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Study on Auditory Impressions of Train Departure Sign Sounds
電車の発車サイン音に関する聴感印象の調査

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Forewords

I dedicate this work to the God Almighty, the Alpha and Omega, who had created me and according to His will had placed me in the place which I do not deserve. He is the source of my strength and inspiration who had never even once let me go afar from His glorious and mighty love.

This thesis was written as the part of completion requirement from The University of Tokyo, Graduate School of Frontier Science, Department of Socio-cultural Environment Studies. All works done in this thesis were conducted under the guidance of Associate Professor Tetsuya Sakuma. This thesis will never be able to be completed without the careful guidance by Associate Professor Tetsuya Sakuma as my supervisor for the past two and a-half years.

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Richard A. J. Limesa

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Chapter 1 Introduction

In this chapter, research background, past studies regarding train departure sign sounds, and research objectives will be presented.

1.1 Research Background

In Japan, trains are one of the most common methods of transportation, especially for commuter transport in major cities. One unique aspect which characterizes train commuting in Japan is the presence of train departure sign sounds. These sounds mark departures of the trains from stations. There are two types of train departure sign sounds which are used at stations currently: bell type and melody type [1].

1.1.1 Development of Train Departure Sign Sounds in Japan

Before 1872, train departures in Japan were marked using *taiko* or Japanese drum, before then changed into metal bells in 1873. From 1912, electric metal bells were introduced and used until the early 80s. Electric metal bells were then changed into artificial bell sounds which are considered softer than the former. In 1988, melody sounds were introduced at train stations and becoming more popular in the 90s [2]. Since then, the number of stations that use train departure melodies has significantly increased. However, there are currently some stations that maintained the use of bell types for departure sign sounds.

In the current era, there are many variations of train departure sign sounds for both bell and melody types. The difference may vary between lines or even stations. Some stations used a particular type of sounds which is considered a representation of that area. Moreover, some railway companies even tried to make distinct train departure sounds characteristics to differentiate them from other companies.

1.1.2 Importance of Train Departure Sign Sounds

Jimbo (1996) described the reason why train departure sign sounds in Japan evolved from time to time. There are three main reasons that he outlined in the study which includes annoyance, safety, and importance. Annoyance is considered as the biggest reason that train departure sign sound types are continuously changed. New sounds were designed to have more pleasant timbre than the previous kind. It was also considered that some sounds caused pain to the listeners. Safety is also a factor which was considered for departure sign sounds. Some artificial bell types mimic sounds of those from telephones which have the effect of making people hurry. There are some problems where people fell from stairs due to being hurried by the bells [2].

However, despite having so many downsides, removing these sounds from train stations are implausible. In some cases, these sounds play a role in informing people that the train is departing soon, so the closing train doors will not pinch people. From another perspective, this sound can also inform people to wait for the next train because the currently available train is departing [2]. In conclusion, departure sign sounds are necessary to exist inside train stations.

1.1.3 Appropriate Train Departure Sign Sounds

The problem arises when there are too many varieties of train departure sign sounds. There is no current guideline for designing and broadcasting these sounds at stations. However, due to its diversity, establishing guidelines is not an easy task. There are sound types that were claimed to trigger annoyance and stressful feelings as well as causing discomfort in train station spaces while some others were considered enjoyable and fun.

In some specific cases, there are problems where the current condition of train departure sounds are just played inside stations without considering hearing sensitivity difference between passengers. Some hearing impaired people or people with hearing hypersensitivity might be disturbed by sounds which are too loud. Therefore it is important to consider these aspects during the designing process and during the broadcasting time.

1.2 Related Studies

Kameda *et al*. (2016) tried to describe the current condition of train departure sign sounds at train stations in Tokyo Metropolitan Area. They measured the sound levels from different stations in Japan to find the distribution. It was found that departure bells and departure melodies have the average of 87.4 dB and 81.5 dB of sound level respectively. The highest measured sound volume of departure bells and melodies lie at 97.6 dB and 89.7 dB respectively. The lowest measured volumes are 80 dB for bell sounds, and 73.9 dB for melody sounds. The results are shown in Figure 1.1. Overall, bell sounds are broadcasted higher than melody sounds in the current condition. They found out that the maximum broadcast volume in 2016 does not show any significant difference compared to data in 1993. This result shows almost no change or improvement done by the railway companies [1].

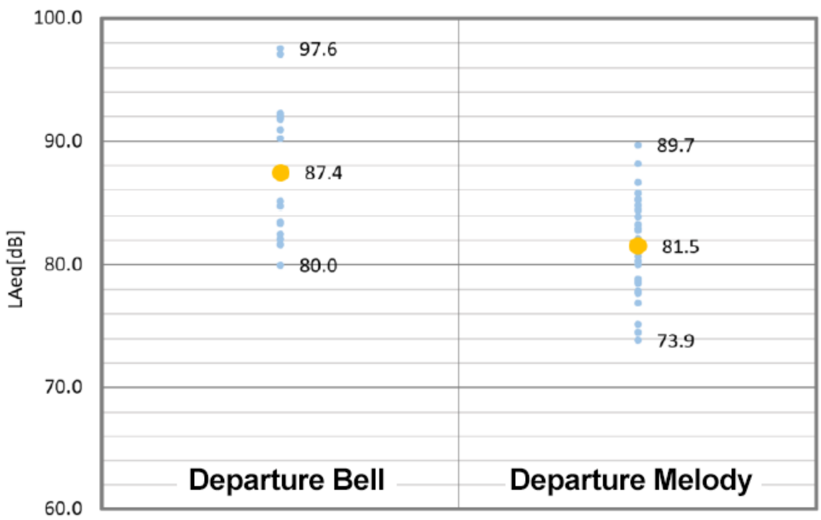

Figure 1.1 Distribution of LAeq of departure sign sounds in Tokyo Area. Adapted from *[1]*.

Jimbo *et al*. (1997) studied about the train departure melodies characteristics which are preferred according to the train users. In their preliminary study, more than 50% of the respondents showed a tendency in which melody sounds are much more preferred than the other types as shown in Table 1.1. Therefore they described that it is important to define characteristics of train departure melodies that can induce joyful emotions. They made several departure melody samples and found out that two of their designed departure melody samples are highly regarded as joyful and preferable by the experiment participants [3].

Table 1.1 The percentage of sound preference response towards various sound types. Excerpted from *[3]*.

Sound Type	%
Metal Bells	2.7
Departure Bells	21.6
Departure Melody	59.5
Announcement	10.8
Whistle	5.4
TOTAL	100

Goto (2012) studied about the correlation between human impression and structure of timbre in departure melody. Timbre was manipulated to explore the impressions towards departure melodies. The study tried to find the most comfortable and effective timbre which should be used in departure melodies. They figured out in their study that departure melodies should only be considered as effective if they are both distinguishable or audible and comfortable [4].

Based on the previous studies regarding train departure sign sounds, it can be concluded that since 1993 up until 2016 there was no significant improvement in the condition of these departure sounds. Also, the finding that respondents tend to choose melody type as a preferable departure sign sounds needs to be considered. Lastly, it is important to evaluate train departure sign sounds with the quality of distinguishability and comfortability, in which the passengers can clearly recognize the sound without causing stress or annoyance feelings.

1.3 Objectives

This study aims to improve the quality of train station spaces by increasing the comfortability and effectiveness of train departure sign sounds. Therefore, it is important to reexamine the current departure sign sound planning for passenger facilities to evaluate the current actual condition. Consequently, the most appropriate setting of broadcasting volume and quality of departure sign sound will also be examined. This appropriate setting will be based on how effective the signal sounds regarding comfort and audibility. From the results, a thorough guideline in designing the departure sign sounds is more likely to be proposed.

Concretely, this study will investigate the relationship of acoustic features and human impressions, estimate the occurrences of discomfort and stress from departure sounds, examine environmental influence in audibility of the sounds, and consider people with different socio-demographic aspects which might suffer worse from the train departure sign sounds.

1.4 Research Approach

Marquis-Favre *et al.* (2005) studied about the factors that influence annoyance towards sound in general. He divided the factors into two principal categories, acoustic factors, and non-acoustic factors. Acoustic factors are related to traits related to the sounds such as physical and psychoacoustic features. The presence of another noise as in masking effect also is considered as one of the acoustic features. Non-acoustic factors are related to the receiver of the sounds, which in most cases are human-being. Human factors include socio-demographic aspect, attitude aspect, and situational aspect. In their study, they put an additional factor called environmental factor. This factor is expanded from the noise presence category coming from acoustic factors. The environmental factor is related that the presence of other sounds than the targeted one will affect human impressions on the latter [5]. Figure 1.2 summarized the factor model described in this section.

The current study was designed based on the described model. Each factor that is considered to have an influence on noise annoyance were explored in this research. There will be three main chapters in this study in which each of them describes one of these factors respectively.

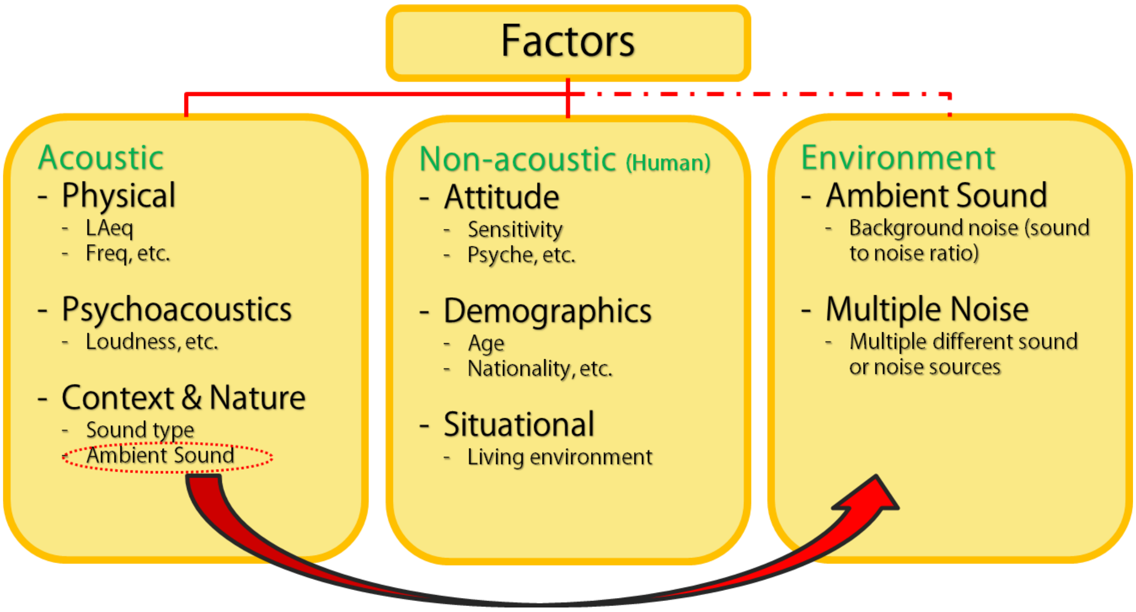

Figure 1.2 Model of factors that influence sound annoyance. Adapted from *[5]*.

1.5 Thesis Structure

In the first chapter, the background, as well as the problems that exist regarding train departure sign, sounds in Japan is discussed. Moreover, the objectives and research model which are used as the base of the whole research is also described in this chapter.

In the second chapter, the analysis of characteristics of train departure sounds is conducted. Based on its features, sound samples were grouped based on their similarities with each other. Sounds which are considered to be a representative of their respective sounds were chosen for the listening experiment. Also, the study regarding the relationship between these characteristics towards human auditory impressions is presented. Lastly, the prediction of discomfort which is caused by sound characteristics has been investigated as well to propose design guideline.

In the third chapter, the relationship between departure sign sounds and ambient noise is presented. The ambient noise was recorded from a station in Tokyo. This chapter tries to find the most appropriate broadcasting level as opposed to the ambient noise level. The broadcasting guideline is expected from the result of the study.

In the fourth chapter, the differences between groups of people with different traits are compared. Comparison between gender, nationalities, and hearing sensitivity was conducted. This study aims to find any significant differences that might exist between socio-demographic and physiological groups. If there are groups that most likely be a subject of discomfort, future research should be conducted to find a consideration for people of that group.

In the fifth chapter, the conclusion of this investigation and possibilities of research topics for the continuation of the current study are discussed.

Chapter 2 Acoustic Features Effect on Auditory Impressions of Train Departure Sign Sounds

In this chapter, the characteristics of departure sign sounds will be described. Consequently, how these features influence auditory impressions will also be addressed. Sound can be described by using various parameters. Finding the most suitable parameters to design a proper departure sign sounds are considered to be necessary.

2.1 Sound Characteristics

Sound can be described with different definition depending on the field it is being studied. For example, in physics sound is described as a mechanical disturbance of the medium in which it propagates from a source, while in physiology it is described as a hearing sensation caused by physical deviation. From this definition, they are called objective and subjective sounds respectively [6].

Knowing that there are multiple ways to describe sound, it is natural that there are different parameters used to describe it. In this research, there are multiple parameters which are used to describe the departure sounds.

2.1.1 Acoustical Parameters

2.1.1.1 Sound Pressure Level

Sound was described as a disturbance in a medium caused by particle vibration due to a sound wave which is called *sound pressure*. The unit of sound pressure (p) is notated in Pascal (Pa). However since the range of sound pressure is extensive, a logarithmic scale called *Sound Pressure Level* (L) is more commonly used which is notated in decibel (dB). The following equation relates sound pressure and Sound Pressure Level

$$L = 20\log(p/p_0)\ dB. \quad (2.1)$$

Where reference value of $P_0 = 20$ μPa. This dictates the loudness sensation of sound [6, 7].

Modern time measurement prefers the *equivalent continuous sound level* (Leq) due to the unstable sound pressure over time. The most common method to measure sound pressure level is *A-weighted equivalent continuous sound level* (LAeq), where the value is normalized following human ear response [8].

Table 2.1 Sound Pressure Level of several sound sources. Adapted from *[6]*.

Sound Types	Decibels	Effect
Jet aircraft taking off, canon shot	130	**Deafening**
Sonic boom, fortissimo orchestra, rock band	100-120	
Mufflerless truck, traffic noise, police whistle	80-100	**Very Loud**
Busy office, quiet typing machine, radio	60-80	**Loud**
Noisy house, normal conversation, quiet radio	40-60	**Moderate**
Private Office, quiet house, quiet conversation	20-40	**Weak**
Leaf rustle, whisper, human breathing	10	**Very weak**

2.1.1.2 Frequency

Sound in the form of wave vibrates in its propagation medium. The oscillations that vibrate in a second is called *frequency*. Frequency is notated by hertz (Hz) which in definition is the number of oscillations in a second. Human ears can perceive sound within the range of 20 to 20.000 Hz. The sensation which is caused by frequency is called *pitch* which shows the lowness or highness of sounds [6].

A sound that has a constant pitch is called a *tone*. Sounds generated by musical instruments has many component tones of various frequencies which are called *complex tone*. The tone of the lowest frequency is called *fundamental* while all the others are known as *overtones*. The pitch of complex tones is perceived as that of the frequencies which are the highest common factor of the frequencies of all the component sounds [9].

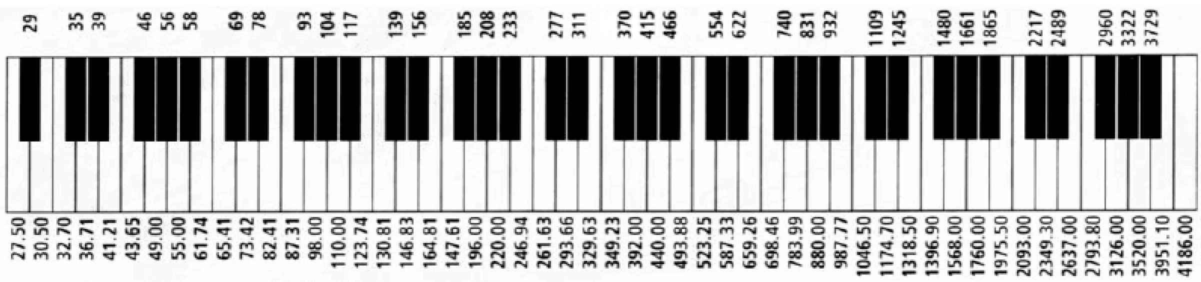

Figure 2.1 The frequencies of piano notes. Excerpted from *[10]*.

2.1.1.3 Timbre

American National Standard Institute describes timbre as quoted: "Timbre is that attribute of auditory sensation regarding which a listener can judge two sounds similarly presented and having the same loudness and pitch as being dissimilar." [11]. There is no subjective rating scale to describe timbre, unlike pitch or loudness. The timbre of a note is the aspect by which a listener recognizes the instrument which is playing a note [12].

Scholes (1970) describes that "Timbre means tone quality – coarse or smooth, ringing or more subtly penetrating, 'scarlet' like that of a trumpet, 'rich brown' like that of a cello, or 'silver' like that of a flute. These color analogies come naturally to every mind. . . . The one and only factor in sound production which conditions timbre is the presence, absence, or relative strength or weakness, of overtones." [13]. Human beings can distinguish the difference between tones produced by different musical instruments, despite having the same intensity and pitch because they possess timbre [9].

In summary, timbre is the characteristic of sound that distinguishes one sound from another, and it can be called as *tone color*. People usually recognize what kind of source produces a certain sound by its timbre. Some psychoacoustic parameters try to quantify this parameter such as sharpness (section 2.1.2.2), roughness (section 2.1.2.3), and fluctuation strength (section 2.1.2.4).

2.1.2 Psychoacoustic Parameters

2.1.2.1 Loudness and Loudness Level

Loudness belongs to the category of intensity sensations. This sensation value belongs between sensation and physical values. Loudness comparison can lead to more precise results than magnitude estimations in which loudness level measure was built to characterize loudness sensation of any sound [7]. Loudness level of a sound is defined as the sound pressure level in dB of a standard frequency 1000 Hz, pure tone, in which is heard equally and measured in *phon*. Figure 2.2 shows equal loudness levels with the corresponding sound pressure level for each frequency of pure tones. Curves shown in the figure are called *equal loudness contour* [9].

Loudness level can be used to compare directly sounds that are equally loud but cannot be used to compare sounds at different levels. For this purpose, a measurement unit called *sone* was created to compare subjective loudness. The level of a 1000 Hz pure tone at 40 dB was standardized as 1 sone. In loudness evaluation, it was found that the increase of 10 dB of a pure 1000 Hz tone is equal to the double loudness perception. [7, 9]. For example, a sound 1000 Hz pure tone with 40 dB sound pressure level, which corresponds with 1 sone, need to be increased to 50 dB to receive the value of 2 sones.

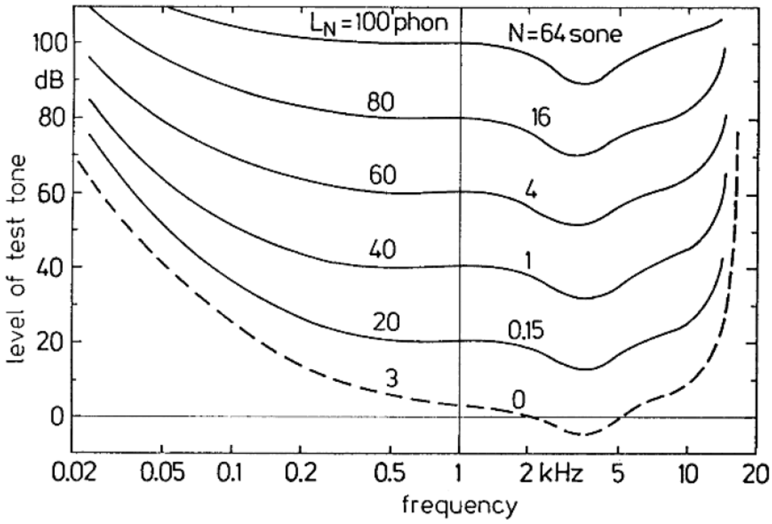

Figure 2.2 Equal loudness contours for pure tones in a free sound field. Excerpted from *[7]*.

Calculation of loudness for more complex sounds is also influenced by factors other than the pressure level. An important factor is *Critical Bandwidth*, which is a measure of frequency resolution of the ear. In loudness, two tones which are too close in its critical bandwidth will not be perceived as two separate sounds and mask each other. Consequently, if there are two tones at an equal level with frequency separation higher than the critical bandwidth, the loudness produced is larger than a single tone in between that frequency range that has a total intensity equal to the two tones. Because two tones with different frequency were proved to have an effect, the total loudness should be treated as an integral of a value which can be drawn as a function of *critical-band rate* (z). This value is called *specific loudness* (N') which is noted in Sone/Bark. Loudness is described as the integral of specific loudness over critical-band rate where the integral is taken over all critical-band rates [7].

$$N = \int_0^{24\,Bark} N' dz \tag{2.2}$$

2.1.2.2 Sharpness

In section 2.1.1.3, timbre was discussed. However, timbre itself does not have specific parameters for it to be assessed. In psychoacoustic, several parameters were developed as a trial to describe timbre. Zwicker *et al.* (1999) stated that sharpness could be related to the sensation of 'density' [7].

Sharpness measures the spectral contents of sound and its center frequency of narrow-band sound. The more high frequencies exist in a sound, the 'sharper' is the sound. Sharpness is measured using the unit *acum* which came from Latin that translates into English word 'sharp'. The definition of 1 acum is the sound of 1000 Hz at loudness level of 60 phons. Zwicker and Fastl made a model of sharpness which can be seen in equation 2.3 [7].

$$S = 0.11 \frac{\int_0^{24Bark} N' g(z) z dz}{\int_0^{24\,Bark} N' dz}\ acum \tag{2.3}$$

2.1.2.3 Roughness

Another attempt to describe timbre is roughness. It is a sensation which can be considered without regarding other timbre sensations. Roughness quantifies the subjective perception of rapid amplitude modulation of a sound which is modulated between 15 to 300 Hz. Roughness can be measured by using *asper* which is the Latin word of rough. Zwicker *et al.* (1999) defined that 1 asper is the value of a sound of 1000 Hz at 60 dB being 100% modulated in amplitude at the modulation frequency (f_{mod}) of 70 Hz [7].

Roughness is influenced not only by the modulation frequency but as well as the *degree of modulation* (m). Amplitude modulated sound is a sound where its intensities are changed back and forth repetitively in a given period. While modulation frequency denotes the amount of this shift, the depth of intensity change is shown by the degree of modulation in the form of scale between its peak intensity and decreased intensity. The degree of modulation of roughness for 1000 Hz in modulation frequency of 70 Hz is presented in figure 2.3. Roughness also depends on the center frequencies of the sounds. In Figure 2.4, the dependence of roughness on modulation frequencies at different center frequencies for 100% modulation can is presented [7].

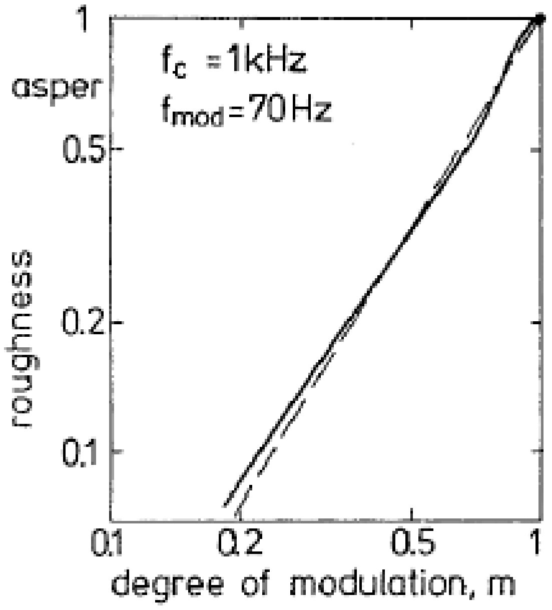

*Figure 2.3*Roughness as a function of the degree of modulation. Excerpted from *[7]*.

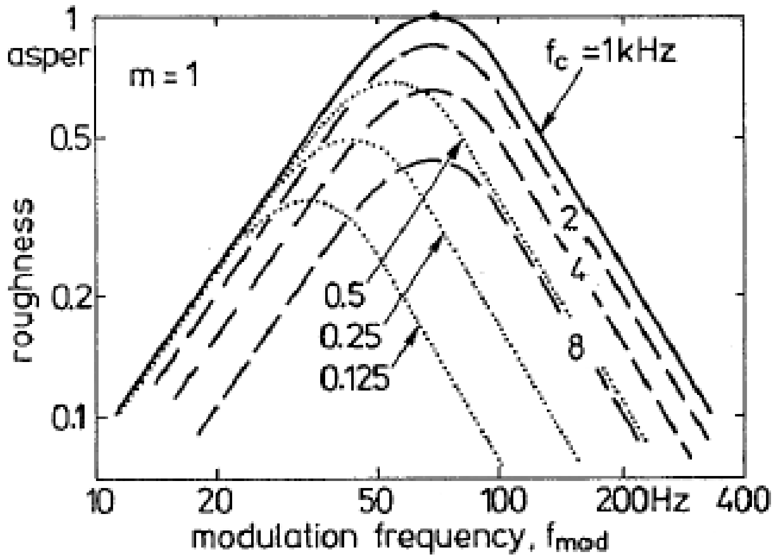

Figure 2.4 Roughness of 100% amplitude-modulated tones of the given center frequency as a function of the frequency of modulation. Excerpted from *[7]*.

2.1.2.4 Fluctuation Strength

While modulation frequency between 15 to 300 Hz induces roughness sensation, lower modulation frequency creates different sensation which is called fluctuation strength. This perception happens around modulation frequency of 20 Hz. The unit of fluctuation strength is called *vacil* from the word ‘vacillate’. The roughness of 1 vacil is produced by a 1000 Hz sound at 60 dB with 100% amplitude modulation at 4 Hz. Fluctuation strength can be influenced by amplitude and frequency modulation, sound pressure level, modulation depth, and frequency of the sound [7].

2.1.3 Musical Parameters

2.1.3.1 Beat and Meter

In music, beats exist to give music its regular rhythmic pattern. Beats are grouped together in a measure and notated by *notes* and *rests* correspond to a certain number of beats. Meter refers to rhythmic patterns produced by grouping robust and weak beats. The meter may be in *duple* (2 beats in a measure), *triple* (3 beats in a measure), *quadruple* (4 beats in a measure), and so on [14].

2.1.3.2 Dynamics

Dynamics are abbreviations or symbols used to signify the ‘loudness’ or ‘softness’ of a musical piece. It also indicates any change in volume inside music pieces [14].

2.1.3.3 Harmony

In general, harmony refers to the combination of notes played together and the relationship between a series of chords. While being played together with melody, musical texture is given inside a musical piece [14].

2.1.3.4 Key

Key is also known as *tonality*. It is a principle in music composition wherein at the end of the piece a 'feeling of completion' is achieved by going back to the *tonic*. The tonic, which can be called the *main key* or *home key*, is the principal pitch of a composition. Key refers to central note, scale, and chord [14].

2.1.3.5 Melody

Melody refers to the tune of a song or piece of music. It is a tune created by playing a succession or series of pitches or tones [14]. Melody in certain scales is describable by the term *modality* or *mode*. This mode can simply be described as *major* and *minor* modes.

2.1.3.6 Pitch

Pitch as mentioned in section 2.1.1.2 is the sensation of highness or lowness of a sound, which is based on the frequency of oscillation by a vibrating object. Slower vibration gives smaller frequency value thus resulting in a lower perception of pitch. On the other hand, the faster the oscillation, the higher is the frequency value and pitch [6, 14].Pitch perception follows the Weber-Fechner's law where the smallest noticeable change of physical stimulus is logarithmically proportional to the intensity of the stimulus. Similar sensation of a sound but with different 'highness' can be perceived by doubling its frequency which is defined as one octave [9].

Musical scales are basic to most Western music and is defined by pitch. In modern keyboard instruments, there are 12 notes per octave with a musical interval of one *semitone* between adjacent notes [12]. Musical interval can be measured using *cent*. Warrier *et al.* (2002) described cents as logarithmically equal steps in the frequency dimension where each semitone is 100 cents apart. Therefore an octave is 1200 cents apart [15]. In MIDI (Musical Instrument Digital Interface) standard tuning, the frequency of 440Hz is considered as having an absolute cent value of 0 Cent [16]. Table 2.2 shows the comparison of frequency in hertz and cent for two octaves of piano notes.

Table 2.2 Comparison of Cent and Hertz for piano notes. Adapted from *[16]*.

MIDI Octave	Note Name	Frequency (Hz)	Absolute Cent
-1	A	220.00	-1200
-1	$A^{\#}/B^{b}$	233.08	-1100
-1	B	246.94	-1000
0	C	261.63	-900
0	$C^{\#}/D^{b}$	277.18	-800
0	D	293.66	-700
0	$D^{\#}/E^{b}$	311.13	-600
0	E	329.63	-500
0	F	349.23	-400
0	$F^{\#}/G^{b}$	369.99	-300
0	G	391.99	-200
0	$G^{\#}/A^{b}$	415.30	-100
0	A	440.00	0
0	$A^{\#}/B^{b}$	466.16	100
0	B	493.88	200
1	C	523.25	300
1	$C^{\#}/D^{b}$	554.37	400
1	D	587.33	500
1	$D^{\#}/E^{b}$	622.25	600
1	E	659.26	700
1	F	698.46	800
1	$F^{\#}/G^{b}$	739.99	900
1	G	783.99	1000
1	$G^{\#}/A^{b}$	830.61	1100
1	A	880.00	1200

2.1.3.7 Rhythm

Rhythm may be defined as the pattern or placement of sounds in time and beats in music. It can also be said as the particular arrangement of note lengths in a piece of music. Rhythm is shaped by meter and has certain elements such as beat and tempo [14].

2.1.3.8 Tempo

Tempo is the parameter of musical speed. Tempo can be measured by *beats per minute* (BPM). For example, a tempo of 60 BPM shows that there are 60 beats in one minute which mean that the interval between beats is 1 second, while 120 BPM is twice as fast in which it has an only 0.5-second interval between beats.

2.1.3.9 Texture

Musical texture refers to the number of layers as well as the type of layers used in a composition and how these layers are related [14].

2.2 Acoustic Features of Train Departure Sign Sounds

In the previous section, various acoustic parameters have been described. Several parameters were selected in this study to analyze train departure sign sounds in Tokyo Area. The method and results of the analysis will be presented in this section.

2.2.1 Objective

Acoustics features influence how people hear sounds. While many individuals can enjoy a sound with a series of characteristics, there are sounds with different traits that may cause annoyance to people. The study of characteristics of sound is considered to be important because it can describe the features of sound in which causing discomfort to people. In the long run, the influence of acoustic features towards human impression can be used as a consideration for proposing future guidelines of train departure sign sounds design.

2.2.2 Feature Extraction Method

2.2.2.1 Research Objects

➢ *Train lines and sound types*

A total of 40 sounds recorded from various stations in Tokyo is used in the analysis. There is a total of 11 train lines in which their departure sounds were sampled for this study. Table 2.3 shows the train lines and types of departure sound along with the measured LAeq (dB) and duration (s).

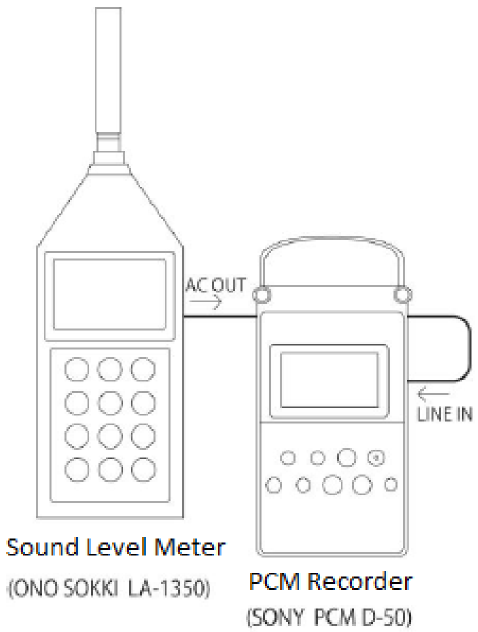

Figure 2.5 PCM Recorder and Sound Level Meter.

Figure 2.6 LAeq measurement under the speakers.

*Table 2.3*Measured LAeq and duration data for sampled lines and stations in Tokyo Area.

Sound No.	Line	Station	Sound Type	Laeq (dB)	Duration (s)
S1	ODK Line	SJK	Bell	82.4	14.3
S2	KIO Line	SJK	Bell	90.1	11.8
S3	KKY Line	KMT	Bell	91.2	8.5
S4		KMT	Bell	84.0	8.7
S5		SNG	Bell	95.3	6.2
S6	KSI Line	UEN	Bell	89.2	2.8
S7		UEN	Bell	97.7	2.9
S8		AOT	Bell	91.7	3.9
S9		AOT	Bell	91.6	4.0
S10	SBI Line	IKB	Melody	94.2	2.3
S11		NTD	Melody	73.3	5.2
S12		NTD	Melody	77.3	4.3
S13		FJM	Melody	78.7	2.5
S14	YNT Line	SBY	Melody	87.7	13.0
S15		HJK	Melody	84.4	10.4
S16		IKB	Melody	82.9	9.8
S17		SOK	Bell	92.9	5.1
S18		SOK	Bell	93.2	4.1
S19		SJK	Melody	80.3	7.1
S20	TTY Line	MKS	Melody	80.0	5.8
S21		SBY	Melody	88.8	5.7
S22		GDG	Bell	83.6	2.8
S23		GDG	Bell	81.8	2.7
S24		SMK	Melody	78.6	5.1
S25	GNZ Line	SBY	Bell	80.3	2.8
S26		TRN	Bell	84.9	3.5
S27		TRN	Bell	82.2	2.8
S28		TIS	Melody	79.5	6.2
S29		TIS	Melody	88.7	6.0
S30		ASM	Bell	94.8	3.7
S31		KND	Melody	85.3	5.0
S32		KND	Melody	86.3	6.1
S33	TZI Line	OCH	Melody	81.6	3.7
S34		OCH	Melody	81.3	6.4
S35		NHB	Melody	81.1	6.1
S36		NHB	Melody	79.1	5.3
S37	TBT Line	TKW	Melody	74.9	3.4
S38		TKW	Melody	79.1	2.4
S39	TOD Line	KSG	Melody	81.9	4.7
S40		KSG	Melody	78.4	3.9

➢ *Recording and measurement method*

At each station, LAeq (dB) of each train departure melodies are measured using a sound level meter (ONO SOKKI LA-1350). The measurement was made exactly below the speakers. Simultaneously, the output of sound level meter was connected to a PCM recorder (SONY PCM D-50) to record the departure sign sounds as shown in figure 2.5. The sound level meter is positioned around the chest during measurement which is around 120 cm from the ground. For departure sign sound which played from speakers installed at fences, the measurement was made about 80 cm in front of the speaker. Figure 2.6 illustrates the measurement condition on speakers installed at ceilings.

In every station, the measurement was conducted at multiple spots where speakers are installed. Every measurement was repeated 3 times. The inputted data is the result of averaged value from the measurements. Duration was measured based on the recording data using a computer and a stop watch.

2.2.2.2 Parameters and Tools

There is a total of 9 acoustic features that are extracted using 3 different types of software. The features and software used in the study are listed in Table 2.4. Each color on the table represents the categories of the parameter in which each software are used. Blue represents psychoacoustic parameters, green represents musical parameters, and red is for modulation frequency. Before calculation using the software, background noise from each recorded sound was removed, then the volume is readjusted to the measured LAeq level.

Table 2.4 List of Software and Features.

Software	**Features**	**Value**
AARAE	Loudness Level	***LN*** *[Phon]*
	Loudness	***N5*** *(Percentile Loudness) [Sone]*
	Sharpness	***S*** *[Acum]*
	Roughness	***R*** *[Asper]*
MIRToolbox	Average Pitch	F_{ave} *[Cent]*
	Standard Deviation of Pitch	F_{SD} *[Cent]*
	Modality	***Major/Minor***
	Tempo	***Tempo*** *[BPM]*
SAP2011	Modulation Frequency	F_{mod} *[Hz]*

➢ <u>*Parameters*</u>

Sound characteristics can be described with multiple parameters which had been outlined in section 2.1. Parameters of psychoacoustics regarding loudness level, loudness, sharpness, and roughness were selected. Also, departure sign sound is divided into departure bells and melodies as classified by Kameda *et al.* (2016) [1], have each own specific characteristics.

Departure melodies are considered to have musical characteristics inside. Therefore parameters such as pitch, modality, and tempo were included in the consideration. On the other hand, departure bells do not have melody and musical rhythm. Therefore modality, which relates to melody, and tempo, which relates to rhythm, cannot be used to describe bell sounds. However, since some bells are modulated, modulation frequency is considered to be an equivalent of tempo for departure bells.

Loudness parameter is measured using the percentile value. Following the findings by Zwicker as cited from a publication by Genuit *et al*. (2007), the response of subjective loudness is meager as opposed to the total loudness value. The value of 5% percentile loudness was then proposed due to its correspondence as opposed to perceived overall loudness [17]. This proposal is implemented in DIN 45631 which stated: "since the mean value of time varying loudness compared with the subjectively evaluated loudness provides a value, which is too low, the 5% percentile loudness (N5) has to be used with respect to the perceived overall loudness. Further loudness percentiles can be additionally used." [18].

The psychoacoustic parameter of Fluctuation Strength is not considered in this study. Fluctuation strength is an unstandardized parameter, and there are much interpretations on how to calculate this value. From a software comparison done by Shin (2008), there is currently no fluctuation strength calculation software that can satisfy the theoretical value by Zwicker [19].

➢ *Tools*

- AARAE

  AARAE (Audio and Acoustical Response Analysis Environment) is a Matlab-based measurement, processing and analysis environment for audio and acoustic system response. It is an open source software which is primarily focused for education and research [20].
- MIRtoolbox

  MIRtoolbox (Music Information Retrieval Tool Box) is an open source Matlab-based software that is dedicated to extract musical parameters. The purpose of this software is to offer an overview of computational approaches in the area of Music Information Retrieval [21].
- SAP2011

  SAP2011 (Sound Analysis Pro 2011) is a software which is mainly utilized to study animal vocalization. Some features include extraction of spectral characteristics and modern spectral analysis [22]

2.2.2.3 Analysis Method

In order to find similarities of the train departure sounds, cluster analysis and principal component analysis (PCA) were conducted. This analysis was carried out in order to group sounds with similar characteristics for understanding the trend of departure sign sounds which are currently used. Statistical analysis was undertaken in IBM SPSS Statistics 20 software.

2.2.3 Results and Discussion

2.2.3.1 Actual Condition

➢ *LAeq, Loudness level, and Percentile loudness*

Figure 2.7 shows the loudness level and percentile loudness for both departure bell and melody in their real condition as compared to their measured LAeq. Train departure bells LAeq values are distributed from 80.3 up to 97.7 dB. Train departure melodies LAeq values are distributed between 73.3 to 94.2 dB. The average LAeq of departure bell and melody are 88.64 dB and 81.89 dB respectively. Bell sounds are mostly distributed between 80 to 85 dB and 90 to 95 dB while melody sounds mostly lies between 77 to 83 dB. Loudness level for train departure sign sounds lies between 83.37 and 105.96 phones. Average loudness level value for bell and melody sounds are 94.23 phones and 94.24 phones respectively. Percentile loudness levels are 37.43 sones and 40.27 sones for bell and melodies respectively.

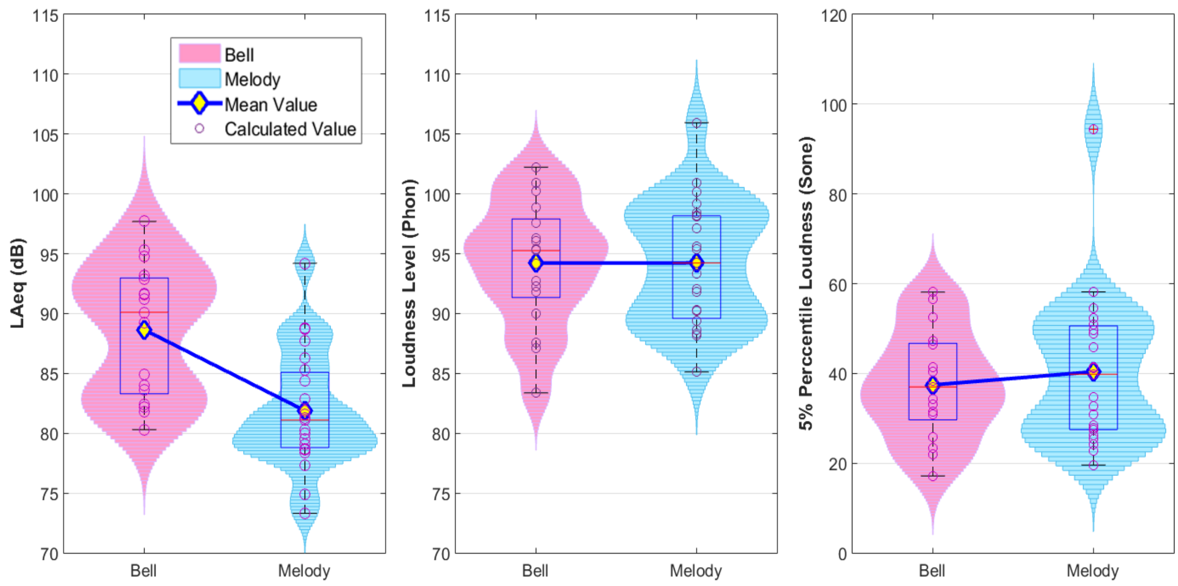

Figure 2.7 Distribution of LAeq, loudness level, and percentile loudness of the real condition.

Despite departure melodies having lower average LAeq than bell sounds, mean loudness level and percentile loudness are comparatively similar. Therefore, it can be inferred that the distribution of loudness between melody and bell departure sounds in real life is comparatively equal.

➢ <u>*Sharpness and Roughness*</u>

Figure 2.8 shows the distribution of departure bells and melodies in the actual condition. The average sharpness value for bell is 1.44 acums and the value for melody is 1.45 acums which are comparatively similar. The maximum value of melody is 1.97 acums which is higher than bell at 1.87 acums. Roughness of bell is more widespread compared to the melody. The average roughness of bell is 0.17 asper which is greater than melody at 0.13 asper. The roughness values of melody are mostly spread around 0.10 to 0.15 asper.

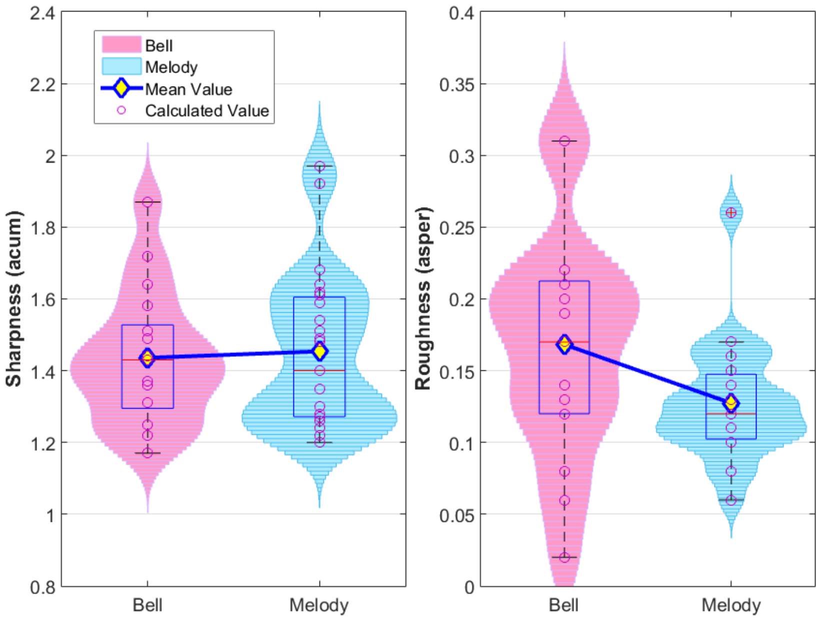

Figure 2.8 Distribution of sharpness and roughness in actual condition.

Bell sounds and melody sounds are comparatively equal at their sharpness value, however, are quite different at roughness. The distribution of roughness value of bell in actual condition is wider than melody followed by a higher average value.

➢ *Average pitch and pitch standard deviation*

Complex and fluctuating sound cannot be described with a single value of frequency because it may change over time. Therefore average pitch and pitch standard deviation is the parameter chosen to describe the perceived highness of train departure sound. Average pitch shows the average frequency exist in a sound, while pitch standard deviation explains how far is the fluctuation of the frequencies.

Figure 2.9 illustrates the distribution of average pitch and pitch standard deviation of train departure bells and melodies. In the violin plot, the mean value from average pitch of bells is higher than the one of the melodies with a difference around 600 cents or equal to 6 semitones. Mean values for bells and melodies are 991.24 cents and 372.96 cents respectively. The average pitch of melodies is wider in range as compared to departure bells. The highest average pitch of the departure sounds is 1538.75 cents which about equal to 1070 Hz while the lowest pitch is -704.43 cents which about equal to 293 Hz. The average pitch of departure bells lies between 1000 to 1500 cents which equal to 784 to 1046 Hz. On the other hand, the average pitch of melodies mostly lies between 500 to 1000 cents which is equal to 587 to 784 Hz. Pitch standard deviation of bell is less than 350 cents while melodies have it up to 1502 cents. The mean value of pitch standard deviation for bell and melody sounds are 83.13 cents and 727.14 cents respectively.

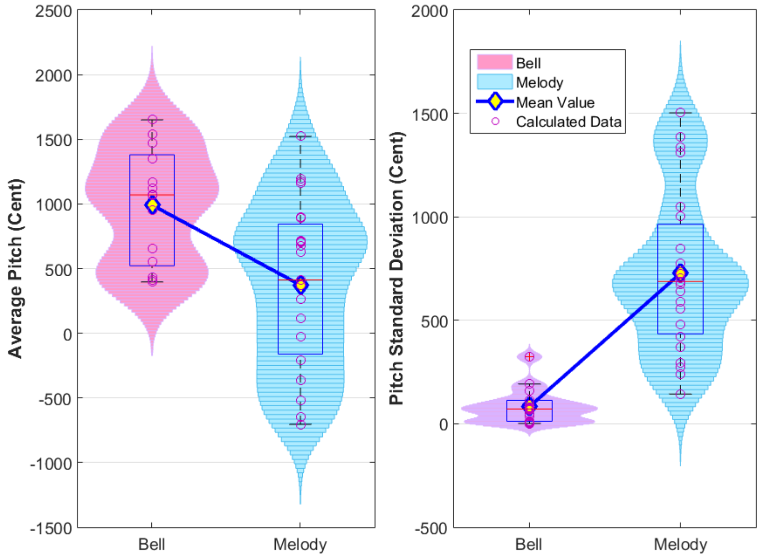

Figure 2.9 Distribution of average pitch and pitch standard deviation.

Departure melodies have a naturally broader range in pitch than bells because of their variability. The widespread of pitch standard deviation value for melodies is due to the variety of melodies exist inside them, where bells only have a minimum change in their frequency. The average pitch of the sign sounds is mostly located within the midrange spectrum of frequency.

➢ *Temporal features*

Figure 2.10 shows the temporal aspects of both departure bells and melodies. The distribution of train departure sounds ranges from 2 to more than 10 seconds. The average duration of melody and bell are comparatively close, at 5.66 seconds and 5.32 seconds respectively. Bell sounds are heavily distributed between 2 to 4 seconds and melody sounds between 5 to 7 seconds. Temporal parameters are modulation frequency for bell sounds and tempo for melody sounds. Modulation frequencies of bell sound range between 0 to 25 Hz with an average of 11.12 Hz. It is mostly distributed between 10 to 15 Hz. Tempos of melody sounds range between 102.44 Hz to 185.76 BPM with the average of 129.73 BPM. It is mostly distributed below 130 BPM.

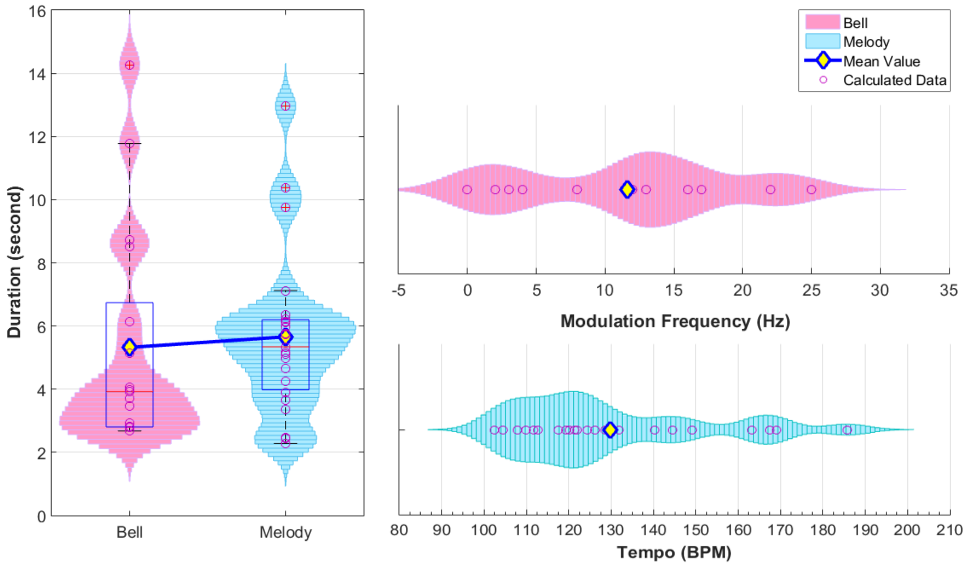

Figure 2.10 Distribution of temporal aspects of train departure sign sounds.

Both modulation frequency and tempo describe temporal characteristic for their respective sound types. Modulation frequency of bell sounds is related to the value of roughness. The tempo of departure melodies is all higher than the tempo range of *moderato*.

➢ Modality

Modality is an exclusive parameter for departure melody. This feature tells the category of notes combination used in melody sounds. Figure 2.11 shows that more melodies are using the major scales than minor scales. The values of each characteristic for each which was described in this section are presented in table 2.5.

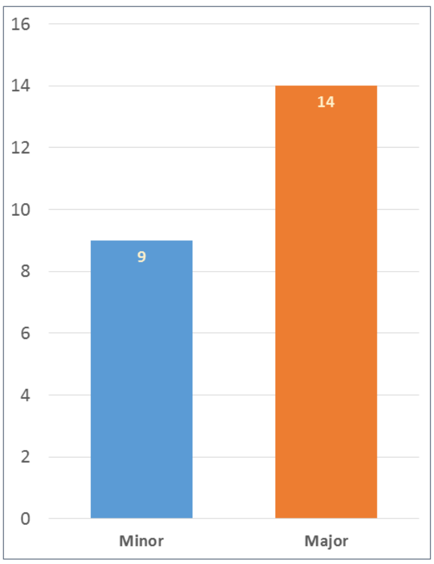

Figure 2.11 Modality of departure melodies.

Table 2.5 Table of acoustic features of departure sign sounds in real condition.

Sound No.	Sound Type	LAeq[dB]	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Tempo [BPM]	Mode	F_{ave} [Cent]	F_{SD} [Cent]	F_{mod} [Hz]
S1	Bell	82.4	14.27	87.57	23.47	1.25	0.08	-	-	955.30	50.29	16
S2	Bell	90.1	11.78	96.30	41.44	1.50	0.17	-	-	1066.35	39.36	25
S3	Bell	91.2	8.51	92.75	33.06	1.36	0.19	-	-	1351.40	74.33	12
S4	Bell	84	8.74	87.08	21.87	1.24	0.22	-	-	1118.40	71.52	22
S5	Bell	95.3	6.15	96.03	40.46	1.43	0.22	-	-	1538.75	79.99	12
S6	Bell	89.2	2.78	97.57	47.32	1.22	0.20	-	-	401.86	115.29	22
S7	Bell	97.7	2.93	98.91	46.49	1.43	0.31	-	-	1538.19	113.27	13
S8	Bell	91.7	3.92	95.27	36.99	1.37	0.02	-	-	1074.25	1.33	0
S9	Bell	91.6	3.99	94.17	34.23	1.31	0.06	-	-	1069.80	3.15	0
S10	Melody	94.2	2.28	105.96	92.37	1.92	0.26	149.04	Minor	629.38	143.54	-
S11	Melody	73.3	5.18	88.61	24.16	1.62	0.08	185.76	Minor	-360.96	1002.75	-
S12	Melody	77.3	4.25	90.32	27.86	1.28	0.11	124.32	Major	-205.22	640.80	-
S13	Melody	78.7	2.47	94.22	41.15	1.97	0.13	131.77	Major	369.34	294.46	-
S14	Melody	87.7	12.96	98.39	49.70	1.35	0.14	119.41	Major	888.06	688.03	-
S15	Melody	84.4	10.38	88.66	26.22	1.22	0.16	104.52	Minor	1162.63	372.13	-
S16	Melody	82.9	9.76	95.61	39.83	1.24	0.17	104.43	Major	-23.42	725.57	-
S17	Bell	92.9	5.13	100.22	52.52	1.58	0.21	-	-	1170.11	91.26	16
S18	Bell	93.2	4.05	102.23	56.61	1.43	0.19	-	-	652.83	323.46	8
S19	Melody	80.3	7.12	91.83	30.96	1.40	0.11	117.49	Minor	1194.96	705.59	-
S20	Melody	80	5.77	93.30	34.65	1.30	0.10	168.98	Major	411.98	419.11	-
S21	Melody	88.8	5.74	98.16	50.97	1.68	0.16	140.28	Major	1521.94	240.13	-
S22	Bell	83.6	2.81	89.96	25.86	1.16	0.12	-	-	550.71	192.96	13
S23	Bell	81.8	2.68	83.37	17.13	1.38	0.14	-	-	1469.21	67.08	17
S24	Melody	78.6	5.12	90.19	27.33	1.48	0.10	167.41	Major	709.18	848.48	-
S25	Bell	80.3	2.78	92.27	31.53	1.67	0.17	-	-	432.95	6.76	0
S26	Bell	84.9	3.46	95.40	38.38	1.53	0.12	-	-	396.47	8.26	0
S27	Bell	82.2	2.79	91.81	30.91	1.71	0.13	-	-	413.91	161.16	0
S28	Melody	79.5	6.22	92.07	32.73	1.22	0.12	128.50	Minor	674.65	591.23	-
S29	Melody	88.7	5.98	100.14	54.48	1.26	0.15	120.08	Major	114.46	705.43	-
S30	Bell	94.8	3.71	100.96	58.11	1.87	0.31	-	-	1650.54	13.82	13
S31	Melody	85.3	4.97	99.21	52.21	1.20	0.11	126.27	Minor	-643.37	1049.98	-
S32	Melody	86.3	6.12	100.90	58.16	1.64	0.08	122.03	Minor	-26.54	775.05	-
S33	Melody	81.6	3.65	98.12	48.93	1.51	0.13	107.92	Major	-519.69	1502.56	-
S34	Melody	81.3	6.36	98.18	50.92	1.61	0.12	111.60	Major	-704.43	1334.67	-
S35	Melody	81.1	6.14	97.14	45.91	1.54	0.13	112.65	Minor	-363.43	1311.93	-
S36	Melody	79.1	5.34	95.38	41.44	1.59	0.13	109.98	Minor	260.78	1384.96	-
S37	Melody	74.9	3.36	85.12	19.57	1.35	0.06	163.14	Major	714.81	676.10	-
S38	Melody	79.1	2.43	88.20	22.74	1.49	0.17	121.26	Major	1171.35	480.15	-
S39	Melody	81.9	4.65	89.41	28.48	1.27	0.10	102.44	Major	898.31	274.13	-
S40	Melody	78.4	3.89	88.32	25.47	1.30	0.11	144.51	Major	703.31	557.54	-

2.2.3.2 Normalized Level Conditions

After understanding the distribution of departure sounds characteristics in real condition from the previous section, the features of sound in a normalized LAeq will be presented in this section. The purpose of this normalization is to compare acoustic features of sound within the same sound pressure level, especially psychoacoustic related features. Psychoacoustic parameters are influenced by the change of sound volume. Therefore this section will discuss the comparison of loudness level, percentile loudness, sharpness, and roughness of departure sign sounds which are normalized to 60, 70, and 80 dB.

Parameters such as average pitch, pitch standard deviation, tempo, modulation frequency, and modality are not influenced by the change of sound level. Regardless the change in sound level, their value remain the same. Therefore, these parameters will not be compared in this section.

➢ *Loudness level*

Figure 2.12 shows the comparison of average value and overall distribution of loudness level for departure bells and melodies at 60, 70, and 80 dB. The increment of 10 dB of respective sound type rises loudness level by 9 to 10 phones. At the same sound level, average loudness level of melody sounds are higher than bell sounds with the difference of 6.4 to 7.3 phones. The average melodies at 10 dB lower than the bell counterpart have a difference of 2.4 phones.

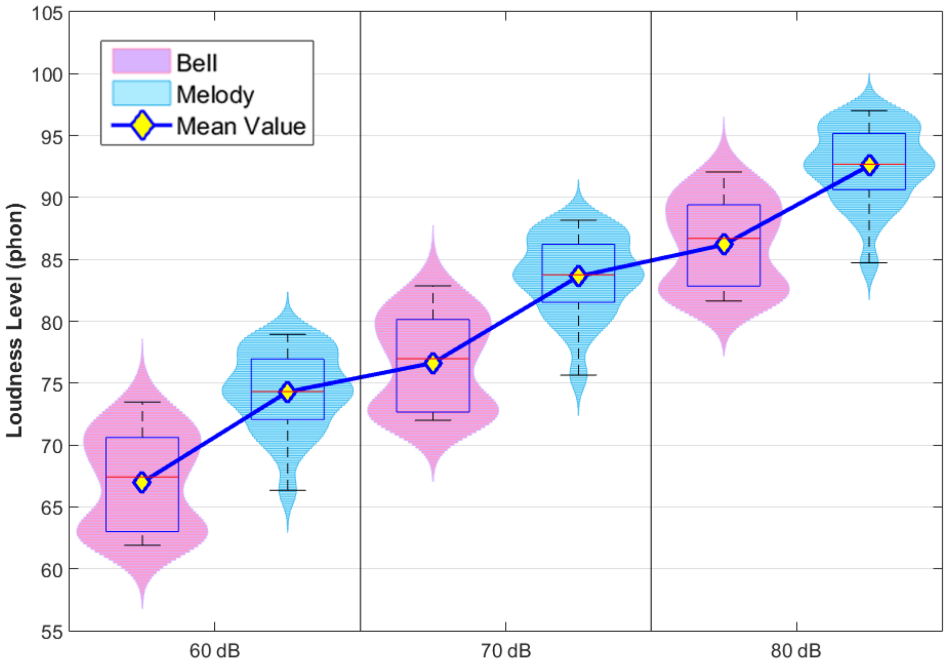

Figure 2.12 Violin plots of loudness level in 3 different LAeq.

➢ *Percentile loudness*

Figure 2.13 shows the comparison of average value and overall distribution of percentile loudness for departure bells and melodies at 60, 70, and 80 dB. The plots show that the increment of LAeq also increases percentile loudness value logarithmically. The increment of 10 dB doubles the spread of percentile loudness value for each type of sounds, which shows that the increment of 10 dB equals to doubling perception of loudness. This result is supported by the theory of Zwicker *et al*. (1999) [7].

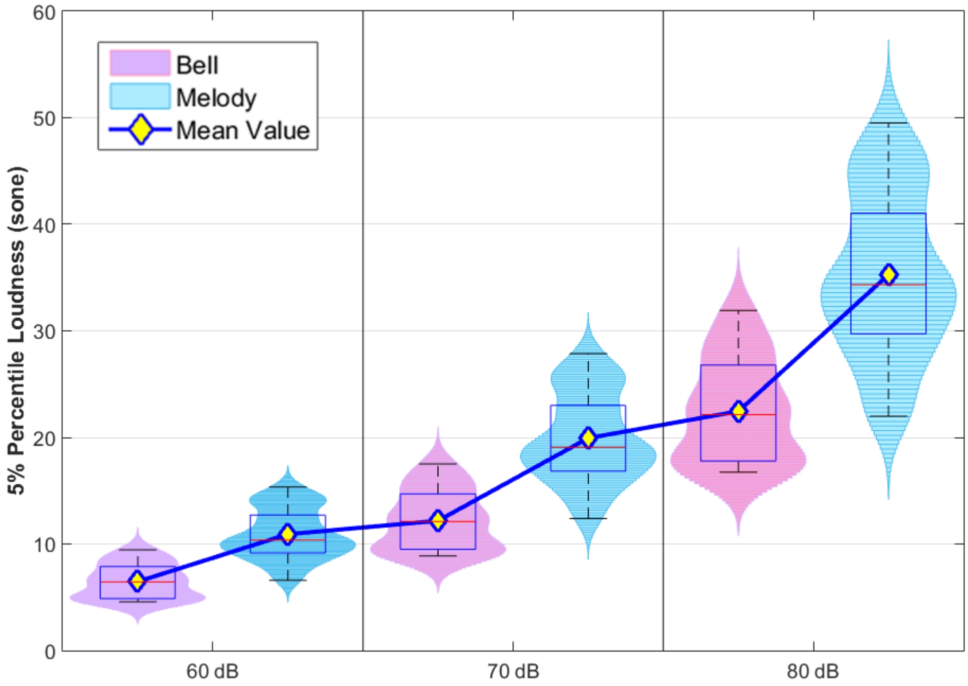

Figure 2.13 Violin plots of 5% percentile loudness in 3 different LAeq.

➢ *Sharpness*

Figure 2.14 shows the comparison indicates the comparison of average value and overall distribution of sharpness for departure bells and melodies at 60, 70, and 80 dB. There is a slight increase for each sound type by raising the LAeq by 10 dB. The sharpness value for melody sounds does not show a significant increase between sound levels. The average values for melody sounds at 70 and 80 dB are 1.43 and 1.44 acums respectively in which there is no significant difference between the two. The difference of sharpness of melody sounds in 60 and 70 dB is 0.05 acum. The average value for bell sounds increases by 0.09 acum from 60 to 70 dB, and 0.05 acum from 70 to 80 dB. At sound level of 80 dB, the sharpness of bell is very close to the one of melody at 1.42 and 1.44 acums respectively.

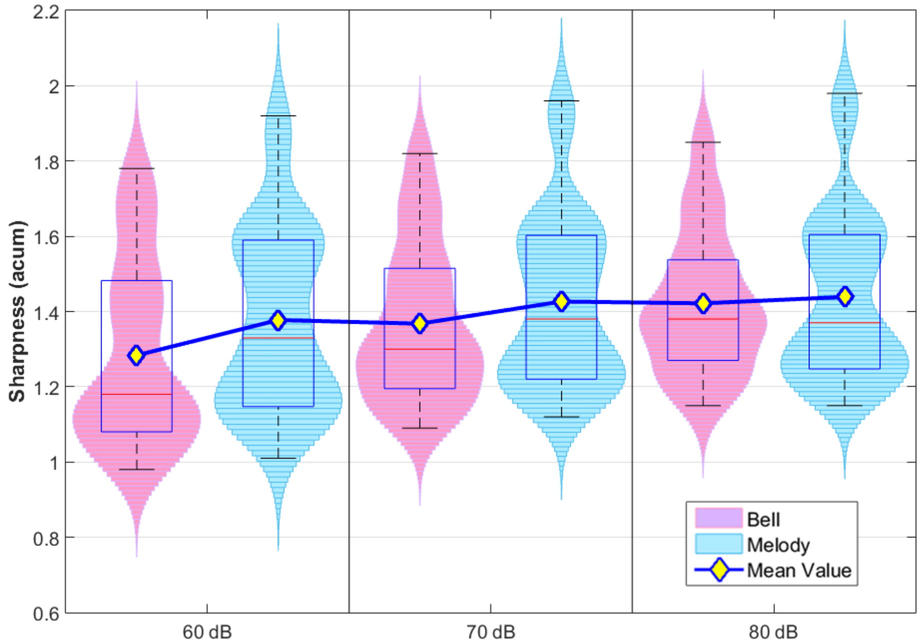

Figure 2.14 Violin plots of sharpness in 3 different LAeq.

➢ <u>*Roughness*</u>

Figure 2.15 shows the comparison demonstrates the comparison of average value and overall distribution of sharpness for departure bells and melodies at 60, 70, and 80 dB. The average roughness of melody sounds is lower than bells. The increment of 10 dB increases the mean value by 0.03 asper, as well as broadens roughness distribution for each sound type. The difference of roughness for bell and melody sounds at each sound level is constant at 0.02 asper.

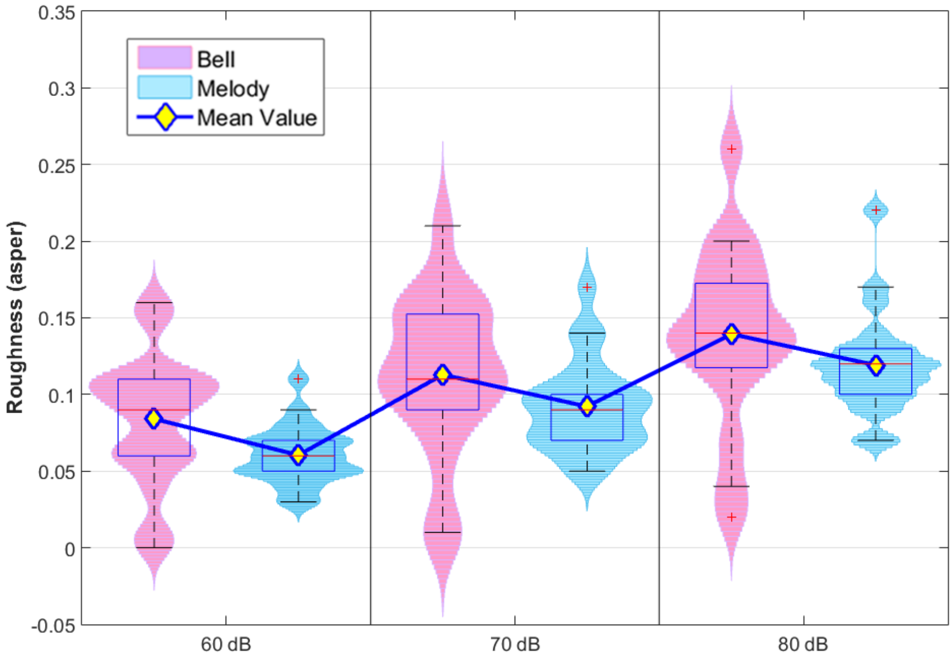

Figure 2.15 Violin plots of roughness in 3 different LAeq.

2.2.4 Cluster Analysis

For the cluster analysis, departure bell and departure melodies are analyzed separately. Hierarchical cluster analysis was conducted in IBM SPSS Statistics 20 software, using Ward's method to group each sound type.

The purpose of cluster analysis is to examine any similarities of sound departure sounds. By grouping the sounds, classification of departure bells and melodies respectively may be found based on their characteristics. This analysis will also help to reduce samples for the experiment conducted in section 2.3 by selecting one sound from each classification.

2.2.4.1 Bell

Bell sounds are considered to be constant and in practice the duration of each broadcast may vary depending on the person broadcasting them as well as the situation of the crowds. Therefore, the factor of duration is omitted from this cluster analysis.

Figure 2.16 shows the classification of departure bells. There are five groups established for departure bells. Based on Ward's method the classification starts from the loudness level above and below 65 phones. For each loudness level, sounds are divided by modulation frequency equal to or above 0 Hz. In one sub-category (red and blue), the division was made from the value of average pitch of above and below 1000 Cents. The value of the parameters for each sound as well as the cluster division meaning can be seen in table 2.6.

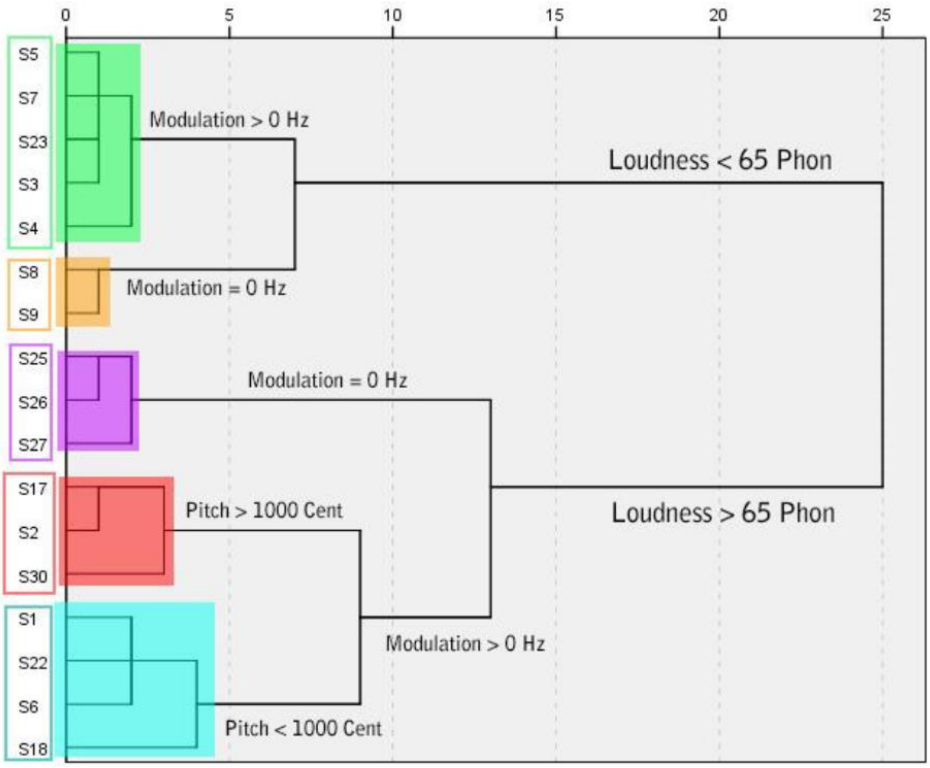

Figure 2.16 Cluster analysis result of bell sounds using Ward Linkage Method.

Table 2.6 Features of bell sounds at 60 dB along with their cluster number and meaning. Highlighted sounds are the selected samples for the experiment.

			Cluster	Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
Bell	Low Pitch		B1	S01	Bell	14.27	66.15	6.44	1.08	0.04	16	-	-	955.30	50.29
			B1	S06	Bell	2.78	70.42	8.24	1.06	0.06	22	-	-	401.86	115.29
			B1	S18	Bell	4.05	71.26	7.78	1.35	0.11	8	-	-	652.83	323.46
			B1	S22	Bell	2.81	67.41	6.25	0.98	0.07	13	-	-	550.71	192.96
	High Pitch	Quiet	B2	S03	Bell	8.51	61.90	4.84	1.11	0.06	12	-	-	1351.40	74.33
			B2	S04	Bell	8.74	64.25	5.02	1.01	0.11	22	-	-	1118.40	71.52
			B2	S05	Bell	6.15	62.76	4.69	1.17	0.10	12	-	-	1538.75	79.99
			B2	S07	Bell	2.93	63.07	4.58	1.18	0.10	13	-	-	1538.19	113.27
			B2	S23	Bell	2.68	62.59	4.77	1.16	0.06	17	-	-	1469.21	67.08
		Loud	B3	S02	Bell	11.78	68.25	6.50	1.38	0.09	25	-	-	1066.35	39.36
			B3	S17	Bell	5.13	69.87	6.98	1.49	0.11	16	-	-	1170.11	91.26
			B3	S30	Bell	3.71	68.59	7.01	1.78	0.16	13	-	-	1650.54	13.82
Buzzer	Low Pitch		B4	S25	Bell	2.78	73.46	9.46	1.63	0.15	0	-	-	432.95	6.76
			B4	S26	Bell	3.46	71.80	8.84	1.48	0.11	0	-	-	396.47	8.26
			B4	S27	Bell	2.79	71.17	8.40	1.69	0.09	0	-	-	413.91	161.16
	High Pitch		B5	S08	Bell	3.92	63.68	5.29	1.19	0.01	0	-	-	1074.25	1.33
			B5	S09	Bell	3.99	62.20	4.90	1.08	0.00	0	-	-	1069.80	3.15

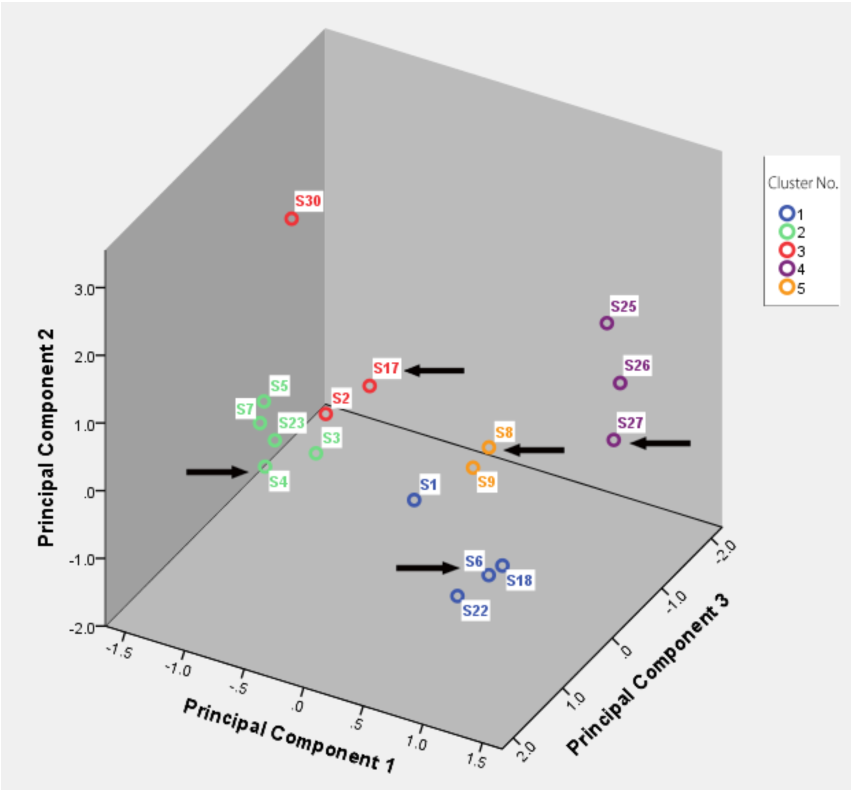

Figure 2.17 Scatter plot of bell sounds in PCA factors.

Table 2.6 shows the clustering result of bell sounds at 60 dB. Referring to the description by Kameda *et al*. (2016) [1], bells with 0 Hz of modulation frequency is classified as *buzzer*. The colors at the left side of the table correspond to the grouping color in figure 2.16 and figure 2.17. Highlighted sounds represent the samples selected for the experiment in section 2.3. Samples selected for the analysis was based on their similarities with the other objects inside a 3-dimensional scatter plot as shown in figure 2.17. The plot illustrates the position of each cluster based on factors based on principal component analysis with the selected sounds marked by black arrows.

Factor loadings of each component can be seen in table 2.7. Based on the factor loadings, component 1 is defined by average pitch, percentile loudness, and loudness level. Component 2 is defined by roughness and sharpness. Lastly, Component 3 is defined by modulation frequency and pitch standard deviation.

For comparison, features of departure bells at 70 dB and 80 dB is also shown in table 2.8 and table 2.9 respectively.

Table 2.7 Factor Loading of each component from Principal Component Analysis for bell sounds.

	Component		
	1	2	3
F_{ave}	-.965	.039	-.002
N5	.807	.541	-.077
LN	.765	.611	.063
R	.008	.925	.190
S	.225	.853	-.339
F_{mod}	-.441	.048	.746
F_{SD}	.405	-.071	.737

Table 2.8 Features of bell sounds at 70 dB with their cluster meaning.

			Cluster	Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
Bell	Low Pitch		B1	S01	Bell	14.27	75.93	12.15	1.18	0.06	16	-	-	955.30	50.29
			B1	S06	Bell	2.78	80.01	15.30	1.15	0.09	22	-	-	401.86	115.29
			B1	S18	Bell	4.05	80.74	14.49	1.39	0.12	8	-	-	652.83	323.46
			B1	S22	Bell	2.81	76.98	11.86	1.09	0.09	13	-	-	550.71	192.96
	High Pitch	Quiet	B2	S03	Bell	8.51	71.99	9.30	1.24	0.11	12	-	-	1351.40	74.33
			B2	S04	Bell	8.74	73.84	9.58	1.14	0.16	22	-	-	1118.40	71.52
			B2	S05	Bell	6.15	72.22	9.08	1.30	0.15	12	-	-	1538.75	79.99
			B2	S07	Bell	2.93	72.48	8.89	1.31	0.16	13	-	-	1538.19	113.27
			B2	S23	Bell	2.68	72.08	9.16	1.29	0.10	17	-	-	1469.21	67.08
		Loud	B3	S02	Bell	11.78	77.86	12.12	1.45	0.11	25	-	-	1066.35	39.36
			B3	S17	Bell	5.13	79.32	12.91	1.53	0.15	16	-	-	1170.11	91.26
			B3	S30	Bell	3.71	78.18	13.04	1.82	0.21	13	-	-	1650.54	13.82
Buzzer	Low Pitch		B4	S25	Bell	2.78	82.86	17.50	1.65	0.16	0	-	-	432.95	6.76
			B4	S26	Bell	3.46	81.33	16.45	1.51	0.12	0	-	-	396.47	8.26
			B4	S27	Bell	2.79	80.58	15.38	1.70	0.11	0	-	-	413.91	161.16
	High Pitch		B5	S08	Bell	3.92	73.68	10.22	1.30	0.01	0	-	-	1074.25	1.33
			B5	S09	Bell	3.99	72.71	9.63	1.20	0.01	0	-	-	1069.80	3.15

Table 2.9 Features of bell sounds at 80 dB with their cluster meaning.

			Cluster	Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
Bell	Low Pitch		B1	S01	Bell	14.27	85.35	22.43	1.24	0.07	16	-	-	955.30	50.29
			B1	S06	Bell	2.78	89.30	27.72	1.20	0.15	22	-	-	401.86	115.29
			B1	S18	Bell	4.05	90.23	26.48	1.42	0.14	8	-	-	652.83	323.46
			B1	S22	Bell	2.81	86.69	21.98	1.15	0.11	13	-	-	550.71	192.96
	High Pitch	Quiet	B2	S03	Bell	8.51	81.65	17.66	1.32	0.14	12	-	-	1351.40	74.33
			B2	S04	Bell	8.74	83.43	17.83	1.23	0.20	22	-	-	1118.40	71.52
			B2	S05	Bell	6.15	81.64	17.04	1.38	0.17	12	-	-	1538.75	79.99
			B2	S07	Bell	2.93	82.36	16.73	1.39	0.20	13	-	-	1538.19	113.27
			B2	S23	Bell	2.68	81.63	17.17	1.38	0.13	17	-	-	1469.21	67.08
		Loud	B3	S02	Bell	11.78	87.22	22.13	1.49	0.14	25	-	-	1066.35	39.36
			B3	S17	Bell	5.13	88.50	23.53	1.56	0.18	16	-	-	1170.11	91.26
			B3	S30	Bell	3.71	87.43	23.85	1.85	0.26	13	-	-	1650.54	13.82
Buzzer	Low Pitch		B4	S25	Bell	2.78	92.07	31.91	1.67	0.17	0	-	-	432.95	6.76
			B4	S26	Bell	3.46	90.90	29.97	1.53	0.12	0	-	-	396.47	8.26
			B4	S27	Bell	2.79	89.75	27.90	1.71	0.13	0	-	-	413.91	161.16
	High Pitch		B5	S08	Bell	3.92	83.92	19.15	1.37	0.02	0	-	-	1074.25	1.33
			B5	S09	Bell	3.99	83.01	18.22	1.28	0.04	0	-	-	1069.80	3.15

2.2.4.2 Melody

Departure melody is comparatively more complex than its bell counterparts where interpretation of the cluster analysis is much harder. Unlike bell sounds, the duration is included as a consideration for departure melodies due to its change in fluctuation over time. Using the same method as cluster analysis of departure bells, a total of 6 groups were made.

Figure 2.18 shows the cluster division for departure melodies based on Ward's method. The first step of division was based on percentile loudness value whether the sound is above or below 11.2 sones. The next division was made based on modality. On the upper part of the graph, two clusters (black and red) were divided based on their tempo whether it is slower or faster than 125 BPM. On the other hand, at the bottom part of the graph, there is a division in major scale melodies regarding their duration whether it is higher or lower than 3 seconds.

The value of the parameters for each sound as well as the cluster division meaning can be seen in table 2.10. The division order changed from figure 2.18 to make the clusters more comprehensible. Each color at the left side of the table corresponds to the color on figure 2.18 and figure 2.19. The peculiarity of the clustering can be seen in sound number S38 and S39 where their tempo is much lower than the other samples in the group. The highlighted sounds are samples selected for the experiment in section 2.3. Sounds are chosen based on their proximity to the centroid of each cluster. An exception was made for cluster M5 because the sample in their centroid is too close to cluster M6. Therefore the second closest sound was chosen instead.

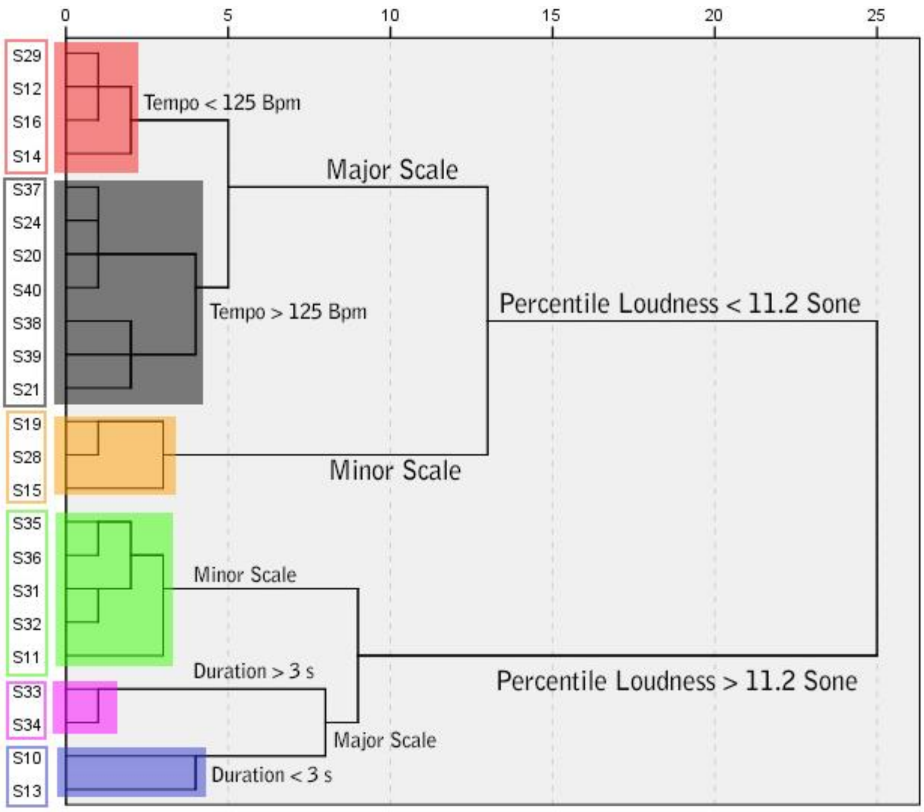

Figure 2.18 Cluster analysis result of melody sounds using Ward Linkage Method.

Table 2.10 Features of bell sounds at 60 dB along with their cluster number and meaning. Highlighted sounds are the selected samples for the experiment.

			Cluster	Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
Loud	Short		M1	S10	Melody	2.28	75.09	12.69	1.83	0.11	-	149.04	Minor	629.38	143.54
Loud	Short		M1	S13	Melody	2.47	77.12	14.12	1.92	0.06	-	131.77	Major	369.34	294.46
Loud	Long	Major	M2	S33	Melody	3.65	78.68	14.06	1.50	0.07	-	107.92	Major	-519.69	1502.56
Loud	Long	Major	M2	S34	Melody	6.36	78.95	15.36	1.61	0.06	-	111.60	Major	-704.43	1334.67
Loud	Long	Minor	M3	S11	Melody	5.18	76.42	11.43	1.59	0.05	-	185.76	Minor	-360.96	1002.75
Loud	Long	Minor	M3	S31	Melody	4.97	76.24	11.97	1.12	0.05	-	126.27	Minor	-643.37	1049.98
Loud	Long	Minor	M3	S32	Melody	6.12	77.43	12.71	1.62	0.03	-	122.03	Minor	-26.54	775.05
Loud	Long	Minor	M3	S35	Melody	6.14	78.23	13.90	1.52	0.07	-	112.65	Minor	-363.43	1311.93
Loud	Long	Minor	M3	S36	Melody	5.34	78.17	14.55	1.59	0.07	-	109.98	Minor	260.78	1384.96
Quiet	Major	Fast	M4	S20	Melody	5.77	75.20	11.08	1.22	0.05	-	168.98	Major	411.98	419.11
Quiet	Major	Fast	M4	S21	Melody	5.74	71.70	9.01	1.63	0.04	-	140.28	Major	1521.94	240.13
Quiet	Major	Fast	M4	S24	Melody	5.12	73.16	9.60	1.42	0.04	-	167.41	Major	709.18	848.48
Quiet	Major	Fast	M4	S37	Melody	3.36	71.22	8.60	1.25	0.03	-	163.14	Major	714.81	676.1
Quiet	Major	Fast	M4	S38	Melody	2.43	70.48	7.56	1.37	0.09	-	121.26	Major	1171.35	480.15
Quiet	Major	Fast	M4	S39	Melody	4.65	69.23	8.21	1.12	0.05	-	102.44	Major	898.31	274.13
Quiet	Major	Fast	M4	S40	Melody	3.89	71.31	8.99	1.17	0.07	-	144.51	Major	703.31	557.54
Quiet	Major	Slow	M5	S12	Melody	4.25	74.33	10.21	1.17	0.05	-	124.32	Major	-205.22	640.8
Quiet	Major	Slow	M5	S14	Melody	12.96	73.26	9.74	1.28	0.05	-	119.41	Major	888.06	688.03
Quiet	Major	Slow	M5	S16	Melody	9.76	74.74	10.38	1.14	0.08	-	104.43	Major	-23.42	725.57
Quiet	Major	Slow	M5	S29	Melody	5.98	74.31	10.23	1.14	0.07	-	120.08	Major	114.46	705.43
Quiet	Minor		M6	S15	Melody	10.38	66.33	6.59	1.01	0.08	-	104.52	Minor	1162.63	372.13
Quiet	Minor		M6	S19	Melody	7.12	73.18	9.62	1.33	0.06	-	117.49	Minor	1194.96	705.59
Quiet	Minor		M6	S28	Melody	6.22	74.22	10.51	1.13	0.06	-	128.50	Minor	674.65	591.23

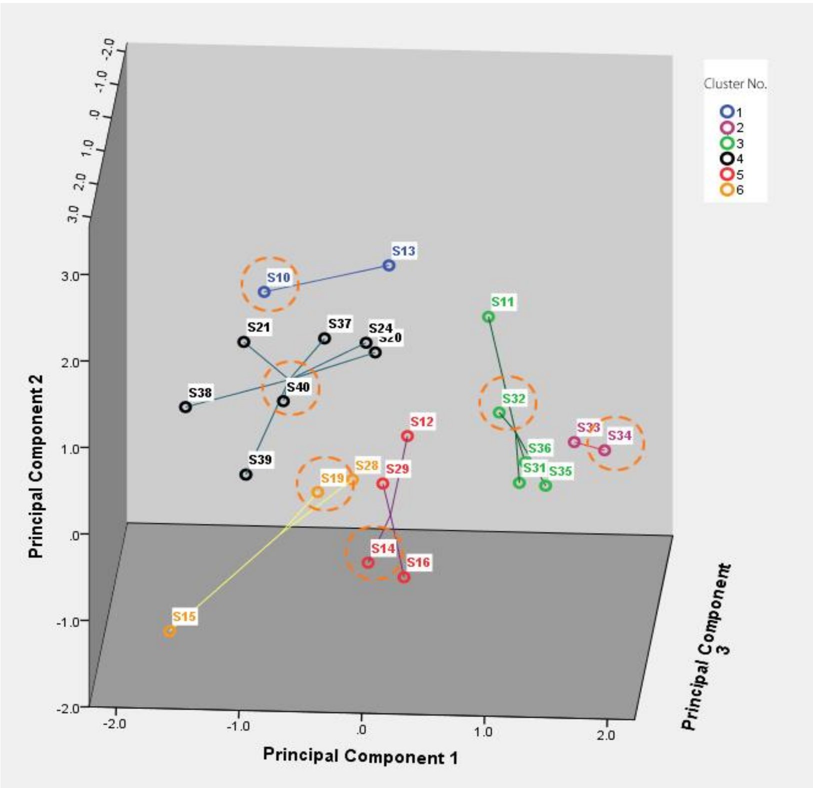

Figure 2.19 Scatter plot of melody sounds in PCA factors along with the centroid lines.

Table 2.11 Factor Loading of each component from Principal Component Analysis for bell sounds.

	Component		
	1	2	3
LN	.911	.315	.094
F_{ave}	-.891	-.004	.008
F_{SD}	.865	-.195	.047
N5	.858	.373	.240
Duration	.004	-.792	.064
S	.311	.783	.208
R	-.146	.134	.867
Tempo	-.133	.550	-.609
Mode	-.192	-.005	-.461

Figure 2.19 shows the position of each group and the selected sample marked by orange circles. Factor loadings of each component can be seen in table 2.11. Based on the factor loadings, component 1 is defined by loudness level, average pitch, pitch standard deviation and percentile loudness. Component 2 is defined by duration and sharpness. Lastly, Component 3 is defined by roughness and tempo. For comparison, features of departure melodies at 70 and 80 dB is also shown in table 2.12 and table 2.13 respectively.

Table 2.12 Features of melody sounds at 70 dB with their cluster meaning.

			Cluster	Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
Loud	Short		M1	S10	Melody	2.28	84.42	23.04	1.89	0.17	-	149.04	Minor	629.38	143.54
			M1	S13	Melody	2.47	86.39	25.38	1.96	0.10	-	131.77	Major	369.34	294.46
	Long	Major	M2	S33	Melody	3.65	87.84	25.59	1.51	0.10	-	107.92	Major	-519.69	1502.56
			M2	S34	Melody	6.36	88.16	27.87	1.61	0.09	-	111.60	Major	-704.43	1334.67
		Minor	M3	S11	Melody	5.18	85.68	20.71	1.62	0.07	-	185.76	Minor	-360.96	1002.75
			M3	S31	Melody	4.97	85.64	22.04	1.17	0.07	-	126.27	Minor	-643.37	1049.98
			M3	S32	Melody	6.12	86.66	22.93	1.63	0.05	-	122.03	Minor	-26.54	775.05
			M3	S35	Melody	6.14	87.39	25.20	1.53	0.10	-	112.65	Minor	-363.43	1311.93
			M3	S36	Melody	5.34	87.30	26.38	1.58	0.10	-	109.98	Minor	260.78	1384.96
Quiet	Major	Fast	M4	S20	Melody	5.77	84.40	20.11	1.27	0.07	-	168.98	Major	411.98	419.11
			M4	S21	Melody	5.74	81.22	16.63	1.66	0.06	-	140.28	Major	1521.94	240.13
			M4	S24	Melody	5.12	82.47	17.51	1.46	0.07	-	167.41	Major	709.18	848.48
			M4	S37	Melody	3.36	80.65	15.75	1.32	0.05	-	163.14	Major	714.81	676.1
			M4	S38	Melody	2.43	79.91	13.99	1.45	0.14	-	121.26	Major	1171.35	480.15
			M4	S39	Melody	4.65	78.67	15.16	1.21	0.07	-	102.44	Major	898.31	274.13
			M4	S40	Melody	3.89	80.66	16.52	1.26	0.14	-	144.51	Major	703.31	557.54
		Slow	M5	S12	Melody	4.25	83.75	18.67	1.25	0.08	-	124.32	Major	-205.22	640.8
			M5	S14	Melody	12.96	82.68	17.94	1.32	0.08	-	119.41	Major	888.06	688.03
			M5	S16	Melody	9.76	84.12	19.07	1.21	0.11	-	104.43	Major	-23.42	725.57
			M5	S29	Melody	5.98	83.66	18.78	1.21	0.10	-	120.08	Major	114.46	705.43
	Minor		M6	S15	Melody	10.38	75.64	12.39	1.12	0.12	-	104.52	Minor	1162.63	372.13
			M6	S19	Melody	7.12	82.59	17.74	1.38	0.09	-	117.49	Minor	1194.96	705.59
			M6	S28	Melody	6.22	83.58	19.15	1.19	0.09	-	128.50	Minor	674.65	591.23

Table 2.13 Features of melody sounds at 80 dB with their cluster meaning.

			Cluster	Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
Loud	Short		M1	S10	Melody	2.28	93.45	41.19	1.91	0.22	-	149.04	Minor	629.38	143.54
			M1	S13	Melody	2.47	95.39	45.00	1.98	0.13	-	131.77	Major	369.34	294.46
	Long	Major	M2	S33	Melody	3.65	96.71	45.44	1.51	0.12	-	107.92	Major	-519.69	1502.56
			M2	S34	Melody	6.36	97.02	49.51	1.61	0.11	-	111.60	Major	-704.43	1334.67
		Minor	M3	S11	Melody	5.18	94.54	36.80	1.63	0.10	-	185.76	Minor	-360.96	1002.75
			M3	S31	Melody	4.97	94.56	39.46	1.19	0.09	-	126.27	Minor	-643.37	1049.98
			M3	S32	Melody	6.12	95.45	40.62	1.64	0.07	-	122.03	Minor	-26.54	775.05
			M3	S35	Melody	6.14	96.19	44.64	1.54	0.13	-	112.65	Minor	-363.43	1311.93
			M3	S36	Melody	5.34	96.18	46.81	1.59	0.13	-	109.98	Minor	260.78	1384.96
Quiet	Major	Fast	M4	S20	Melody	5.77	93.30	35.82	1.30	0.10	-	168.98	Major	411.98	419.11
			M4	S21	Melody	5.74	90.37	30.00	1.67	0.12	-	140.28	Major	1521.94	240.13
			M4	S24	Melody	5.12	91.42	21.98	1.15	0.10	-	167.41	Major	709.18	848.48
			M4	S37	Melody	3.36	89.73	28.30	1.37	0.07	-	163.14	Major	714.81	676.1
			M4	S38	Melody	2.43	89.01	25.58	1.50	0.17	-	121.26	Major	1171.35	480.15
			M4	S39	Melody	4.65	87.70	27.70	1.27	0.09	-	102.44	Major	898.31	274.13
			M4	S40	Melody	3.89	89.68	29.63	1.31	0.11	-	144.51	Major	703.31	557.54
		Slow	M5	S12	Melody	4.25	92.68	33.44	1.28	0.12	-	124.32	Major	-205.22	640.8
			M5	S14	Melody	12.96	91.67	32.25	1.34	0.11	-	119.41	Major	888.06	688.03
			M5	S16	Melody	9.76	93.06	34.34	1.24	0.16	-	104.43	Major	-23.42	725.57
			M5	S29	Melody	5.98	92.54	33.69	1.24	0.12	-	120.08	Major	114.46	705.43
	Minor		M6	S15	Melody	10.38	84.72	22.71	1.20	0.14	-	104.52	Minor	1162.63	372.13
			M6	S19	Melody	7.12	91.56	32.02	1.40	0.11	-	117.49	Minor	1194.96	705.59
			M6	S28	Melody	6.22	92.49	34.58	1.22	0.12	-	128.50	Minor	674.65	591.23

2.3 Experiment 1: Laboratory Experiment for Acoustic Factors

In this experiment, consideration upon acoustic features as a factor that influences auditory impression will be presented. Impressions that are evaluated in this experiment can be divided into two categories, "timbre" and "mood". "Timbre" category is designed to correspond the extracted acoustics features, while "mood" category is intended to assess the unpleasantness caused by each departure sign sounds. Discomfort can also be assessed specifically by stressfulness and annoyance caused by the departure sounds which is included in mood related impression.

2.3.1 Objective

This study aims to understand the effect of acoustic features towards auditory impressions of departure sign sounds. In the long run, by understanding which separate features or even combination of features causing stress or annoyance, a guideline upon designing train departure sounds may be possible to be proposed.

2.3.2 Experiment Outline

2.3.2.1 Time and Place

The experiment was conducted from 1 March 2017 to 9 March 2017 in the anechoic chamber of University of Tokyo, Kashiwa Campus.

2.3.2.2 Participants

There were 23 participants recruited for the first experiment. They consist of 10 Japanese and 13 non-Japanese. There are 5 females from each group of nationality, with 5 and 8 males for Japanese and non-Japanese groups respectively. All participants who are recruited were aged between 20 to 40 years old with a mean of 25.6 years old and median of 24 years old.

2.3.2.3 Sound Samples

Sound samples which were used in this experiment came from the result of cluster analysis in section 2.2.4. One sample from each cluster was selected in order to reduce the experiment time by eliminating sounds which have similar characteristics. In total, there are 5 departure bells and 6 departure melodies that were utilized in the experiment. The selected sounds were normalized at three LAeq levels, 60 dB, 70 dB, and 80 dB. Table 2.14 shows the characteristics of the sound used in this experiment at 60 dB, 70dB, and 80 dB.

Table 2.14 Characteristics of departure sounds that are used in the experiment.

No	Laeq	Type	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
S04	60	Bell	64.3	5.0	1.01	0.11	22	-	-	1118.4	71.5
S06	60	Bell	70.4	8.2	1.06	0.06	22	-	-	401.9	115.3
S08	60	Bell	63.7	5.3	1.19	0.01	0	-	-	1074.3	1.3
S17	60	Bell	69.9	7.0	1.49	0.11	16	-	-	1170.1	91.3
S27	60	Bell	71.2	8.4	1.69	0.09	0	-	-	413.9	161.2
S10	60	Melody	75.1	12.7	1.83	0.11	-	149	Minor	629.4	143.5
S14	60	Melody	73.3	9.7	1.28	0.05	-	119	Major	888.1	688.0
S19	60	Melody	73.2	9.6	1.33	0.06	-	117	Minor	1195.0	705.6
S32	60	Melody	77.4	12.7	1.62	0.03	-	122	Minor	-26.5	775.1
S34	60	Melody	79.0	15.4	1.61	0.06	-	112	Major	-704.4	1334.7
S40	60	Melody	71.3	9.0	1.17	0.07	-	145	Major	703.3	557.5
S04	70	Bell	73.8	9.6	1.14	0.16	22	-	-	1118.4	71.5
S06	70	Bell	80.0	15.3	1.15	0.09	22	-	-	401.9	115.3
S08	70	Bell	73.7	10.2	1.30	0.01	0	-	-	1074.3	1.3
S17	70	Bell	79.3	12.9	1.53	0.15	16	-	-	1170.1	91.3
S27	70	Bell	80.6	15.4	1.70	0.11	0	-	-	413.9	161.2
S10	70	Melody	84.4	23.0	1.89	0.17	-	149	Minor	629.4	143.5
S14	70	Melody	82.7	17.9	1.32	0.08	-	119	Major	888.1	688.0
S19	70	Melody	82.6	17.7	1.38	0.09	-	117	Minor	1195.0	705.6
S32	70	Melody	86.7	22.9	1.63	0.05	-	122	Minor	-26.5	775.1
S34	70	Melody	88.2	27.9	1.61	0.09	-	112	Major	-704.4	1334.7
S40	70	Melody	80.7	16.5	1.26	0.14	-	145	Major	703.3	557.5
S04	80	Bell	83.4	17.8	1.23	0.20	22	-	-	1118.4	71.5
S06	80	Bell	89.3	27.7	1.20	0.15	22	-	-	401.9	115.3
S08	80	Bell	83.9	19.2	1.37	0.02	0	-	-	1074.3	1.3
S17	80	Bell	88.5	23.5	1.56	0.18	16	-	-	1170.1	91.3
S27	80	Bell	89.8	27.9	1.71	0.13	0	-	-	413.9	161.2
S10	80	Melody	93.4	41.2	1.91	0.22	-	149	Minor	629.4	143.5
S14	80	Melody	91.7	32.2	1.34	0.11	-	119	Major	888.1	688.0
S19	80	Melody	91.6	32.0	1.40	0.11	-	117	Minor	1195.0	705.6
S32	80	Melody	95.4	40.6	1.64	0.07	-	122	Minor	-26.5	775.1
S34	80	Melody	97.0	49.5	1.61	0.11	-	112	Major	-704.4	1334.7
S40	80	Melody	89.7	29.6	1.31	0.11	-	145	Major	703.3	557.5

2.3.2.4 Questionnaire

In order to assess the overall impressions of train departure sign sounds, 9 pairs of adjective were selected as shown in Table 2.15. Those adjectives are divided into two categories (timbre and mood) and presented in both Japanese and English. Timbre impressions are related to the subjective characteristics of the sounds such as “loud – soft”, “quiet – noisy”, “low – high”, “metallic – deep”, and “smooth – rough”. Mood impressions are related to perceived unpleasantness caused by the train departure sign sounds such as “calm – hasty”, “exciting – depressing”, “stressful – relaxing”, and “pleasing – annoying”. Each pair of adjectives were rated using a 7-step scale of semantic differential method. In addition to the adjectives, preferences towards each sound was asked in 3-step scale which consist of “like”, “dislike”, and “neither”. In the end, there are 14 questions about hearing sensitivity based on Khalfa’s Hyperacusis Questionnaire [23, 24], followed by questions about profile of the participants. The translation between Japanese and English adjectives was based on previous researches such as [25] and [26], as well as discussion with native some English and Japanese speakers. The questionnaire sample is attached in Appendix 1.

Table 2.15 Adjective pairs for subjective evaluation in experiment 1.

	Rating Scale						
	-3	-2	-1	0	1	2	3
	Highly	Quite	Slightly	Neither	Slightly	Quite	Highly
Timbre		**Soft**		**<==>**		**Loud**	
		Quiet		**<==>**		**Noisy**	
		Low		**<==>**		**High**	
		Deep		**<==>**		**Metallic**	
		Smooth		**<==>**		**Rough**	
Mood		**Calm**		**<==>**		**Hasty**	
		Exciting		**<==>**		**Depressing**	
		Relaxing		**<==>**		**Stressful**	
		Pleasing		**<==>**		**Annoying**	
Preference			-1	0	1		
			Like	**Neither**	**Dislike**		

2.3.2.5 Experiment Design and Procedure

The departure sign sounds were presented to the participants in sets of prepared sequences. There were 3 sets of a semi-randomized sequence of sound. One set consists of 33 sound samples which are identical with the other sets. One set is divided into three different sound level orders as shown in table 2.16.

The experiment was conducted with one participant at a time. The participants were given the questionnaire and asked to sit on a provided chair in the middle of anechoic chamber as shown in figure 2.21. Each sound was played from one speaker located above the participant. Before each set stars, two practice sounds were presented to familiarize the participants with the questionnaire. The prepared practice sounds were selected at random from the unused sound samples. After they had finished listening to the sound, they were asked to fill on the questionnaire provided for each sound. At the end of the experiment, a short profile and hyperacusis test questionnaire were answered by the participants. Figure 2.20 shows the flow of this experiment.

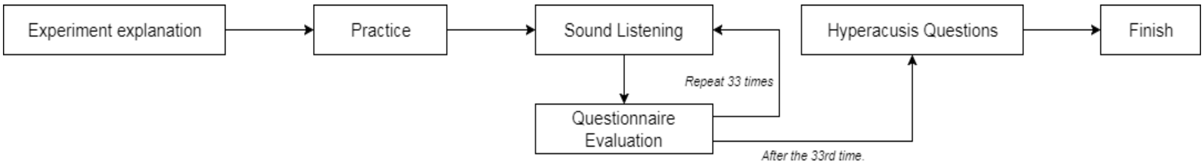

Figure 2.20 Routine of the listening experiment.

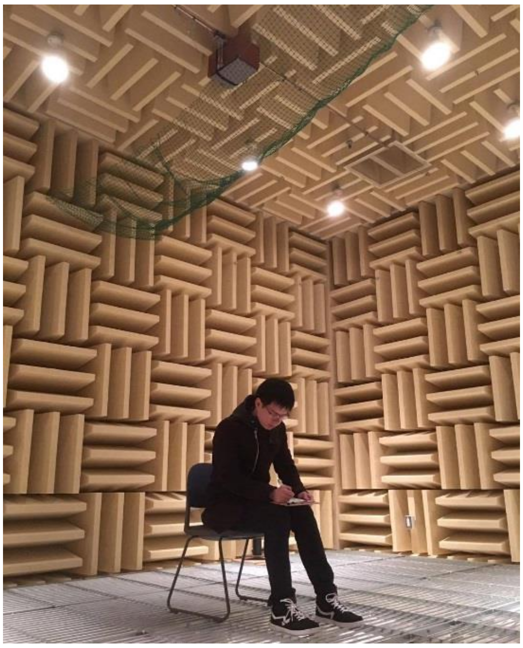

Figure 2.21 Listening experiment condition inside the anechoic chamber.

Table 2.16 Sequence of the sound samples presentation.

	Set 1		Set 2		Set 3	
	Sound	Level	Sound	Level	Sound	Level
1	S27	60	S19	80	S32	70
2	S40	70	S14	70	S27	80
3	S32	80	S34	60	S40	60
4	S14	60	S17	80	S06	70
5	S06	70	S04	70	S34	80
6	S34	80	S10	60	S19	60
7	S19	60	S06	80	S14	70
8	S17	70	S32	70	S04	80
9	S10	80	S08	60	S10	60
10	S04	60	S27	80	S17	70
11	S08	70	S40	70	S08	60
12	S17	80	S14	60	S19	80
13	S14	70	S17	70	S14	60
14	S34	60	S10	80	S34	70
15	S04	80	S32	60	S27	60
16	S27	70	S27	70	S10	80
17	S10	60	S34	80	S04	70
18	S40	80	S04	60	S06	80
19	S32	70	S19	70	S32	60
20	S06	60	S40	80	S08	70
21	S08	80	S06	60	S17	60
22	S19	70	S08	70	S40	80
23	S14	80	S17	60	S27	70
24	S17	60	S14	80	S32	80
25	S10	70	S34	70	S40	70
26	S32	60	S04	80	S06	60
27	S27	80	S27	60	S14	80
28	S34	70	S10	70	S19	70
29	S19	80	S40	60	S34	60
30	S40	60	S32	80	S17	80
31	S04	70	S06	70	S10	70
32	S08	60	S08	80	S04	60
33	S06	80	S19	60	S08	80

2.3.3 Results and Discussion

2.3.3.1 Overall Impression

Figure 2.22 shows the impression of each bell and melody departure sign sounds at 60 dB, 70 dB, and 80 dB of LAeq. For timbre impression, higher scores show that sounds are perceived as “louder”, “noisier”, “higher”, “more metallic” and “rougher”. For mood impression, higher scores show higher unpleasant impression.

Overall timbre related impressions results show that at the same sound level, melody sounds have a tendency to receive higher scores than bell sounds. However, overall mood related impressions results show that melody sounds tend to receive lower scores than bell sound. The increment of sound pressure level indicates the inclination towards higher scores for both timbre and mood related impressions except on “exciting – depressing” pair.

It is notable that despite perceived louder and noisier than departure bells, melody sounds give more positive mood related impressions. Melody sounds start to give negative mood related impression at 80 dB where their scores of "calm – hasty", "relaxing – depressing", and "pleasing – annoying" start to overtake those of melody sounds.

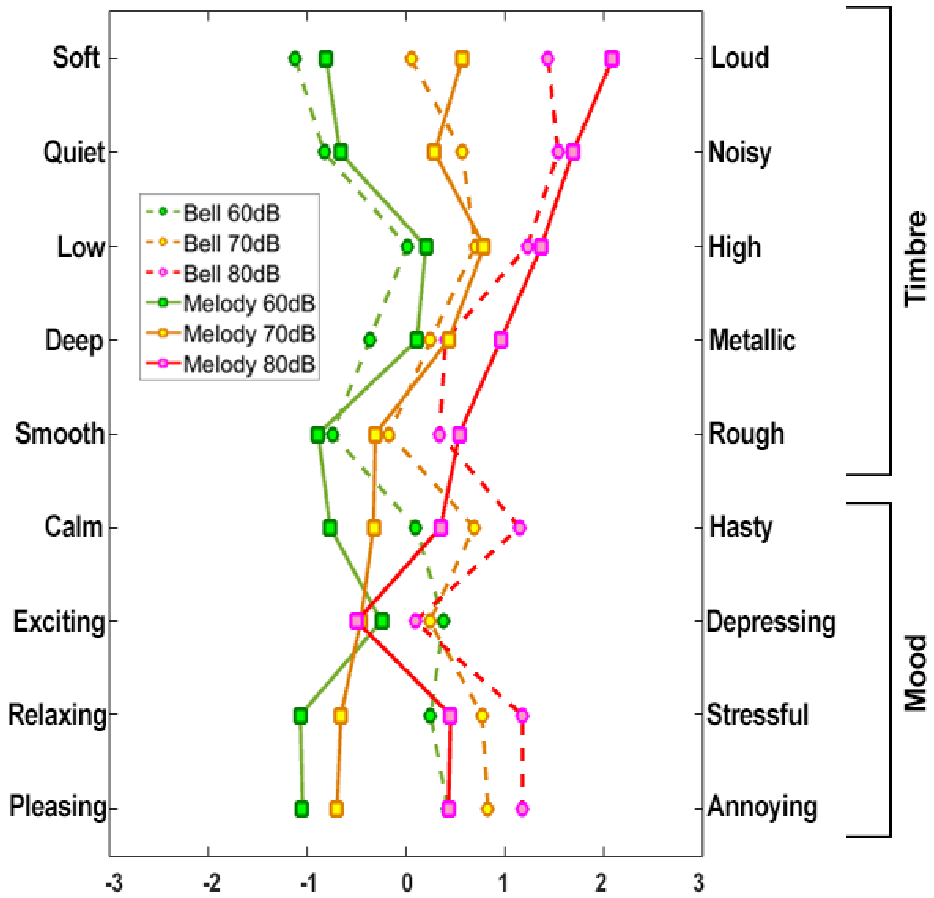

Figure 2.22 Average evaluation scores in semantic differential scale for bell and melody departure sign sounds.

Table 2.17 Correlation matrix for sound features and subjective impressions of bell sounds.

	Laeq	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Fave [Cent]	FSD [Cent]	Soft-Loud	Quiet-Noisy	Low-High	Deep-Metallic	Smooth-Rough	Calm-Hasty	Exciting-Depressing	Relaxing-Stressful	Pleasing-Annoying
Laeq																	
LN [phon]	.933**																
N5 [sone]	.907**	.968**															
S [acum]	.218	.400	.343														
R [asper]	.420	.484	.427	.157													
Fmod [Hz]	0.000	.008	-.023	-.608*	.581*												
Fave [Cent]	0.000	-.250	-.310	-.177	.052	.115											
FSD [Cent]	0.000	.306	.301	.479	.496	.107	-.724**										
Soft-Loud	.925**	.927**	.911**	.432	.232	-.249	-.124	.055									
Quiet-Noisy	.968**	.954**	.911**	.409	.388	-.140	-.090	.113	.964**								
Low-High	.778**	.711**	.646**	.551*	.047	-.489	.177	-.187	.876**	.846**							
Deep-Metallic	.654**	.740**	.675**	.799**	.340	-.408	-.067	.294	.769**	.800**	.799**						
Smooth-Rough	.761**	.839**	.776**	.379	.834**	.300	-.013	.398	.677**	.770**	.500	.694**					
Calm-Hasty	.664**	.799**	.723**	.421	.822**	.349	-.039	.470	.613*	.693**	.418	.671**	.962**				
Exciting-Depressing	-.399	-.542*	-.490	-.262	-.576*	-.361	-.064	-.265	-.416	-.403	-.213	-.449	-.736**	-.817**			
Relaxing-Stressful	.861**	.870**	.790**	.392	.719**	.168	.107	.222	.750**	.853**	.664**	.706**	.924**	.876**	-.560*		
Pleasing-Annoying	.921**	.811**	.735**	.156	.538*	.112	.172	-.057	.773**	.855**	.684**	.532*	.749**	.649**	-.398	.875**	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Note: r > 0.5 r > 0.7 r > 0.8

Table 2.18 Correlation matrix for sound features and subjective impressions of melody sounds.

	Laeq	LN [phon]	N5 [sone]	S [acum]	R [asper]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]	Soft-Loud	Quiet-Noisy	Low-High	Deep-Metallic	Smooth-Rough	Calm-Hasty	Exciting-Depressing	Relaxing-Stressful	Pleasing-Annoying
Laeq																		
LN [phon]	.946**																	
N5 [sone]	.902**	.966**																
S [acum]	.114	.324	.367															
R [asper]	.532*	.444	.488*	.418														
Tempo [BPM]	0.000	-.153	-.104	.221	.603**													
Mode	0.000	-.045	-.022	-.531*	-.111	-.154												
Fave [Cent]	0.000	-.283	-.329	-.437	.201	.337	-.240											
FSD [Cent]	0.000	.185	.178	-.197	-.525*	-.835**	.454	-.679**										
Soft-Loud	.918**	.961**	.951**	.426	.547*	.050	-.120	-.266	.036									
Quiet-Noisy	.885**	.947**	.943**	.482*	.493*	.045	-.177	-.291	.008	.979**								
Low-High	.773**	.782**	.773**	.580*	.706**	.285	-.486*	-.010	-.299	.875**	.853**							
Deep-Metallic	.508*	.684**	.712**	.862**	.456	.143	-.426	-.489*	-.062	.766**	.807**	.807**						
Smooth-Rough	.701**	.841**	.826**	.593**	.328	-.054	-.171	-.474*	.098	.846**	.914**	.706**	.864**					
Calm-Hasty	.629**	.727**	.719**	.688**	.412	.175	-.527*	-.241	-.215	.801**	.868**	.845**	.906**	.898**				
Exciting-Depressing	-.445	-.623**	-.584*	-.303	.161	.311	.052	.665**	-.479*	-.613**	-.611**	-.384	-.599**	-.666**	-.568*			
Relaxing-Stressful	.784**	.864**	.908**	.569*	.501*	.129	-.239	-.332	-.056	.925**	.959**	.842**	.862**	.908**	.903**	-.579*		
Pleasing-Annoying	.784**	.864**	.912**	.534*	.473*	.051	-.226	-.301	-.034	.892**	.946**	.799**	.832**	.924**	.893**	-.546*	.982**	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Note:
r > 0.5 r > 0.7 r > 0.8

In Table 2.17 and 2.18, the correlation matrix tables of sound features and subjective evaluation are presented. Boxes inside the respective tables show the correlation between sound features and subjective impressions. For both bell and melody sounds, the subjective impressions are mostly correlated to the sound loudness features. Sharpness value of bell is moderately correlated to "low – high" impression and strongly correlated to "deep – metallic". For melody, it is correlated moderately to "low – high", "smooth – rough", "calm – hasty", "relaxing – stressful", and "pleasing – annoying", but strongly correlated to "deep-metallic". Roughness value of bell is strongly correlated to "smooth – rough", "calm – hasty", and "relaxing – stressful" while moderately correlated to "exciting – depressing" and "pleasing – annoying". On melody sounds, roughness value is strongly correlated to "low – high" impression and moderately correlated to "soft – loud" and "relaxing – stressful" impressions. Mode and average pitch value of melody sounds also moderately correlated to "calm – hasty" and "exciting – depressing" respectively.

Correlation of mood impressions for bell and melody sounds can also be seen in Table 2.17 and 2.18 respectively. The subjective impression of melody sounds can be seen to be mostly correlated with each other except for "low – high" and "exciting – depressing". For bell sounds, the impression of "exciting – depressing" is almost not correlated to the other impressions, while the rest are mostly correlated.

2.3.3.2 Timbre Related Impressions

Timbre related impressions were selected to check the collinearity of extracted acoustic values with the subjective impressions of the same component. Loudness level and percentile loudness are evaluated using "soft – loud" and "quiet – noisy" adjective pairs. Average pitch is assessed by "low – high", while sharpness is evaluated by "deep – metallic". "Smooth – rough" evaluates roughness and modulation frequency.

➢ *Loudness*

Figure 2.23 shows the scatter plot of subjective loudness impressions as opposed to the calculated loudness value. Each dot presents one sound sample accompanied by its LAeq value. "Soft – loud" impression highly fits the calculated loudness level and percentile loudness. However, in "quiet – noisy" impression differs between bell and melody sounds where bell tends to have higher scores at the same loudness level.

In section 2.2.3.2, the calculated loudness levels of departure melodies are greater than departure bells at the same sound level. This explains the higher score of melodies at "soft – loud" pair for melody sounds. This result is also supported by [27] where they found that the tolerable maximum level for departure bell is higher than departure melodies which indicate that bell sounds are most likely less loud than melodies.

On the other hand, although at the same sound level bell sounds tend to be perceived as less noisy than melody sounds, bell sounds at the same loudness level tend to be perceived noisier as opposed to melody sounds. This distinction might be caused by the connotation of "noisiness" which does not merely assess the level of sound, but also assess the feeling of disturbance towards sound which is related to its volume.

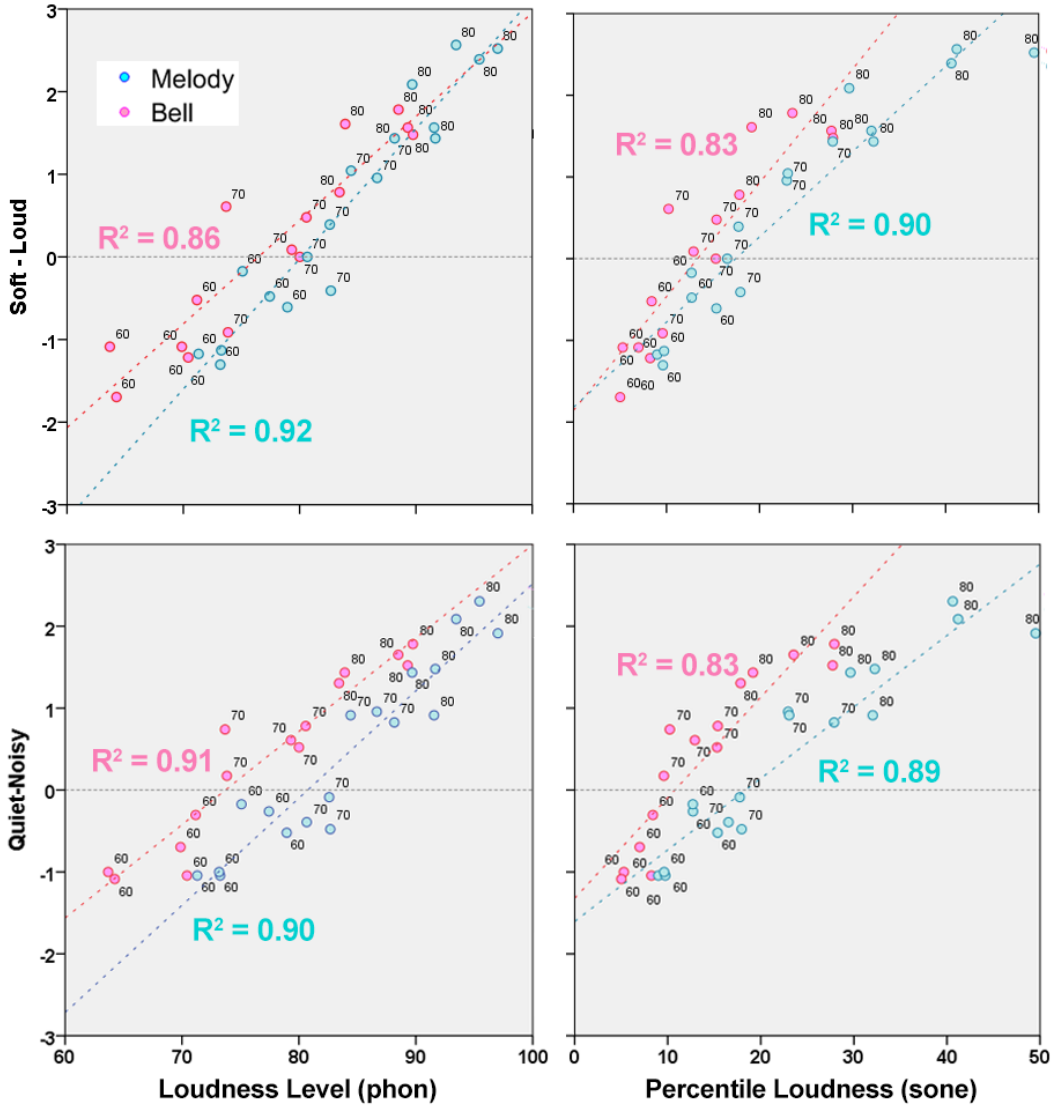

Figure 2.23 Comparison between subjective and calculated loudness.

➢ *Pitch*

Figure 2.24 shows the scatter plot of subjective pitch impressions as opposed to the calculated average pitch value. Each dot presents one sound sample accompanied by its LAeq value. "Low – High" as pitch evaluation point does not seem to reflect the calculated pitch value. The rise of "low – high" score correlates with loudness level which is likely due to misinterpretation of the evaluation item. Another possibility is that the samples provided for the experiment are close in frequency discrepancy, therefore causing a harder judgment of pitch and influencing the participants to judge based on the sound level.

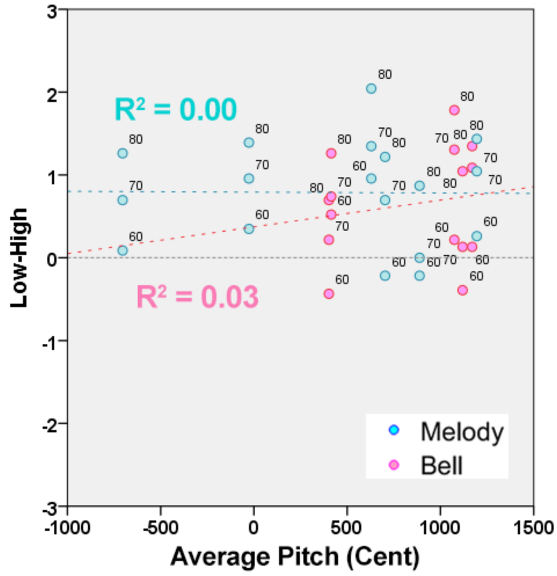

Figure 2.24 Comparison between subjective and calculated pitch.

➢ <u>*Sharpness*</u>

Figure 2.25 shows the scatter plot of subjective sharpness impressions as opposed to the calculated sharpness value. Each dot presents one sound sample accompanied by its LAeq value. The sharpness value of train departure sign sounds correlates quite highly with the "deep – metallic" impression. Calculated sharpness value for both melody and bell sounds does not show a significant distinction.

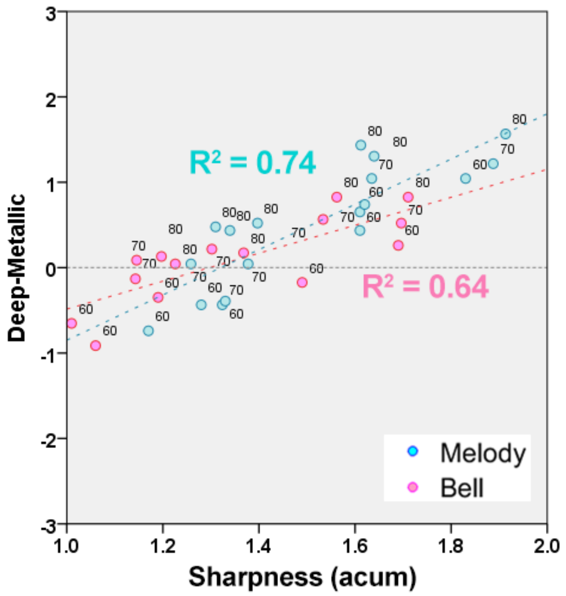

Figure 2.25 Comparison between subjective and calculated sharpness.

➢ Roughness

Figure 2.26 shows the scatter plot of subjective roughness impressions as opposed to the calculated roughness and modulation frequency value. Each dot presents one sound sample accompanied by its LAeq value. “Smooth – rough” impression of bell sounds correlates highly with calculated roughness but does not correlate with modulation frequency. On the other hand, “smooth – roughness” impression of melody sounds does not correlate with the calculated roughness. The impression of roughness can be easily judged for departure bells due to its structural simplicity. On the other hand, the impression of loudness does not correlate to calculated roughness that most likely caused by the complexity of its musical structure. The perception of roughness for melody is more influenced by the volume instead. Modulation frequency also does not correlate with roughness impression. However, this result may be due to the small sample size of modulation frequency variant.

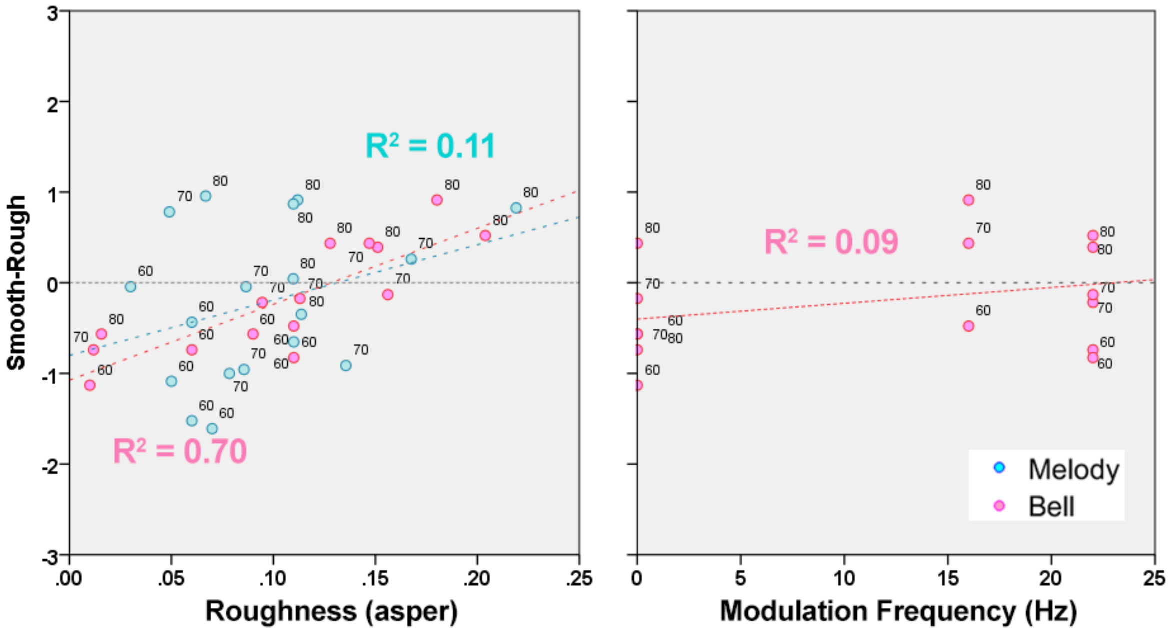

Figure 2.26 Comparison between subjective and calculated roughness.

➢ Comparison between sounds

Figure 2.27 shows the comparison of timbre related impressions between sound samples. For each evaluated component, the increment of sound level increases the score of each impression. The color of each line on the graph shows the difference in LAeq. Green marks sound level of 60 dB, yellow marks sound level of 70 dB, and red marks sound level of 80 dB.

All impressions have their score increases along with the rise of sound level. The “soft – loud” and “quiet – noisy” impressions increase more at each different sound level compared to the other impressions. The impression of “deep – metallic” is relatively close at each increase of sound level. The increment for bell sounds and melody in both “soft – loud” and “quite noisy” is comparably similar at the rise of sound level.

The “soft – loud”, “quiet – noisy”, and “deep – metallic” impressions of bell sounds have minimum variant between sound samples, except at “soft – loud” on 70 dB. Impressions on melody sounds fluctuate between sound samples. Tendencies of melody sounds at “soft – loud”, “quiet – noisy”, “deep – metallic”, and “smooth – rough” are relatively the same. In “deep – metallic” impression, the scores for bell sounds at 70 and 80 dB are very similar while on the other hand, the score of melody sounds have their similarity at 60 and 70 dB.

Sound S19, S32, S34, and S40 are relatively similar in their “low – high” impression despite having a difference in their average pitch. Sound S08 is considered as the smoothest sound which most likely due to 0 modulation frequency, however sound S27 seems to be perceived similar with sound S04 and S06 despite also having 0 modulation frequency. The perception of S27 in the term of its roughness most likely is influenced by its loudness level whereas its loudness level is the highest among all bell sounds at each different sound levels. Sound number S10 is perceived as the highest in “low – high” impression despite not having the highest average pitch. However, its great sharpness might be the reason for this impression.

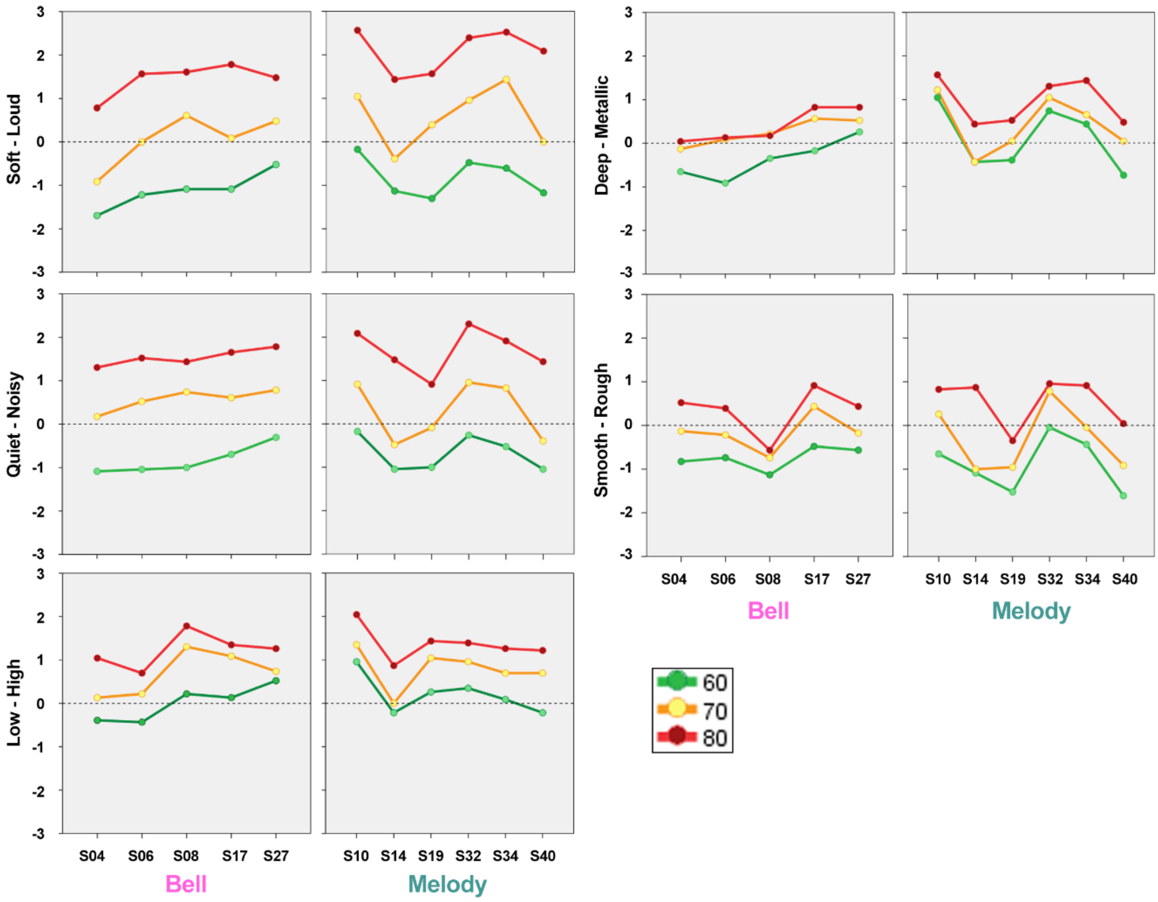

Figure 2.27 Comparison of timbre related impressions between each sound samples.

2.3.3.3 Mood Related Impressions

Higher scores in mood impression components might show discomfort tendency of the sounds. Therefore this parameter is important for the quality assessment of train departure sign sounds.

➢ <u>*Sound loudness and mood impressions*</u>

As shown in table 2.17 and 2.18, mood related impressions are mostly correlated with the increment of sound loudness. Figure 2.28 demonstrates the comparison between LAeq, loudness level, and percentile loudness towards each mood impressions. On each mood impressions, bell sounds are evaluated higher than melody sounds with quite a clear distinction between the two, which means that bell is perceived as more of a discomfort at the same sound loudness value. Both melody and bell sounds received higher scores at higher values of LAeq, loudness level, and percentile loudness, except for “exciting – depressing”.

At the impression of “calm – hasty”, loudness level is the best predictor for higher hasty impression as seen from the coefficient of determination (R^2). Bell sounds are considered hastier at the same LAeq, loudness level and percentile loudness than melody.

The impression of “exciting – depressing” shows that there is a low correlation between sound loudness and the depressing feeling of departure sign sounds. The value of R^2 reveals that loudness level is the most correlated with exciting depressing compared to LAeq and percentile loudness. There is one bell sound sample at 80 dB that received an exciting evaluation with a value comparable to melody sounds.

Correlation between sound loudness and stressfulness is considerably high for both bell and melody sounds. While percentile loudness value highly explains the variance of melody sounds, loudness level explains the evaluated value of bell sounds better. Although bell sounds are mostly considered more relaxing than bell sounds, at loudness value more than 92 phones, there are 3 samples of departure melody that are comparably perceived as stressful as bell sounds at the same LAeq level. There is a possibility that melody sounds above 90 phones might start to cause stress towards people. However, there is also a possibility that factors other than calculated loudness influence the rise of stressfulness.

The annoyance of sound also correlates considerably with the increase of sound loudness. The R^2 value shows that LAeq can highly explain the variance of annoyance for departure bells, while departure melodies are better described by percentile loudness. Similar to “relaxing –stressful” impression, “pleasing – annoying” impression of 3 samples of melody sounds with loudness level above 92 phones show an inclination where their annoyance is comparable to bell sounds at the same sound level.

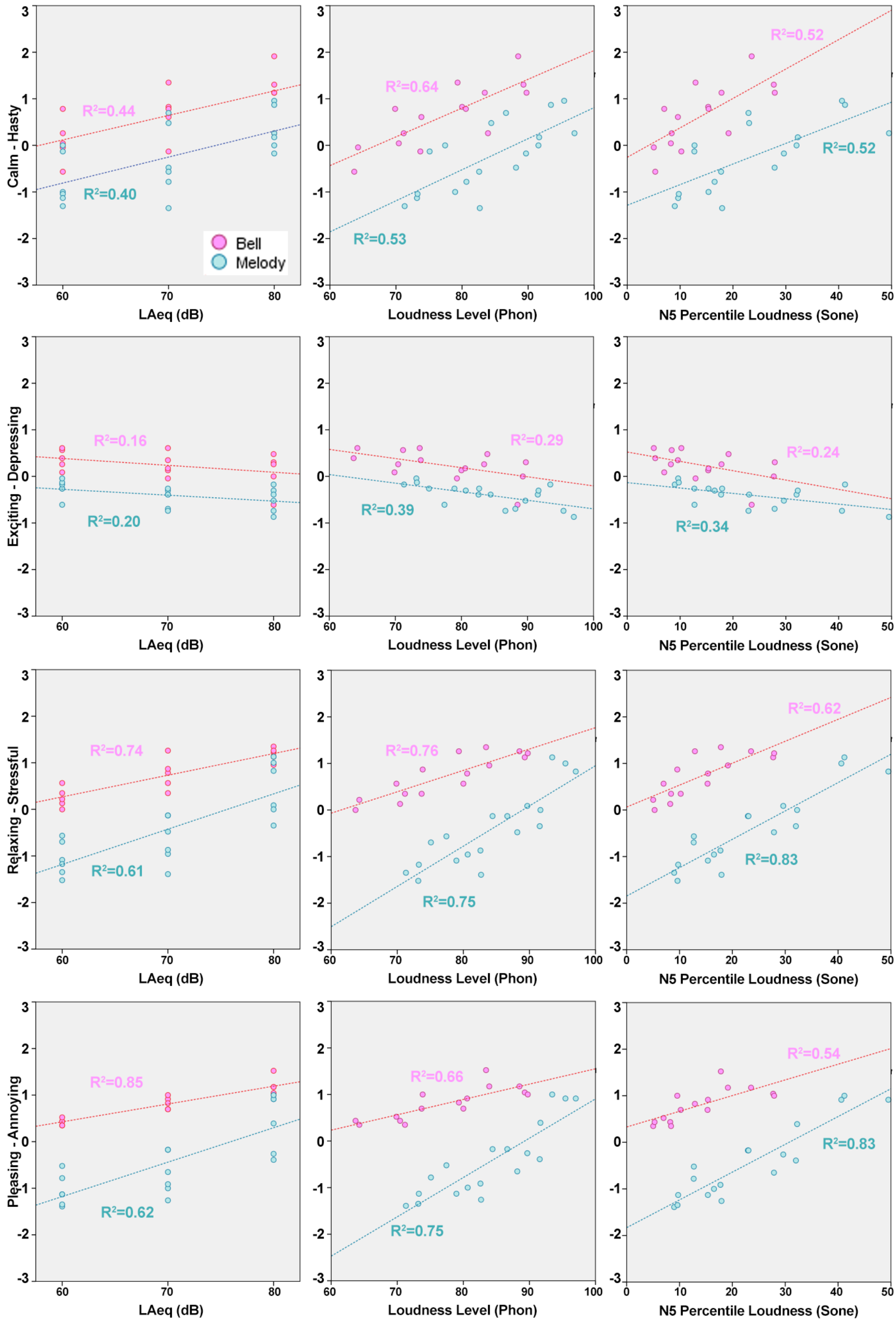

Figure 2.28 Comparison between LAeq, loudness level, and percentile loudness on each subjective impression.

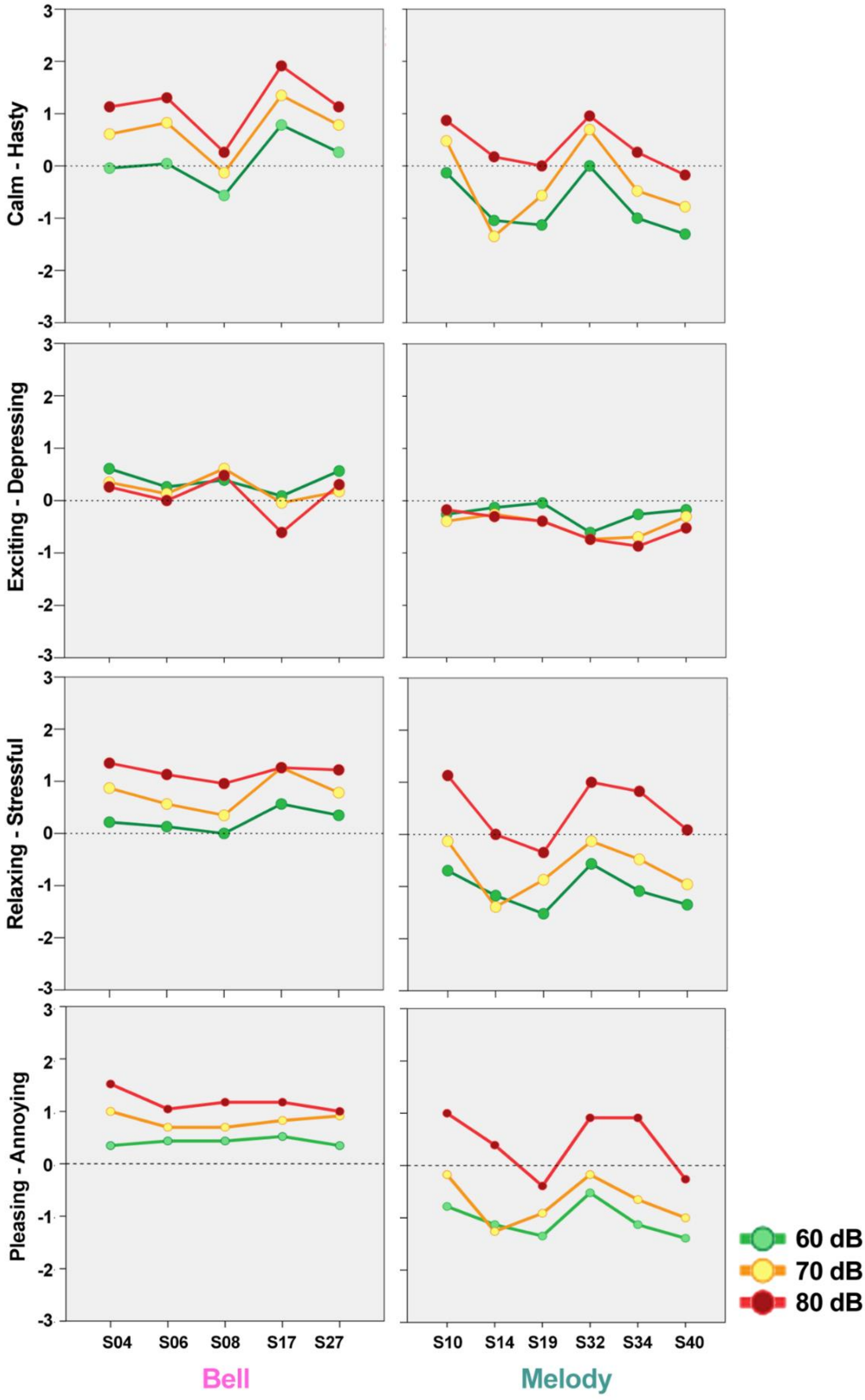

Figure 2.29 Comparison of mood impressions for each sound samples.

➢ *Comparison of mood impressions between sound samples*

Figure 2.29 shows the comparison of mood related impressions for each sound sample at 60 dB, 70 dB, and 80 dB of LAeq. The impression scores for each sound sample shows an increase by the rise of their LAeq, except for "exciting – depressing" impression. "Exciting – depressing" impression for each sound samples show a relatively similar tendency and comparatively close to the neutral evaluation.

The impressions of departure melodies shows fluctuating variance between sound samples for "calm – hasty", "relaxing – stressful" and "pleasing – annoying" and significantly similar to each other. On the other hand, bell impressions show similarities between sound samples except at "calm – hasty" impression.

In comparison with figure 2.27, subjective impression of "calm – hasty" of bell sounds is correlated with their "smooth – rough" impression. Moreover, because the subjective roughness impression of bell sounds is highly correlated with the roughness parameter, it is very likely that the roughness value influences hastiness of bell sounds.

On the other hand, melody sounds show high similarities in "calm – hasty", "relaxing – stressful", and "pleasing – annoying" impressions. This is considered to be correlated with their "soft – loud" and "quiet – noisy" impressions which is deemed to be highly influenced by loudness level of individual sounds.

An interesting finding in "relaxing – stressful" and "pleasing – annoying" impression of melody sounds is that the increment of sound at 80 dB gives a comparatively a high rise in scores. The differences of the scores between 60 dB and 70 dB are relatively close. However, despite having the same 10 dB difference of sound level, the score increment from 70 dB to 80 dB is much higher. An exception can be found for sound S19 where the increments of annoyance and stress from 60 dB to 70 dB and 70 dB to 80 dB are relatively similar.

➢ *Principal component analysis on subjective and calculated variables*

In order to probe deeper in the relationship between variables presented in the experiment, principal component analysis was conducted for more definite confirmation. The analysis was performed using IBM SPSS Statistics 20 software. Departure bell and melody are analyzed separately.

Figure 2.30 shows the factor loading plot of both acoustic factor parameters and auditory impression items of bell sound in three-dimensional space. The distance between points demonstrates the correlation of the variables. Blue circles mark calculated value of acoustic parameters and red circles mark evaluated auditory impressions.

Component 1 is correlated with the loudness of bell sounds. Lower values of component 1 means "softer" and higher value means "louder" which is related to increment of sound level. Impressions which are correlated with this component include "soft – loud", "quiet – noisy", "low – high", "relaxing – stressful", and "pleasing – annoying". Therefore, there is a tendency that bell sounds are perceived as louder, noisier, higher, more stressful, and more annoying when the sound level rises.

Component 2 is correlated with the roughness of bell sounds. Lower value of component 2 means "smoother" and higher value means "rougher" which is related to psychoacoustic parameter of roughness. The impressions which are correlated with this component include "calm – hasty" and "smooth – rough". An inverse correlation is also found in "exciting – depressing" impression. Therefore, there is a tendency that bell sounds are perceived as hastier, rougher, and more exciting as the estimated roughness value rises.

Component 3 is correlated with the sharpness of bell sounds. Lower values of component 3 mean "milder" and higher values mean "shriller" which is related to the psychoacoustic parameter of sharpness. Impression which is correlated to this component includes "deep – metallic". Modulation frequency also shows an inverse correlation with this component. Therefore, there is a tendency that bell sounds are perceived as more metallic as the calculated sharpness value rises.

Table 2.19 presents the summarized component factor loading from the principal component analysis of bell sound. Component 1 is highly correlated to the perception of loudness and discomfort of bell sounds. Component 2 is highly correlated with the roughness perception of bell sounds. Component 3 is highly correlated with the sharpness perception of bell sounds.

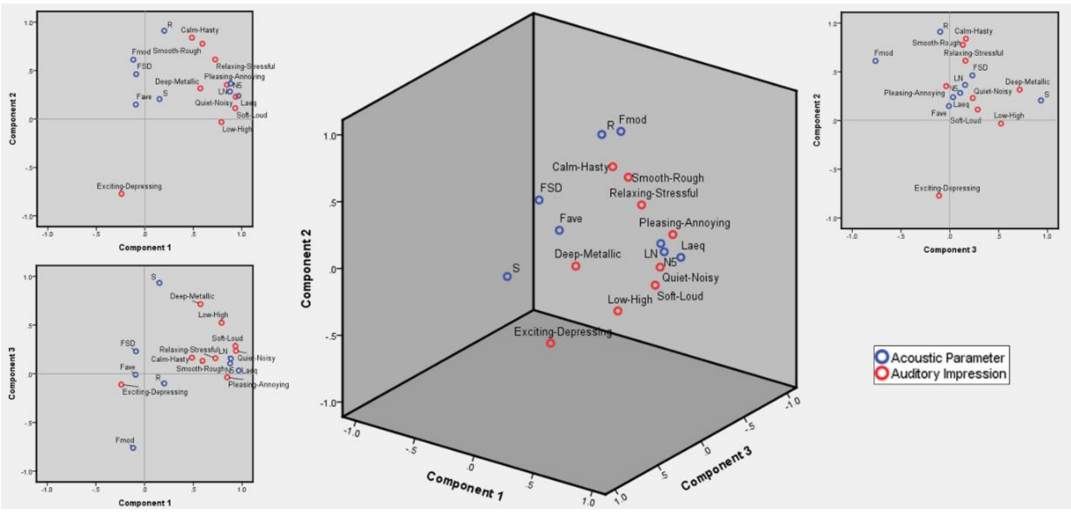

Figure 2.30 Factor loading plot of subjective and calculated variables for bell sounds.

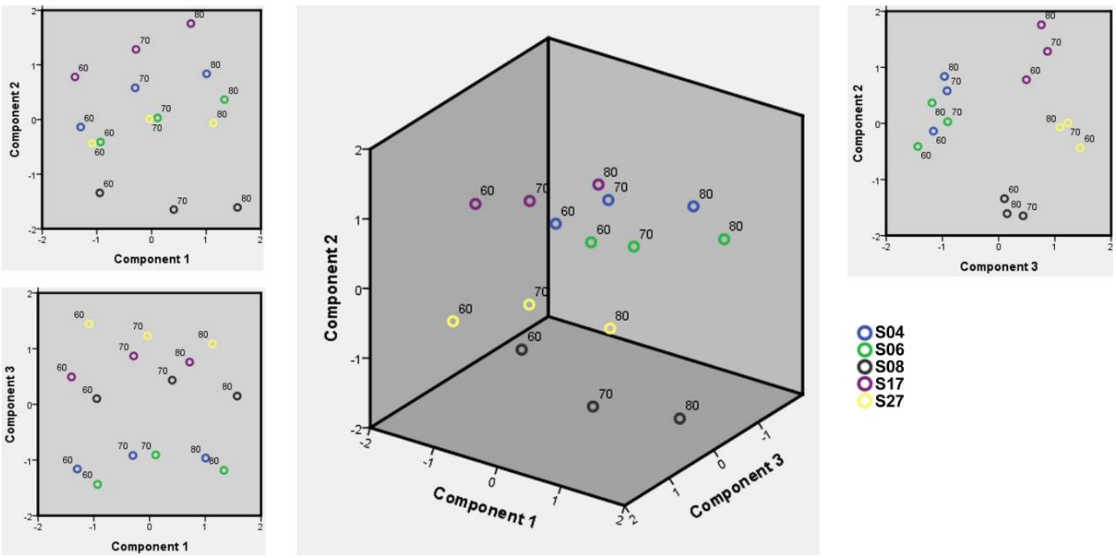

Figure 2.31 Scatter plot of each bell sound in principal component dimension.

Table 2.19 Component factor loading of bell sounds.

	Component		
	1	2	3
Laeq	.966	.239	.034
Quiet-Noisy	.937	.230	.235
Soft-Loud	.932	.112	.285
LN [phon]	.885	.365	.156
N5 [sone]	.878	.283	.106
Pleasing-Annoying	.847	.353	-.037
Low-High	.790	-.032	.524
Relaxing-Stressful	.726	.614	.160
R [asper]	.201	.911	-.099
Calm-Hasty	.486	.839	.165
Smooth-Rough	.594	.777	.133
Exciting-Depressing	-.240	-.772	-.111
S [acum]	.152	.206	.933
Fmod [Hz]	-.118	.612	-.761
Deep-Metallic	.573	.316	.715
Fave [Cent]	-.092	.149	-.009
FSD [Cent]	-.089	.463	.231

Figure 2.31 shows the scatter plot of bell sounds in principal component axes. Each dot presents one bell sound sample accompanied by its LAeq value. In the left 2D graph, the increment of volume can be seen to follow the value of component 1. Inside the right graph, sample S04 and S06 show similarity in low sharpness component. Their roughness impression highly defines sound S08, S17, and S27. Sharpness component divides sound S04, S06, and S27 despite having similar roughness component value.

Figure 2.32 shows the scatter plot of mood impression for bell sounds compared to its loudness level. Each dot presents one sound sample accompanied by its LAeq value. At the same loudness level, sample S08 is comparatively perceived as hastier than sound S06 and S27 which most likely influenced by the difference in roughness component. A similar thing also can be explained for the difference between sound S04 and S08, in which the latter has lower roughness component value.

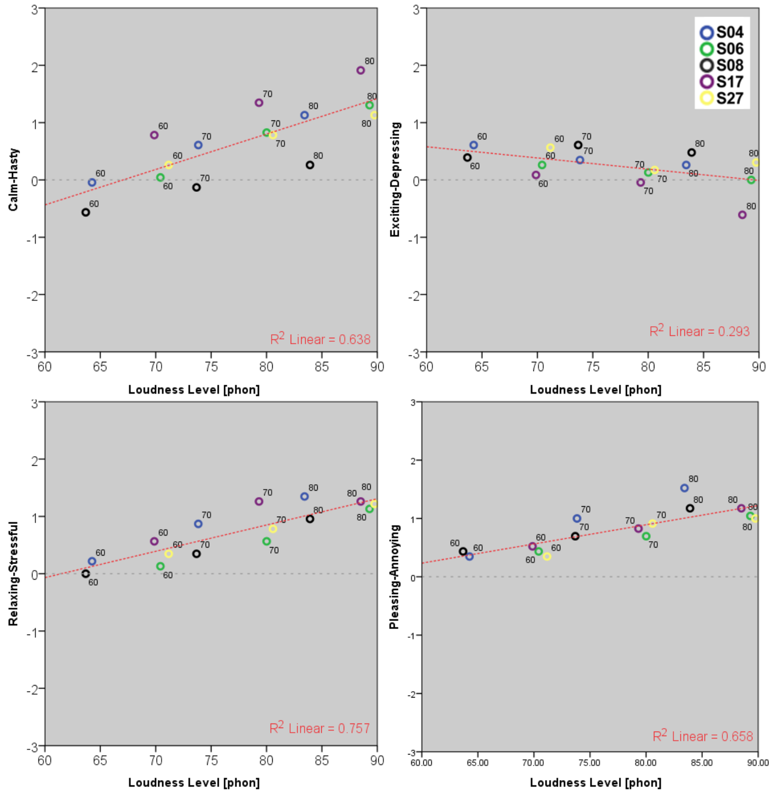

Figure 2.32 Mood related impressions in comparison with loudness level of bell sounds.

Figure 2.33 shows the factor loading plot of both acoustic factor parameters and auditory impression items of melody sound in three-dimensional space. The distance between points illustrates the correlation of the variables. Calculated value of acoustic parameters are marked by blue circles and evaluated auditory impressions are marked by red circles.

Component 1 correlates with the loudness of melody sounds. Lower value of component 1 means "softer" and higher value means "louder" which is related to increment of sound level. Impressions which are correlated with this component include "soft – loud", "quiet – noisy", "low – high", "smooth – rough", "calm – hasty", "relaxing – stressful", and "pleasing – annoying". Therefore, there is a tendency that melody sounds are perceived as louder, noisier, higher, rougher, hastier, more stressful, and more annoying when the sound level rises.

Component 2 is correlated with sound sharpness of melody sounds. Lower value of component 2 means "milder" and higher value means "shriller" which is related to the psychoacoustic parameter of sharpness. Impression included in this component is "deep – metallic". Mode also shows an inverse correlation with this component. Therefore, there is a tendency that melody sounds are perceived as more metallic as the calculated sharpness value rises.

Component 3 is correlated with pitch and tempo of the melody sounds. Average pitch and frequency standard deviation are both included in this component. However, there is no evaluation item included in this component. Therefore, component 3 only explains the pitch characteristic of melody sounds.

Roughness and “exciting – depressing” variables were not included in the three components. However, considering the values that are shown in Table 2.20, roughness and “exciting – depressing” are correlated to the combination of component 1 and 3.

Table 2.20 presents the summarized component factor loading from the principal component analysis of melody sound. Component 1 is highly correlated to perception of loudness, roughness, subjective pitch, and discomfort of melody sound. Component 2 is highly correlated to the sharpness perception of melody sounds. Component 3 is highly correlated to the pitch characteristics and mode.

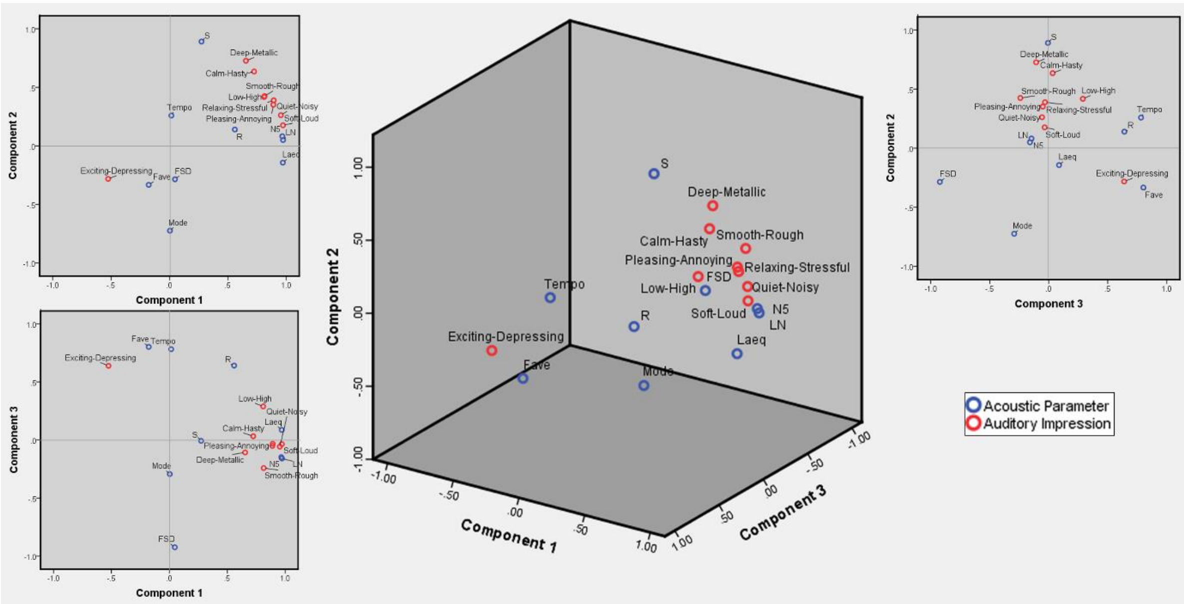

Figure 2.33 Factor loading plot of subjective and calculated variables for melody sounds.

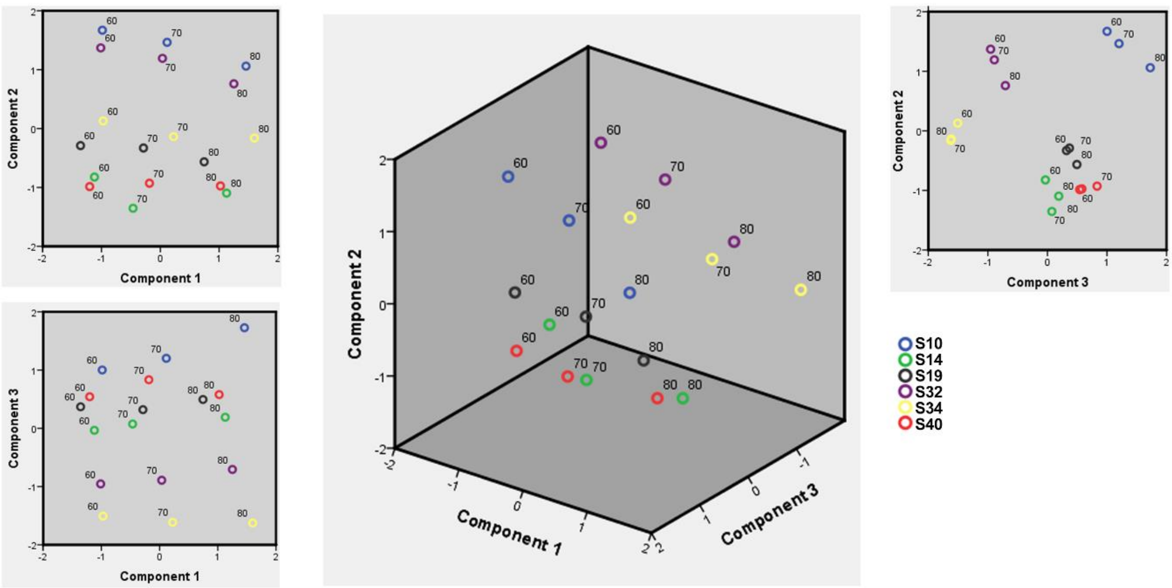

Figure 2.34 Scatter plot of each melody sound in principal component dimension.

Table 2.20 Component factor loading of melody sound.

	Component		
	1	2	3
LN [phon]	.972	.050	-.159
Soft-Loud	.971	.176	-.035
Laeq	.970	-.143	.087
N5 [sone]	.966	.082	-.147
Quiet-Noisy	.953	.262	-.057
Relaxing-Stressful	.892	.389	-.032
Pleasing-Annoying	.889	.352	-.051
Smooth-Rough	.814	.425	-.241
Low-High	.810	.418	.289
Calm-Hasty	.724	.635	.033
S [acum]	.274	.891	-.007
Deep-Metallic	.654	.727	-.107
Mode	.004	-.724	-.293
FSD [Cent]	.047	-.285	-.923
Fave [Cent]	-.178	-.333	.802
Tempo [BPM]	.016	.259	.782
R [asper]	.559	.140	.641
Exciting-Depressing	-.525	-.282	.639

Figure 2.34 shows the scatter plot of melody sounds in principal component axes. Each point presents one melody sound sample accompanied by its LAeq value. In the left 2D graph, the increment of volume can be seen to follow the value of component 1. Inside the right graph, sample S14, S19, and S40 show similarity in low sharpness component. Sound S10, S32, and S34 are highly defined by pitch component.

Figure 2.35 shows the scatter plot of mood impression for bell sounds compared to its loudness level. Each dot presents one sound sample accompanied by its LAeq value. It is noticeable that sample S10, S32, and S34 at LAeq of 80 dB have a significant rise in stressful impression. Despite having higher loudness level value, these three sounds are also higher in their sharpness component compared to sample S14, S19, and S40, which most likely affect the relatively high increment of stressful impression. Sound S10 and S32 are also considered to be the hastiest at the same sound level which most likely due to the relation with sharpness component.

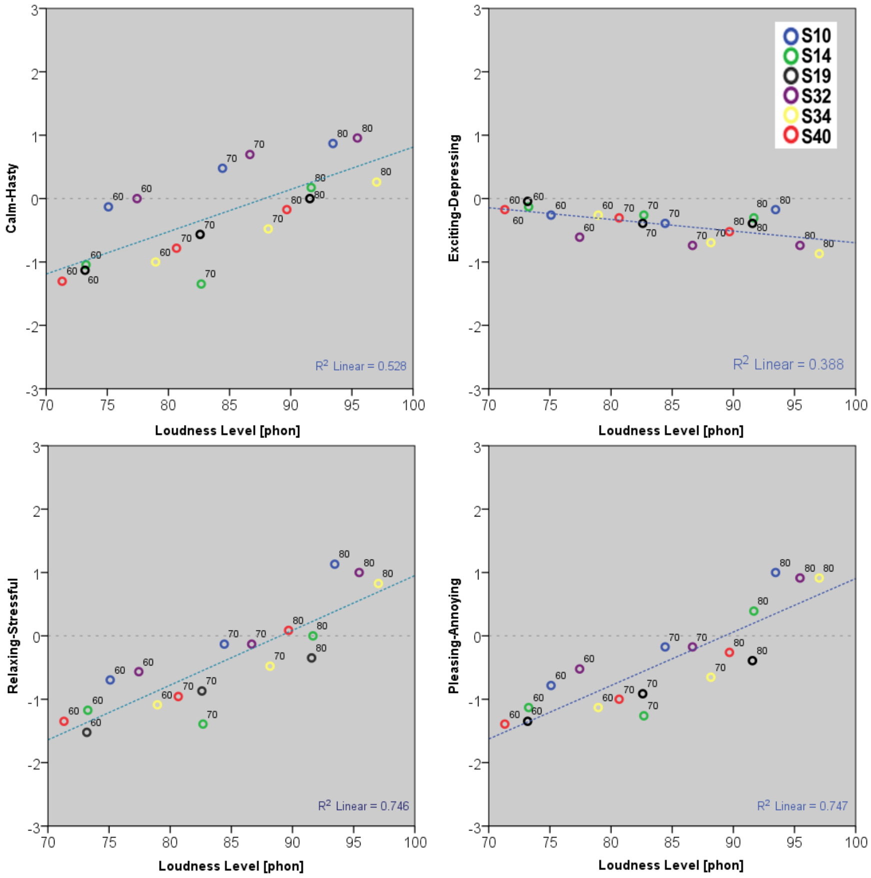

Figure 2.35 Mood related impressions in comparison with loudness level of melody sounds.

➢ *Estimation of mood related impression with multi regression analysis*

Principal component analysis shows sound level as a variable which highly influences mood related impression for both bell and melody sounds. The second highest factor that influences discomfort impression on bell and melody are roughness and sharpness respectively. Using multiple regression analysis, an estimation model to predict discomfort impression are examined. Each mood impression for both bell and melody will be regressed with three variables: LAeq, sharpness, and roughness. Consequently, bell sounds were regressed with LAeq and roughness, while melody sounds were regressed with LAeq and sharpness.

This analysis was conducted in IBM SPSS Statistics 20 software. The examination proposed 5% level of significance which corresponds to 95% of confidence interval in order to verify the significance of predictor variables.

Table 2.21 shows the result of multiple regression analysis for bell departure sound using LAeq, sharpness, and roughness. The result of regression analysis shows that on each mood related impression, the correlation coefficient and coefficient of determination for the combined variables are both higher than the correlation coefficient and coefficient of determination of single variables. However, the p-value shows that sharpness is the most insignificant predictor for impression of bell sounds except "relaxing – stressful".

Insignificancy also found for “exciting – depressing” in which all of the independent variables have p-value above 0.05. Roughness is also considered not significant to predict “pleasing – annoying” impression.

Table 2.21 Multiple regression analysis of bell sounds with 3 predictors.

Auditory Impressions	R	R^2	Independent Variables	B - value	p - value
Calm - Hasty	0.925	0.856	(Constant)	-2.926	0.002
			Laeq	0.027	0.022
			Sharpness	0.681	0.061
			Roughness	7.127	0.000
Exciting - Depressing	0.619	0.384	(Constant)	1.190	0.118
			Laeq	-0.006	0.551
			Sharpness	-0.195	0.549
			Roughness	-2.521	0.091
Relaxing - Stressful	0.964	0.929	(Constant)	-2.516	0.000
			Laeq	0.035	0.000
			Sharpness	0.351	0.046
			Roughness	3.181	0.001
Pleasing - Annoying	0.938	0.879	(Constant)	-1.674	0.001
			Laeq	0.036	0.000
			Sharpness	-0.088	0.586
			Roughness	1.104	0.131

Table 2.22 shows the result of multiple regression analysis for melody departure sound using LAeq, sharpness, and roughness. The result of regression analysis shows that on each mood related impression, the correlation coefficient and coefficient of determination for the combined variables are both higher than the correlation coefficient and coefficient of determination of single variables. However, the p-value shows that roughness is the most insignificant predictor for impressions of bell sounds except “exciting - depressing”. Prediction with 3 variables seems to correlate highly and significantly for “exciting – depressing”.

Based on the Table 2.21 and Table 2.22, sharpness is considered as an insignificant predictor for impression of bell sounds. The same pattern also occurred for roughness impression at melody sounds. Therefore, these two variables are omitted for the next multiple regression analysis for the respective sound types.

Table 2.22 Multiple regression analysis of melody sounds with 3 predictors.

Auditory Impressions	R	R^2	Independent Variables	B - value	p - value
Calm - Hasty	0.904	0.817	(Constant)	-7.618	0.000
			Laeq	0.060	0.000
			Sharpness	2.340	0.000
			Roughness	-4.011	0.118
Exciting - Depressing	0.818	0.670	(Constant)	1.714	0.001
			Laeq	-0.023	0.001
			Sharpness	-0.587	0.006
			Roughness	4.316	0.001
Relaxing - Stressful	0.928	0.861	(Constant)	-8.509	0.000
			Laeq	0.078	0.000
			Sharpness	1.928	0.000
			Roughness	-2.674	0.262
Pleasing - Annoying	0.913	0.834	(Constant)	-8.267	0.000
			Laeq	0.077	0.000
			Sharpness	1.794	0.001
			Roughness	-3.066	0.229

Table 2.23 shows multiple regression analysis result of departure bell using LAeq and roughness. Correlation coefficients on each impression are lower than the analysis with 3 predictors. However, the predictors for “calm – hasty” and “relaxing – stressful” are highly significant. “Exciting – depressing” impression does not seem to correlate with the proposed predictors proved by low correlation coefficient and high p-value. Roughness is also insignificant to predict “pleasing – annoying” impression.

Table 2.23 Multiple regression analysis of bell sounds with 2 predictors.

Auditory Impressions	R	R^2	Independent Variables	B - value	p - value
Calm - Hasty	0.894	0.799	(Constant)	-2.278	0.010
			Laeq	0.031	0.019
			Roughness	7.344	0.001
Exciting - Depressing	0.602	0.362	(Constant)	1.005	0.130
			Laeq	-0.007	0.467
			Roughness	-2.584	0.074
Relaxing - Stressful	0.947	0.897	(Constant)	-2.182	0.000
			Laeq	0.037	0.000
			Roughness	3.292	0.001
Pleasing - Annoying	0.936	0.876	(Constant)	-1.758	0.000
			Laeq	0.035	0.000
			Roughness	1.076	0.127

Table 2.24 Multiple regression analysis of melody sounds with 2 predictors.

Auditory Impressions	R	R^2	Independent Variables	B - value	p - value
Calm - Hasty	0.884	0.781	(Constant)	-6.798	0.000
			Laeq	0.049	0.000
			Sharpness	2.045	0.000
Exciting - Depressing	0.512	0.263	(Constant)	0.832	0.143
			Laeq	-0.012	0.082
			Sharpness	-0.269	0.269
Relaxing - Stressful	0.920	0.847	(Constant)	-7.962	0.000
			Laeq	0.070	0.000
			Sharpness	1.732	0.000
Pleasing - Annoying	0.903	0.815	(Constant)	-7.640	0.000
			Laeq	0.069	0.000
			Sharpness	1.569	0.001

Table 2.24 shows multiple regression analysis results of departure melody using LAeq and sharpness. Correlation coefficients on each impression are lower than the analysis with three predictors. However, the predictors for “calm – hasty”, “relaxing – stressful”, and “pleasing – annoying” are highly significant. “Exciting – depressing” impression does not seem to correlate with the proposed predictors proved by low correlation coefficient and high p-value. In conclusion, “exciting – depressing” impression for melody sound is most likely influenced by roughness value.

Table 2.25 shows a comparison of correlation coefficients of mood related impressions for both bell and melody sounds for different predictors. Consequently, Table 2.26 shows the coefficient of determination comparison for both sounds also with different predictors. The combination of “LAeq – Sharpness” and “LAeq – Roughness” for bell and melody sounds respectively are not examined due to their insignificance. From the tables, combined sound feature variables predict each mood – related impressions better than single variables. However, it is notable that “pleasing – annoying” impression for bell sounds had already obtained a significantly high value on LAeq alone, in which the increment of both coefficients is considerably low. This shows that LAeq can sufficiently describe annoyance of bell sounds. Table 2.27 shows the equation based on the coefficient obtained from the regression analysis for predicting each mood impressions.

Table 2.25 Correlation coefficient comparison of each predictor on mood impressions.

		Correlation Coeffecient (R)				
	Auditory Impressions	**Laeq**	**LN**	**Laeq x S x R**	**Laeq x S**	**Laeq x R**
Bell	Calm - Hasty	0.66	0.80	0.93	-	0.89
	Exciting - Depressing	0.40	-0.54	0.62	-	0.60
	Relaxing - Stressful	0.86	0.87	0.96	-	0.95
	Pleasing - Annoying	0.92	0.81	0.94	-	0.94
Melody	Calm - Hasty	0.63	0.72	0.90	0.88	-
	Exciting - Depressing	0.45	-0.58	0.82	0.51	-
	Relaxing - Stressful	0.78	0.86	0.93	0.92	-
	Pleasing - Annoying	0.78	0.86	0.91	0.90	-

Table 2.26 Coefficient of determination comparison of each predictor on mood impressions.

		Coefficient of Determination (R^2)				
	Auditory Impressions	**Laeq**	**LN**	**Laeq x S x R**	**Laeq x S**	**Laeq x R**
Bell	Calm - Hasty	0.44	0.64	0.86	-	0.80
	Exciting - Depressing	0.16	0.29	0.38	-	0.36
	Relaxing - Stressful	0.74	0.76	0.93	-	0.90
	Pleasing - Annoying	0.85	0.66	0.88	-	0.88
Melody	Calm - Hasty	0.40	0.53	0.82	0.78	-
	Exciting - Depressing	0.20	0.39	0.67	0.26	-
	Relaxing - Stressful	0.61	0.75	0.86	0.85	-
	Pleasing - Annoying	0.62	0.75	0.83	0.82	-

Table 2.27 Coefficient of determination and regression analysis model for both bell and melody sounds.

	Auditory Impressions	Laeq x R or S	Laeq x R or S Model
Bell	Calm - Hasty	0.80	$-2.28 + (0.031 \times LAeq) + (7.3 \times R)$
	Exciting - Depressing	0.36	$1.01 - (0.007 \times LAeq) - (2.6 \times R)$
	Relaxing - Stressful	0.90	$-2.18 + (0.037 \times LAeq) + (3.3 \times R)$
	Pleasing - Annoying	0.88	$-1.76 + (0.035 \times LAeq) + (1.1 \times R)$
Melody	Calm - Hasty	0.78	$-6.79 + (0.049 \times LAeq) + (2.1 \times S)$
	Exciting - Depressing	0.26	$0.83 - (0.012 \times LAeq) - (0.3 \times S)$
	Relaxing - Stressful	0.85	$-7.96 + (0.070 \times LAeq) + (1.7 \times S)$
	Pleasing - Annoying	0.82	$-7.64 + (0.069 \times LAeq) + (1.6 \times S)$

2.3.3.4 Sound Preferences

Lastly, sound preferences of each sound were also examined. Based on this preference score, departure bell and melody with the most likable characteristic can be found.

Figure 2.36 shows the percentage of "like" and "dislike" answers for each sound samples. The dotted line with triangle markers presents "dislike" percentage and line with blue circle markers presents "like" percentage. Line color of red, yellow and green resembles sound level at 60 dB, 70 dB, and 80 dB respectively.

For each sound, the increment of volume increases the "dislike" percentage and decreases "like" percentage simultaneously. "Like" and "dislike" percentage for melody sounds at 60 dB and 70 dB is relatively similar. "Like" percentage of bell sounds at 70 dB and 80 dB are comparatively similar. There is a significant rise in "dislike" percentage for all sounds at 80 dB. The trend of "dislike" percentage for melody sounds at 80 dB resembles the fluctuation shown in the graph of loudness and stressful impressions (Figure 2.27 and 2.29).

The most likable sound is S08 for bell category and S19 for melody category. Bell number S08 is the least rough and hasty sound among all bells although its loudness impression does not differ compared to the other sounds. Sound S19 as the most likable melody sound is one of the least loud and sharp sounds among the melody samples. However, it is considered that its melody structure is an aspect that promotes positive impression towards the listeners.

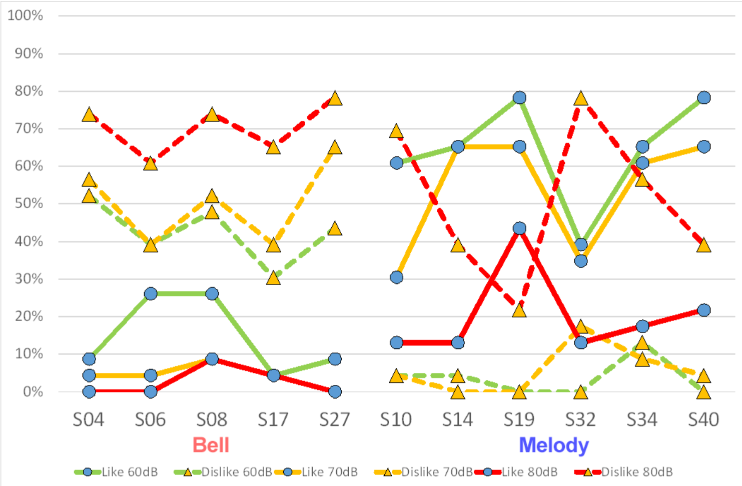

Figure 2.36 Preference chart for each train departure sign sound sample.

2.4 Summary

In this chapter, the analysis of acoustic features and their correlation towards auditory impressions on train departure sign sounds had been conducted.

In chapter 2.2, acoustic features that describe some characteristics of train departure sign sounds was described. In the actual condition, distribution of LAeq for bell sounds is higher than those of melodies, but resulting in a relatively equal loudness level. The normalized sound analysis shows that bell sounds at the same sound level tend to have lower loudness level and sharpness value, however, are higher at roughness. Cluster analysis found that there are 5 groups and 6 groups for melody and bell respectively that describe feature similarities.

Chapter 2.3 studied the correlation between auditory impression and the features. Loudness level was found to correlate highly with almost all evaluation items. Bell sounds tend to be perceived as discomfort as opposed to melody sounds. In order to predict discomfort which is caused by train departure sounds, bell types are best to be predicted using LAeq and roughness variables, while melody types are best to be predicted using LAeq and sharpness. The impression of “exciting – depressing” does not show high correlation with any characteristics.

This study was conducted in a quiet environment while departure sign sounds are actually played at noisy places. In the next experiment, the influence of environmental factor in the form of background noise will be studied.

Chapter 3 Auditory Impressions of Train Departure Sign Sounds under Ambient Noise Condition

In this chapter, the presence of background noise as an environmental factor that influences auditory impression towards departure sounds is addressed, as opposed to the previous chapter where only acoustic parameters were accounted for the judgment between departure sounds. Preis *et al*. (1996) stated that annoyance of sound could be influenced by the difference in sound level between sound and ambient noise [28]. Therefore, it is important to consider the interaction between ambient noise at train stations and departure sounds on auditory impression.

3.1 Sound Listening under Ambient Noise Condition

Listening to a certain sound in a quiet or noisy environment influences auditory impressions and intelligibility. Impressions towards sounds may indicate its perceived acoustic and psychoacoustic characteristics. For example, the ticking sound of a clock during a noisy daytime might not be as loud and annoying compared to a quiet nighttime when people are trying to sleep. On the other hand, the intelligibility of a certain sound indicates its usefulness. For example, a conversation done inside a quiet living room is more understandable compared to a conversation done in a rock music concert venue.

3.1.1 Sound Impressions under Ambient Noise

3.1.1.1 Timbre Related Impressions

Vos (1998) found that pure tones presented in background noise have shown that loudness perception of signal levels 10-15 dB above masked threshold increases considerably higher than the same sounds in a quiet condition. However, the increment of loudness for signal levels greater than 30 dB above masked threshold in background noise and quiet conditions is about the same [29].

Nagel *et al*. (1967) studied the perceived noisiness of tones of 125 Hz, 1000 Hz, and 4000 Hz under a quiet condition and three ambient sound conditions. Ambient conditions were set to be equal to the spectra of NC30, NC40, and NC50. The results show that relative noisiness for each tone at the same sound level decreases as the ambient noise level increases [30].

3.1.1.2 Mood Related Impressions

Powell *et al.* (1974) studied the effect of road traffic noise towards aircraft noise annoyance judgment. The test was divided into two sets. One set has a continuous mean background noise level, while the other one has the level changed for each aircraft noise. Under the continuous background noise, the rated annoyance decreased consistently along the background noise level increment. However, there was no consistent change at discontinuous background test [31].

Lim *et al.* (2008) surveyed the community annoyance towards aircraft sound based on the level of background noise at their living environment. Measurement of aircraft noise was conducted in 20 sites around Gimpo and Gimhae International Airports. Randomly selected respondents who live within 100 meters radius of the measurement sites completed an annoyance questionnaire. The result shows that annoyance responses in lower background noise regions are higher than those in higher background noise regions [32].

3.1.2 Sound Intelligibility under Ambient Noise

Izumi *et al.* (2014) studied ambient noise of several station concourses in Osaka to improve the quality Speech Transmission Index of station announcement. Ambient noise in Osaka stations ranges from 60 to 70 dB. Noisiness impression of ambient sound at 60 dB gives "slightly quiet" impression, 65 dB gives "neither quiet nor noisy" impression, and 70 dB gives "slightly noisy" impression. Subsequently, the relationship between sound-to-noise ratios (SNR) and intelligibility of the announcements was studied. Announcement starts to be comprehensible while broadcasted at 5 dB below the ambient noise and becomes less inaudible as the level increases. However, at the ambient noise above 69 dB, announcement starting at SNR 10 dB louder than the background noise tend to become incomprehensible [33].

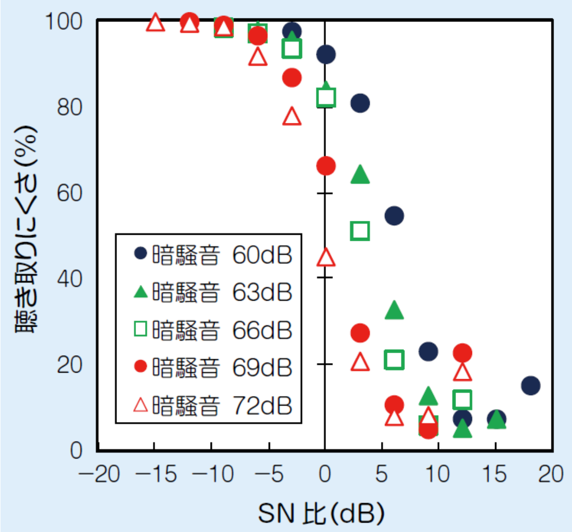

Figure 3.1 The relationship between listening intelligibility and sound to noise ratio. Excerpted from *[33]*.

Sato *et al*. (2004) studied about speech intelligibility at train stations in Tokyo area. The measured average ambient noises of 3 different stations were found to have only small level differences at various time period. The ambient noises measured ranged from 65 to 85 dB. A listening experiment was conducted in 3 conditions (train absence, train arrival, and train idling) for 5 different levels of train announcement ranging from 65 to 85 dB. Listening difficulty started to drop when the announcement is 5 dB lower than ambient noise and intelligibility increases as the announcement becomes louder. However, 10 dB difference between announcement and ambient noise only increases the intelligibility up to 50%. It was found that at 65 dB of ambient noise, the announcement of 80 dB could minimize listening difficulty [34].

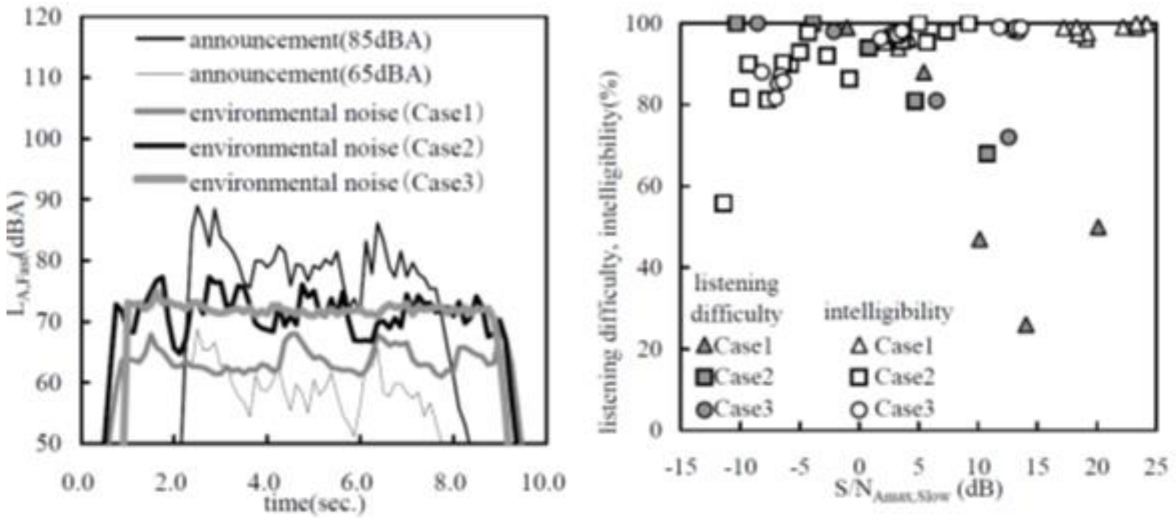

Figure 3.2 Experiment condition (left) and the relationship between listening intelligibility and sound to noise ratio (right). Excerpted from *[34]*.

Tsujimura *et al*. (2015) studied the control method of announcement at stations in consideration of older users. In the experiment, two conditions were set, whereas sound absorber is present or absent at the platform. For each condition, there are 3 levels of background noise (65 dB, 70 dB, and 75 dB) as a sub-condition. SNR ranging from -12 dB to +16 dB by 4 dB increment was set as the parameter. Listening difficulties regardless age at all ambient sound level starts to drop when the announcement is 8 dB lower than ambient noise. At 65 dB of ambient noise, announcement above 8 dB is considered fully intelligible, while at 75 dB a difference of 12 dB is needed to be considered fully intelligible. However, at the ambient noise of 70 dB, while the youngsters consider that 8 dB higher is intelligible for both condition of sound absorber presence and absence, older adults have 5% more difficulties upon comprehending announcement 8 dB louder in a reverberant environment. On the other hand, at SNR +8dB in absorber presence condition, older adults have slightly higher intelligibility than youngsters at the ambient noise of 70 dB [35].

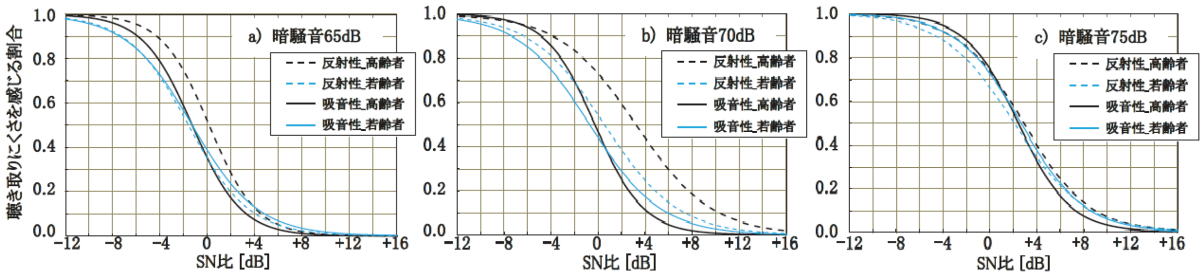

Figure 3.3 Relationship between listening intelligibility and SNR for different conditions. Excerpted from *[35]*.

3.1.3 Review Summary

Although none of the research in the previous sections directly discussed train departure sound, in conclusion, background noise influences auditory impressions and intelligibility. Therefore it is important to consider the interaction of ambient sound factor upon auditory impressions of train departure sounds.

3.2 Experiment 2: Laboratory Experiment for Ambient Noise Factor

The experiment considering ambient noise factor is similar to the experiment conducted in Chapter 2. However, an addition of "effectiveness" impressions is also considered along with "timbre" and "mood" impressions.

3.2.1 Objective

This study aims to search the proper sound to noise ratio for broadcasting departure sounds at different levels of ambient noise considering stress and annoyance impressions. Noise conditions from previous studies will be used as a reference for experiment conditions in this study.

3.2.2 Experiment Outline

3.2.2.1 Time and Place

The experiment was conducted from 15 May 2017 to 26 May 2017 in the anechoic chamber of University of Tokyo, Kashiwa Campus.

3.2.2.2 Participants

There were 21 participants recruited for the second experiment. They consist of 10 Japanese and 11 non-Japanese. There are 5 females of each group of nationality, with 5 and 6 males for Japanese and non-Japanese groups respectively. All participants who are recruited were aged between 20 to 35 years old with a mean of 24.9 years old and median of 24 years old.

3.2.2.3 Ambient Sound and Sound Samples

The ambient sound sample which was used in this experiment was recorded from a platform at one train station in Tokyo Metropolitan area. Because departure sounds are played during the time when trains stay on the platform, the ambient noise selected for this experiment contains engine sound of a stationary train that was waiting for passengers to board in. The spectrum of the ambient noise is presented in Figure 3.4 when it is normalized to 65 dB.

Table 3.1 shows the characteristics of the sound samples which are used for the second experiment when normalized to 60 dB. These train departure sound samples were chosen based on their acoustic features and their preference percentage. Two sounds have been selected for each category. Figure 3.5 and Figure 3.6 shows the bell and melody sounds respectively as compared to the noise spectrum at normalized 65 dB.

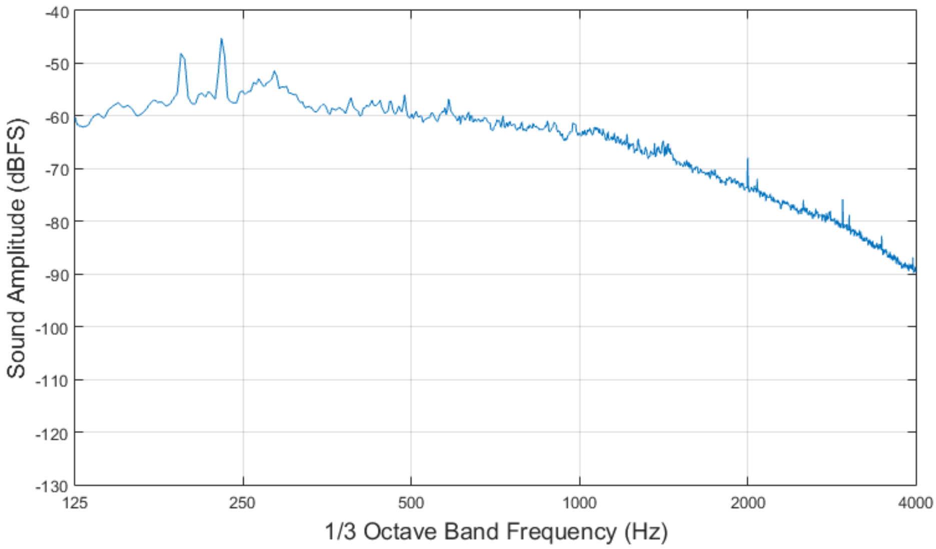

Figure 3.4 Spectrum of ambient noise used in the experiment, normalized at 65 dB.

Table 3.1 Sound features of departure signal sounds for experiment 2.

Sample Number	Sound Type	Duration [s]	LN [phon]	N5 [sone]	S [acum]	R [asper]	Fmod [Hz]	Tempo [BPM]	Mode	Fave [Cent]	FSD [Cent]
S17	Bell	5.1	69.9	7.0	1.49	0.11	16	-	-	1170.1	91.3
S27	Bell	2.8	71.2	8.4	1.69	0.09	0	-	-	413.9	161.2
S19	Melody	7.1	73.2	9.6	1.33	0.06	-	117	Minor	1195.0	705.6
S32	Melody	6.1	77.4	12.7	1.62	0.03	-	122	Minor	-26.5	775.1

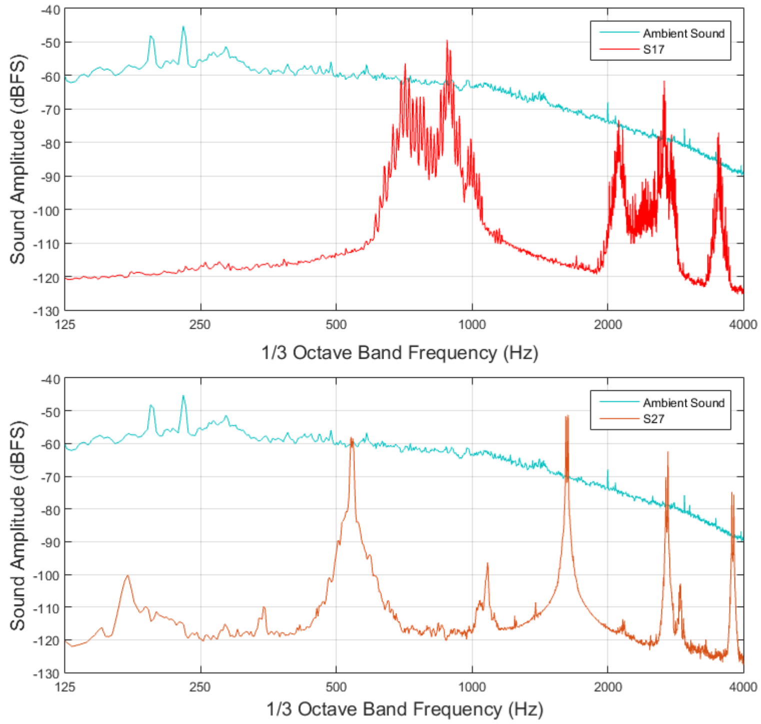

Figure 3.5 Spectrum of bell sounds used in the experiment compared with the ambient sounds, normalized at 65 dB.

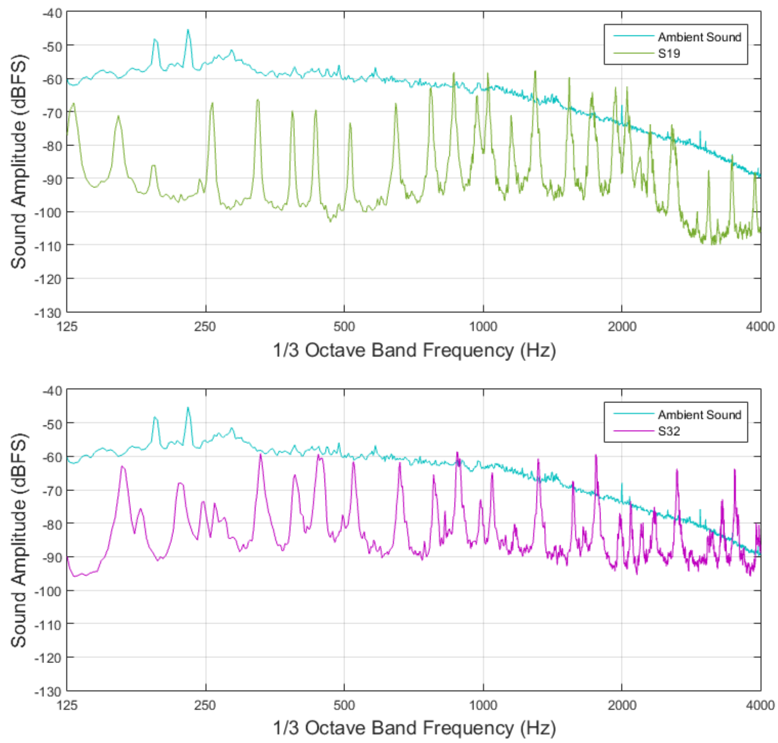

Figure 3.6 Spectrum of melody sounds used in the experiment compared with the ambient sounds, normalized at 65 dB.

3.2.2.4 Questionnaire

The questionnaire consisted of 3 impression categories (timbre, mood, and effectiveness) and presented in both Japanese and English languages. Adjectives related to "timbre" and "mood" are equivalent to the description in section 2.3.2.4. In addition, "effectiveness" category is also considered in this experiment.

Effectiveness impressions are related to the usefulness of the sound such as "audible – inaudible" and "noticeable – unnoticeable". For each train departure sound samples, a series of 7-step semantic differential questions consisting adjectives in Table 3.2 was prepared. Ambient sound was also evaluated using 7-step semantic differential questions consisting 4 pairs of adjectives: "Soft – Loud", "Quiet – Noisy", "Pleasing – Annoying", and "Relaxing – Stressful". Preference regarding the sounds was also asked in the form of "Like", "Dislike" and "Neither". At the end, there are 14 questions about hearing sensitivity based on Khalfa's Hyperacusis Questionnaire [23, 24], followed by questions about the profile of the participants. The questionnaire sample is attached in Appendix 2.

Table 3.2 Adjective pairs for subjective evaluation in experiment 2.

	Rating Scale						
	-3	-2	-1	0	1	2	3
	Highly	Quite	Slightly	Neither	Slightly	Quite	Highly
Timbre		**Soft**		**<==>**		**Loud**	
		Quiet		**<==>**		**Noisy**	
		Low		**<==>**		**High**	
		Deep		**<==>**		**Metallic**	
		Smooth		**<==>**		**Rough**	
Mood		**Calm**		**<==>**		**Hasty**	
		Exciting		**<==>**		**Depressing**	
		Relaxing		**<==>**		**Stressful**	
		Pleasing		**<==>**		**Annoying**	
Effectiveness		**Audible**		**<==>**		**Inaudible**	
		Noticeable		**<==>**		**Unnoticeable**	
Preference			-1	0	1		
			Like	**Neither**	**Dislike**		

3.2.2.5 Experiment Design and Procedure

In the second experiment, ambient sound was set in 65 and 75dB sound level conditions. These levels was chosen based on previous studies that described the average ambient noise in train stations is around 75 dB. There are only a few stations in which the ambient noise surpasses 80 dB and there are quite many stations in the ambient noise around 65 dB in Japan [33, 36]. Therefore, these two sound levels were chosen to represent the actual station noise sound level condition.

The departure sign sounds were presented to the participants in sets of prepared sequences. There were 4 sets of a semi-randomized sequence of sound. One set consists of 40 sound samples which are identical with the other sets. One set is divided into 2 sections where in each section different ambient noise level was used. In each set, the order of SNR was designed to either increase or decrease by 5 dB. The SNR range employed in the experiment spans from +0 dB up to +20 dB louder than the ambient noise. In each set, melody and bell sounds are played alternately. The summary of the experiment condition is presented in Table 3.3.

Table 3.3 Summary of the experiment conditions for experiment 2.

Variable	Ambient Noise Level (dB)	S/N (dB)	Sound Samples
Sign Sound	65 75	+0 +5 +10 +15 +20	S17 S19 S27 S32
Ambient Sound	65 75	Noise Only	

The experiment was conducted with one participant at a time. The participants were given the questionnaire and asked to sit on a provided chair in the middle of anechoic chamber as shown in figure 3.8. Train departure sounds were played from one speaker located above the participant. Ambient noise was played from 4 speakers surrounding the participant. Before each set starts, two practice sounds were presented in order to familiarize the participants with the questionnaire. The prepared practice sounds were selected at random from the unused sound samples. At the beginning of each set, ambient noise was played before each participant listens to the departure sign sounds. Without stopping the ambient noise, each participant was asked to listen to the departure sign sounds. After listening to each sound, they were asked to fill in the questionnaire provided. After 20 sounds were presented to the participants, a five-minute break was provided before continuing to the next section. At the end of the experiment, a short profile and hyperacusis test questionnaire were answered by the participants. Figure 3.7 shows the flow of this experiment.

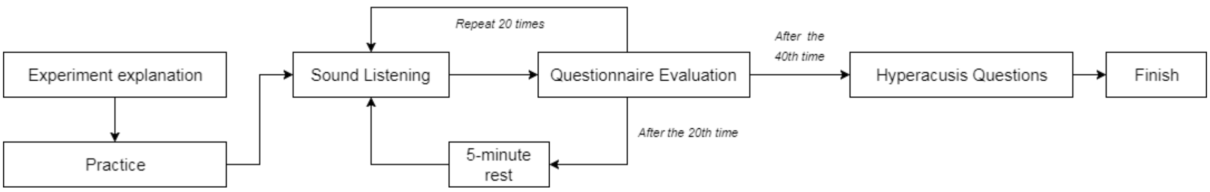

Figure 3.7 Routine of experiment 2.

Figure 3.8 Experiment condition in anechoic chamber.

3.2.3 Results and discussion

3.2.3.1 Ambient Sound Impression

In the second experiment, the background noise was played in two sound levels, which are 65 dB and 75 dB of LAeq. Each of the respondents was told that the background noise that would be used in the experiment is a sound recorded inside a train station.

Figure 3.9 shows the auditory impressions towards the ambient sound. At sound level 65 dB, auditory impressions shows a tendency of being evaluated around the neutral value. On the other hand, at sound level of 75 dB the ambient sound was evaluated with higher scores at each evaluation item. This result is supported by Izumi *et al*. [33] in which train station ambient sounds at 65 dB are mostly considered as neither noisy nor quiet and at 70 dB start to be considered as a noisy environment.

Figure 3.10 shows the preference score of the ambient noise in two different sound levels. At 65 dB of sound level, the ambient noise mostly evaluated with “neutral” preference score. It is notable that there are some “like” answers as well which most likely is influenced by the order of the experiment. On the other hand, at 75 dB, the same sound was highly rated with the impression of “dislike” with less than 25% of the respondents answered “neutral” and 0% of the respondents answered “like”.

From this result, it can be concluded that people can tolerate the ambient noise of train stations on 65 dB and relatively consider them as a relatively normal noise level. On the other hand, most of the respondents showed the result that train station ambient noise at 75 dB is most likely intolerable.

Figure 3.9 Subjective evaluation for ambient noise.

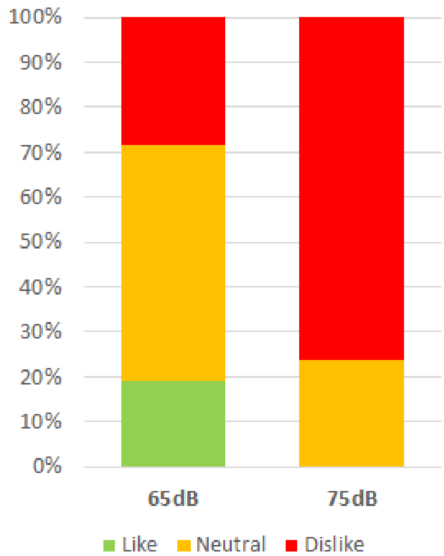

Figure 3.10 Preference score of ambient noise.

3.2.3.2 Overall Impressions

Figure 3.11 shows the results of listening experiment at both 65 dB and 75 dB of ambient noise conditions. The colors show SNR level as compared to the ambient noise conditions. The result shown in the graph presents a similar tendency as the result shown in Figure 2.22 for both ambient noise conditions. Melody sounds received higher score of evaluation at timbre related impression but received lower scores at mood-related impressions as opposed to bell sounds at the SNR.

A new finding which is presented in Figure 3.11 is that melody sounds tend to be perceived as more audible and noticeable than bell sounds. This result is mostly correlated to the impression of loudness in which melody sounds are perceived louder than bell sounds, therefore improving their audibility.

Figure 3.12 presents the impression of each sound at each ambient sound level as opposed to the SNR value. Green color shows the sounds at ambient noise of 65 dB while red color shows the sounds at ambient noise of 75 dB. At timbre related impressions, melody sounds tend to be perceived with higher scores at the same ambient sounds level than bells. However, mood related impressions show that melody sounds mostly received lower score than bell sounds regardless the SNR level on each ambient condition. Effectiveness related impressions show that at each ambient condition, melody sounds received lower scores than bell sounds.

“Quiet – noisy” impression of bell and melody sounds shows almost no difference with each other at the same ambient noise level. “Deep – metallic” impression between sample and ambient condition is similar at SNR below +10 dB. Impression of “smooth – rough” differs between sound type at SNR +0 dB and became similar to each other at SNR +5 dB and above.

Impressions of “calm – hasty”, “relaxing – stressful”, and “pleasing – annoying” show a steeper increment in score at ambient condition of 75dB above SNR value of +10 dB for melody type of sound. At ambient condition of 75 dB, SNR value of +15 dB and +20 dB gives the train departure sound the sound levels of 90 dB and 95 dB respectively. This sound is considered as very loud as shown in Table 2.1 which most likely triggers the stressfulness and annoyance impressions towards the melody sounds.

"Audible – inaudible" and "noticeable – unnoticeable" impressions show the similarity of scores. It is highly possible that the meaning of "audible" and "noticeable" is understood similarly by the participants. It is notable that melody sounds at ambient of 65 dB received quite similar scores with bell sounds at 75 dB of ambient condition.

Analogous to the result of the first experiment, the impression of "exciting – depressing" does not show any notable difference with the increment of sound level. There is a slight distinction between bell and melody at each ambient noise level which shows that melody is perceived as more exciting than bell sounds. However, it is considered that this adjective pair might not be suitable to be used for train departure sound evaluation.

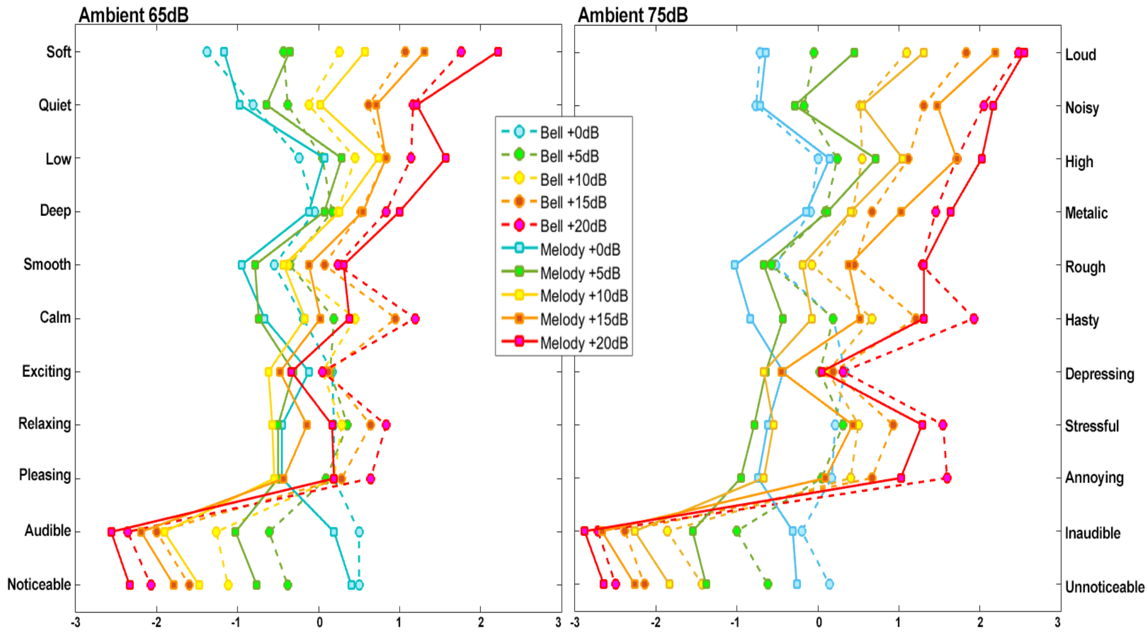

Figure 3.11 Overall auditory impressions of train departure sign sounds under ambient noise condition.

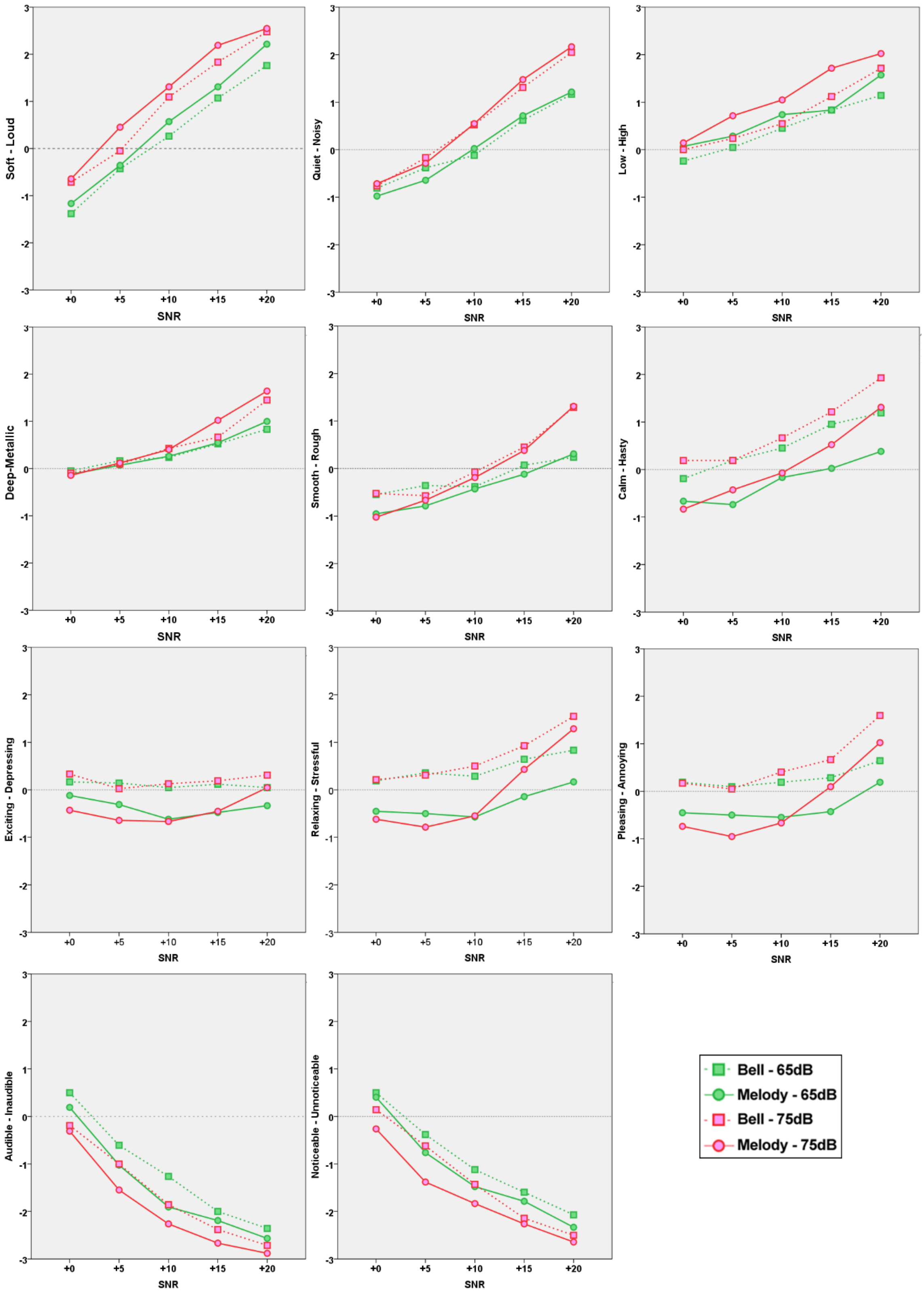

Figure 3.12 Comparison of bell and melody on each evaluation item as opposed to SNR value.

3.2.3.3 Discomfort and Inaudibility Impressions

In this section, the effectiveness and discomfort percentage caused by departure sign sound will be presented. It had been mentioned at the beginning of section 2.3 that discomfort impression is related to stressful and annoyance impressions. Therefore, in the current section, only “relaxing – stressful” and “pleasing – annoying” will be presented for describing discomfort perception. Inaudibility impression will consequently be described by using both effectiveness related impression, which is “audible – inaudible” and “noticeable – unnoticeable” adjective pairs.

Figure 3.13 shows the percentage of stressful and relaxing impressions. Bell sounds receive only a few of “relaxing” response which is less than 20% for each ambient sound conditions. On the contrary, melody sounds received mostly more than 25% of relaxing response on each ambient sound condition and SNR value, except for SNR +20 dB at 75 dB of ambient noise. The highest “stressful” percentage for each sounds lies on SNR +20 dB at each ambient noise conditions. The highest relaxing percentage for melody sounds lies on +10 dB of SNR at 65 dB of ambient noise level and +5 dB of SNR at 75 dB of ambient noise level.

Figure 3.14 shows the percentage of pleasantness and annoyance impressions. Bell sounds received much less pleasantness impression compared to melody sounds. In some conditions, melody sounds are perceived as “pleasing” by more than 50% of the respondents while bell sounds only received not more than 25% “pleasing” response. Bell sounds at each ambient noise condition received “highly pleasing” response at +5 dB of SNR. Consequently, SNR of +5 dB shows the highest pleasantness percentage of both sounds at each ambient noise condition.

Figure 3.15 demonstrates the percentage of audibility and inaudibility of train departure sign sounds. Sounds above +5 dB of SNR at each ambient noise condition received more than 50% of audible responses. It is also notable that melody sounds received more audible impression response than bell sounds. This implies that melody sounds are more audible than bell types.

Figure 3.16 shows the percentage of noticeability of train departure sign sounds. The result shows a similar trend with “audible – inaudible” percentage. However, the percentage of “noticeable – unnoticeable” impression slightly lower with the audibility response. The percentages of “highly noticeable” and “quite noticeable” are lower than those of audibility response. However, it is still notable that sounds above +5 dB of SNR at each ambient noise condition show more than 50% response of noticeability which illustrates the effectiveness of the sounds.

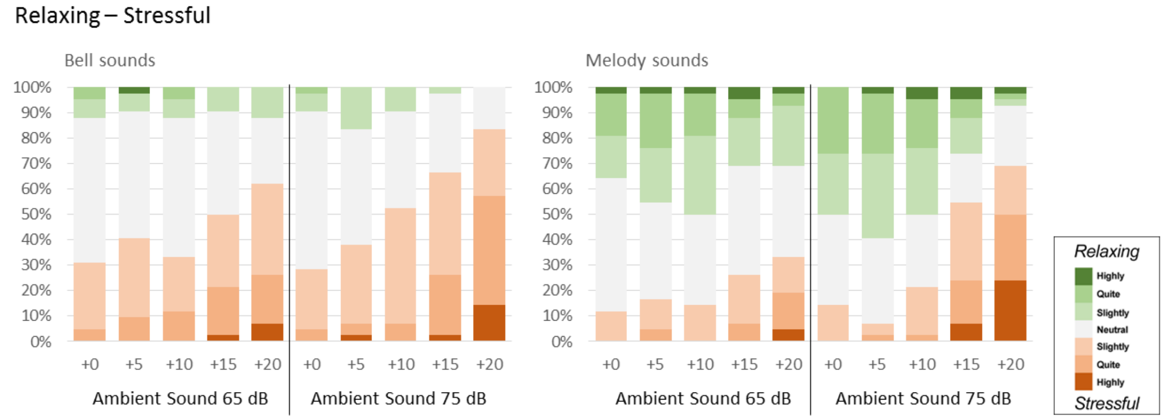

Figure 3.13 Percentage of "relaxing - stressful" impression of train departure sign sounds under ambient noise condition.

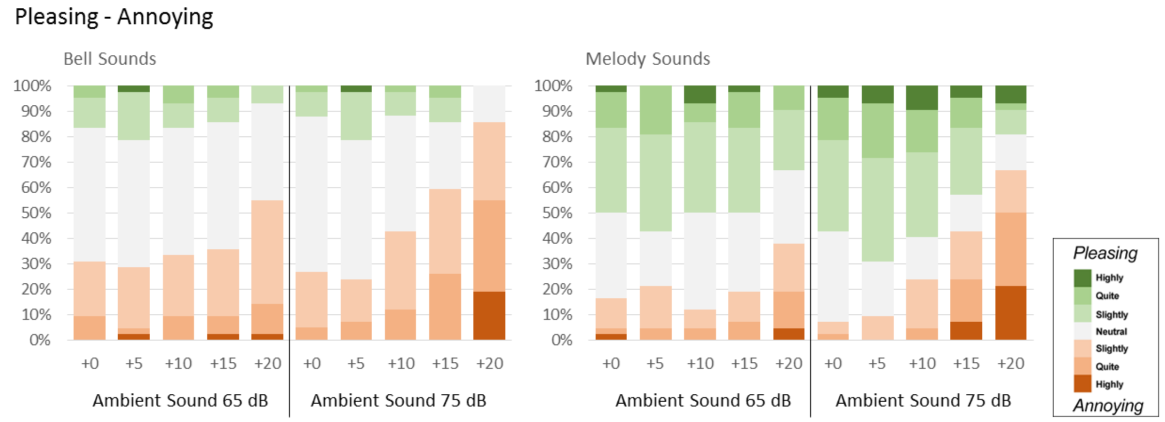

Figure 3.14 Percentage of "pleasing - annoying" impression of train departure sign sounds under ambient noise condition.

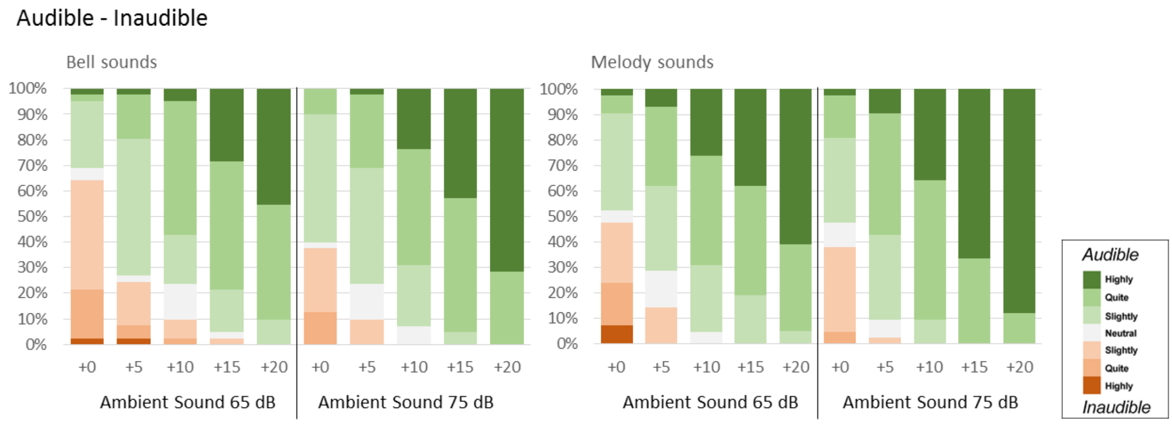

Figure 3.15 Percentage of "audible - inaudible" impression of train departure sign sounds under ambient noise condition.

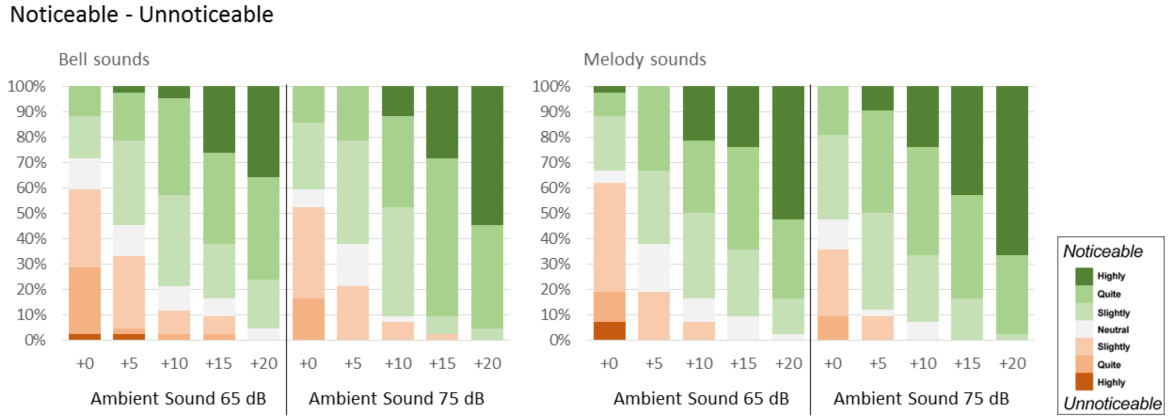

Figure 3.16 Percentage of "noticeable - unnoticeable" impression of departure sign sounds under ambient noise condition.

3.2.3.4 Severe Discomfort and Inaudibility Impressions Comparison

In continuation with the previous section, further comparison of discomfort and inaudibility is considered essential to make a guideline proposal. In this section, combined percentage of “quite” and “highly” evaluation terms related to stress, annoyance, and inaudibility will be compared. The “quite” and “highly” responses are considered as the severe condition of discomfort and inaudibility.

Figure 3.17 shows the comparison of “highly” response percentage for bell sounds. Bell sounds which is played at the same sound level as the ambient noise tend to have more than 10% of severe inaudibility response, which decreases significantly with 5 dB of difference in sound level. At the ambient sound of 65 dB, severe inaudibility reached 0% at +15 dB of SNR, while on the contrary, severe stressfulness rises above 20% at the same SNR value. At 75 dB of ambient noise condition, discomfort response exceeds 20%. Therefore, it is considered that the SNR value between +5 dB and +10 dB is the most effective for bell sounds for both ambient noise conditions.

Figure 3.18 shows the comparison of “highly” response percentage for melody sounds. At 65 dB of ambient noise, the response of severe inaudibility at +0 dB of SNR is around 20% and dropped to 0% starting from +5 dB of SNR and above. As well, severe discomfort impression rises above 10% at +20 dB of SNR. At 75 dB of ambient noise condition, severe inaudibility response is considerably low. However, starting from +15 dB of SNR, severe discomfort increases above 20%. From these results, it is considered that the most effective range of SNR for melody sounds at 65 dB of ambient sound is between +5 dB to +15 dB, while at 75 of ambient noise, SNR between +5 dB and +10 dB is considered to be the most effective.In comparison of both figures, melody sounds are found to be not only considered as less stressful than bell sounds, but also more audible.

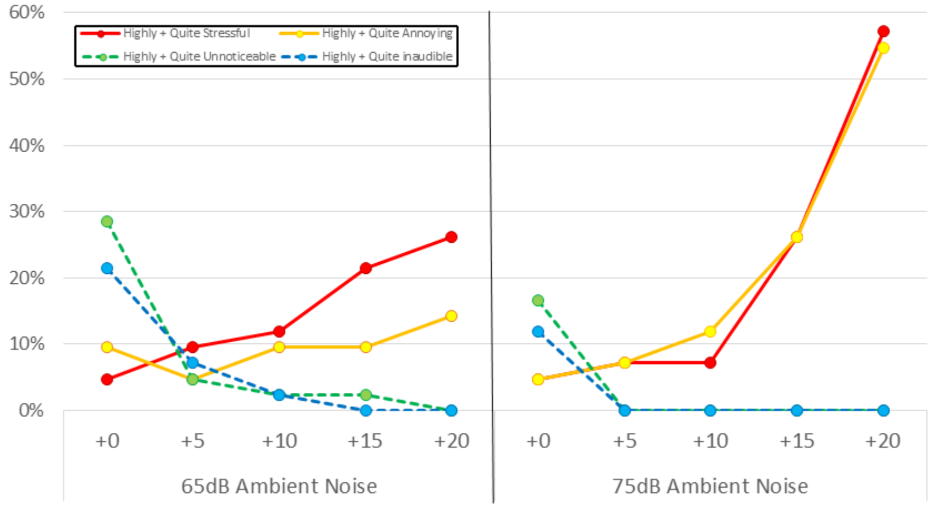

Figure 3.17 Combined percentage of "highly" and "quite" evaluation for discomfort and inaudibility impressions of departure bell.

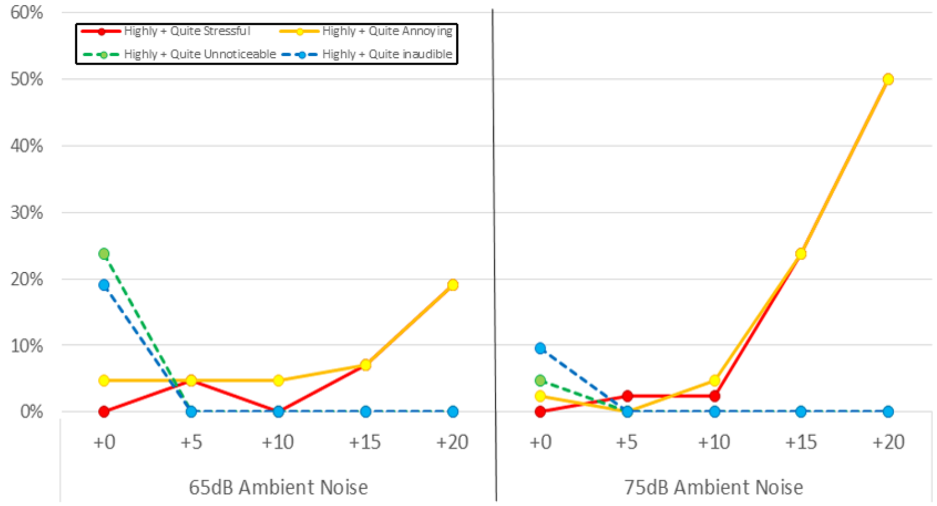

Figure 3.18 Combined percentage of "highly" and "quite" evaluation for discomfort and inaudibility impressions of departure melody.

In consideration of difficulties upon adjusting sound broadcast volume for every change in ambient noise condition, an absolute value needs to be proposed. For bell sounds, SNR of +5 dB and +10 dB for ambient condition of 65 dB represents the volume between 70 dB to 75 dB. At 75 dB of ambient sound, the same SNR value represents 80 dB to 85 dB of sound level. For melody sounds, +5 dB to +15 dB of SNR at 65 dB of ambient sound shows the sound level of 70 to 80 dB, while +5 to +10 dB of SNR at 75 dB of ambient sound means 80 dB to 85 dB.

In section 2.2.3.1, the distribution of actual train departure sounds volume was presented. The average sound level of bell sounds is around 89 dB and average sound level of melody sound is around 82 dB. Considering that the average train stations noise is around 75 dB, it can be concluded that the current broadcast level of bell sounds is too high which is likely to trigger stressfulness on passengers. On the other hand, the average of melody can be considered to be inside the effective sounds level range.

3.2.3.5 Sound Preferences

Figure 3.19 presents the "like" and "dislike" percentage comparison of each train departure sound samples under two different noise conditions. The dotted lines show the value of bell sounds and the straight lines demonstrates the value of melody sounds.

"Like" percentage of melody sounds is considerably higher than bell sounds. Highest "like" response lies between +5 dB and +10 dB of SNR which corresponds with pleasantness and relax impressions. Sound S32 at SNR +20 dB received low "like" percentage which is comparable to those of bell sounds.

"Dislike" percentage of melody sounds are lower than bell sounds at lower SNR value. However, melody S32 shows a significant increase of dislike score more than those of bell sounds at SNR +15 dB and above. It is notable that sound S32 has the highest loudness level value compared to the other sound samples which might be the cause of this result.

Despite having lower stressfulness and annoyance response, melody sounds with certain characteristics might be disliked more than bell sounds at higher sound levels. Therefore it is important to design a departure sign sounds which have the characteristics or sound features which are preferable by the passengers.

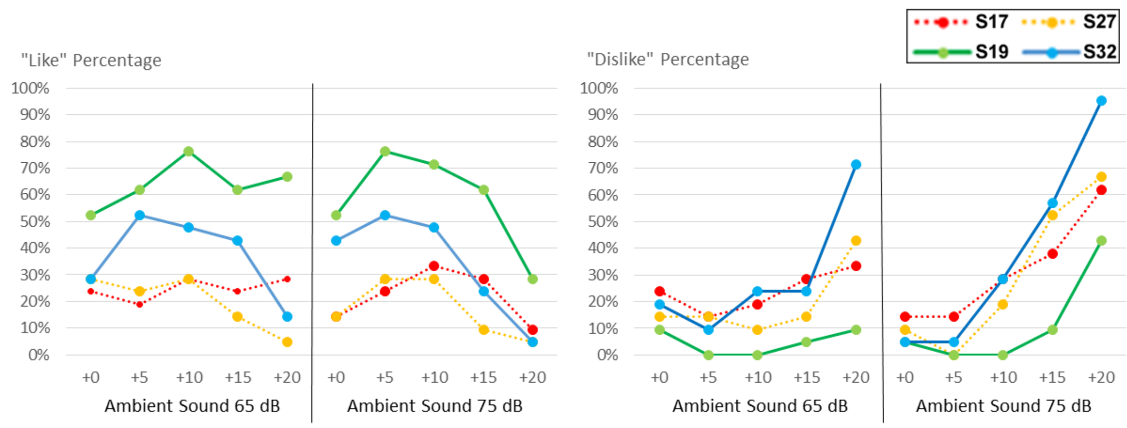

Figure 3.19 Sound preference percentage comparison for each sound samples at different noise conditions.

3.2.3.6 Comparison with Noiseless Condition

In the previous chapter, auditory impressions experiment of departure bells and melodies were conducted in an anechoic chamber without the presence of any generated noise. In this section, the result of the same sound samples on 80 dB between noiseless condition, 65 dB and 75 dB of noise conditions will be compared.

➢ <u>*Comparison of overall impressions*</u>

Figure 3.20 shows the comparison of average values from the samples used in the experiment on different ambient noise conditions. The dotted line shows bell sounds impressions and straight lines indicate melody sounds impressions. The increment of ambient noise level influence to lower score impressions of the sounds. Melodies are still perceived louder than bells at each ambient sound conditions. Mood related impressions of melody sounds are lower in scores than those of bell sounds regardless the ambient level.

It is notable that the increment of ambient sound level reduces the stressfulness and annoyance of each sound. A possibility is that the ambient sound itself is considered as a more severe annoyance and stress source which decreases the stressfulness of departure sign sounds.

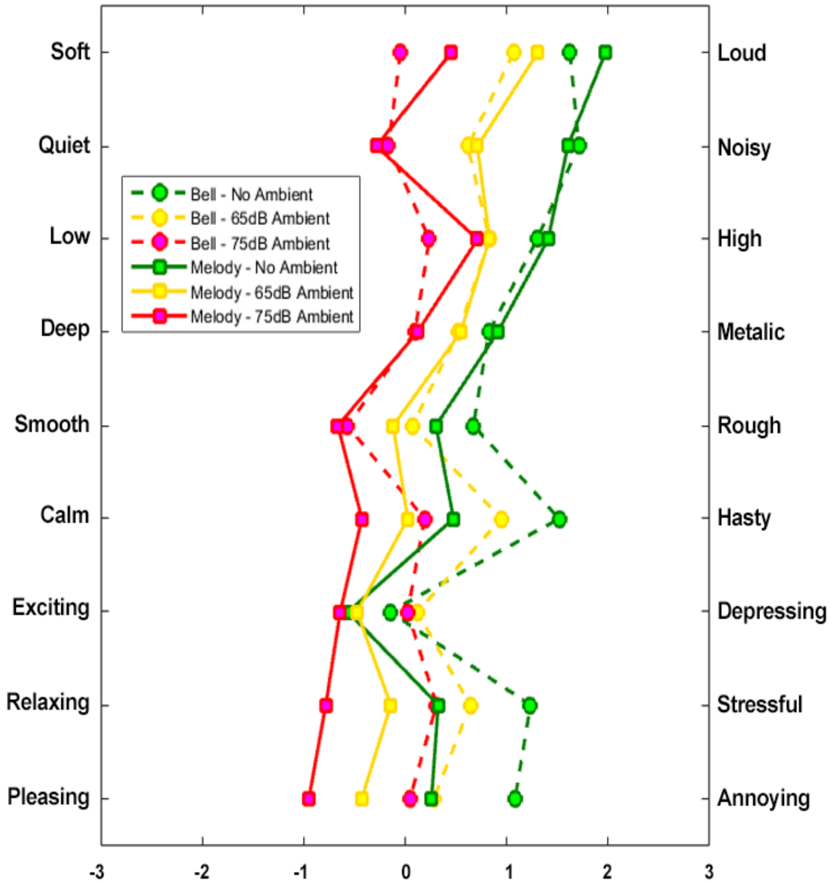

Figure 3.20 Comparison of auditory impressions of departure sign sounds at 80 dB in different ambient conditions.

➢ <u>*Comparison of sound preferences*</u>

Figure 3.21 shows the preference percentage for each sounds samples at different ambient noise conditions. Straight lines show the “like” percentage and dotted lines show “dislike” percentage. “Like” percentage increases as the ambient noise level increases. The increment is relatively steady between ambient noise conditions. “Dislike” percentage increases as the ambient sound level decreases. It is notable that the increment to the noiseless condition is significantly high.

Bell sounds are less preferable than melody sounds. Melody number S19 is the most preferred sound at each sound levels. Melody S32 receives comparably “dislike” response with bell sounds at the noiseless condition.

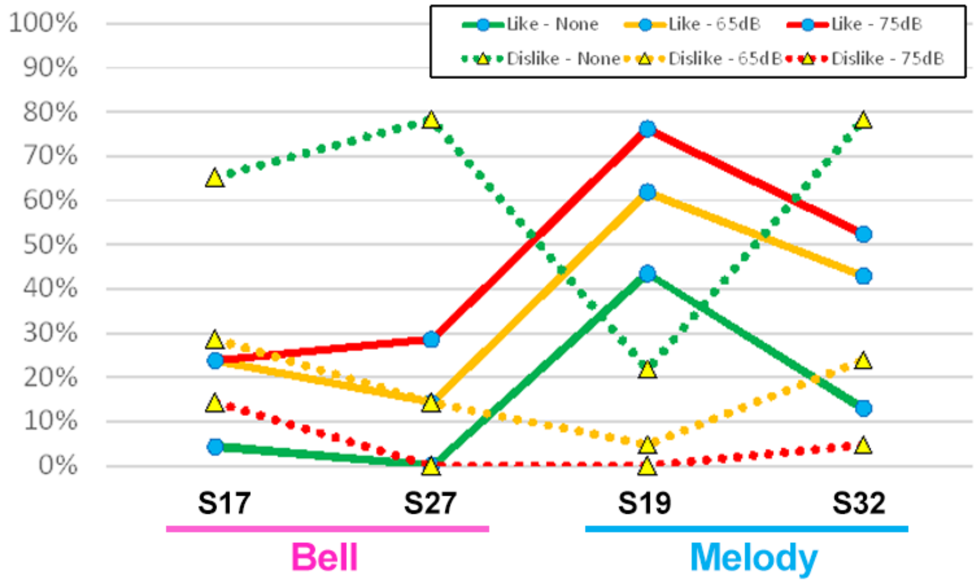

Figure 3.21 Comparison of preference score of departure sign sounds at 80 dB in different ambient conditions.

3.2.3.7 Comparison between Samples

Figure 3.22 shows the comparison between sounds on each auditory impressions. Scores of timbre related impressions increase steadily for each sound sample at both 65 dB and 75 dB of ambient sounds in accordance with the increment of SNR value. Mood related impressions scores increase rapidly for each increment of SNR at 75 dB of ambient condition. “Relaxing – stressful” and “pleasing – annoying” impressions at 65 dB of ambient noise do not show a significant difference as compared to the 75 dB condition. In effectiveness impression, scores decrease steadily as the SNR value increases at both ambient noise conditions.

“Audible – inaudible” impression at +0 dB of SNR corresponds to “soft – loud” and “quiet – noisy” impressions. However as the volume increases, the difference of inaudibility between sounds become less distinct. Similar tendency can also be seen in “noticeable – unnoticeable” impression.

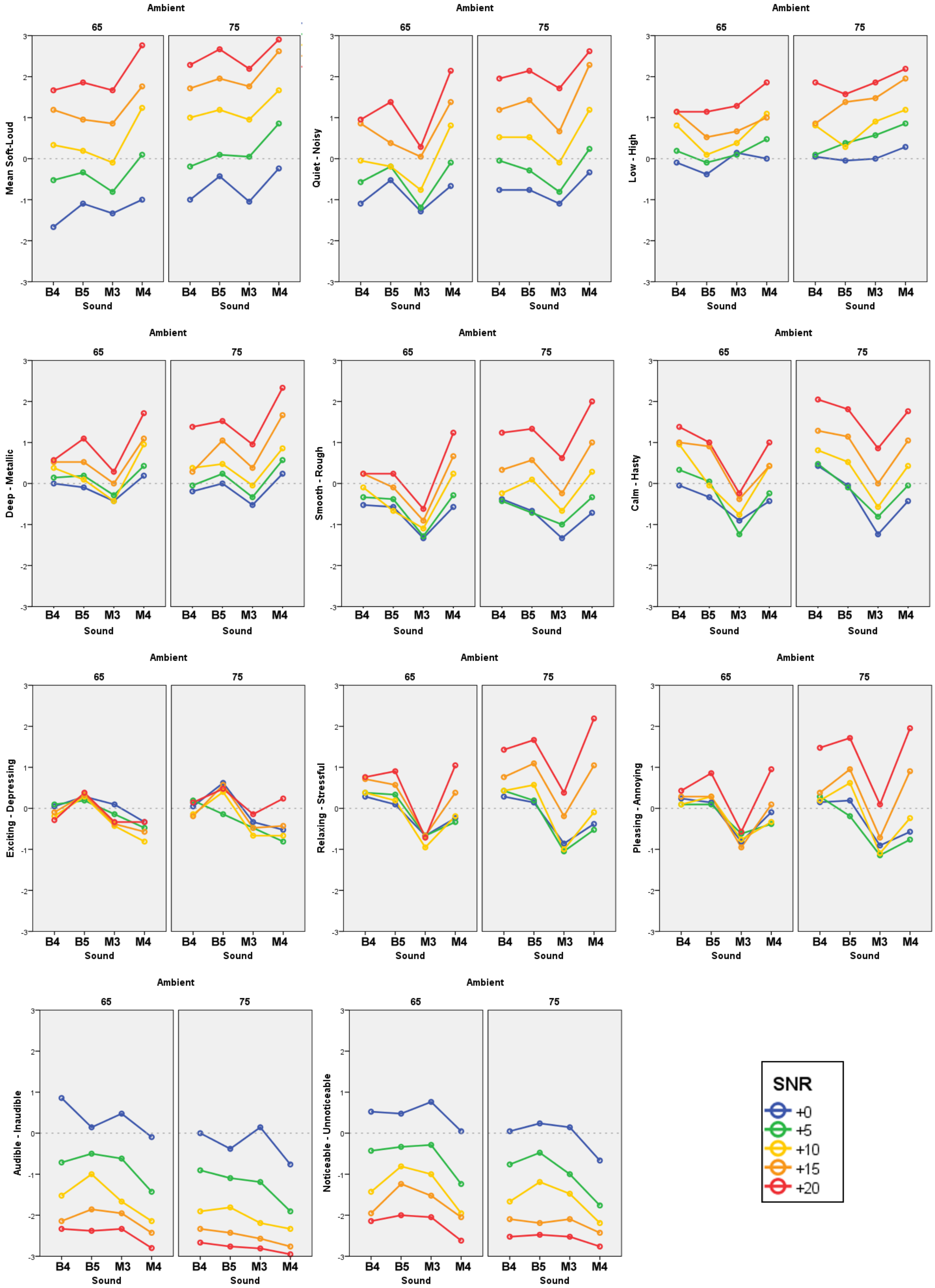

Figure 3.22 Auditory impressions of each sound on different ambient sound level conditions.

3.3 Summary

In this chapter, the auditory impressions of train departure sign sounds under ambient noise conditions had been examined. It is found that there is a difference of impression for sounds which is influenced by the environment in where the sound is presented.

Based on the result in section 3.2.3.4, train departure sign sounds are supposed to be broadcasted around 75 dB to 85 dB of sound level. Sound less than 75 dB tend to be perceived as unnoticeable while sound above 85 dB tends to cause stress and annoyance. It is also important to consider the type of departure sign sounds which is used. Melody sounds tend to be perceived as less stressful than bell sounds at the same sound level and also considered to be more audible. Bell sounds need to be broadcasted louder than melody sound at the same ambient noise condition to minimize its inaudibility.

In section 3.2.3.5, the preference score between bell and melody sounds was also studied. Although bell tends to be less likable than melody sounds, there are some cases in which melody sounds perceived worse than bell sounds. Because bell sounds have less variety in their features, the change of preference of bell sounds is relatively steady at the increment of volume. However, melody sounds with their broad variation might have some features that annoy passengers more than bell sounds at higher sound level. Therefore, it is important to design a melody which does not cause possible annoyance impression due to its characteristic.

From section 3.2.3.6, it is important to consider the presence of background noise at train stations upon broadcasting train departure sounds. There is a possibility that the sounds which are played may not be noticed by the passengers due to the noisiness of the environment. On the other hand, overestimating the sound level for noisy condition might also cause a problem which trigger the stressfulness and annoyance upon the passengers.

In this chapter, the environmental factor that correlates with auditory impression has been examined. In the next chapter the consideration of individual impression difference due to the subjectivity of the listeners will be discussed.

Chapter 4 Human Factor on Auditory Impressions of Train Departure Sign Sounds

In this chapter, human factor influence on auditory impressions of train departure sign sounds will be presented. According to Marquis-Favre *et al.* [5] there are non-acoustical factors that affect human perception on annoyance towards a certain sound. These factors are mostly correlated to the socio-demographic aspects, physiological aspects, or even psychological aspects of the listeners. In order to find whether special considerations are necessary for people with a specific socio-demographic or psychophysiological characteristic, it is important to search any distinct difference between groups of individuals with those difference.

4.1 Non-acoustic Factors that Influence Subjective Impressions

Marquis-Favre *et al.* (2005) stated that annoyance could be affected by both acoustic and non-acoustic factors. They described that non-acoustical factors could be divided into socio-demographic, situational, and attitude aspects. Socio-demographic and situational aspect correlates with the living environment and social status of the subject. Attitude aspect correlates with how people rate a noise as an annoyance due to psychological or physiological problems they may have.

4.1.1 Socio-demographic and Situational Aspects

Tsujimura *et al*. (2015) studied the noisiness and audibility of announcement sounds at train stations. Studied group was divided into two categories based on their age. The first group consists of elderly participants around 60 to 70 years old. The second group consists of younger participants around the age of 20 to 30 years old. It was found that there is only a small difference in response of noisiness and audibility between the groups which is considered to be irrelevant [35].

Hamamura *et al*. (2013) studied the difference of sound volume toleration between male and female respondents towards sounds broadcasted at train stations. Sound samples used was two announcement broadcast with male and female voice each, and also one train departure bell and melody. Each participant were asked to set the volume in three levels which represent the highest tolerated level, the lowest audible level, and the most comfortable level. The highest tolerated sound level between male and female respondents is very similar for each. The difference for lowest audible level ranges around 2-4 dB where female respondents answered higher for departure sign sounds but lower for announcement sounds. The biggest difference lies in the most comfortable sound level where female respondents tend to answer 5-7 dB lower than male respondents for all sound samples. They concluded that at lower sound levels there is a difference in response between male and female respondents [27].

Kuwano *et al*. (1999) studied the response difference between people from different countries towards some particular sounds. Respondents from Japan, Germany, China, and U.S were recruited. Sound samples which are used for the experiment consist of train noises, aircraft noises, traffic noises, construction noises, speech, and music. Respondents from U.S and China shows a similar tendency in response. Responses from German and Japanese respondents are also similar. It was concluded that there is differences in perception of the terms between languages towards "noisiness" which impact the difference in response [37].

Iwamiya *et al*. (1998) studied about the difference in opinion of foreigners who live in Japan. Each respondent was asked to answer the features of soundscape which characterize the environment in Fukuoka. It was found out that sounds which are considered as everyday sounds by Japanese people are considered as unique by the foreigners. There is also a distinction found between respondents who came from different continents. People from Asia tend to perceive Japan as a quiet country while people from Europe and America regarded Japan as a noisy country [38].

Lim *et al.* (2008) show that people who live in noisier environment tend to respond lower annoyance score caused by passing aircraft. This study is correlated with the situational aspect. The study divided two groups of the community which live in two different conditions of noise level. The first group lives in an area with average LAeq of 42 dB, while the second group lives in an area with average LAeq of 55.5 dB. It is measured that at both areas passing aircraft produces similar noise level. However, there is a 35% difference in annoyance response between the community groups which are most likely correlated to their living environment [32].

4.1.2 Physiological and Psychological Hearing Sensitivity Aspects

Becker *et al.* (1971) found the differences of annoyance response in groups with different psychological hearing sensitivity while physiological sensitivity does not show any individual differences. The respondents were exposed to recorded noise in one, two, or three-hour sessions over six months. After each session, the respondents were asked to answer on how much annoyance the sound had inflicted. It was found out that people who are considered to be psychologically sensitive tend to be more annoyed with the stimuli and felt that their health is highly influenced by noise [39].

Khalfa *et al.* (2002) studied about hypersensitivity in noise reception. This hypersensitivity is called Hyperacusis by many experts. Hyperacusis is diagnosed based on reports from the patients where a discomfort was caused by a sound which is acceptable by most of normal hearing people. There are people with normal hearing who suffers from hyperacusis. Therefore it can be considered as a psychophysiological aspect of hearing sensitivity. This research developed a questionnaire to identify people who are sensitive to sound. In their research, they defined that individuals who obtained scores more than 28 points can be considered to have hypersensitivity in hearing [23].

Fioretti *et al*. (2015) and Oishi *et al*. (2017) studied about the validation of Khalfa's Hyperacusis Questionnaire in Italian and Japanese respectively. Both researches found out that the translation in both Italian and Japanese have high validity. However, they discovered that the cut-off score to diagnose hyperacusis needs to be reduced. While it was proposed originally that people who obtained a score above 28 points are considered having high sensitivity, both Fioretti and Oishi proposed score of 16 points as the new cut-off to diagnose hyperacusis [40, 41].

4.1.3 Review Summary

Previous studies showed the influence of socio-demographic aspects towards impression of existing sounds. Therefore it is notable that individual differences based on these factors need to be put into consideration upon studying train departure sign sounds impressions.

Sensitivity aspect in this research was studied using Khalfa's Hyperacusis Questionnaire in English and Japanese version. The division of high sensitivity and normal sensitivity groups was conducted by using the new proposed cut-off sensitivity score at 16 points based on [40] and [41].

4.2 Analysis of Human Factor on Auditory Impressions

In this study, three kinds of human factors were studied as shown in Figure 4.1. These factors were selected due to their possibility of having a distinct difference between each group. There are many other factors which are more common to be examined, such as age and occupation. However in this research most of the participants fall into the same group of age and occupation. Therefore it is considered that these two factors are not possible to be analyzed in the current study.

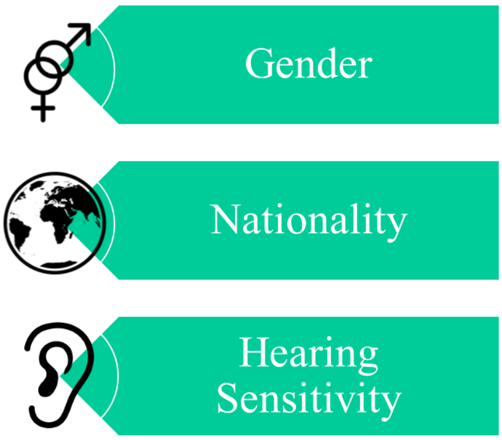

Figure 4.1 Human factors which are considered in the current study.

4.2.1 Objective

Based on past researches, it was found that individual differences influence perception of sounds. Considering the diverse community in Japan, it is seen as important to study the differences between individuals to prevent occurring annoyance and stressfulness caused by the train departure sign sounds.

In this study, it was particularly important to see if there is a difference in discomfort perception between high sensitivity respondents and normal sensitivity respondents which can be used in the consideration upon designing and broadcasting train departure sign sounds.

4.2.2 Analysis Method

One-way ANOVA using IBM SPSS Statistics 20 software was used as a method to check the significance of mean difference between each group. A p-value below 5% will be considered as the significance value for this analysis.

4.2.3 Result from Experiment 1

In experiment 1, there were 23 participants joined the experiment consisting 11 Japanese and 12 non-Japanese participants. Figure 4.2 shows the distribution of the nationality among the participants. There were 5 Indonesian, 3 Chinese, 1 Thai, 1 Mexican, 1 Bruneian and 1 Sri Lankan participants. Additionally, based on hyperacusis questionnaire result from the first experiment, distribution of high and normal hearing sensitivity is also presented. Figure 4.3 shows the distribution of hearing sensitivity between gender and Figure 4.4 shows the same distribution between nationality types. There are 3 people on each male and female group that shows higher hearing sensitivity. Unfortunately, the distribution of high sensitivity people is concentrated in non-Japanese respondents only, therefore making 6 of the foreigner respondents considered having high sensitivity.

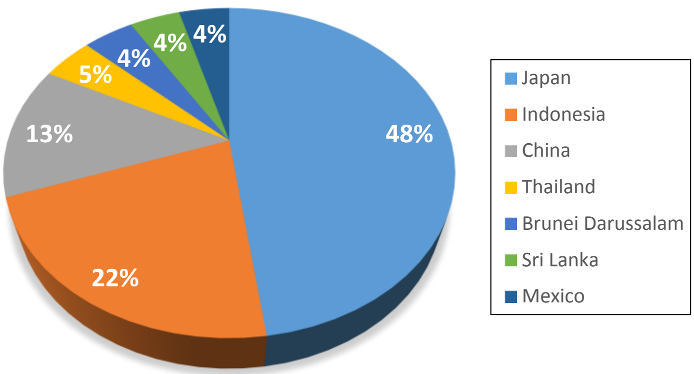

Figure 4.2 Percentage of participants joined experiment 1.

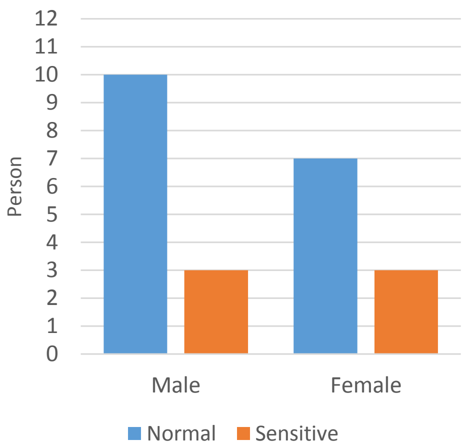

Figure 4.3 Distribution of people with normal and high hearing sensitivity on each gender.

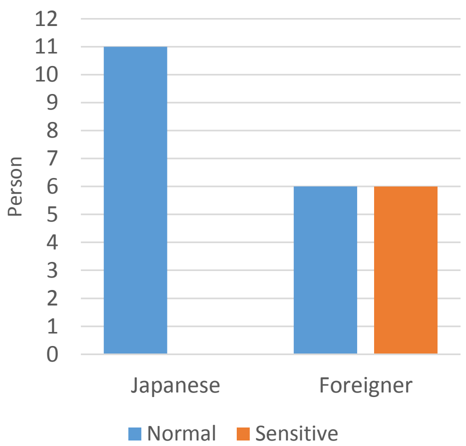

Figure 4.4 Distribution of people with normal and high hearing sensitivity on each nationality group.

4.2.3.1 Gender

Figure 4.5 shows the comparison of response between male and female participants on each auditory impression items. In bell sounds, it can be seen that male respondents tend to answer higher scores for timbre related impression except on “smooth – rough” impression. However, there seems to be no significant difference between genders upon melody sounds.

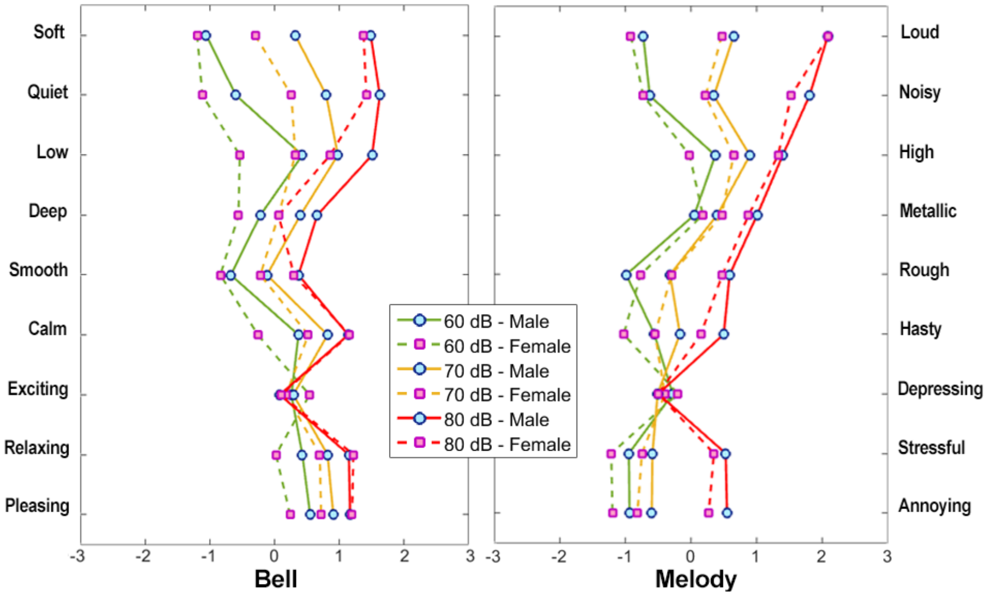

Figure 4.5 Average score between genders on all auditory impression items.

Table 4.1 shows the result of one-way analysis of variance regarding the difference in gender towards departure sign sounds auditory impressions. Similar to the result shown in the previous graph, the significant difference is mostly located in timbre related impressions except on “smooth – rough” impression on bell sounds. Consistent with that, melody sounds shows almost no significant difference in impressions between genders except for “low – high” and “calm – hasty” impressions at 60 dB.

Table 4.1 One-way ANOVA results for gender factor.

	Laeq (dB)	soft - loud	quiet - noisy	low - high	deep - metallic	smooth - rough	calm - hasty	exciting - depressing	relaxing - stressful	pleasing - annoying
Bell	60		*	**			**		*	
	70	**	**	**						
	80			**	**					
Melody	60			*			*			
	70									
	80									

** : p ≤ 1%   * : p ≤ 5%

The result of bell sounds shows that male participants tend to rate the sounds as noisier than female participants which contradict the finding in [27]. However, it supported the result in which no difference was found between genders at louder sounds.

4.2.3.2 Nationality

Figure 4.6 shows the comparison of response between Japanese and non-Japanese participants on each auditory impression items. A similar trend can be seen throughout timbre related impression for both bell and melody sounds with small differences. It is notable that at noisiness impression, non-Japanese respondents consider the sound to be noisier than Japanese respondents. At mood impression, although the response of melody type is somewhat similar, bell sounds tend to be perceived as more stressful and annoying by foreign respondents. This is considered to be the effect that Japanese people are more familiar with the sound, therefore, they consider it as not so annoying or stressful.

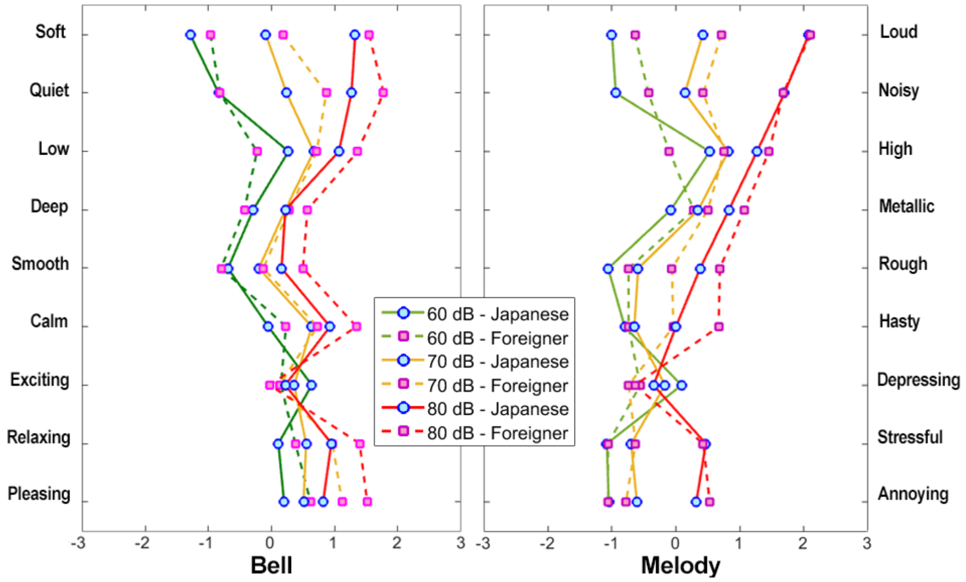

Figure 4.6 Average score between Japanese and non-Japanese on all auditory impression items.

Table 4.2 shows the result of one-way analysis of variance regarding the difference between nationality groups. It can be seen that the difference between Japanese and non-Japanese respondents mostly lies in the mood-related impressions.

Table 4.2 One-way ANOVA results for nationality factor.

	Laeq (dB)	soft - loud	quiet - noisy	low - high	deep - metallic	smooth - rough	calm - hasty	exciting - depressing	relaxing - stressful	pleasing - annoying
Bell	60			*				**		*
	70		**						*	**
	80		**				*		*	**
Melody	60	*	**	**				**		
	70					*	**	**		
	80						**			

** : p ≤ 1%   * : p ≤ 5%

This result shows that although there is no difference in discomfort impression on melody sounds, some considerations need to be accounted on bell sounds for foreigners. People who are not familiar to the departure bells are likely to become annoyed.

4.2.3.3 Sensitivity

Figure 4.7 shows the comparison between different hearing sensitivity groups. Differences in melody sounds are comparatively larger than those of bell sounds between the groups. At bell sounds of 70 dB and 80 dB, higher sensitivity group responded with higher scores than the other group. However, at 60 dB of ambient sound, the sensitive group answered lower scores. In bell sounds, there is a tendency that higher sensitivity groups of respondent answer the sound as being more annoying than the other group.

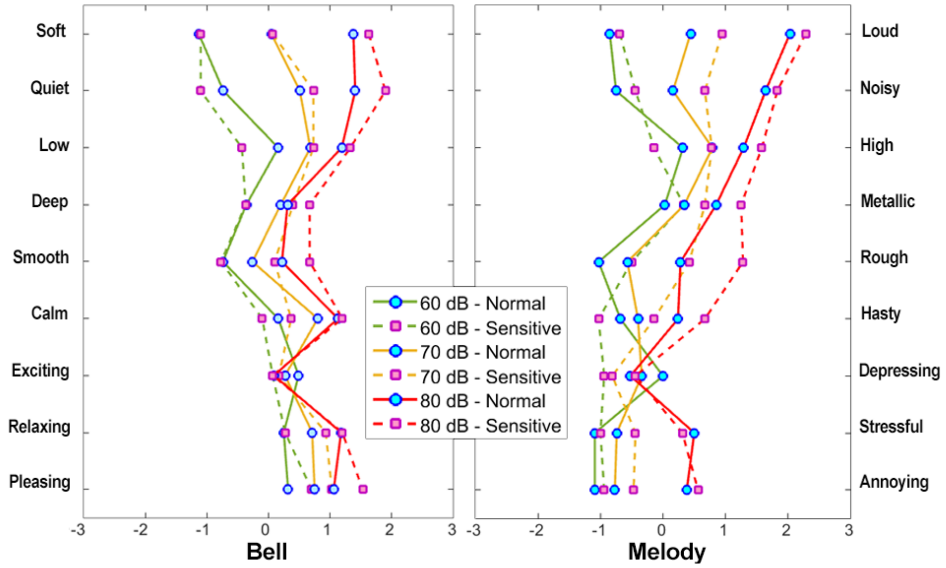

Figure 4.7 Average score between normal and high sensitivity respondents on all auditory impression items.

Table 4.3 shows the result of analysis of variance between the sensitivity groups. There is only a small number of significant difference in bell sound between the groups. There is a statistically significant difference in "smooth – rough" impression for melody sounds between the groups, in which sensitive people tend to answer higher scores. It is notable that there is no significant difference between the groups regarding stressfulness of departure sign sounds.

Table 4.3 One-way ANOVA results for sensitivity factor.

	Laeq (dB)	soft - loud	quiet - noisy	low - high	deep - metallic	smooth - rough	calm - hasty	exciting - depressing	relaxing - stressful	pleasing - annoying
Bell	60			*				*		
	70									
	80		**							*
Melody	60			*		*		**		
	70	*	*			**		**		
	80					**				

** : p ≤ 1% * : p ≤ 5%

From this result, it can be seen that people who have higher listening sensitivity tend to answer higher score in "pleasing – annoyance" impression especially for bell sounds at 80 dB. Therefore appropriate sound level for sensitive people needs to be considered.

4.2.4 Result from Experiment 2

In experiment 2, there were 21 participants joined the experiment consisting 10 Japanese and 11 non-Japanese participants. Figure 4.8 shows the distribution of the nationality among the participants. There were 3 Chinese, 2 Ghanaian, 2 Indonesian, 1 Greek, 1 Mexican, 1 American and 1 Canadian participants. Additionally, based on hyperacusis questionnaire result from the first experiment, distribution of high and normal hearing sensitivity is also presented. Figure 4.9 and Figure 4.10 show the distribution of normal and high sensitivity group over gender and nationality categories respectively. There are two people on each gender groups and two people on each nationality group as well with a total of 4 people considered as highly sensitive.

For the second experiment, it is considered to be more important to study the difference discomfort and effectiveness impressions between each group. Therefore, only “relaxing – stressful”, “pleasing – annoying”, “audible – inaudible” and “noticeable – unnoticeable” evaluation items are compared in this section.

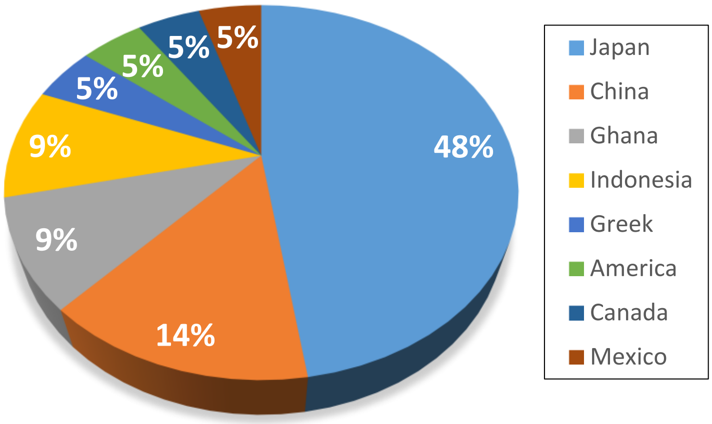

Figure 4.8 Percentage of participants joined experiment 2.

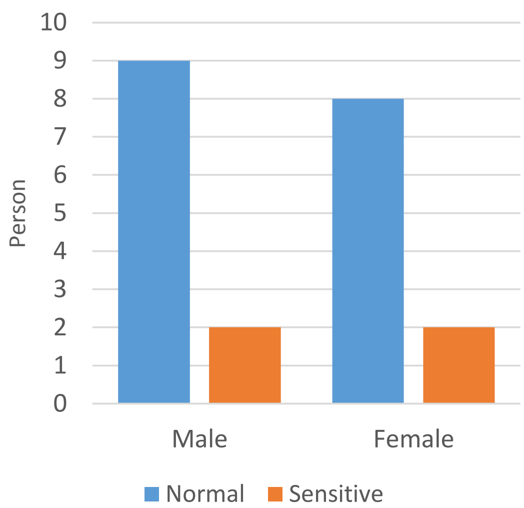

Figure 4.9 Distribution of people with normal and high hearing sensitivity on each gender.

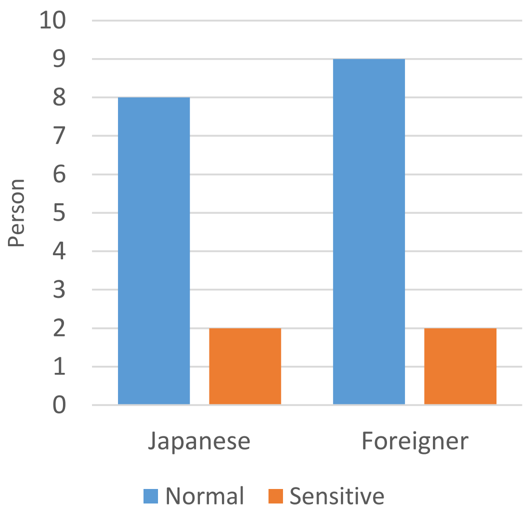

Figure 4.10 Distribution of people with normal and high hearing sensitivity on each nationality group.

4.2.4.1 Gender

Figure 4.11 shows the comparison between gender groups. Female respondents tend to answer higher annoyance and stressfulness as opposed to male respondents on bell sound. For “audible – inaudible” impression, bell sounds shows a slight difference between the groups. At 65 dB of ambient condition, male participants responded with lower scores at +10 dB of SNR and below. The contrary happened at the ambient noise of 75 dB in which female respondents answered higher scores than male group. Overall, effectiveness impressions between groups for both bell and melody sounds are pretty similar.

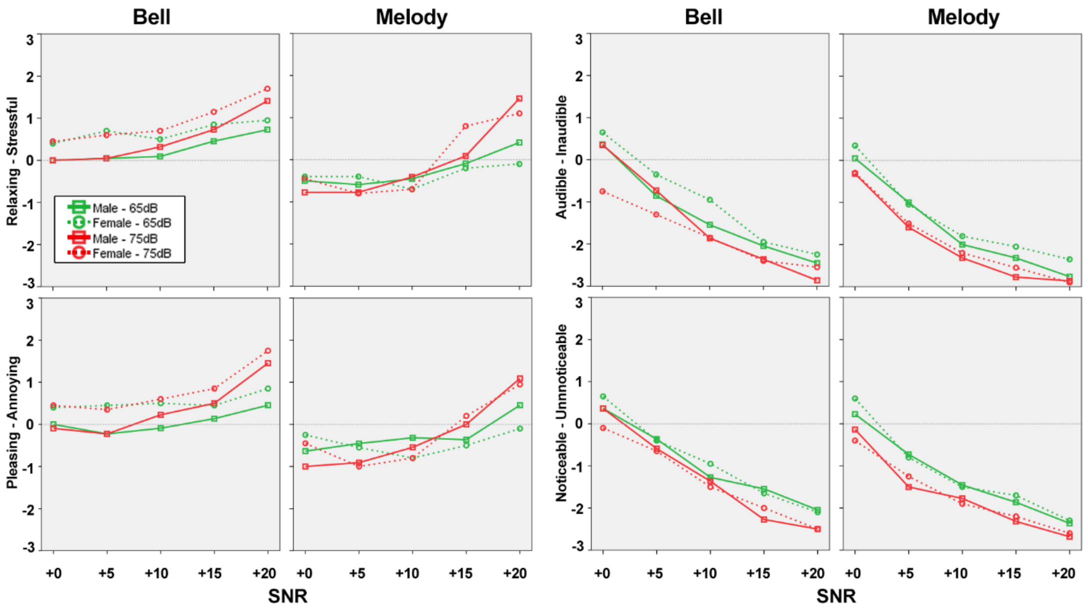

Figure 4.11 Average of discomfort and effectiveness items between gender groups.

Table 4.4 shows the analysis of variance results between gender groups. There is a significant difference in “relaxing – stressful” and “pleasing – annoying” impressions for bell sounds at both ambient noise level. This result shows a different tendency as compared to the result from experiment 1 in which there was no significant difference on these impressions between groups. It is possible that ambient noise presence caused this difference in result.

Table 4.4 One-way ANOVA results for gender factor.

	Ambient (dB)	relaxing - stressful	pleasing - annoying	audible-inaudible	noticeable - unnoticeable
Bell	65	**	**		
	75	**	**		
Melody	65				
	75				

** : p ≤ 1%   * : p ≤ 5%

4.2.4.2 Nationality

Figure 4.12 shows the comparison between nationality groups. There is no significant difference in stressfulness and annoyance impressions of bell sounds between the groups. On the other hand, on melody sounds, Japanese participants tend to answer with higher scores for the same impressions. Audibility of both bell and melody sounds are roughly similar between groups. On noticeability impression, non-Japanese respondents tend to perceive train departure sounds as more noticeable as compared to the Japanese respondents.

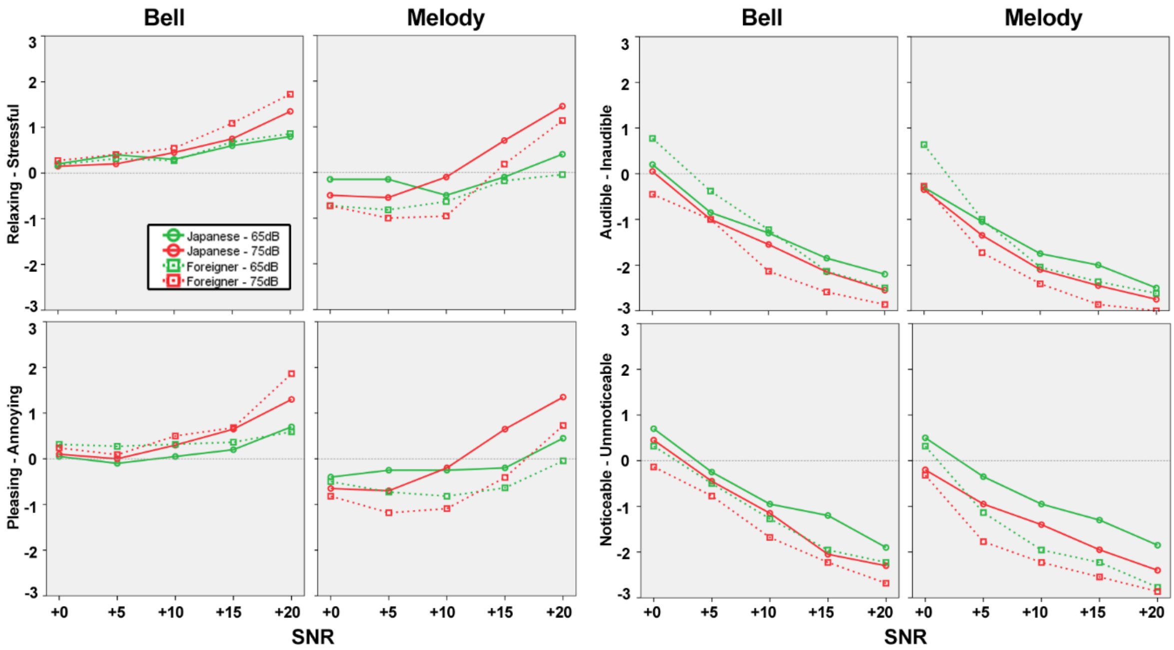

Figure 4.12 Average of discomfort and effectiveness items between nationality groups.

Table 4.5 shows the analysis of variance results between nationality groups. It is shown that there is no significant difference between the groups on bell at 65 dB of ambient noise. It is notable that the distinctions between groups for melody sounds at both ambient noise conditions are significant except for "audible – inaudible" impressions.

The analysis result in the second experiment contradicts the result from experiment 1. The similarity in impression of bell sounds between the groups might occur due to the influence of background noise presence.

Table 4.5 One-way ANOVA results for nationality factor.

	Ambient (dB)	relaxing - stressful	pleasing - annoying	audible-inaudible	noticeable - unnoticeable
Bell	65				
	75			*	*
Melody	65	*	*		**
	75	*	**		**

** : p ≤ 1% * : p ≤ 5%

4.2.4.3 Sensitivity

Figure 4.13 shows the comparison between sensitivity groups. People with higher sensitivity tend to respond in higher score in stressfulness and annoyance impression. This implies that people with higher sensitivity will likely perceive train departure sounds as discomfort. The distinction between groups on this impression can be seen clearly at bell sounds. The "audible – inaudible" and "noticeable – unnoticeable" impressions on the other hand do not show any difference in response between each group.

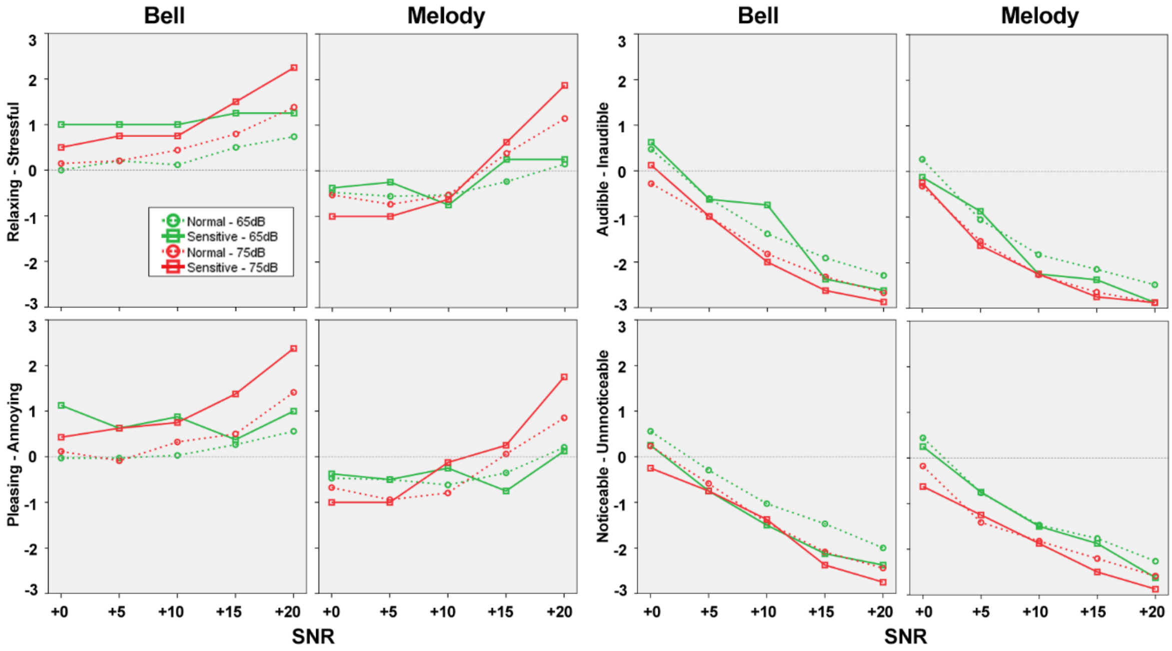

Figure 4.13 Average of discomfort and effectiveness items between sensitivity groups.

Table 4.6 shows the results of analysis of variance between sensitivity groups. It is shown that there is a significant difference between the groups at discomfort impression of bell sounds. Both groups are confirmed to have no difference in audibility and noticeability impressions.

This result is fairly similar to the experiment 1 in which people with higher sensitivity tend to perceive sound as more annoying and stressful, especially bell sounds. Perceived annoyance by high hearing sensitivity people needs to be considered for departure sign sounds.

Table 4.6 One-way ANOVA results for sensitivity factor.

	Ambient (dB)	relaxing - stressful	pleasing - annoying	audible-inaudible	noticeable - unnoticeable
Bell	65	**	**		
	75	**	**		
Melody	65				
	75				

** : p ≤ 1% * : p ≤ 5%

4.3 Summary

This chapter had discussed the difference between socio-demographic groups on their perception towards sounds. The results from both experiments were presented to study any differences that may occur between groups in each experiment.

Section 4.2.3 showed the results from participants of the first experiment. It has been demonstrated that male participants tend to answer higher score on timbre impressions, but much similarities on mood related impressions. Consequently, foreign respondents tend to rate bell sounds as more annoyance than Japanese respondents. Finally, sensitive people tend to suffer from discomfort caused by train departure sign sounds.

Section 4.2.4 showed the results from participants of the second experiment. Female respondents tend to perceive bell sounds as annoyance compared to male respondents. Consequently, foreign respondents, there was no difference found between respondents on bell sounds. However foreigners found melody sounds as more comfortable than Japanese respondents. Lastly, similar to the result from experiment 1, people with higher sensitivity tend to be more annoyed than normal sensitivity people.

In conclusion, it is notable that the results between gender and nationality in the first and second experiments were different. It might be caused by the difference in experiment condition or caused by the difference of participants in both experiments. It is also possible that this opposite result resulted from the small sample size of participants joining the study. On the other hand, the results of sensitivity between the two experiments corresponded with each other despite the difference in listening condition. Therefore, people with high sensitivity are most likely perceive train departure sound as an annoyance, especially at high sound level. It is important to study deeper on the best broadcasting method while taking this group of people into account.

Chapter 5 Conclusion

This chapter will summarize results and findings presented in the previous chapters regarding auditory impressions of train departure sign sounds as well as ideas for future study.

5.1 Summary of the Current Study

In this study, auditory impressions of train departure sign sounds had been presented. This study considered that auditory impressions of train departure sign sounds are influenced by three factors: acoustic factors, environmental factors, and human factors. Acoustic factors which are considered in this research include the psychoacoustic aspects and musical aspects of train departure sign sounds. Environmental factors correlate with the presence of another noise during the broadcasting of the train departure sign sounds. Finally, subjective difference based on gender, nationality, and hearing sensitivity was also studied.

In Chapter 2, the acoustic factors of train departure sign sounds was described as well as its correlation with auditory impression. It was found out that the impressions of bell and melody sounds are highly influenced by their sound level or loudness level. At the same sound level, bell sounds tend to be perceived as less loud than melody sounds. However the former is considered as discomfort than the latter one. In order to predict the discomfort impressions towards departure sign sounds, each bell and melody sounds cannot be generalized. Based on the principal component analysis, bell sounds are better to be predicted by sound level and roughness value, while melody sounds are better to be predicted by sound level and sharpness value.

In Chapter 3, the environmental factors from train stations that were considered to influence auditory impressions had been studied. Ambient noise as an environmental factor showed a result in which it influences the impression of train departure sign sounds. As the ambient sound becomes louder, the negative impressions towards departure sign sound decreases. It is possible that the annoyance which is initially targeted towards the departure sign sounds shifted to the ambient noise instead. Another important finding is that at ambient sound between 65 to 75 dB of LAeq, train departure sounds are better to be played between 5 dB to 10 dB above the noise level which maximizes the audibility and minimizes stressfulness at the same time. As a rule of thumb, 80 dB of LAeq is the most appropriate level to broadcast departure sign sounds at train stations.

In Chapter 4, individual differences between socio-demographic factors were described. Although it seemed that difference between gender and nationality existed on auditory impressions, consistency in trend was not found. This result might be influenced by the limitation of sample size which might be able to be studied further with more sample size. However, the consistency in the difference of response on different sensitivity groups can be seen from both analyses from experiment 1 and 2. This concluded that higher sensitivity influences higher discomfort response towards train departure sign sounds.

In conclusion, this study had done some considerations on various factors that influenced auditory impressions. Prediction of discomfort by sound features can be used as an early guideline for designing train departure sounds that are less stressful. Consequently, the result from ambient noise factor experiment can be utilized as a configuration guideline for broadcasting level.

5.2 Future Research

Acoustic factors, environmental factors, and human factors were all studied in this research. However, each of those factors can actually be expanded more to grasp more detailed pictures of relationship between auditory impressions and train departure sounds. For example in the current study, there was no consideration regarding duration, and phrase length of the departure sounds towards auditory impressions. In the real condition, the duration of train departure sounds may vary. In some cases, train departure bells are played in a considerably long duration which annoys the passengers, while on the contrary there are moments when departure melodies are played shorter than its phrase length which triggers the "incompleteness" feeling towards the sound. These aspects might influence stress and annoyance and might need further study.

One other concern regarding this study is that the experiments are all conducted inside an anechoic chamber. There might be a difference in impression based on the atmosphere in where the sounds are heard. Therefore, it is important to study the impressions on real train stations site for more comprehensive result.

Lastly, based on the result of subjective impressions difference, it was found that people with higher sensitivity tend to perceive train departure sign sounds as an annoyance, especially at higher sound levels. This study did not examine the value of sound level which can be tolerated by people with higher sensitivity. Hence, a specific study of departure sign sounds in correlation with sensitivity consideration might need to be considered.

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Appendix 1 – Questionnaire of Experiment 1

English translations are available behind this page.

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電車の発車サイン音に関する調査

本日は忙しい中、ご協力ありがとうございます。

当研究は、駅の音環境の向上・改善のために、発車サイン音計画の一助となることを目標としております。

手順は次のように行います。

【手順】

皆さんはこの部屋で次の①，②，③を繰り返し行っていただきます。

① 音源が始まる前に目を瞑ってください。

② 発車サイン音の音源を聞いてください。

③ 音源が終わったら、目を開けて、アンケートを答えてください。

全部の音源を聞いていただいた後に、聴感に関する１４個の質問をお答えいただきます。実験の最後に、ご自身のプロフィルについてご記入ください。

【注意項目】

- ご回答いただいた情報は全て厳重に管理し、かつ研究目的以外での個人情報の使用は一切ございません。
- アンケートは気楽にお答えください。また、記入漏れの無いようにお願い致します。
- 既に回答済みの評価とは比較せず、その時の印象をお答えください。

以下に示すそれぞれの印象を 7 段階にし、最も適当な箇所に○を付けてください。その際、あまり深く考えずにお答えください。

＜記入例・１＞　「かなり音が小さい」と感じた場合。

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が大きい Loud						○		音が小さい Soft

更に、聞いていただいたサイン音について、好き嫌いを３段階にし、最も適当な箇所に○を付けてください。その際、あまり深く考えずにお答えください。

＜記入例・２＞　「音が好き」と感じた場合。

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:	○		

この実験に関してご不明な点などございましたら、ご遠慮なくお尋ねください。

1

Train Departure Sound Examination

Thank you for coming to the experiment today.

This study aims to improve acoustic environment in train stations by proposing a regulation for designing and broadcasting train departure sounds.

The procedure of the experiment is as follows.

【PROCEDURE】

For each sound, please follow the following procedures.

1. Please close your eyes before the sound starts playing.
2. Listen to the sound while closing your eyes.
3. Open your eyes after the sound stops, and fill in the form provided.

After you finished listening to all of the sounds, please answer a 14-points questionnaire related to hearing sensitivity. Please also fill a short profile in the last page.

【CAUTION】

- All information will be kept in the strictest confidence: individuals will not be identifiable in any output from this work.
- Please fill the form without hesitation. **Please make sure that you do not skip any questions.**
- Please answer according to what you feel about the sound you hear **without comparing to your previous answers.**

Below, you can see an example on how to fill in the questionnaire. Without thinking too deeply, please put '✓' or'○' mark in the box corresponding to your feeling.

＜Example 1＞　If you feel the sound is quite soft.

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が大きい Loud						○		音が小さい Soft

At the bottom of each table, there is another table that asks whether you like or dislike the sound. Please put '✓' or'○' mark in the box corresponding to what you feel.

＜Example 2＞　If you feel that you like the sound.

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:	○		

Please do not hesitate to ask the person in charge regarding the things on this experiment.

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手順を理解するために、2 個のサンプルが提示されます。以下のアンケートで評価してください。
In order to familiarize you with the procedure, 2 samples will be presented. Please rate these sounds in the following form.

【練習 1・Practice 1】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【練習 2・Practice 2】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

手順は理解したと思うので、これからは本実験が始まります。

You should be more familiar with the procedure now. From now on, the real experiment will start.

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聞こえた発車サイン音の印象について最も適当な箇所に〇を付けてください。
Please put a '✓' or '〇' inside the box corresponding to what you're feeling about the sound.

【Sound 1】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 2】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 3】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 4】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 5】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

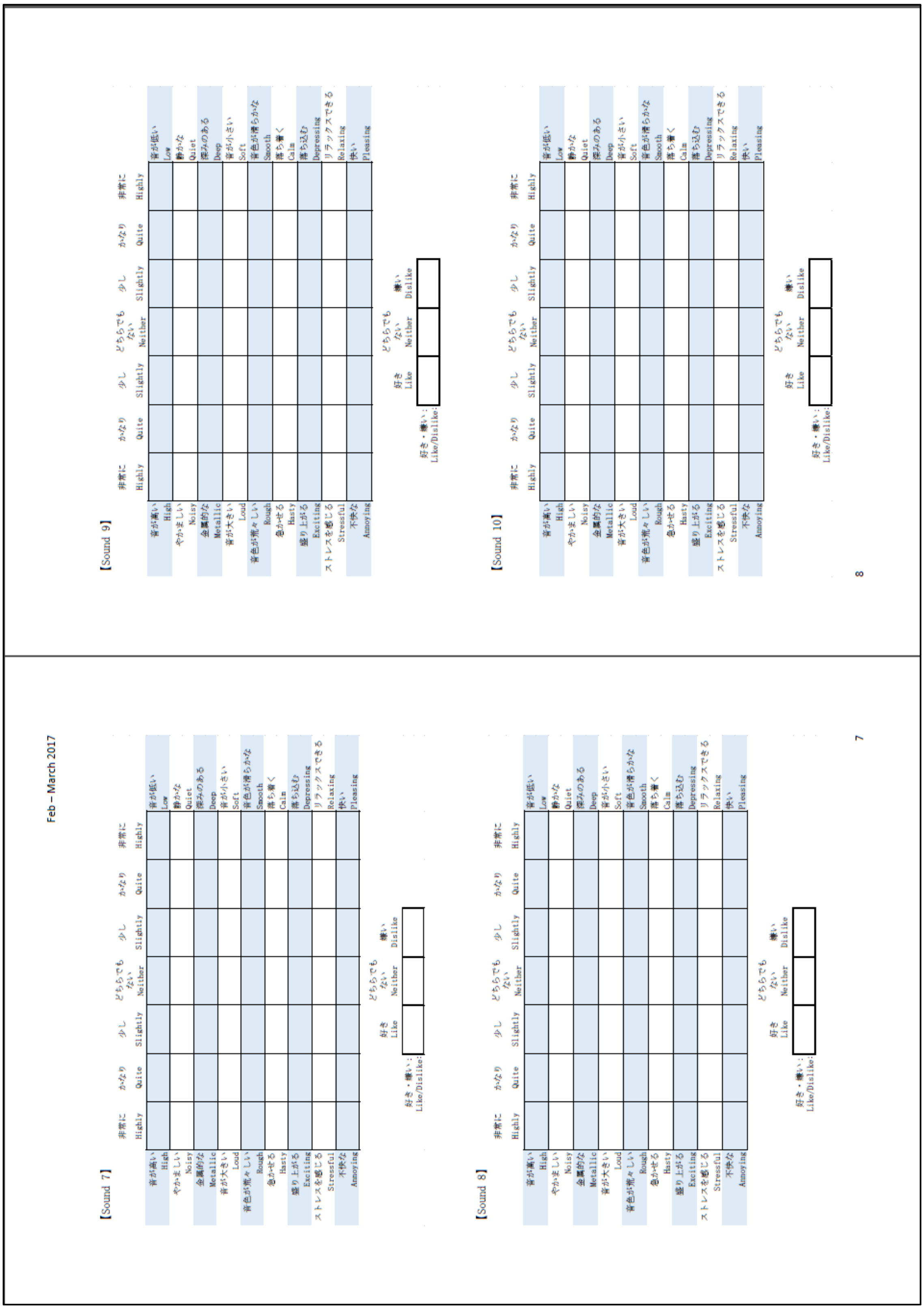
	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 6】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

6



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【Sound 7】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 8】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 9】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 10】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 11】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 12】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 13】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 14】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 15】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 16】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 17】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 18】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 19】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 20】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 21】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 22】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 23】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 24】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 25】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 26】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 27】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 28】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 29】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 30】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 31】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 32】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 33】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が高い High								音が低い Low
やかましい Noisy								静かな Quiet
金属的な Metallic								深みのある Deep
音が大きい Loud								音が小さい Soft
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
ストレスを感じる Stressful								リラックスできる Relaxing
不快な Annoying								快い Pleasing

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

聴覚実験は以上となりました。次のページに聴感に関するアンケートをお答えください。

This is the end of the listening experiment. Please answer hearing sensitivity questionnaire in the following page.

English translations are available behind this page.

Feb – March 2017

日本語の質問用紙

以下の質問では、ご自身にとって最も適当だと思われるも箇所に〇を付けてください。

		いいえ	はい、少し	はい、かなり	はい、非常に
1	騒音を減らすために，これまで耳栓やイヤーマフを使用したことがありますか？（異常なほどに激しい騒音にさらされている状況下での聴覚保護のための使用は除きます）				
2	日常生活において，周りの音を無視することにしんどさを感じますか？				
3	騒々しい場所や大きな音のする環境で文字を読むことに，困難を抱えていますか？				
4	周囲が騒々しい中で集中することに困難を抱えていますか？				
5	騒々しい場所で会話を聞くのが難しいですか？				
6	知人に「あなたは騒音や特定の種類の音を我慢するのが苦手だ」と言われたことがありますか？				
7	通りの騒音に特に敏感だったり悩まされたりしていますか？				
8	ある社会的な場面で，音を不快だと感じますか？（例：ナイトクラブ，居酒屋やバー，コンサート，花火大会，立食パーティ）				
9	人に何かをしようと提案された時（外出，映画，コンサートなど），そこで我慢することになるであろう騒音についてすぐに考えますか？				
10	直面せねばならないであろう騒音が原因で，今まで招待を断ったり，外出しなかったりしたことがありますか？				
11	少しうるさい部屋にいる時よりも静かな場所にいる時のほうが，騒音や特定の音に悩まされますか？				
12	ストレスや疲労は，あなたが騒音の中で集中する力を減弱させますか？				
13	一日の終わりが近づくにつれて，騒音の中で集中することができなくなっていきますか？				
14	騒音や特定の音が，ストレスやいらだちの原因になりますか？				

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ENGLISH QUESTIONNAIRE

Please put a '√' or'〇'in the box corresponding to the answer which best applies to you.

		No	Yes, a little	Yes, quite a lot	Yes, a lot
1	Do you ever use earplugs or earmuffs to reduce your noise perception? (*Do not consider the use of hearing protection during abnormally high noise exposure situations*)				
2	Do you find it harder to ignore sounds around you in everyday situations?				
3	Do you have trouble reading in a noisy or loud environment?				
4	Do you have trouble concentrating in noisy surroundings?				
5	Do you have difficulty listening to conversations in noisy places?				
6	Has anyone you know ever told you that you tolerate noise or certain kinds of sound badly?				
7	Are you particularly sensitive to or bothered by street noise?				
8	Do you find the noise unpleasant in certain social situations? (*e.g. night clubs, pubs or bars, concerts, firework displays, cocktail receptions*)				
9	When someone suggests doing something (going out, to the cinema, to a concert, etc.), do you immediately think about the noise you are going to have to put up with?				
10	Do you ever turn down an invitation or not go out because of the noise you would have to face?				
11	Do noises or particular sounds bother you more in a quiet place than in a slightly noisy room?				
12	Do stress and tiredness reduce your ability to concentrate in noise?				
13	Are you less able to concentrate in noise towards the end of the day?				
14	Do noise and certain sounds cause you stress and irritation?				

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プロフイル・BIODATA

1. 性別・Gender : 男・Male 女・Female

2. 年齢・Age : __________ 歳・years old

3. 国籍・Nationality : ____

日本人ではない方は次の質問を答えてください。For non-Japanese, please answer the following question.

4. どのぐらい日本に住んでいますか？ - How long have you been living in Japan?
   ____________________年・Year________________ヵ月・Month

お疲れ様でした。実験は終了となります。ご協力ありがとうございました。

This is the end of the experiment, thank you for your participation.

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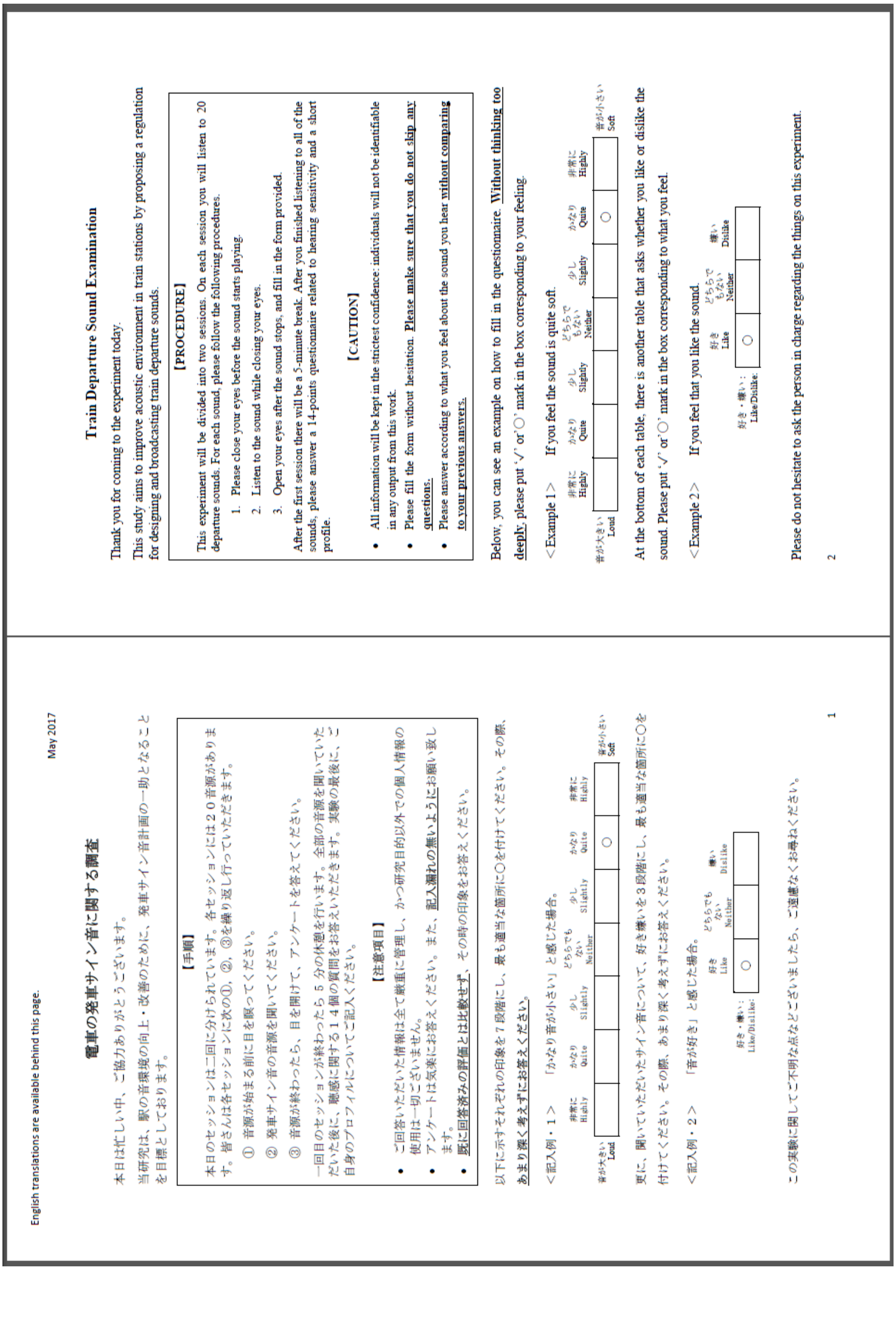
Appendix 2 – Questionnaire of Experiment 2



English translations are available behind this page.

May 2017

電車の発車サイン音に関する調査

本日は忙しい中、ご協力ありがとうございます。

当研究は、駅の音環境の向上・改善のために、発車サイン音計画の一助となることを目標としております。

【手順】

本日のセッションは二回に分けられています。各セッションには２０音源があります。皆さんは各セッションに次の①，②，③を繰り返し行っていただきます。

① 音源が始まる前に目を瞑ってください。

② 発車サイン音の音源を聞いてください。

③ 音源が終わったら、目を開けて、アンケートを答えてください。

一回目のセッションが終わったら５分の休憩を行います。全部の音源を聞いていただいた後に、聴感に関する１４個の質問をお答えいただきます。実験の最後に、ご自身のプロフィルについてご記入ください。

【注意項目】

- ご回答いただいた情報は全て厳重に管理し、かつ研究目的以外での個人情報の使用は一切ございません。
- アンケートは気楽にお答えください。また、**記入漏れの無いように**お願い致します。
- **既に回答済みの評価とは比較せず**、その時の印象をお答えください。

以下に示すそれぞれの印象を７段階にし、最も適当な箇所に〇を付けてください。その際、**あまり深く考えずにお答えください。**

＜記入例・１＞　「かなり音が小さい」と感じた場合。

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が大きい Loud						〇		音が小さい Soft

更に、聞いていただいたサイン音について、好き嫌いを３段階にし、最も適当な箇所に〇を付けてください。その際、あまり深く考えずにお答えください。

＜記入例・２＞　「音が好き」と感じた場合。

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:	〇		

この実験に関してご不明な点などございましたら、ご遠慮なくお尋ねください。

1

Train Departure Sound Examination

Thank you for coming to the experiment today.

This study aims to improve acoustic environment in train stations by proposing a regulation for designing and broadcasting train departure sounds.

【PROCEDURE】

This experiment will be divided into two sessions. On each session you will listen to 20 departure sounds. For each sound, please follow the following procedures.

1. Please close your eyes before the sound starts playing.
2. Listen to the sound while closing your eyes.
3. Open your eyes after the sound stops, and fill in the form provided.

After the first session there will be a 5-minute break. After you finished listening to all of the sounds, please answer a 14-points questionnaire related to hearing sensitivity and a short profile.

【CAUTION】

- All information will be kept in the strictest confidence: individuals will not be identifiable in any output from this work.
- Please fill the form without hesitation. **Please make sure that you do not skip any questions.**
- Please answer according to what you feel about the sound you hear **without comparing to your previous answers.**

Below, you can see an example on how to fill in the questionnaire. **Without thinking too deeply**, please put '✓' or'〇' mark in the box corresponding to your feeling.

＜Example 1＞　If you feel the sound is quite soft.

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が大きい Loud						〇		音が小さい Soft

At the bottom of each table, there is another table that asks whether you like or dislike the sound. Please put '✓' or'〇' mark in the box corresponding to what you feel.

＜Example 2＞　If you feel that you like the sound.

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:	〇		

Please do not hesitate to ask the person in charge regarding the things on this experiment.

2

May 2017

手順を理解するために、2 個のサンプルが提示されます。以下のアンケートで評価してください。
In order to familiarize you with the procedure, 2 samples will be presented. Please rate these sounds in the following form.

【練習 1・Practice 1】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【練習 2・Practice 2】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

手順は理解したと思うので、これからは本実験が始まります。
You should be more familiar with the procedure now. From now on, the real experiment will start.

3

【Session 1】

聞こえた発車サイン音の印象について最も適当な箇所に〇を付けてください。
Please put a '✓' or '〇' inside the box corresponding to what you're feeling about the sound.

【暗騒音・Ambient Sound】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が大きい Loud								音が小さい Soft
やかましい Noisy								静かな Quiet
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 1】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

4

【Sound 2】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 3】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 4】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 5】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 6】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 7】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 8】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 9】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 10】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 11】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 12】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 13】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 14】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 15】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 16】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 17】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 18】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

【Sound 19】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

【Sound 20】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

セッション１は以上になりました。どうぞご休憩ください。

This is the end of the first session. Please have a break.

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【Session 2】

聞こえた発車サイン音の印象について最も適当な箇所に○を付けてください。
Please put a '√' or 'O' inside the box corresponding to what you're feeling about the sound.

【暗騒音・Ambient Sound】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
音が大きい Loud								音が小さい Soft
やかましい Noisy								静かな Quiet
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

【Sound 21】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

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【Sound 22】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

【Sound 23】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

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【Sound 24】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 25】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 26】

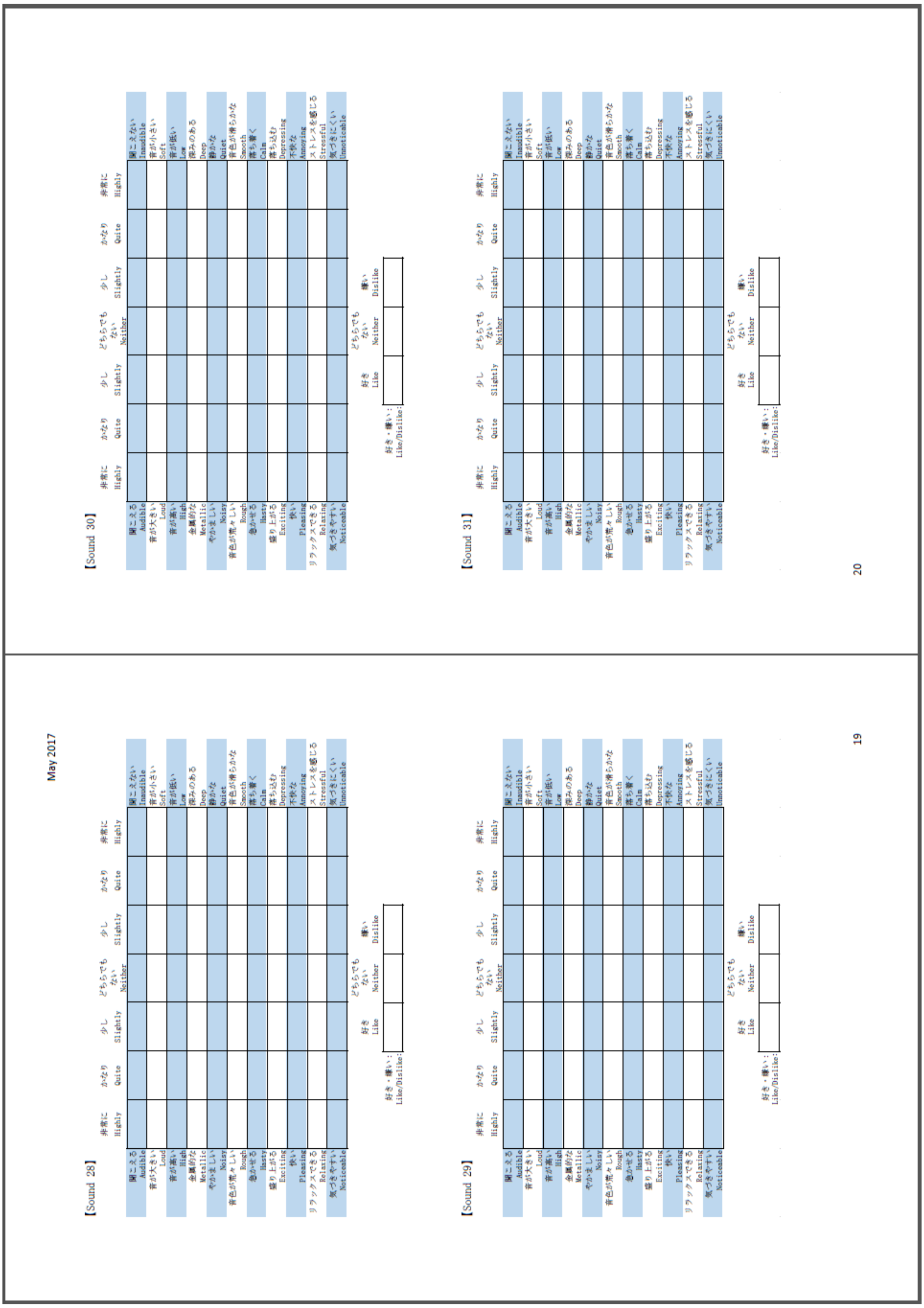
	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 27】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			



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【Sound 28】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 29】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 30】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 31】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

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【Sound 32】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 33】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 34】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 35】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 36】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 37】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 38】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 39】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticeable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い：Like/Dislike:			

【Sound 40】

	非常に Highly	かなり Quite	少し Slightly	どちらでもない Neither	少し Slightly	かなり Quite	非常に Highly	
聞こえる Audible								聞こえない Inaudible
音が大きい Loud								音が小さい Soft
音が高い High								音が低い Low
金属的な Metallic								深みのある Deep
やかましい Noisy								静かな Quiet
音色が荒々しい Rough								音色が滑らかな Smooth
急かせる Hasty								落ち着く Calm
盛り上がる Exciting								落ち込む Depressing
快い Pleasing								不快な Annoying
リラックスできる Relaxing								ストレスを感じる Stressful
気づきやすい Noticeable								気づきにくい Unnoticable

	好き Like	どちらでもない Neither	嫌い Dislike
好き・嫌い： Like/Dislike:			

聴覚実験は以上となりました。次のページに聴感に関するアンケートをお答えください。

This is the end of the listening experiment. Please answer hearing sensitivity questionnaire in the following page.

English translations are available behind this page.

日本語の質問用紙

以下の質問では、ご自身にとって最も適当だと思われるも箇所に〇を付けてください。

		いいえ	はい、少し	はい、かなり	はい、非常に
1	騒音を減らすために，これまで耳栓やイヤーマフを使用したことがありますか？（異常なほどに激しい騒音にさらされている状況下での聴覚保護のための使用は除きます）				
2	日常生活において，周りの音を無視することにしんどさを感じますか？				
3	騒々しい場所や大きな音のする環境で文字を読むことに，困難を抱えていますか？				
4	周囲が騒々しい中で集中することに困難を抱えていますか？				
5	騒々しい場所で会話を聞くのが難しいですか？				
6	知人に「あなたは騒音や特定の種類の音を我慢するのが苦手だ」と言われたことがありますか？				
7	通りの騒音に特に敏感だったり悩まされたりしていますか？				
8	ある社会的な場面で，音を不快だと感じますか？（例：ナイトクラブ，居酒屋やバー，コンサート，花火大会，立食パーティ）				
9	人に何かをしようと提案された時（外出，映画，コンサートなど），そこで我慢することになるであろう騒音についてすぐに考えますか？				
10	直面せねばならないであろう騒音が原因で，今まで招待を断ったり，外出しなかったりしたことがありますか？				
11	少しうるさい部屋にいる時よりも静かな場所にいる時のほうが，騒音や特定の音に悩まされますか？				
12	ストレスや疲労は，あなたが騒音の中で集中する力を減弱させますか？				
13	一日の終わりが近づくにつれて，騒音の中で集中することができなくなっていきますか？				
14	騒音や特定の音が，ストレスやいらだちの原因になりますか？				

May 2017

ENGLISH QUESTIONNAIRE

Please put a '✓' or'○'in the box corresponding to the answer which best applies to you.

		No	Yes, a little	Yes, quite a lot	Yes, a lot
1	Do you ever use earplugs or earmuffs to reduce your noise perception? (*Do not consider the use of hearing protection during abnormally high noise exposure situations*)				
2	Do you find it harder to ignore sounds around you in everyday situations?				
3	Do you have trouble reading in a noisy or loud environment?				
4	Do you have trouble concentrating in noisy surroundings?				
5	Do you have difficulty listening to conversations in noisy places?				
6	Has anyone you know ever told you that you tolerate noise or certain kinds of sound badly?				
7	Are you particularly sensitive to or bothered by street noise?				
8	Do you find the noise unpleasant in certain social situations? (*e.g. night clubs, pubs or bars, concerts, firework displays, cocktail receptions*)				
9	When someone suggests doing something (going out, to the cinema, to a concert, etc.), do you immediately think about the noise you are going to have to put up with?				
10	Do you ever turn down an invitation or not go out because of the noise you would have to face?				
11	Do noises or particular sounds bother you more in a quiet place than in a slightly noisy room?				
12	Do stress and tiredness reduce your ability to concentrate in noise?				
13	Are you less able to concentrate in noise towards the end of the day?				
14	Do noise and certain sounds cause you stress and irritation?				

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プロフイル・BIODATA

1. **性別・Gender : 男・Male 女・Female**
2. **年齢・Age : ________ 歳・years old**
3. **国籍・Nationality : ____________________**

日本人ではない方は次の質問を答えてください。**For non-Japanese, please answer the following question.**

4. どのぐらい日本に住んでいますか？ **- How long have you been living in Japan?**
   ____________年・**Year**____________ヵ月・**Month**

お疲れ様でした。実験は終了となります。ご協力ありがとうございました。

This is the end of the experiment, thank you for your participation.

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