JAPANESE INDUSTRIAL STANDARDS ON AUDITORY SIGNALS OF CONSUMER PRODUCTS

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ABSTRACT

Consumer products, such as domestic appliances, which are recently available on the market often adopt auditory signals to enhance interface usability. The signals, however, have been a cause of trouble for the user; this is because either (a) users can be confused since signals for different purposes are similar to each other or (b) some signals are hard to hear, especially by elderly users. This paper introduces two Japanese Industrial Standards (JIS) and a related JIS Technical Report that aim at improving design of user-friendly auditory signals.

1. INTRODUCTION

Consumer products, such as domestic appliances, which are currently available on the market often adopt auditory signals in their user-interfaces. Such signals notify users that the appliance has finished its function, such as cooking, or that it has some malfunction. Use of auditory signals has become popular along with full automation and sophistication of appliance functions. The user can leave an appliance while it is working, yet remain informed of its progress. Sometimes the user must do something depending on what the appliance requires her to do. Auditory signals are expected to improve usability of those appliances. Signals are also indispensable for the elderly, who are not accustomed to such products, and for the visually impaired, who need to manage appliances solely by responding to auditory signals.

One common criticism, however, is that users have difficulty judging meaning of auditory signals since similar sounds are sometimes used for different purposes. If a signal warns the user that something dangerous is happening (e.g., an iron has been turned over), he needs to do something immediately. On the other hand, if it is simply signaling that the appliance has finished its function (e.g., a washing machine has finished washing), she does not have to take action right away and may leave it as it is. Thus, signals for one purpose should be clearly distinguishable from those for another purpose. It is also desirable that rules for assigning acoustic properties to signals with different purposes be broadly similar across products and manufacturers.

Another criticism of current auditory signals is that they cannot be heard distinctly enough or not at all in some cases. A major reason for this is that loud domestic sounds, such as noise from a vacuum cleaner or washing dishes, might mask signals and render them difficult to hear. Thus, it is desirable that signal levels be determined such that they can be heard clearly in noisy situations. Another cause of problems is attributed to reduced hearing ability of elderly persons; ability to discern signals from background noise deteriorates with age. Therefore, signal-level criteria should be carefully determined so that signals can be heard clearly not only by young users, but also elderly users.

In order to help developing user-friendly auditory signals used in consumer products, the Japanese Ministry of Economy, Trade and Industry has been engaged in establishing two Japanese Industrial Standards (JISs) and a JIS Technical Report (TR) in collaboration with the National Institute of Advanced Industrial Science and Technology (AIST), Japan. The following briefly introduces those Standards.

2. TEMPORAL PATTERNS OF AUDITORY SIGNALS - JIS S 0013:2002

JIS S 0013[1] is a comprehensive guideline for product designers to develop auditory signals suitable for the elderly and the visually impaired as well as young people with normal hearing faculties, which was recently established in January 2002. (It is actually a revised version of another Standard[2] and was made separate to expand its contents.). Items prescribed in this Standard are: (a) definitions and classifications of auditory signals, (b) recommended temporal patterns classified in terms of signal purpose, (c) other notes on acoustical properties of auditory signals to make them clearly audible and understandable, such as fundamental frequencies and the number of sound components.

Auditory signals were classified into three types in terms of the signal purpose: (1) *operating and feedback signals* that sound when the user pushes a button on a control panel and tell whether the operation was correctly accepted, (2) *completion signals* that sound when the appliance has finished its function, (3) *attention signals* that notify the user that the machine has some malfunction or that the user has mishandled it.

Although this Standard is to be a basis of related Standards on auditory signals, item (b) was emphasized -- temporal patterns of auditory signals. Confusion caused by similar signals has become a serious matter due to the large number of domestic appliances using auditory signals as described above. Another reason was that temporal pattern is, perceptually, a relatively reliable cue for users to identify auditory signals compared to other cues such as frequency or intensity patterns.

The Standard recommends temporal patterns of auditory signals for each of the three signal types. Patterns were selected based on psychoacoustic experiments where young, elderly, and visually impaired persons served as listeners. In the experiments, listeners were presented with a series of sample signals and rated each of them on a rating scale. For *operating and feedback signals* and *completion signals*, they evaluated how well the signal impression fit the signal purpose. For *attention signals*, they judged the degree of perceived urgency. For every case of judgment, temporal patterns which ranked higher were selected for recommendation.

Figure 1 shows patterns for *operating and feedback signals* prescribed in the Standard. Short single tones were adopted for *start or acceptance signals* and long single tones for *stop signals*. Short paired tones were used for *origin signals* that notify the user that he has returned to the starting point on a cyclic menu. (This signal is especially beneficial for a visually impaired person who gets lost navigating a menu.)

Figures 2 and 3 show examples of recommended patterns for *completion signals* and *attention signals*, respectively. Five patterns were adopted for *completion signals* and four for *attention signals*. Relatively rapid tone sequences were assigned to *attention signals* to elicit the impression of greater urgency.

As more manufacturers design auditory signals following this guideline, inconsistency of signal-patterns will be minimized across manufacturers and products; users will be able to identify more easily the meaning of each signal.

Category	Temporal pattern	Sound type	ON time s	OFF time s	Remarks
start or acceptance signal	ON	single tone	0.1~0.15	—	short tone
stop signal	ON	single tone	0.5~0.6	—	long tone
origin signal	ON1 ON2 OFF Note: ON1 = ON2 ON ≧ OFF	single paired tones	0.05~0.075	0.05~0.075	paired tones with a short interval

Fig. 1 Recommended temporal patterns of *operating and feedback signals*.

Category	Temporal pattern	Sound type	ON time s	OFF time s	Remarks
comple-tion signal	ON ----- OFF Note 1. ON ≦ OFF 2. The number of repetitions can be arbitrarily determined.	repeti-tion of single tones	0.3~0.8	0.5~1.0	repeated slowly

Fig. 2 An example of recommended temporal patterns of *completion signals*.

Category	Temporal pattern	Sound type	ON time s	OFF time s	Remarks
attention signal	ON ----- OFF Note: ON = OFF	repeti-tion of single tones	0.1	0.1	repeated rapidly

Fig. 3 An example of recommended temporal patterns of *attention signals*.

3. DATABASE OF DOMESTIC SOUNDS – JIS/TR S 0001:2002

Although JIS S 0013 prescribes basic principles for designing auditory signals, there remains a matter that this Standard does not fully address: sound pressure levels of signals. Since auditory signals may be masked by background domestic noises, designers need to know what level is required for signals to be heard in noisy situations. The working group of the Standard was aware of that problem, but refrained from including definitive descriptions on signal sound levels in the Standard. A variety of domestic sounds come from different sources and have different acoustic properties. They may also differ from room to room. Thus, it was not easy either to propose a method for designing signals which are audible against domestic sounds or make recommendations on necessary sound levels.

Although there may be large differences among domestic sounds, their characteristics can be determined statistically by collecting large quantities of measured data. If their average acoustic properties and statistical distribution are made clear, it would be possible to estimate a sound level necessary for auditory signals to be discerned among background noises.

At the time when JIS S 0013 was established, a database of domestic sounds was made public as JIS/TR S 0001[3]. The TR consists of two database types: (a) a set of graphical data of frequency characteristics of domestic sounds, and (b) a recorded library of domestic sounds that have median frequency characteristics shown in the database (a). The former can be used to find, graphically, combinations of suitable frequencies and sound pressure levels for signals. The latter is contained on a compact disc attached to the main text of the TR. The library can be used in psychoacoustic experiments in which auditory signals are presented with recorded sound(s); listeners then judge, for example, whether they can hear signals against them. Such experiments may be carried out using either a loudspeaker or headphones.

3.1 Graphical Data of Domestic Sounds

Recording of domestic sounds was conducted in 14 model or private houses. Recorded sounds were those generated by the following 11 appliances and by a person doing housework in four types of rooms. (1) In a kitchen: washing dishes, boiling water in a pot, a ventilation fan, and a microwave oven. (2) In a washroom: a washing machine, a clothes drier, washing hands, and a hair drier. (3) In a bathroom: running water from a faucet or a shower. (4) In a living room: a television and a vacuum cleaner.

Sounds were recorded with an omni-directional microphone located at a position that would correspond to the center of the head of a person using the appliance or doing housework (Fig. 4a). Thus, recorded sounds have typical characteristics that a person in each situation might perceive.

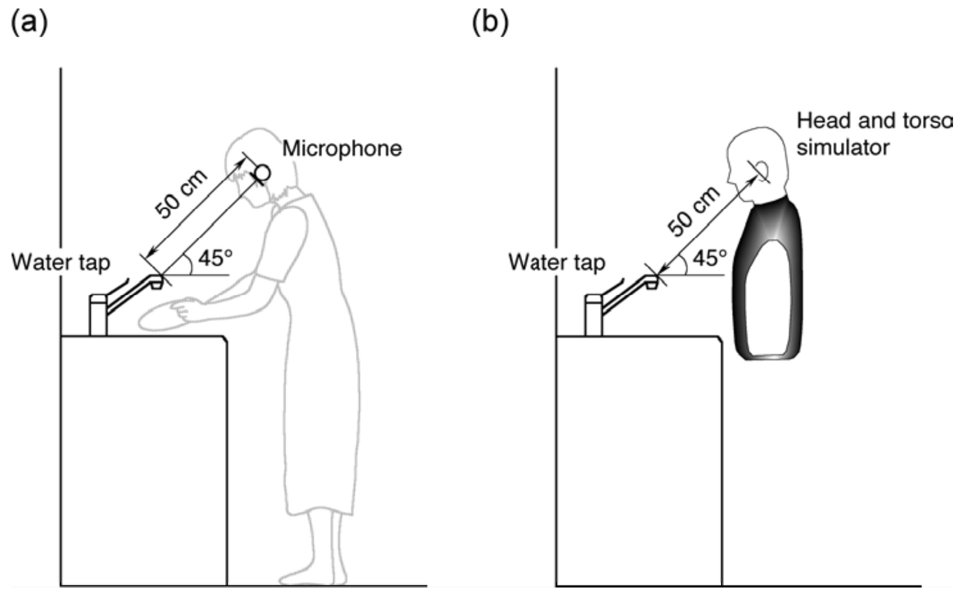

Fig. 4 A setting of recording apparatus and materials. (a) A microphone, (b) a head and torso simulator. (Recording of a sound of washing dishes.)

Figure 5 shows an example of graphical data showing average one-third octave band levels of domestic sounds. Five curves appear in each graph, each indicating percentile levels of all data recorded in identical conditions. These curves mean, for example, that 90% of data around the median lie within the range between the 5 and 95 percentile levels.

When a pure tone is presented against a broadband noise, one can just detect the tone if it has about the same power as that within the critical band with the same center frequency as the pure tone. As the bandwidth of critical bands can be approximated by one-third octave bandwidth when its center frequency is around 500 Hz and above, one-third octave band levels of domestic sounds can be a good measure for audibility of auditory signals presented against them; if a pure tone signal has a sound level sufficiently higher, say 10 dB or more, than the one-third octave band level of a domestic sound at a corresponding center frequency, the signal would be audible for the user in that situation.

As data appear with statistical distributions, one can also use them to determine a sound volume range. For example, if a volume control covers the range corresponding to that between the 5 and 95 percentile levels, one can expect the variable signal would be just detectable in 90% of users' houses by adjusting the volume.

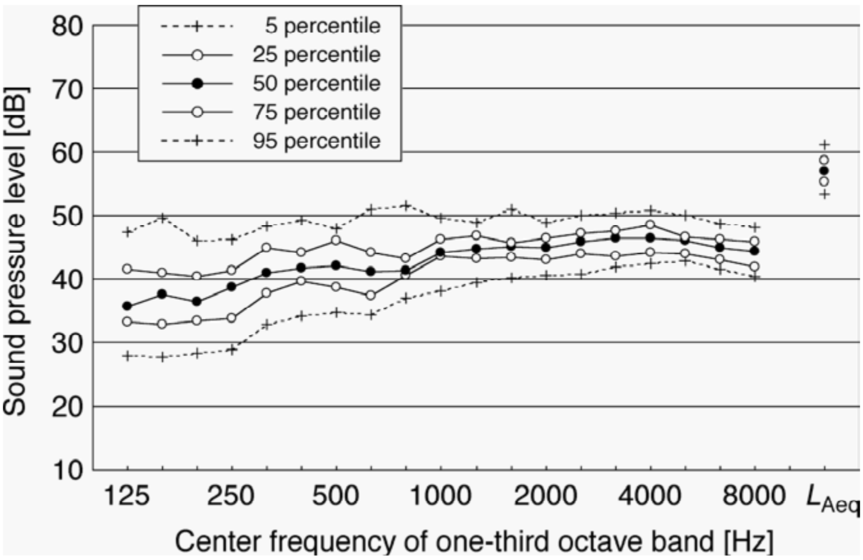

Fig. 5 Graphical data showing domestic sound frequency characteristics. (A sound of washing dishes.)

3.2 Recorded Library of Domestic Sounds

Although one-third octave band levels can be used for rough estimation of audibility, some kinds of auditory signals may require further examination. For example, detectability of a sound varying in amplitude or frequency, such as "melody" signals or speech sounds, cannot be estimated based on long-term average characteristics. Elderly people typically have some hearing loss and their hearing ability can be adversely affected by extraneous noise. Thus, product designers need to find a sound level ensuring signal reception for the elderly as well as for young people. Furthermore, the criteria of determining a signal level are not restricted to whether it is detectable or not. Designers may want to know what level is required for a signal to be heard "loudly enough."

Sounds in the library can be used in a psychoacoustic experiment to assess audibility of signals from these points of view. Recording of domestic sounds was done with a microphone (Fig. 4a) and a head and torso simulator (Fig. 4b). Sounds were then modulated to have median frequency characteristics in the graphical data described in the previous section. Thus, if one plays back sounds at a designated level, a domestic sound with typical frequency characteristics in each situation can be reproduced at the listener's position (with a loudspeaker) or at her ears (with headphones).

In the listening experiment, auditory signals in question are presented with domestic sound(s) along with which an appliance with signals would be used. After listening to a signal with the background sound(s), listeners may be asked, for example, whether they could hear the signal or whether the signal was loud enough. Through such an experimental procedure, one can evaluate various aspects of audibility for any kind of auditory signal.

4. SOUND PRESSURE LEVELS OF AUDITORY SIGNALS FOR ELDERLY USERS

As elderly people generally have hearing loss and their hearing ability is adversely affected in noise backgrounds, the sound level of auditory signals should be adjusted adequately to ensure their audibility. Signals with higher levels may be beneficial for elderly users, but excessively high-level sounds would be annoying for young users with normal hearing.

AIST is trying to establish another JIS on this issue. The new JIS is to prescribe a procedure to determine necessary and sufficient levels of auditory signals used in noisy conditions by elderly as well as young users. In this procedure, one first measures sound pressure levels of auditory signals and domestic sounds against which the signals would be heard. Next, by examining levels of these two sounds while referring to values in tables of the Standard, he can judge whether the designed signals will be audible for elderly users. If not, he can find a necessary level to be added to the signals. Since maximum levels can be evaluated in a similar way, signals designed with this procedure will have a volume range extending from a level loud enough for the elderly to one sufficiently quiet for the young.

The draft of the Standard is now under consideration in the Committee concerned and will be made public within the year.

5. CONCLUDING REMARKS

With rapid growth of the elderly population, the need to develop products suitable to it is increasing year by year. The author is expecting many researchers to take interest in this issue and cooperatively improve methods for designing auditory signals suitable for all users, including the elderly and hearing impaired.

The JISs and TR described here are written in Japanese, but the author will be eager to help translate it into English or other languages on request.

REFERENCES

[1] JIS S 0013, “A guideline for the elderly and impaired persons - Auditory signals on consumer products,” (Japanese Standards Association, Tokyo, 2002).
[2] JIS C 9102, “Guideline for usability-design of electric home appliances,” (Japanese Standards Association, Tokyo, 1996).
[3] JIS/TR S 0001, “A guideline for determining the acoustic properties of auditory signals used in consumer products - A database of domestic sounds,” (Japanese Standards Association, Tokyo, 2002).