Audio Signals in Domestic Appliances
Evaluated in Terms of the Hearing Ability of Older Adults

KURAKATA Kenji*, KUBA Yasuyoshi*, KUCHINOMACHI Yasuo*, and MATSUSHITA Kazuma†

*Nat. Inst. of Bioscience and Human-Technology, AIST, MITI, 1-1 Higashi, Tsukuba, Ibaraki, 305-8566 Japan and †Nat. Inst. of Technology and Evaluation, MITI, 2-49-10 Nishihara, Shibuya, Tokyo, 151-0066 Japan

Abstract: The audio signals used in domestic appliances currently available on the market were recorded to identify suitable signals for the hearing ability of older adults. The results of the analysis indicated the following three problems: (1) Some appliances use high-frequency tones around 4000 Hz. Since these sounds are hard for older adults with presbycusis to hear, it would be better to use signals with lower frequencies. However, the problem here is that if the frequency is lowered, then the signal might be masked by domestic sounds whose power would be greater relative to the lower-frequency signals. (2) The signals used by some appliances are too soft. The intensity of some signals should be adjusted to compensate for the hearing loss among older adults. (3) The sounds used in these appliances are often very similar in terms of both timbre and temporal ringing patterns. This may cause confusion because it is difficult to identify which appliance is signaling.

INTRODUCTION

As the serious problems of an aging society approach, measures are being taken in various fields to overcome them. Domestic appliances, such as microwave oven and videotape recorder, which are designed for elderly people have appeared on the market, although most have been developed from models originally designed for younger adults. However, there are still several features with these products which make them unsuitable for the elderly. One of the problems is the auditory signals used in these appliances. Elderly people often claim that the sounds are hard to hear(1). To determine the current situation, we recorded the auditory signals used in domestic appliances on the market with the help of four manufacturers in Japan. In this paper, we will discuss the results of the analysis and the problems which might be expected to occur given the hearing ability of the elderly.

SOUND CHARACTERISTICS OF AUDITORY SIGNALS IN DOMESTIC APPLIANCES

Method

Auditory signals of domestic appliances made by four of the major manufacturers in Japan were recorded. The recordings were conducted in soundproof rooms at each of the manufacturers. The appliances investigated were as follows: air conditioner, clothes drier, electric fan, electric pot, electric water heater, electromagnetic cooker, facsimile, humidifier, iron, microwave oven, oil fan-heater, refrigerator, rice cooker, tableware washer and drier, videotape recorder, and washing machine. Microphones (Rion, UC-52) were set at two positions: (1) At a distance of 10 cm above the control panels under which the sound sources are embedded, and (2) at a distance of 50 cm and an angle of 45 degrees upward (downward for air conditioners) from the panels. The latter position corresponds to the center of the user's head when using the appliance. Every signal was rung several times and recorded on a digital audio tape. The complete range of sound signals for the various appliances were collected, such as the different sounds emitted when a control button is pressed or something is wrong, or those to notify the user that the machine has finished working.

Results of Analysis

Figure 1 shows a histogram of the fundamental frequencies for 16 kinds of appliances, with 46 products in total (In some cases, the products have more than one kind of sound). It is clear from this figure that the graph has two peaks between the frequencies, 2000 - 2500 Hz and 3500 - 4500 Hz. Considering the equal-loudness contours (ISO 226), the human auditory system is most sensitive to tones around 4000 Hz. In this sense, tones around the peak of the higher frequencies may be suitable as signals for young adults. However, this frequency range also corresponds to where hearing loss due to aging is most commonly observed(2). Therefore, tones within the frequency region around 4000 Hz are hard for the elderly to hear and may not be suitable as auditory signals, as has been pointed out in JIS (Japanese Industrial Standard) C 9102(3). In response to that guideline, the number of products which employ lower-frequency tones has been increasing recently. The peak of the distribution around 2000 Hz seems to be a reflection of this trend. In particular, many electric ovens and washing machines use auditory signals around this frequency.

There is another aspect to be considered in regard to frequency. Domestic sounds such as those of televisions and of vacuum cleaners have relatively greater power at low-frequency regions. If the frequency of an auditory signal is simply lowered, then it becomes harder to hear against those domestic sounds which might mask it out. Thus we
must also take into account the effect of masking when we determine suitable frequencies for the signals.

Figure 2 shows the sound pressure levels for auditory signal used in 14 kinds of appliances, with 26 products in total. Closed squares indicate sounds which signal that the appliance has finished working, as with cooking or washing products. Triangles indicate sounds which notify the user of some handling error (e.g., heating an empty pot) or malfunctions. Open squares indicate other general sounds which ring, for example, when pushing a button on a control panel. The figure shows that the sound pressure levels vary widely among the appliances. Washing machines use relatively high-level sounds. It is reasonable when we consider that the user will leave them while they are running. On the other hand, the levels of some sounds, such as those which notify that an empty electric pot is being heated, or that an iron has been overturned (indicated by triangles) are relatively low compared with other danger signals. Furthermore, in the case of rice cookers, the levels of signals used by two manufacturers to indicate that cooking has finished differed by about 20 dB. These weaker signals cannot be heard against background noises.

It is hard to determine definitely suitable sound levels to use as signals. It depends on the level of background domestic sounds and on that of the operating noise of the appliances themselves. In addition, as hearing ability deteriorates, people tend to turn up the volume controls on televisions and to speak louder. Thus, we must consider these points to ensure that the signals are sufficiently audible.

**PROBLEMS RELATED TO HIGHER COGNITIVE PROCESSES**

Even if auditory signals are loud enough to hear, there are still some problems related to higher cognitive processes. For example, (1) it is sometimes impossible to distinguish which appliance is signaling. Part of the reason for this is that current auditory signals are very similar to each other in timbre and time patterns. (2) Users do not know what to do next because the meaning of signal is not always clear. These problems can be serious especially in kitchens, where many kinds of electric appliances are used at the same time. Furthermore, elderly people sometimes fail to detect signals when they are engaged in other activities, due to a general deterioration in ability to pay attention to more than one thing at a time. This problem must also be taken into consideration when we design alarms to warn of mishandling or danger.

**REFERENCES**