DIFFERENCE OF OPTIMUM LISTENING LEVEL OF MUSIC AND PERCIEVED LOUDNESS OF SOUND BETWEEN MEN AND WOMEN

Mariko Hamamura and Shin-ichiro Iwamiya

Faculty of Design, Kyushu University

ABSTRACT

To determine the factor affecting the difference of optimum listening level of music between men and women, the measurement experiment of optimum listening level and the rating experiment of perceived loudness of broadband and various center frequencies' narrowband noise were conducted.

The optimum listening levels of music of male participants were higher than those of female participants. The rating experiments on loudness showed that the female participants rated higher loudness scores than the male participants for broadband and narrowband noises of various center frequencies of the same sound pressure levels. This tendency suggested that the optimum listening level of music was affected by the loudness perception of sound. The difference of optimum listening level of music between men and women was due to the difference of perceived loudness of sound between men and women.

1. INTRODUCTION

Previous studies indicated the difference of optimum listening level of music between men and women (Barrett and Hodgets, 1995; Fligor and Ives, 2006; Hodgetts et al., 2007; Hamamura and Iwamiya, 2013). All of them reported that the optimum listening level of men was higher than that of women. However, the factors affecting the difference of optimum listening level between men and women were not clarified yet. Furthermore, the experimental conditions of the previous studies were not systematically enough to discuss the difference of optimum listening level between men and women.

In the present study, the optimum listening level of music was measured by systematic psychoacoustical experiment to confirm the difference of the optimum listening level of music between men and women. Furthermore, the rating experiment of perceived loudness of broadband and various center frequencies' narrowband noise was conducted to clarify the factor affecting the difference of the optimum listening level between men and women. The difference of loudness perception between men and women was supposed to be such a factor.

2. MEASUREMENT EXPERIMENT OF OPTIMUM LISTEING LEVEL OF MUSIC

To discuss the difference of the optimum listening level of music between men and women, the measurement experiment of the optimum listening level of music was conducted by using a method of adjustment.

2.1 Experimental condition and procedure

The sound stimuli were 4 music experts (approximately 90 s in duration). The information of each stimulus is shown in Table 1. The participants listened to the stimuli via headphones and adjusted the sound volume of headphone amplifier to the optimum listening level for enjoying each tune. In the previous studies, the optimum listening level was measured only once for each stimulus (Barrett and Hodgets, 1995; Fligor and Ives, 2006; Hodgetts et al., 2007; Hamamura and Iwamiya, 2013). However, if we adjusted the optimum listening level several times, the optimum listening level might be different even if the tune was the same. In the present study, the difference among the adjustment levels of each participant's trials for each stimulus was compared with the difference of the average adjustment level between the male and female participants. To discuss such differences, the optimum listening level for each stimulus was measured 5 times. The experiment was consisted of 5 sessions and 4 sound stimuli were reproduced randomly in each session. To avoid the case that the optimum listening level adjusted in previous sessions influence to the adjustment of current optimum listening level, the headphone amplifier and participants' hand were covered by a box.

The participants were 14 students of Kyushu University (7 males and 7 females), aged 21 to 31. All of them had normal hearing but difference of hearing thresholds at some frequencies between the male and female participants were statistically significant by Man Whitney's U test (250 Hz : U =50.5, $p < 0.05$; 500 Hz : U = 39.5, $p < 0.01$; 6 kHz : U = 52.5, $p < 0.05$). In these conditions, the hearing thresholds of the male participants were lower than those of the female participants.

Table 1: The information of music used as the sound stimuli for measurement of the optimum listening level.

No.	Title and artist	Genre
1	Numb, Linkin Park	American Rock
2	Sing, Sing, Sing, Benny Goodman	Jazz (Big band)
3	Linda Linda, THE BLUE HEARTS	Japanese Punk
4	Rock and Roll, Led Zeppelin	British Rock

Table 2: The average of optimum listening level and intra-individual variation for each stimulus [dB].

	Tune 1		Tune 2		Tune 3		Tune 4	
	Average of optimum listening level	Intra-individual variation	Average of optimum listening level	Intra-individual variation	Average of optimum listening level	Intra-individual variation	Average of optimum listening level	Intra-individual variation
M1	61.6	2.9	60.4	5.3	58.8	4.5	62.0	4.0
M2	62.1	3.5	74.0	0.1	66.0	7.0	72.5	6.3
M3	65.6	4.7	64.2	3.7	66.4	8.8	73.9	3.3
M4	76.5	9.0	80.8	9.8	75.0	12.6	80.5	9.7
M5	60.4	4.0	62.5	5.6	59.9	1.9	60.8	3.5
M6	63.2	6.5	61.8	4.3	62.1	4.6	64.9	3.7
M7	74.4	14.3	77.9	11.0	78.3	6.8	77.3	7.0
F1	67.7	3.6	69.5	3.6	65.6	2.8	67.4	2.3
F2	49.1	9.0	50.3	11.2	48.4	4.5	48.2	8.1
F3	51.2	4.0	52.6	4.4	50.3	4.7	51.0	5.2
F4	60.1	1.7	62.2	4.5	59.1	4.0	62.5	4.5
F5	45.6	7.2	48.3	10.4	46.0	3.9	49.3	9.7
F6	59.1	2.4	60.0	2.9	60.1	6.4	59.4	1.5
F7	58.4	4.9	58.7	5.5	55.2	4.9	58.6	5.3
Average of male	66.3		68.8		66.6		70.3	
Average of female	55.9		57.4		54.9		56.6	
Difference between male and female	10.4		11.4		11.7		13.7	

Table 3: 95 % confidence intervals for intra-individual variation in each stimulus [dB].

	Tune 1	Tune 2	Tune 3	Tune 4
Upper limit	7.4	7.8	7.1	6.8
Lower limit	4.0	3.9	4.0	3.8

2.2 Results

In this paper, the difference of the optimum listening levels within a session was called as "intra-individual variation". The intra-individual variation was defined as the difference between the maximum and minimum optimum listening level in each session. The intra-individuals variations and the average values of optimum listening level of 5 sessions for each participant for each stimulus are shown in Table 2. Table 2 also shows the average optimum listening levels for the male participants and those for the female participants for each stimulus. In Table 2, the male participants are shown as M and the female participants are shown as F. The subsequent number of each alphabet means participants' number. For example, M1 means the male participant 1, F2 means the female participant 2.

As shown in Table 2, the male participants adjusted the optimum listening level higher than that of the female participants for all stimuli. This tendency is the same to the previous studies (Barrett and Hodgets, 1995; Fligor and Ives, 2006; Hodgetts et al., 2007; Hamamura and Iwamiya, 2013). The differences of the optimum listening levels between the male and female participants were larger than intra-individual variations expect M7 for tune 1 and M4 for tune 3.

In Table 3, 95 % confidence intervals for intra-individual

variations are shown. The upper limits of 95 % confidence intervals for intra-individual variation are smaller than the differences of optimum listening level between the male and female participants for all the stimuli. These results showed that intra-individual variation of the optimum listening level caused by adjusting it several times was smaller than the difference of optimum listening level between the male and female participants.

The two-way ANOVA was applied to the optimum listening level of music. As a result, the effect of gender was statistically significant ($F(1,272) = 177.88$, $p < 0.01$) and the male participants adjusted the optimum listening level higher than the female participants. The effect of tune and the interaction between gender and tune were not statistically significant.

The experimental results confirmed the existence of the difference of optimum listening level between men and women. This difference was not observed coincidentally.

3. RATING EXPERIMENT OF PERCIEVED LOUDNESS OF BROADBAND NOISE AND NARROWBAND NOISE

According to the measurement experiment of the optimum listening level of music, the optimum listening level for the male participants was higher than that for the female participants. To determine the factor affecting the difference of optimum listening level between men and women, we discussed another different factor between men and women. The previous studies reported that efferent inhibition was relatively less in female than in male (McFadden, 1998) and higher sensitivity of hearing in female than in male (Velle, 1987). From these reports, we could hypothesize that there was the difference of the loudness perception between men and women; women might perceive loudness of sound higher than men. If perceived loudness for sound of the same sound pressure level was different between men and women, the optimum listening level of men would be felt 'louder' by women. Therefore, the female participants might adjust the optimum listening level lower than that of the male participants and the difference of optimum listening level between the male and female participants might be observed. The difference of loudness perception between men and women was supposed to be a factor affecting the difference of the optimum listening level of music between men and women. To confirm this assumption, the rating experiment of perceived loudness of broadband and various center frequencies' narrowband noise was conducted.

3.1 Experimental condition and procedure

Pink noise and 1/3 octave band noises of 8 center frequencies (125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz) were used as the stimuli. The duration of each stimulus was 15 s and the sound pressure levels were adjusted to 55 dB, 60 dB, 65 dB, 70 dB and 75 dB. These sound pressure levels were determined from the distribution range of the optimum listening level of music obtained in the present study and the previous study (Hamamura and Iwamiya, 2013). The stimuli were reproduced from a loudspeaker positioned at 2 m in front of the participants. The participants rated the loudness of the stimuli using the rating scale from 1 to 7 (1: very soft, 2: considerably soft, 3: slightly soft, 4: neither, 5: slightly loud, 6: considerably loud, 7: very loud) after listening to each stimulus.

The experiment was conducted in a semi-anechoic chamber. The participants were 14 students of Kyushu University (7 males and 7 females), aged 21 to 32. All of them had normal hearing and there was no significant difference in hearing ability between the male and female participants.

3.2 Results

The average evaluated values on loudness and their standard deviations for each stimulus were shown in Fig. 1. The female participants tended to rate higher loudness scores than those of the male participants for all the stimuli of the same sound pressure level. The three-way ANOVA was applied to the obtained data. As a result, the effect of sound pressure level ($F(4,508) = 257.91$, $p < 0.01$), that of the kind of stimuli ($F(7,508) = 29.666$, $p < 0.01$) and that of gender ($F(1,508) = 87.362$, $p < 0.01$) were statistically significant. In addition, the interaction between sound pressure level and gender was also statistically significant ($F(4,508) = 8.707$, $p < 0.01$).

The effect of sound pressure level means that when the sound pressure levels were louder, the evaluated values on loudness were also increased. Concerning the effect of the kind of stimuli, multiple comparison procedure was applied to the data. The evaluated values for pink noise were higher than those of other narrowband noises. This tendency was due to the fact that we perceived louder for broadband sound than narrowband sound when the total acoustic energy was the same (Zwicker and Fastl, 1990). The effect of gender means the obtained evaluated values for the stimuli of the same sound pressure level were statistically different between the male and female participants. The female participants rated higher loudness scores than the male participants.

The interaction between sound pressure level and gender was based on the difference of evaluation range between the male and female participants. The male participants rated 1 or 2 for 55 dB stimuli while the female participants rated more than 3 for the same stimuli. The loudness evaluation scores of the male participants distributed from 1 to 7 for the sound stimuli from 55 dB to 75 dB while those of the female participants were from 3 to 7.

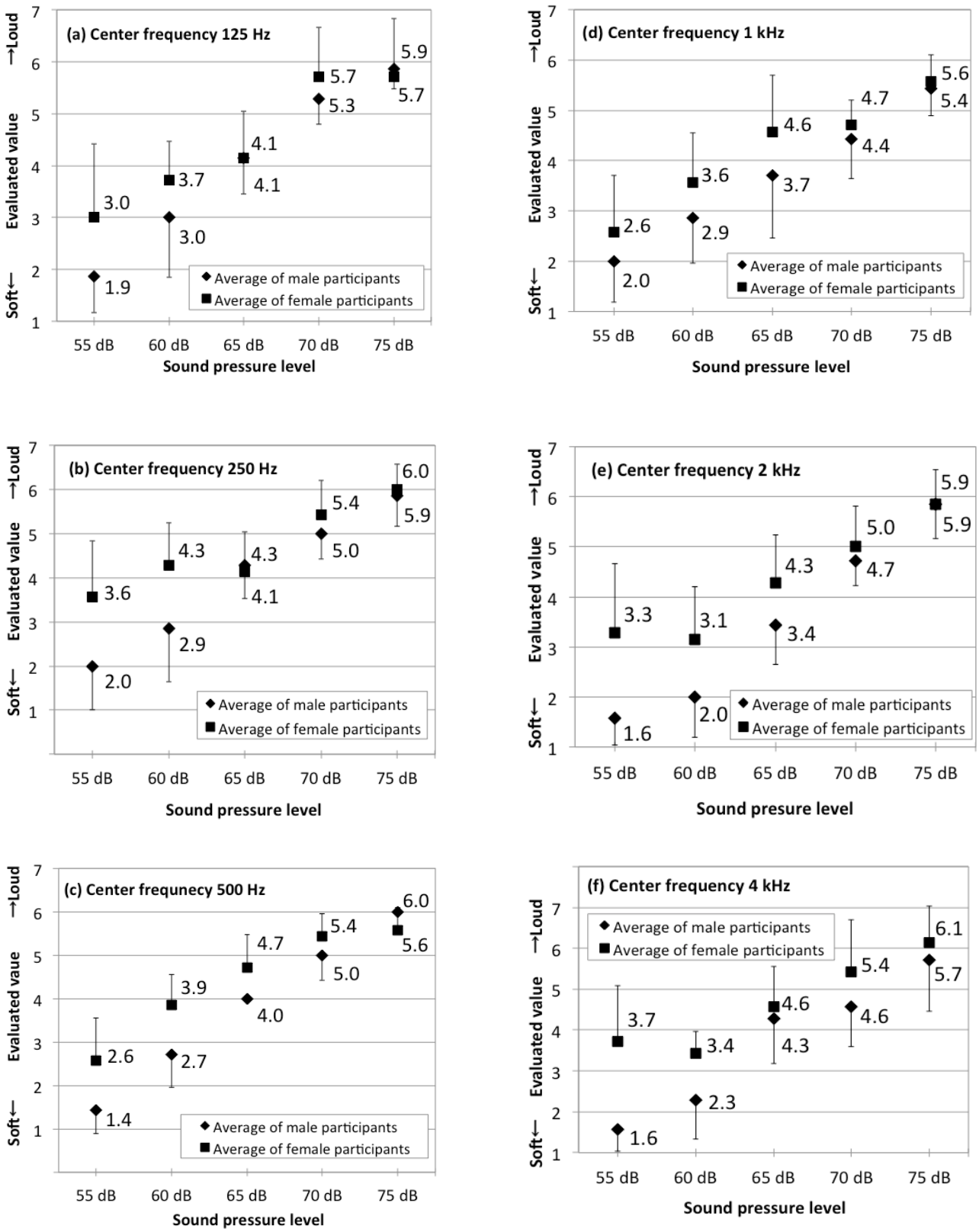
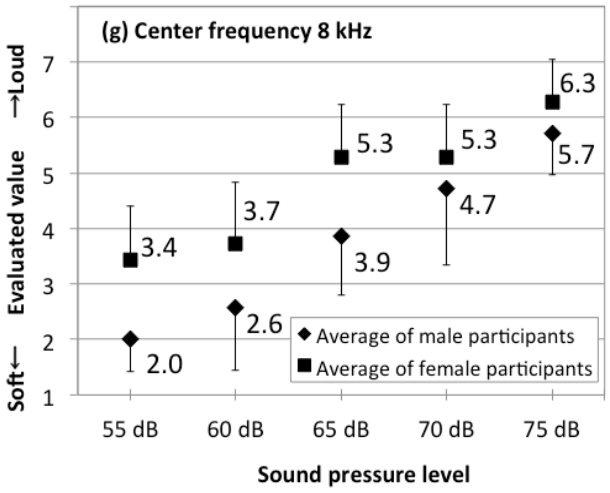


Figure 1: The rating scores for reproduced band noises of male and female participants.



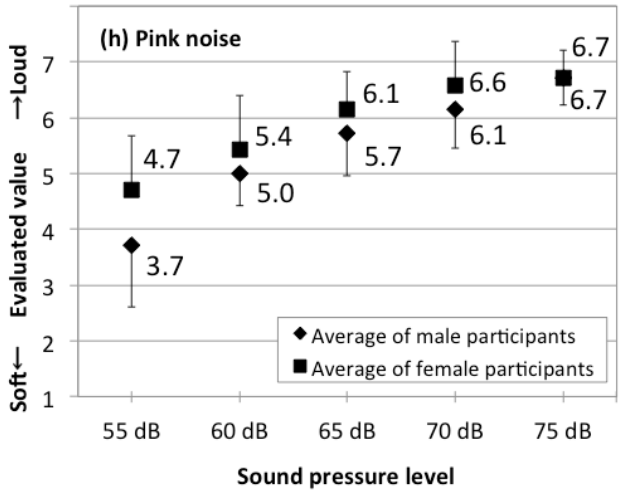


Figure 1: Continued.

4. CONCLUSIONS

The difference of optimum listening level of music between men and women was observed. The male participants adjusted higher optimum listening level than that of the female participants. In addition, intra-individual variations of the optimum listening levels for each participant for each stimulus was smaller than the difference of optimum listening level between the male and female participants. The existence of the difference of optimum listening level between men and women was confirmed. This difference should not be observed coincidentally.

The female participants rated higher loudness scores than those of the male participants for the broadband noise and narrowband noise regardless of center frequency of the same sound pressure level. The difference of loudness perception between men and women existed irrespective of the frequency region. Such difference of loudness perception of sound between men and women is a factor affecting the difference of optimum listening level between men and women.

Because of the difference on the loudness perception based on the gender, the female participants might feel 'louder' for the optimum listening level for the male participants. The female participants might feel 'optimum' when the sound pressure level was lower than the optimum listening level for the male participants. Therefore, the optimum listening level of the female participants was lower than that of the male participants.

5. REFERENCES

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