REVIEW OF ASPECTS OF AUDITORY SIGNAL STUDIES IN JAPAN

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ABSTRACT

Sound is very important in human communication. It evokes an attention and conveys much information even if a listener does not pay attention to the signal. These are very big advantages for information transmission. Information transmission that uses sound in addition to a speech have similar characteristics. Therefore, a lot of auditory auditory signal sounds other than language, such as alarms and warning signals are used frequently. Social conditions surrounding auditory signals and recent researchs are reviewed here.

1. INTRODUCTION

At the point of information transmission by sound, it shouldn't disturb the sound environment of the public space with unnecessary or inappropriate sound, and shouldn't be a factor in the loss of the amenities of the environment. Also, it should transmit desired information precisely without stress. These problems have only been researched individually in Japan so far. Though, recently, research at the general view has proceeded and more researchers have started to research signal sounds. This review surveys this situation.

1.1. Previous Research of Auditory Signal

Research of articulation is one of a research regarding information transmission that coincides with the international current. The main goal was to estimate articulation from physical indicators. Only normal listeners have been evaluated previously, but creating the acoustically comfortable environment for elder people whose audibility declined and attention to visual defects are more emphasized at present. This is because of the social recognition of the importance of universal design after 1990. Some research in sound articulation at present focuses not only on physical conditions but also on the articulation for elder people.

1.2. Situation Surrounding Auditory Signal in Japan

Sound in public spaces has been rarely had social interest in Japan until recent years. When you come right down to it, the only problem registered was that the sound of loudspeaker was too noisy. It has been regarded as a noise problem.

Since JR Sinjuku and JR Shibuya stations changed the departure bell sound to melodies, the sound in public spaces has greatly changed. Not only at stations but also various signal sounds started to change to more melodious sound.

This tendency was criticized by intellectuals[1]. Many sound responses, not only to bells at stations but also crossings, vending machines, and cash dispensers at banks have problems.

In the late 1990s, when mobile telephones became widely used, ring tones became melodies and "ring melodies" became common. After the handsets with sound and rhythm customization functions were introduced, it became fad, and "ring-melody book" and so on were sold. More sophisticated models which are available for harmony and sampled real sound have appeared recently. Since Internet connection functions were standardized, various ring-melodies have been able to be down loaded from the web. However, ring sounds make people very uncomfortable in public spaces such as trains. This has focused on as a social problem.

The alarm sounds of home electronic appliances are emerging, as well. At home, every home electronic appliances, such as washing machines, rice cookers and video decks, transmit their condition by sound. Though, it is sometimes confusing to define what is beeping and what to do with it. Manufacturers have tried to make good easily defined sound at low cost. Unnecessary loud sounds are decreasing, but there are many interface related problems to solve. Especially, action for elder people is needed since Japan is now an aging society.

Research of images and impressions of public sound design is very difficult. There are still many cases where designers decide by intuition, or of interface designers who don't really know about sound.

1.3. Research Subject as Auditory Signal

Considering the above historical background of Japanese society, the following could be the research subjects:
Focus on objects, researches are conducted in two fields: one is the signal sound of domestic electronic appliances and the other is that used in public spaces. Though auditory signal in the industrial field (cockpit and various machines) is an important interface to improve safety, it could hardly be a research subjects.
Focus on humans, researches are conducted also on two points. Response of elder people losing hearing abilities and that of visually impaired defect people.

1.4. Research Organization and Journal

Researches regarding to auditory signal have presented at the following associations:

+ The Acoustical Society of Japan
+ Architectural Institute of Japan
+ Japan Ergonomics Society
+ Soundscape Association of Japan

Following institutions conduct researches:

+ Research Institute of Human Engineering for Quality Life
+ Japan Sign Design Association

Research Institute of Human Engineering for Quality Life measures human perception based on government project and possesses an enormous quantity of database. Japan Sign Design Association has set a committee to survey and promote the sign design at public spaces. Three reports have been published [2,3,4]. Mailing list (as-ml) is published, working with this committee. As for the rest, individual university, governmental institution such as National Institute of Advanced Industrial Science and Technology (AIST) and local researchers conduct researches.

1.5. Japanese Industrial Standards（JIS）

JIS is Japanese Industrial Standards, and sets up mainly the physical features and its measure of industrial products.
Looking at the present JIS, words and concepts are not standardized. Also, other than the following standards are the least physical feature and experimental method, but no standard of how to ring.

1.5.1. General rules for alarms of medical equipment

Based on this standard (JIS T 1031) [5], alarm can be divided into three groups according to the situation: “emergency alarm”, “alert” and “sound off”. Pattern of time wave and primary frequency for each alarm is stated. Also, a property sound pressure level at 1m point of machine operation board should be more than 70dB for maximum sound pressure level, Primary wave should be square or close wave and its attenuation /complex wave. However, machines are not always built according to the standard.

1.5.2. Alarm of Consumers’ Products

In August 1999, Association for Electric Home Appliances (AEHA) suggested Guideline (draft) [6] for single frequency alarm. JIS has stated standard at the point of usability in advance and has ideological standard about alarm as a part of it [7]. JIS S 0031 [8], the latest standard, is one of the design guideline for elder and disability people. At the functional point, alarm of home electric appliance alarms can be classified into three: “operation confirmation”, “completion” and “alert”. Each alarm recommends the primary spec of time pattern. Also, considering the high frequency that elder people can usually not hear, it suggests to set under 2.5kHz.

1.6. Domestic laws

Domestic laws regulate whistle, emergency bell, operation sign of machines, road alarm facility, car alarming horn, emergency car siren and etc. Foreign countries should be considered to have various standards, but individual standard and law exist independently without systematic regulation.

2. REVIEW OF PUBLISHED PAPERS IN JAPAN

2.1. Basic Principle of Information Transmission by Sound

Transmission Process of signal sound can be shown as figure 1 [9]. There are causes of problems at the contact point where the information between signal origin and its receiver is conversed. Problems can be classified as follows:

*Impossible to hear: occurs when the sound physically gets below the hearing threshold. Also, masking sometimes disturbs hearing.

*Impossible to be aware: occurs in lack of attention, though physically received.

*Impossible to comprehend: occurs when the signal receiver doesn’t know the conversion code of the signal expression.

*Mistake of comprehension: occurs under condition when the receiver knows the conversion code. It is same as misunderstanding even when they heard words precisely.

Slight misunderstanding of the conversion code between sender and receiver can be the cause.

*Little credibility: is mainly a problem of the system. Continuous misreport reduces the credibility of information.

*Noise: gives the receiver uncomfortable impression by the signal. No matter useful information it is, receivers feel it noisy if it has inappropriate sound or volume. Being forced to listen to unnecessary information increases discomfort index.

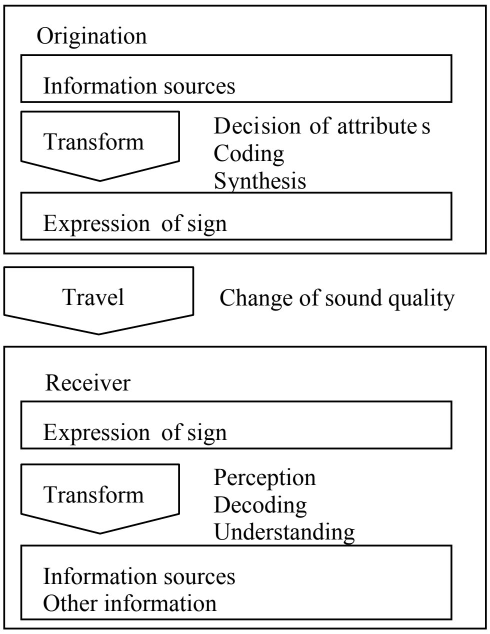

Figure 1 Flow of information

2.2. Effect of Impression by Sound

To design Auditory signal, the effect of the impression of the sound itself is not considered enough. Though, focusing on those factors is important for designing sound that transmits information.

KUWANOs [10] survey the impression of alarm sound energetically. Especially, comparing alarm sound in different countries, they clarified that a sound with no sense of danger can't be in the same way in another country. Also, they clarified from experiment that general condition for sense of danger should be a sound with frequency change (FM sound) and of quick circle.

MIZUTANIs [11] experimented with acoustic sense along time pattern supposing an alarm for home electric appliances. Increment of time lag decreases sense of urgency.

KURAKATAs [12] survey the stopping patterns of home electric appliances and considered compatibility with intended content. As a result, they found out that volume setting is clearly inappropriate or some trumpet patterns are hard to define.

IWAMIYAs [13][14] examine how to classify the imitation sound of auditory signal and its relationship with the physical volume of Japanese sound. There is no significant tendency between primary frequency of vocal spectrum and Auditory signal. Vocal usage seems to be very arbitrary. Nasal sound is used for normal or damped long sound, geminative consonant is for short sound and long sound is used for normal, especially long sound.

KOSAKA [15] is trying to estimate the impression of sound by neural networks. The tendency is hardly seen since there is no reference about the change of parameter at each sound. Also, inappropriate reference about physical volume of sound (Volt was used for volume of sound) can be seen, but it is worth while paying attention as a technique to design the impression which changes nonlinearly.

I experimented with the change of impressions according to slight differences of time forms of sound evaluated by SD method [16]. Following is the summary.

2.2.1. Impression Change of Rising and Decaying Sound

Sound such as alarm or alert sounds by simple device like piezoelectric speaker. It is generally a time form exhibiting rapid rise and decay. The sound is not comfortable. Change of sound impression by time wave of sound pressure level is clarified here quantitatively.

(1)Experiment Method

Rise time and decay time of sample sound is the time to change 60dB (figure 2). Sample sound is pure sound that lasts 500ms with frequency 2000Hz. These sounds were created by computer and recorded to music CD type.

Speaker was placed at 2m horizontal from subjects. Subjects were 13 men and 2 women of 20-29 years old.

Sample sound was set in brief anechoic room. Subjects were given each sound twice at random. After the hearing, subjects evaluated with 5 levels adjective measure.

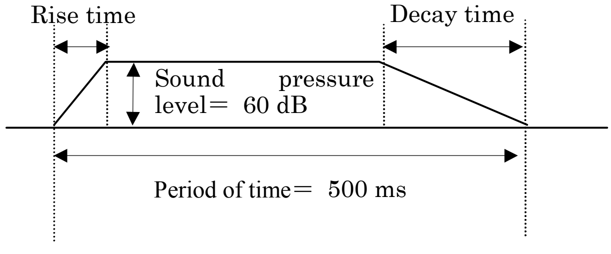

Figure 2 The structure of stimulus sound

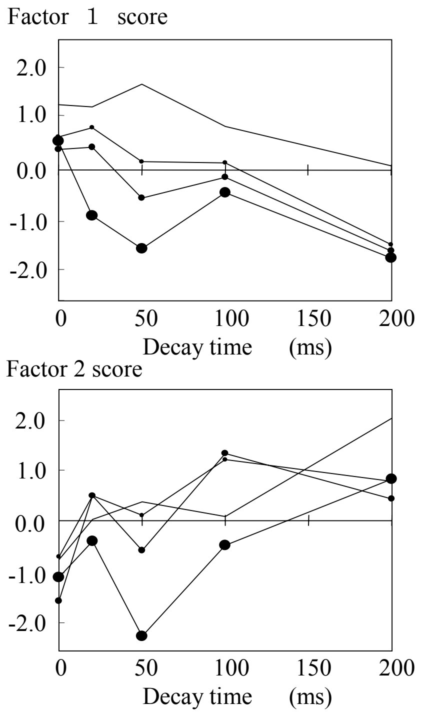

Figure 3 Relation among factor score, rise time and decay time

Rise time — 0 (ms) —•— 20 (ms) —•— 50 (ms) —●— 100 (ms)

(2) Speculation

Average was calculated from every result of SD method and analyzed the factors (SPSS for PC ver.9). Based on the eigenvalue 1.0 and obtained 2 factors.

First factor was estimated to “metal factor” and second factor was “nonmaterial factor” by the factor loadings after varimax rotation.

Three factors “beautiful factor”, “vigor factor” and “metal factor” express the sound. However, “vigor factor” wasn’t shown at this time. Since the change of transitional sound pressure was focused, overall loud was almost the same. As a result, “vigorous” or “rough” didn’t create individual factor.

Figure 3 show the relationship between attributes of sample sound and factor scores. Rise time greatly effects on metal factor. Less the rise time is, harder the image of metal is. Contrary, more the rise time is, softer the image of metal is. Decay time greatly effects on nonmaterial factor. If the decay is longer than rise, nonmaterial factor becomes higher. Under the condition of too long a rise time (100ms) makes either metal or nonmaterial factor lower.

(3)Conclusion

At present, a few signal sounds of electric appliances control rise and decay time. It is inevitable since it costs a lot. However, the configuration of the device could greatly improve the comfort index of sound.

2.3. Easiness of Hearing for Elder People

Since elder people are losing their hearing ability, the masking situation should be different from normal people. Those people are not an exception, but exist in high rate in the aging society of Japan. However, surveys of the masking feature of elder people are a few.

Plomp [17] conducted primary investigation of articulation and age. It is found out that losing audibility leads to lose articulation. Universal Design investigates in detail about the acoustic function of elder people [18][19].

KAWATAs [20] investigated the difference of impression against alarm by elder and young people, using pure pink noise for background and pure sound, AM sound and sweep sound for alarm. Either generation shows that frequency modulated sound has sense of emergency. It coincides the result of KUWANOs and MIZUTANIs.

Actual operating space / life space have various background noise. Under such environment with lower articulation, problem is which sound of frequency is easy to hear. Following is the examples of evidence [21].

2.3.1. Hearing Threshold of Alarm at Domestic Background Noise

Many primary frequencies of alarms used with home electric appliances are 2k-4kHz. Higher frequencies are hard for elder people to hear because of loss of hearing. Though, if an alarm sound is of a low frequency, it could be masked in the daily background noise.

This essay shows the masking threshold of elder people with backup sound.

(1)Experiment Method

Time pattern of alarm is that to repeat on-time and off-time5 times, 0.10s each. Frequency is pure sound with 1-4kHz.

Real domestic sound of 5 second is used as background noise. Sound pressure level is as much as to replicate the recorded situation. 1 second alarm sounds in 5 seconds backup sound.

Sample sound is recorded to music CD by PC and plays from the speaker in the experiment room. Subjects can adjust the sound pressure level of alarm when they want. Under the background noise, subjects adjust the alarm as small as they can possibly hear. Alarm is only ascending series, because many of them had illusion that they can hear longer with descending series. (Ascending series is the method to increase the volume from slight sound.)

Subjects are 40 elder people and 10 young people. According to the result of acoustic exams with pure sound of 1kHz and 4kHz, elder subjects were classified to normal group (18 who hasn't lost any audibility with 25dB) and auditory disturbance group (22 who have lost audibility of more than 25dB at more than one sound).

(2)Frequency Comparison of Threshold

Figure 4 shows the average of frequency characteristics of each background sound and hearing threshold according to the subject group. Frequency characteristics indicate 5 seconds Leq, so that hearing level of object, which has wide change such as TV, seemed to be much less than background sound. Actually, they evaluated when the provided background sound became smaller.

In case of softer sound, such as TVs, pianos or washing machines, the auditory disturbance group of elder people and young people shows significant difference. It is an effect of audibility. Even in the case of high sound of sound pressure with no effect of physical threshold, elder people shows high tendency of hearing level. It indicates the possibility of changing of masking threshold.

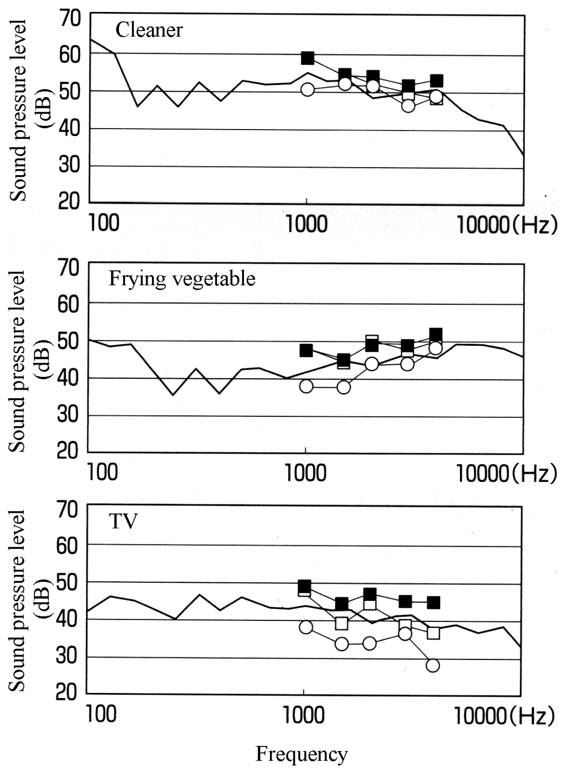

Figure 4 Frequency characteristics of background noise and masked threshold
Filled square: elder [auditory disturbance group]
White square: elder [normal group]
Circle: young

(3)Conclusions

Hearing threshold in actual cases are changed by the masking of background noise. Frequency features of domestic environment sounds are varied; especially high sounds are greatly varied. It is efficient to make alarms with less than 3kHz primary frequency.

To consider the effect of background noise, JIS [22] has published some life environment sound. It is desirable to expand more sound sources.

3. CONCLUSIONS

Regarding the standardization of information transmission sounds, international coordination is desirable, especially for information regarding safety. However, total international standardization is impossible. Impressions of sound greatly affect the meaning of sound. There are many undefined points concerning acoustic psychological problems that various sounds have various impression tendencies, and continuous research is needed.

Also, the historical background of sound used can't be ignored. Every country has different culture and customs about sound. For making international standards, social problem would occur about how to reach agreement.

For comprehensive sound for everyone, the response of elder people is one of the most important points. Though, considering the effect of background noise as mentioned above, state condition is not simple, and the efforts to find case-by-case solutions are necessary.

Recently, basic technology makes it possible to create and use not only simple sounds but also music and sound comparatively easy. Music may make the classification of sound easy and may create a comfortable situation. Also, sound may decrease miscomprehension and realize understandable usability.

However, we shouldn't use such sound easily. It is not only because raising cost can't be avoided. The more information increases, the more people may feel it is noise. Forcing unnecessary information greatly increases discomfort index. Further consideration is necessary to define in which cases interfaces with a large volume of information are appropriate. In reality, there are many cases where information by sound is exceeded in public spaces.

To simplify the sound environment and to achieve functional information transmission, the relationship between information transmission by sound and physical and psychological response should be clarified. It will be more necessary to utilize it in the concrete design of the sound environment.

Based on above research, design guideline should be stated in the future. It is desirable to meet international standard at some parts. As a result, more comprehensible and easily hearing sound of information transmission would be realized.

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