

# **TECHNICAL LISTENING TRAINING: IMPROVEMENT OF SOUND SENSITIVITY FOR ACOUSTIC ENGINEERS AND SOUND DESIGNERS**

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## **ABSTRACT**

The purpose of this paper is to present the concept and design of Technical Listening Training, a systematic education program designed to allow prospective acoustic engineers and sound designers to enhance their auditory sensitivity. Sound professionals should have the ability to express auditory differences using appropriate technical terms for the physical properties of sounds. Furthermore, they should be able to imagine the sounds when given the acoustic properties of the sounds. Training starts with a discrimination task for pitch, loudness, and timbre in order to increase sensitivity to auditory differences. This is followed by instruction on sound property identification to improve students' ability to correlate auditory impressions with the physical properties of the sound, thereby allowing them to imagine the sound. Through Technical Listening Training, students improve their sound sensitivity and understanding of the relationship between acoustic properties and auditory impression.

## **INTRODUCTION**

The Department of Acoustic Design of the Kyushu Institute of Design provides an education program for acoustic engineers and sound designers. The students in this program wish, for example, to become recording engineers, design concert halls, make musical instruments or develop new audio technology.

Such sound experts must have a basic and broad knowledge of sound and the latest information on audio technology. In addition, professionals in this field are required to have special auditory sensitivity. Skilful acoustic engineers and creative sound designers have acquired special auditory sensitivity through various experiences during their careers. Generally, improving auditory sensitivity requires a great deal of time. Moreover, this improved sensitivity is thought by many to be obtainable only through experiences on the job.

Technical Listening Training is a systematic training program designed to improve auditory sensitivity. Through this program, students can obtain the necessary auditory sensitivity before gaining work experience on the job. The type of auditory sensitivity acquired through experience depends of course on the occupation. In contrast, Technical Listening Training provides a wide

varieties of experiences, so that students can obtain auditory sensitivities associated with various fields and easily adapt to new auditory environments.

Technical Listening Training plays a role similar to that of the simulation training which astronauts undergo. Astronauts experience numerous simulated missions and operational tasks before ever setting foot on a spaceship. Simulation training provides the opportunity to train for not only routine or expected situations, but also for rare or unexpected situations. Through this type of training, astronauts are able to obtain sufficient experience so that they are able to handle even the most difficult or unexpected situation. Technical listening training provides students various experiences, which will face in the real job contexts.

Technical Listening Training was developed at the Department of Acoustic Design of the Kyushu Institute of Design. The program has been improved and is still included as part of the curriculum of the Department of Acoustic Design. The present paper describes the concept of Technical Listening Training as well as its practical application at the Kyushu Institute of Design.

## AUDITORY SENSITIVITY REQUIRED IN ORDER TO BE A SOUND PROFESSIONAL

What special auditory sensitivity is required in order to be sound experts? This chapter describes what we mean by professional auditory sensitivity.

As a basic ability, sound professionals should have the ability to discriminate between different sounds. The first step is discerning a difference. After learning to recognize a difference, the sound professional should be able to identify various types of perceived differences, such as differences in pitch, loudness and timbre. These three elements are the most basic auditory aspects of sounds.

However, the ability to discriminate is not sufficient. Sound professionals should also develop the ability to correlate the auditory difference with the physical properties of sounds. The sound professional should expect to come across numerous technical terms expressing acoustic features, e.g. sound pressure level, frequency, and spectrum. When a sound professional needs to explain an auditory difference, this difference should be expressed using the appropriate technical term.

Furthermore, the sound professional should be able to imagine the proper sounds when given the acoustic properties of the sounds, just as expert musicians can imagine music by looking at a score. Design plans and specifications are described by the acoustical technical terms: e.g. transmission loss or reverberation time. Sound professionals should be able to imagine sounds upon inspection of specifications. When controlling audio equipment, the sound professional should be able to imagine the controlled sounds. For example, when recording engineers use sound effecters, such as equalizers and reverb processors, they can anticipate the processed sounds before controlling the effector.

Through Technical Listening Training, students can improve their sound sensitivity and understanding of the relationship between acoustic properties and auditory impression.

## ELEMENTS OF TECHNICAL LISTENING TRAINING

Technical Listening Training is required for freshmen and sophomores, and the respective

classes are called Technical Listening Training I and II. This chapter introduces the goals and practical programs of Technical Listening Training. Figure 1 shows a picture of class.

### Technical Listening Training I

First-semester freshmen are enrolled in Technical Listening Training I. This class focuses on basic acoustic properties: frequency, sound pressure level and spectrum. Through the training, students develop a feel for hertz and decibel levels.

The class begins with discrimination tasks for pitch, loudness and timbre in order to increase sensitivity to auditory differences.

At the pitch discrimination training, students listen to pure tone pairs. The two tones have the same loudness and duration, but slightly different frequencies. The frequency of the standard tone is constant (440 Hz) and that of the comparison tone is a few Hz higher or lower than the standard. The task of students is to indicate whether the comparison tone is higher or lower. At the easiest level, the frequency difference is 5 Hz (rather easy to differentiate), and at the most difficult level, the frequency difference reaches 1 Hz. When the frequency difference reaches 1 Hz, differentiation becomes more difficult because the difference approaches the difference limen.

The tasks of loudness and timbre discrimination are similar to the pitch discrimination task. For loudness discrimination, the answer is louder or softer. For timbre discrimination, the answer is same or different. Training for these tasks enhances sensitivity to auditory differences. Through these discrimination training tasks, students come to comprehend the various types of auditory differences and learn how to listen to a sound.

After discrimination training, the students undergo identification training. At the rehearsal sessions for this training, students learn the auditory features of physical properties of sound. Afterward, the students attempt to perform identification tasks.

The tasks vary in type: difference in sound pressure level, frequency of pure tones, center frequency of band noise, number of harmonics, amplitudes slope of harmonic components, and frequency of enhanced bandwidth of colored music.

First, as an example of this type of training, we introduce the identification training tasks for the difference of sound pressure level. In this training task, a short music excerpt is presented twice. The first sound is the standard, and the second is attenuated from the standard. At the rehearsal session, students listen to a series of sound pairs and correlate loudness differences to differences in the sound pressure level. Next, the students perform identification tasks for randomly presented sound pairs. At the basic level, the difference in sound pressure level between the standard and attenuated sounds is 0, 10, 20 and 30 dB (10 dB stepwise). At the intermediate level, the difference in sound pressure level is 5 dB stepwise: from 0 to 20 dB or from 0 to 30 dB. At the advanced level, the difference in sound pressure level is 2 dB stepwise: from 0 to 10 dB. As the level difference is smaller, the task is more difficult.

The "Decibel (dB)" is the unit of sound volume which is used for amplifier volume, control of mixing consoles, adjustment of equalizers, measurement standard of noise exposure, and attenuation level of sound-proof barriers. Sound professionals should understand the physical definition of the decibel. However, as sound professionals, this is not sufficient. Sound professionals should be able to correlate the loudness of sounds to the sound pressure level. Sound professionals should be able to frame the loudness difference in terms of decibels when presented with a change in volume. Training in sound-pressure-level-difference identification is provided in order to comprehend the decibel scales by ear. This training gives students the ability

to "decibel" sounds.

Another important concept for sound professionals is "frequency." Frequency is a basic acoustic property which affects pitch and timbre. The feel for frequency is also crucial for sound professionals. Generally, acousticians use the term "frequency" in two senses. One is frequency of periodic wave as a signal (typically the frequency of a pure tone). The other is frequency response of acoustic equipment, an example of which is the frequency characteristics of loudspeakers. The Technical Listening Training program includes training tasks corresponding to both aspects.

One task involving the frequency response of audio equipment is the frequency of enhanced bandwidth of colored music. In this task, students listen to a pair of a short music excerpts: one is the standard and the other is the characterization of its acoustic spectrum. In this training task, a one-octave frequency region of the characterized sound is boosted by 10 dB. The standard and comparison sounds are from the same music source but have different acoustic spectra. The task of students is to identify the center frequency of boosted octave-bandwidth. The center frequency of enhanced bandwidth is 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz. Through this training, students learn the auditory characteristics of each frequency region of musical sounds and gain an understanding of the spectrum and frequency characteristics of audio equipment. In order to increase the effectiveness of the training, different genres of music are used, because key auditory characteristics differ according to the type of music or combination of musical instruments.

The other training task involving frequency is the identification of frequencies of pure tone and the center frequency of band noises. The frequency of these training tasks is also an octave-band step: 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz. This training helps students gain a sense of frequency.

In the case of pure tones, frequency correlates to pitch. Musicians having absolute pitch can identify the pitch of a sound by name without referring to a standard tone. Sound professionals should be able to identify the pitch by the "hertz" level; however, unlike absolute pitch musicians, sound professionals need not acquire extremely high resolution power. Of course, frequency sense is linked to timbre sense. The identification task involving the center frequency of band noise helps students to recognize the difference in timbre between discrete and continuous spectrum.

Identification tasks involving harmonic number and amplitude slope of harmonic components help to provide students with a sense of spectrum and harmonics. In these training tasks, students correlate acoustic spectrum to perceived timbre.

### Technical Listening Training II

First-semester sophomores are enrolled in Technical Listening Training II as an advanced course. This class consists of more practical training tasks, because students already have a knowledge of basic acoustics.

This course further explores the identification of enhanced frequency of colored music. The advanced task is identical to the basic task, but the boosted level is 6 dB.

In addition, students receive training in identification of low-cut and high-cut frequencies. In the low-cut frequency training, the low-frequency region of reproduced sounds from music excerpts is eliminated. Students compare the original and the low-cut sound and then judge the low-cut frequency. At the high-cut frequency training, the task of the student is to judge the high-cut frequency. Technical Listening Training II explores a wider variety of tasks throughout the acoustic spectrum.

As an advanced identification training exercise involving the sound pressure level difference, students practice the identification task of sound pressure level difference of one part of a music ensemble. In this training task, students judge the level balance between parts of the ensemble. This training simulates control of the mixing console used by recording engineers.

An additional identification task is identification of spectrum envelope slope using a music excerpt. There is a task to identify the time difference between two parts of an ensemble.

Another goal of Technical Listening Training is an understanding of "reverberation time," which is the most fundamental concept in room acoustics. One task is identification of the reverberation time of a synthesized sound, and the other task is identification of the reverberation time of music. In addition, students undergo training involving the identification of just and mean temperament and total harmonic distortion.

## SYSTEM FOR TECHNICAL LISTENING TRAINING

The current system used for Technical Listening Training consists of a host computer and PDA terminals. The training tasks are performed in a sound-proof room having a small control room. The WindowsNT-based host computer is set at the control room. This computer controls the presentation of training sounds. In addition, this computer collects the responses of students and provides feedback to the students via PDA terminals. Figure 2 shows the host computer situated in the control room.

Palm (IBM WorkPad c3) PDA terminals are used in training exercises, as shown in Figure 3. The categories of answers can be displayed on a PDA screen. For example, in the case of the 10-dB-step sound-pressure-level-difference training, 0, -10 dB, -20 dB and -30 dB are displayed on the screen. Students answer by selecting a category on the screen using a pen-like pointing device. The host computer then provides feedback to the students. The student is first informed as to the correctness of his or her response. The computer then displays the correct category. After each training session, the percentage of correct responses is displayed so that students can monitor their achievement level.

PDA terminals provide an inexpensive, compact, noise-free, commercially available and easy-to-maintain interface for which software can be easily developed. In addition, functions such as message display and data-input by direct selection of answers on a screen is an appropriate response tool for students.

## THE ROLE OF TECHNICAL LISTENING TRAINING IN THE CURRICULUM OF THE DEPARTMENT OF ACOUSTIC DESIGN OF THE KYUSHU INSTITUTE OF DESIGN

The Department of Acoustic Design of the Kyushu Institute of Design has developed a curriculum for prospective acoustic engineers and sound designers. The curriculum consists of elements such as physical acoustics, psychoacoustics, room acoustics, noise control, acoustic engineering, digital signal processing, sound recording technique, musicology and computer music.

Students learn "sound" from an interdisciplinary point of view, and begin to understand sound as a physical phenomenon and as a function of the hearing process. In addition, students study

various technologies for controlling sound and creating a comfortable sound environment. In addition to the progress of this curriculum, students participate in Technical Listening Training so that students can begin to correlate their acquired knowledge to the sensations they experience.



Figure 1: Picture of class of Technical Listening Training



Figure 2: Host computer situated in the control room



Figure 3: Palm PDA terminal