Three-dimensional Sound Image Localization by Interaural Differences and the Median Plane HRTF

- Part II. Effects of ITD and ILD on Perception of Lateral Angle -

M. Itoh[a], K. Iida[b], E. Rin[a] and M. Morimoto[a]

[a]*Environmental Acoustics Lab, Fac. of Eng., Kobe University, Nada, 657-8501 Kobe, Japan*
[b]*Multimedia Solution Labs, Matsushita Comm. Ind. Co., Ltd, 600 Saedo, Tsuzuki, 224-8539 Yokohama, Japan*

In this paper, localization tests were performed to examine the effect of each interaural difference on the perception of the lateral angle. When the HRTF on the median plane and ITD were simulated, subjects perceived both of lateral and vertical angles accurately. On the other hand, when the HRTF on the median plane and ILD were simulated, the subjects' responses did not agree with the simulated direction. They perceived lateral angles near the median plane regardless of the simulated lateral angles. Moreover, the listeners sometimes perceived unnatural sound images. These results mean that ITD is dominant on the perception of the lateral angle. This agrees with the findings by Wightman et al.

INTRODUCTION

In Part I [1], it is shown that the sound image of any direction could be localized using the HRTF in the median plane and interaural differences. The interaural differences consist of interaural time difference (ITD) and interaural level difference (ILD). In this paper, localization tests were performed to examine the effect of each interaural difference on the perception of the lateral angle.

LOCALIZATION TESTS

The method is the same as Part I, with the exception that either ITD or ILD is simulated as interaural difference.

Figure 1 shows examples of the responses to the stimuli simulated by using the HRTF in the median plane and ITD. Similarly, Figure 2 shows the responses to the stimuli simulated by using ILD for ITD. Both results were obtained from subject IT. Table 1 and 2 indicate the mean localization error when ITD and ILD were simulated, respectively.

Figure 1 shows that perceived lateral angles almost agree with the simulated lateral angles when ITD was simulated. The mean localization errors are about the same as the test in which both interaural differences were simulated (see Table 1 in Part I). On the other hand, Figure 2 shows that perceived lateral angles do not agree with the simulated lateral angles, and all responses distribute near the median plane ($a = 0°$) when ILD was simulated. Accordingly, the mean localization error becomes larger as ILD increases.

These results agree with Wightman's [2] that ITD is dominant to other cues when the signal contains low frequency components. When ILD was simulated, subjects localized near the median plane because ITD was zero.

Concerning vertical angle, perceived angles almost agree with the simulated ones in both cases.

In each localization tests, 840 responses were obtained in total. Unnatural sound images, such as multiple images, appeared 6 and 41 times when ITD and ILD were simulated, respectively. The reason can be considered as follows: The simulation system used in the tests does not reproduce the frequency dependence of ILD that is small at lower frequencies and is large at higher frequencies. Then the subjects perceived unnatural interaural differences. Furthermore, unnatural sound images hardly appeared in the tests in Part I where both interaural differences were simulated. From these results, it can be inferred that ILD contributes for the sound image localization to some extent.

CONCLUSION

Localization tests in which ITD and ILD are simulated separately indicate that ITD is dominant on the perception of the lateral angle.

REFERENCES

1. Iida et al., Proc. 17th Int'l Congr. on Acoustics (2001).
2. F. Wightman and D. Kistler, J. Acoust. Soc. Am., **91**, 1648-1661 (1992).

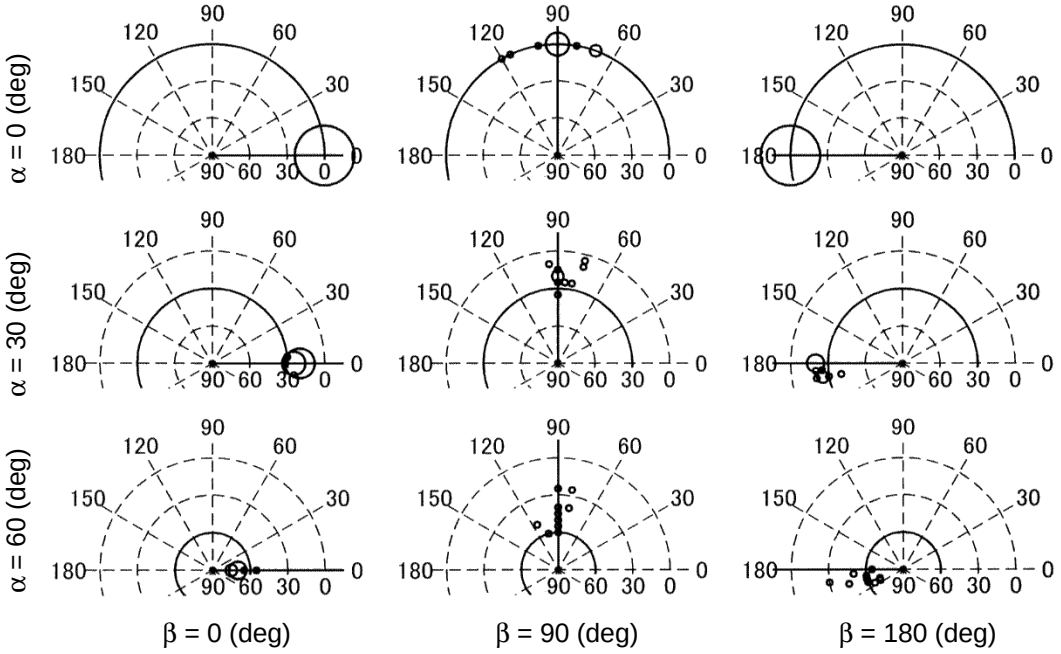

FIGURE 1. Examples of the responses to the stimuli simulated by using median plane HRTF and interaural time differences. Bold lines indicate simulated lateral angle α and vertical angle β.

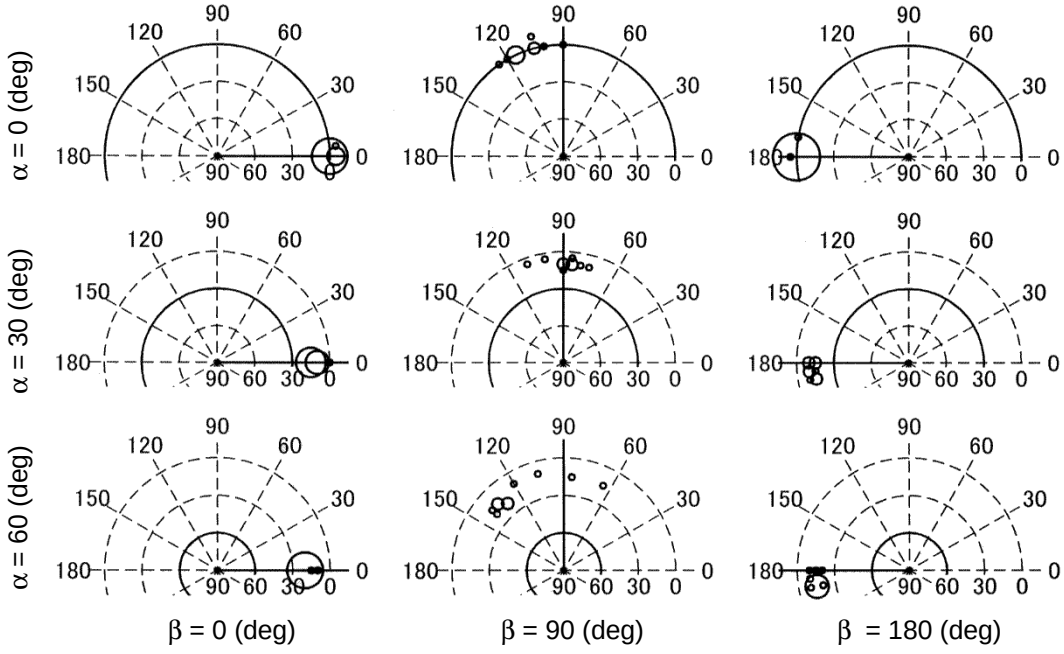

FIGURE 2. Examples of the responses to the stimuli simulated by using median plane HRTF and interaural level differences. Bold lines indicate simulated lateral angle α and vertical angle β.

Table 1. Mean localization error when ITD is simulated

Error	Source angle α (deg)			
	0	30	60	90
Perceived angle α	1	13	22	29
Perceived angle β	13	14	16	-

Table 2. Mean localization error when ILD is simulated

Error	Source angle α (deg)			
	0	30	60	90
Perceived angle α	1	15	33	67
Perceived angle β	15	15	21	-