducted simultaneously with 3 to 10 participants in the experimental room, so the presented sound pressure level might have slightly differed among the participants depending on their position in the room.

In the present study, we conducted an experiment with individual participants and used a method similar to the one in the previous report (1). Participants were divided into two groups. One was provided an explanation of the meaning of oppressive and vibratory feelings (explanation group), and the other was provided no such explanation (no explanation group), and results were compared between the groups. The purpose of this study was to provide up-to-date findings on the frequency characteristics of sound pressure levels where oppressive or vibratory feeling tends to occur due to low-frequency sound.

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2. EXPERIMENTAL METHODS

2.1 Procedure

The experiment was conducted in an experimental room at the Kobayasi Institute of Physical Research that was specially designed for investigations of low-frequency sound exposure. As shown in Fig. 1, sixteen 38-cm loudspeakers for reproducing low-frequency sound were installed in the ceiling of the chamber, which had dimensions of 2.8 m (L) × 2.1 m (W) × 2.2 m (H). The experimental room was the same as used in the previous study by Tokita et al (1). Participants were 43 adults who were divided into the explanation and no explanation groups. The experiment was carried out for each participant individually. A total of 36 kinds of stimuli were presented to the participants, and they selected one from eight impressions shown in Table 1 that most matched with their impression to the stimulus. The explanation group used the item shown in Table 1A, and the no explanation group used the item shown in Table 1B. The participants in the explanation group were told that oppressive feeling and vibratory feeling referred to the sensations that a part of the body (head, chest, or abdomen) is being compressed and vibrated, respectively. In the no explanation group, participants used the same rating item as in the previous study, and they were not given a detailed explanation of the meaning of oppressive and vibratory feelings.

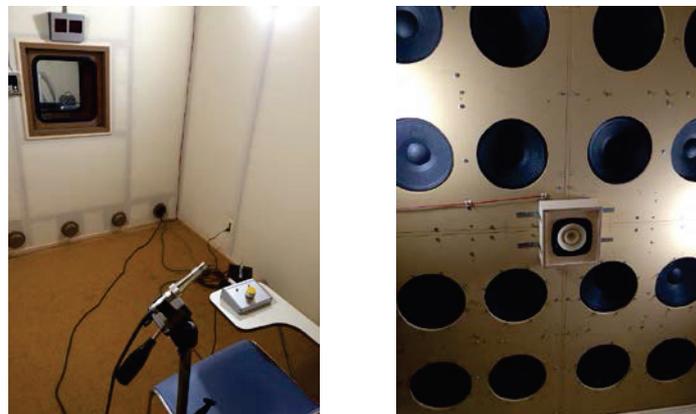


Figure 1 – Photos in the experimental room.

Table 1 – Impression rating items used for evaluating the stimuli

A: Explanation group

1	Undetectable	5	Oppressive feeling in the head, chest, or abdomen
2	Detectable	6	Vibratory feeling in the head, chest, or abdomen
3	Annoying	7	Pain
4	Highly annoying	8	Feeling of impure

B: No explanation group

1	Undetectable	5	Oppressive feeling
2	Detectable	6	Vibratory feeling
3	Annoying	7	Pain
4	Highly annoying	8	Feeling of impure

2.2 Stimuli

As is the previous study, stimuli were one-third octave band noise of 20 s duration. The ranges of sound pressure level and frequency are shown in Table 2. Although these ranges were almost identical

to those used in the previous study, stimuli of 90 dB and 100 dB at 315 Hz and 630 Hz were excluded because those sounds were too loud to safely present to the participants. Stimuli of 50 dB at 40 Hz and 40 dB at 80 Hz were added.

Table 2 – Ranges of sound pressure level and frequency of the stimuli

	10 Hz	20 Hz	40 Hz	80 Hz	160 Hz	315 Hz	630 Hz
110 dB	*						
100 dB	*	*	*	*	*		
90 dB	*	*	*	*	*		
80 dB	*	*	*	*	*	*	*
70 dB		*	*	*	*	*	*
60 dB			*	*	*	*	*
50 dB			*	*	*	*	*
40 dB				*		*	

2.3 Participants

Participants were 21 and 22 adults aged 20 to 69 years in the explanation group and no explanation group, respectively; the distributions of sex and age are given in Table 3. The participants were recruited by telephone or e-mail through our laboratory colleagues and were students, homemakers, and working people. Having recruited widely from acquaintances of acquaintances, we assume that the participants are representative of the general population. Before the experiment, we conducted a hearing test using a pure-tone audiometer and calculated average hearing levels for 125 Hz, 500 Hz, 1 kHz, 2 kHz, and 4 kHz (6). All participants had an average hearing level of 25 dB or less. The World Health Organization (7) states that a hearing level over 25 dB marks the onset of mild hearing loss. Accordingly, we considered that all participants had normal hearing ability.

Table 3 – Distributions of age and sex of the participants

A: Explanation group

Age (years)	20-29	30-39	40-49	50-59	60-69
Male (n=10)	1	2	2	2	3
Female (n=11)	2	2	3	3	1

B: No explanation group

Age (years)	20-29	30-39	40-49	50-59	60-69
Male (n=11)	1	3	1	2	4
Female (n=11)	2	1	3	4	1

3. RESULTS & DISCUSSION

3.1 Comparison of the results between the groups

The selection rates of each feeling shown in Table 1 were calculated for each stimulus; Table 4 shows the feeling with the highest selection rate for each stimulus. As in the previous study, the rate of selecting either oppressive or vibratory feeling was calculated. In the frequency range from 10 Hz to 80 Hz, the tendency was very similar between the explanation and no explanation groups, and the feeling with the highest selection rate was mostly the same. However, participants in the explanation group more frequently selected oppressive or vibratory feeling in the range of 80 dB to 100 dB at 160

Hz. Table 5 shows differences in the selection rate of oppressive or vibratory feeling between the groups. Oppressive or vibratory feeling tended to be more frequently selected in the frequency range from 10 Hz to 80 Hz by the no explanation group but in the range of 160 Hz or higher by the explanation group,. These results suggest that whether or not an explanation of oppressive and vibratory feelings was given affected the evaluation by the participants, and it is expected that the explanation enabled adequate evaluation of the feelings.

Table 4 – Frequency characteristics of sound pressure level for the selected feelings

A: Explanation group

	10 Hz	20 Hz	40 Hz	80 Hz	160 Hz	315 Hz	630 Hz
110 dB	O.V.	-	-	-	-	-	-
100 dB	Ann.	O.V.	O.V.	O.V.	O.V.	-	-
90 dB	Und.	O.V.	O.V.	O.V.	O.V.	-	-
80 dB	Und.	Und.	O.V.	O.V.	O.V.	H.A.	H.A.
70 dB	-	Und.	Ann.	Ann.	H.A.	H.A.	H.A.
60 dB	-	-	Und.	Ann.	Ann.	Ann.	Ann.
50 dB	-	-	Und.	Det.	Ann.	Ann.	Ann.
40 dB	-	-	-	Det.	-	Ann.	-

B: No explanation group

	10 Hz	20 Hz	40 Hz	80 Hz	160 Hz	315 Hz	630 Hz
110 dB	O.V.	-	-	-	-	-	-
100 dB	Det.	O.V.	O.V.	O.V.	H.A.	-	-
90 dB	Und.	O.V.	O.V.	O.V.	H.A.	-	-
80 dB	Und.	Und.	O.V.	O.V.	H.A.	H.A.	H.A.
70 dB	-	Und.	O.V.	Ann.	Ann.	H.A.	H.A.
60 dB	-	-	Det.	Ann.	Ann.	Ann.	Ann.
50 dB	-	-	Und.	Det.	Ann.	Ann.	Ann.
40 dB	-	-	-	Det.	-	Ann.	-

Und.: undetectable; Det.: detectable; Ann.: annoying; H.A.: highly annoying; O.V.: oppressive or vibratory feeling.

Table 5 –Differences in the selection rate of oppressive or vibratory feeling between the groups (explanation group minus no explanation group)

	10 Hz	20 Hz	40 Hz	80 Hz	160 Hz	315 Hz	630 Hz
110 dB	-1%						
100 dB	-8%	-24%	-10%	4%	20%		
90 dB	0%	-7%	-5%	-24%	26%		
80 dB	0%	-4%	-20%	-16%	25%	19%	0%
70 dB		0%	-12%	1%	6%	10%	0%
60 dB			-9%	-14%	-4%	-4%	10%
50 dB			-5%	-5%	0%	-5%	5%
40 dB				0%		-9%	

3.2 Level at which 50% of participants experienced oppressive or vibratory feeling

The sound pressure level at which 50% of participants experienced oppressive or vibratory feeling was estimated by linear regression analysis with the sound pressure level of the stimuli as an independent variable and the z-value of the selection rate of oppressive or vibratory feeling as the dependent variable in each octave band, and those levels were compared between the explanation group, the no explanation group, and the previous study (1). The results are shown in Table 6 and Figure 2. The values from the previous study shown in the table were read from the figure in the published report. The estimated 50% levels were different between the explanation and no explanation groups, especially at 160 Hz. Although the 50% levels from 10 Hz to 80 Hz were almost identical in

the explanation group and the previous study, the results suggest that oppressive or vibratory feeling at 160 Hz may tend to occur at a lower sound pressure level when an explanation is given. Additionally, the sound pressure level for oppressive or vibratory feeling was above the hearing threshold specified in ISO 226, and a similar tendency is also shown in Table 4.

Table 6 – One-third octave band level at which 50% of participants experienced oppressive or vibratory feeling: Comparison between the explanation group, the no explanation group, and the previous study

Center frequency of 1/3 octave band [Hz]	Previous study [dB]	Explanation group [dB]	No explanation group [dB]
10	105	105	104
20	93	93	89
40	78	79	75
80	84	82	77
160	96	83	102

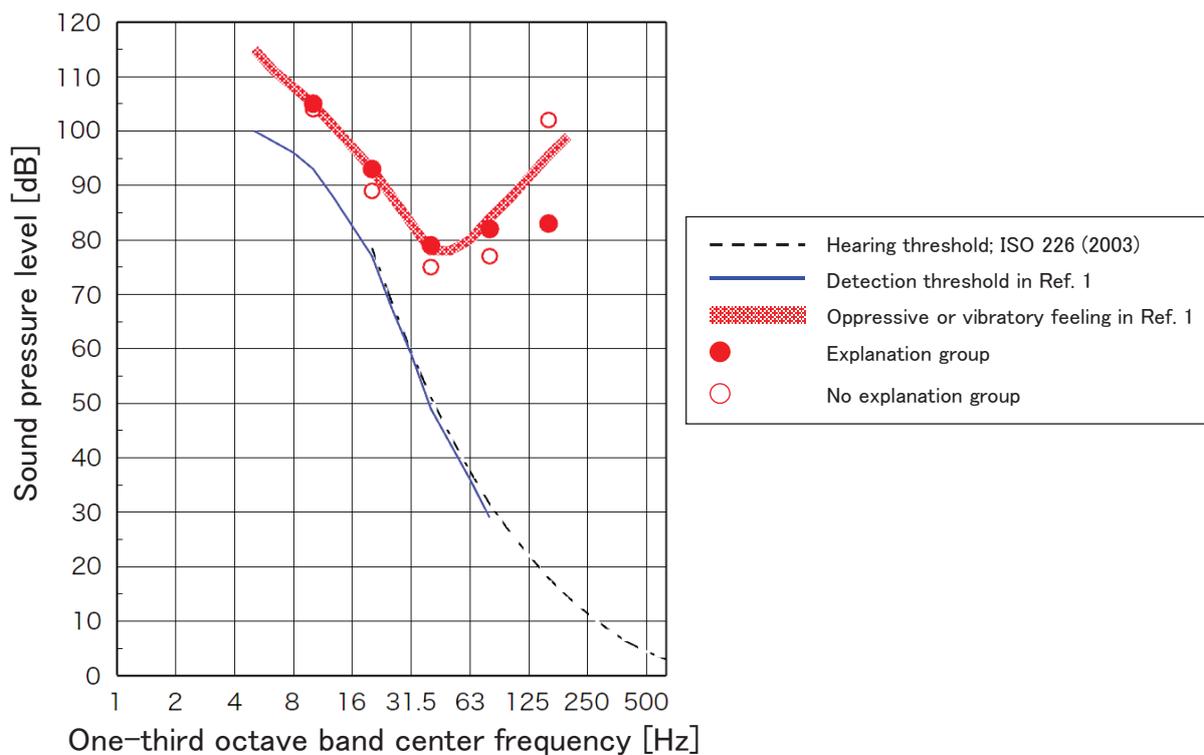


Figure 2 – Comparison of the results between the present study and the previous study with the ISO 226 hearing threshold shown for reference (8)

4. CONCLUDING REMARKS

Studies of oppressive and vibratory feelings were conducted more than 40 years ago, and their findings have been used in various surveys. For example, the findings are often used for environmental assessment of low-frequency sound in Japan. However, as shown in the present study, the results change depending on how the participants understand the terms “oppressive feeling” and “vibratory feeling”. We interviewed the participants in the no explanation group after the experiment and asked them how they envisioned the terms of oppressive feeling and vibration feelings. Rather than sensations that a part of the body was compressed or vibrated, almost half of the participants regarded the feelings as an auditory impression such as “sounds that are trembling” or “sounds that can be heard underwater”.

The results for the explanation group were obtained after providing appropriate instruction, while improving some experimental issues. A novel finding of this study is that oppressive or vibratory feeling at 160 Hz tends to occur at lower sound pressure levels compared with estimates from the previous study. In the future, we plan to perform further experiments after examining other methodological issues

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