A Research of Effects on Timbre Perception by Phase Changes

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1 Introduction

It has been told that amplitude information has mattered than phase information in auditory system. However, recently the relationship between phase and timbre perception has been attached great importance in examining about timbre perception.

There has been a few of reports which has stated about effects on timbre perception by phase changes, but they have not referred to phase revision in experimental system and it is not clear whether the conclusions stated in the mare reliable.

Therefore, this paper proposes a method to make an inverse filter which removes effects of phase distortion as correct as possible to improve reliabiyl of stimuli, and verifies the conclusions of such reports by psychophysical experiments with these sounds. Moreover, this paper examines effects on timbre perception by phase using consequences of these experiments.

2 Experimental System

If we carry out the psychophysical experiment considering phase information, we must pay attention to characteristic of headphone. The characteristic of group delay is unstable under the influence of AC source. Therefore a stable electric power supply has to be uesd for headphone amplifier.

The experimental system in this research is composed as follows.

Work Station → DAT-LINK → **DA converter** → **Headphone Amp.** → **Headphone** → **Artificial Ear + Microphone** → **Microphone Preamp.** → **Microphone Power Supply** → **DAT**

Here, bold types indicate analogue signal blocks.

3 Phase Revision

Characteristics of group delay are employed as one of the evaluation criterion for phase distortion in the experimental system.

On the other hand, it is reported that if the standard deviation of group delay in frequency region (about 8kHz or less) is greater than or equal to 500μs, timbre of two stimuli can be discriminated[2]. In the proposed system, the phase distortion may be occured. Therefore, we measured characteristcs of group delay of the system as phase distortion. The result shows that peak positions and peak values are changed as time goes on. In particular, peak positions and peak values are unstable in the lower frequency band. In addition, using headphone Lambda Nova, mean of standard deviation of group delay from 100 Hz to 9.3 kHz was 757 μs without the stable power supply and was 347 μs with it. As a result, it was shown that the phase distortion is reduced and became stable using the stable power supply. Hence, the inverse filter to reduce the phase distortion is needed. This filter can be determined as follows;

TSP response → Impulse response → Frequency characteristics → Inverse filter

Experimental stimuli are obtained by multiplying the DFTs of desired stimuli and the inverse filter in the frequency region.

The band-width of the inverse filter is designed from 300 Hz to 9.3 kHz,

the reasons are as follows:

- to be small in quantity of group revision
- to be stable in time
- to be small in difference between coupler-response for Lambda Nova and real-response for human ear, and
- to be convenient for making stimuli

The inverse filter is evaluated by comparing the coupler-responses of inverse filtered and original waveforms. The results show that not only phase but also amplitude distortions are revised. Therefore, the inverse filter is adopted for the following experiments.

4 Experiments

In this paper, we carry out three experiments. Preliminary Experiment 1 re-examines Plomp et al.'s experiment [1] to verify the past results. Preliminary Experiment 2 and Main Experiment examine how much phase changes affect timbre perception.

4.1 Preliminary Experiment 1

This experiment re-examines Plomp et al.'s experiment to verify the result that phase changes effect timbre perception, using the inverse filter. Here, we don't use the stable power supply because Plomp et al.'s experiment don't use one.

The results indicate the same aspects as Plomp et al.'s in which it is easy to discriminate timbre of two stimuli when the fundamental frequency is less than or equal to 200 Hz.

4.2 Preliminary Experiment 2

Assuming that original stimuli are complex tone with 31 harmonics and that the bandwidth of the inverse filter is from 300 Hz to 9.3 kHz. Input stimuli are made using the inverse filter. In addition, the accuracy of the inverse filter is improved because of using the stable power supply. Therefore, it is considered that the reliabiyl of results is higher than that of the Preliminary Experiment 1. The results indicate that the difference between timbre of two stimuli is related to density of harmonics whose phases are changed and degree of harmonics.

4.3 Main Experiment

Assuming that an original stimulus are complex tone with 31 harmonics, where the phase of only one is adjusted by π.

Input stimuli are made using the inverse filter. In addition, we adjusted the effects of phase changes by fixing the power of harmonics at same level and by varying change-range of phases. The results indicate that the difference of timbre is related to phase changes of harmonics contained with hi auditory filter bank. The results don't agree the past report which indicates that it is difficult to discriminate timbre of two stimuli beyond 2 kHz.

5 Conclusion

This paper proposes a method to revise phase distortion the experiment system we not only re-examined adequacy for the results of Plomp et al.'s experiment but also examined auditory characteristics for phase information. The results show that the difference of timbre is related to phase changes of harmonics contained with hi auditory filter bank.

References

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