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THE TIMBRE AND ANNOYANCE OF AUDITORY WARNING SIGNALS IN DIFFERENT COUNTRIES

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ABSTRACT
It is desirable to have internationally standardized auditory warning signals which are used for informing people of dangerous happenings. The results of our former studies suggest that there is a cross-cultural difference in the impression of some signals and that generally speaking frequency-modulated sounds are perceived as being dangerous. On the basis of these results, the present study was designed to investigate the effects of frequency components and temporal factors. Systematically controlled synthetic sounds were used as stimuli and their timbre was judged by subjects using semantic differential. The results of the experiments conducted in Osaka, Oldenburg, Munich and Boston suggested that the signal whose frequency shifts from low to high in wide range and which is repeated without pause gives the impression of dangerousness and is appropriate for the auditory warning signal.

1 - INTRODUCTION

Signals of various sensory modalities may be used as warning signals which inform people of dangerous happenings. Among them, auditory signals have advantages that they are nondirectional and can be transferred in wide areas. It would be desirable to meet the following requirements in order that the auditory warning signals should be effective.

- They are easily detected in noisy situations.
- They are easily detected by people of any generations including the aged people.
- They are easily recognized as a warning signal.
- There is no cultural difference in the recognition of the signals.

The results of our former studies concerning the aspects of [3] and [4] suggest that there is a cross-cultural difference in the impression of some signals and that generally speaking frequency-modulated sounds are perceived as being dangerous in different countries [1-3].
On the basis of these results, the present study was designed to investigate the effects of frequency components and temporal factors on the impression of dangerousness with systematically controlled synthetic sounds. Cross-cultural comparison was made among four places in three countries.

2 - EXPERIMENT

2.1 - Stimuli

Systematically controlled synthetic sounds were used as stimuli. The stimuli consisted of a sound of 500 msec which was repeated 10 times with off-time. The frequency was shifted from low to high in two octaves. Six kinds of frequency components and four kinds of off-time were used as shown in Table 1. These 24 kinds of sound were prepared with and without low frequency components. In total 48 kinds of sound were used. The maximum level of each signal was 75 dB.

Stimulus	Frequency (Hz)	off-time (ms)
1	125 →500	0
2	125 →500	100
3	125 →500	300
4	125 →500	500
5	250 →1k	0
6	250 →1k	100
7	250 →1k	300
8	250 →1k	500
9	500 →2k	0
10	500 →2k	100
11	500 →2k	300
12	500 →2k	500
13	1k →4k	0
14	1k →4k	100
15	1k →4k	300
16	1k →4k	500
17	2k →8k	0
18	2k →8k	100
19	2k →8k	300
20	2k →8k	500
21	(125 →500)+(500 →2k)	0
22	(125 →500)+(500 →2k)	100
23	(125 →500)+(500 →2k)	300
24	(125 →500)+(500 →2k)	500

Table 1: List of stimuli (the stimuli from 25 to 48 are the same as the stimuli from 1 to 24, respectively, except for low frequency components).

2.2 - Procedure

The timbre of the stimuli was judged using semantic differential. Sixteen pairs of adjectives were used. They are shown in Fig. 2. The experiment was conducted in Osaka, Japan, Oldenburg, and Munich in Germany and Boston in the US. Adjectives were indicated in Japanese in Osaka, in German in Oldenburg and in English in Munich and Boston. In Osaka the experiment was conducted in a sound proof room with one subject at a time. All the subjects conducted the experiment twice in different days. In Oldenburg the experiment was conducted once with all the subjects together in a sound proof room. In Munich the experiment was conducted in a sound proof room with small group of subjects. All the subjects conducted the experiment twice in different days. In Boston the experiment was conducted in a sound proof room with one subject at a time. Ten subjects did experiment twice in different days, but the other fourteen subjects once.

2.3 - Subjects

Eleven female and nine male subjects aged between 19 and 40 years old participated in Osaka, twelve female and fourteen male subjects aged between 19 and 40 years old in Oldenburg, two female and nine male subjects aged between 23 and 55 years old in Munich and fourteen female and ten male subjects aged between 18 and 51 in Boston.

3 - RESULTS AND DISCUSSION

3.1 - Impression of the signals

Since the reliability of the judgment of the subjects was confirmed in each place, all the judgments were used for the following analyses.

The adjective scale values for "dangerous − safe" are shown in Fig. 1. It was found that stimuli No. 21 and 45 were perceived as being the most dangerous among the 48 stimuli in all the four places and also No.17 and 41 in Munich and Oldenburg. The stimuli No. 17 and 41 are the sounds with high frequencies and the stimuli No.21 and 45 are with wide frequency range. Semantic profiles of the stimuli No.17 and 21 are shown in Fig. 2, Fig. 3. It can be seen that these sounds give the impression "dangerous", "exciting", "powerful", "busy", "tense" and "unpleasant".

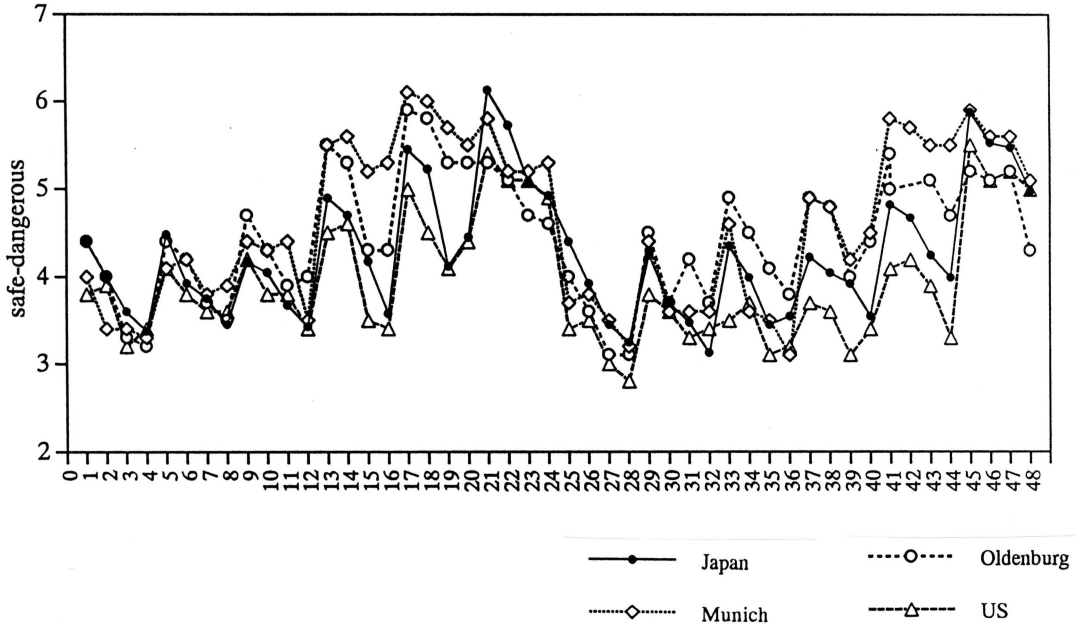

Figure 1.

3.2 - Effect of frequency components

The relations between the adjective scale values for "dangerous − safe" and the lowest frequency of the sounds are shown in Figs. 4, 5, 6 and 7. It is indicated that the impression becomes more dangerous as higher the frequency becomes in all the four places except for the stimuli No.21 to 24. The stimuli No.21 to 24 include wide frequency range and were perceived as being dangerous.

3.3 - Effect of off-time

The relations between the adjective scale values for "dangerous − safe" and off-time are shown in Figs. 8, 9, 10 and 11. It is shown that the impression becomes more dangerous as shorter the off-time becomes in all the four places.

4 - CONCLUSION

From the results of the experiments conducted in Osaka, Oldenburg, Munich and Boston, it was suggested that the signal whose frequency shifts from low to high in wide range and which is repeated without pause (off-time) gives the impression of dangerousness and is appropriate for the auditory warning signal. When the signal consists of wide frequency range, it would not be masked in noisy situations [4] and can be detected by the aged people whose hearing is deteriorated. It would be desirable have the international standard for auditory warning signals.

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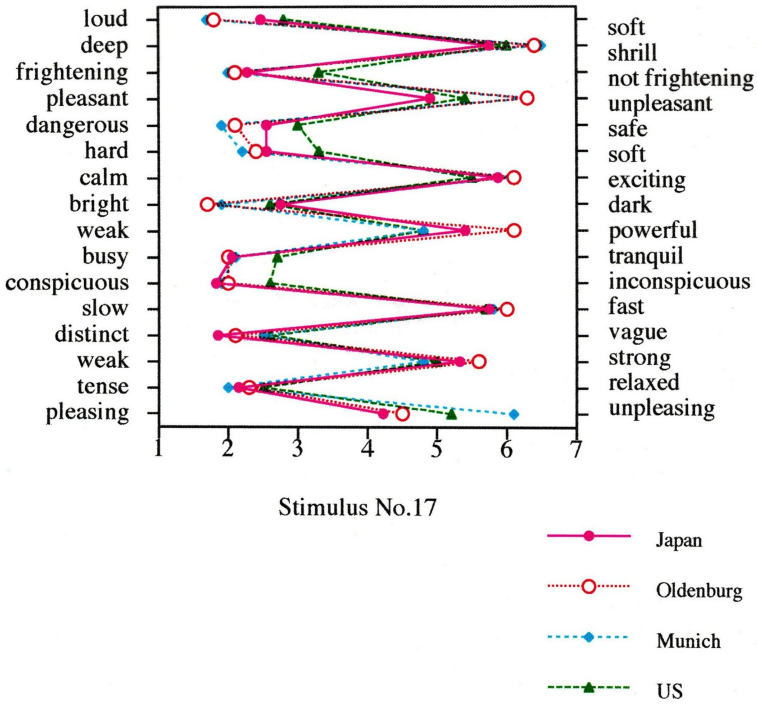

Figure 2.

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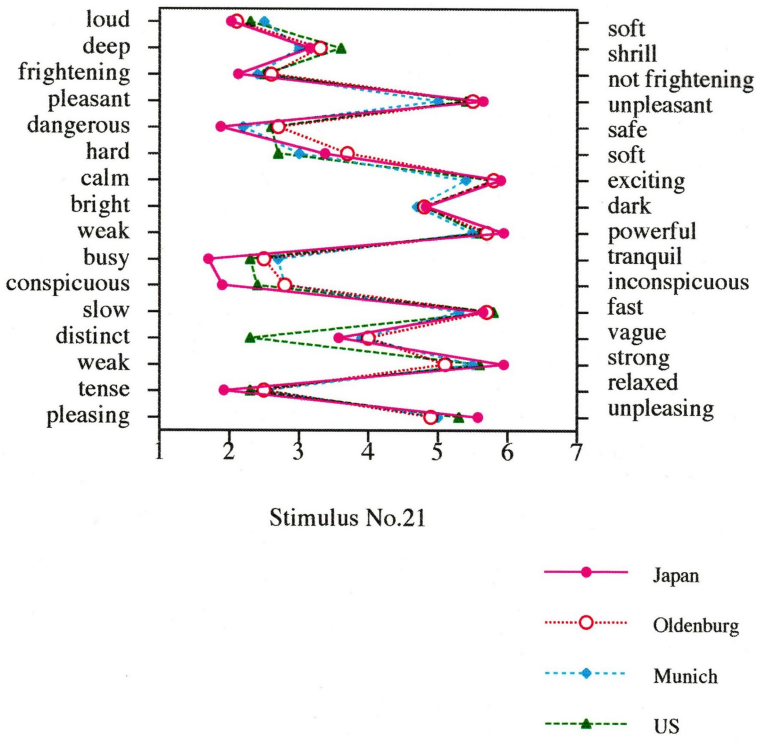


Figure 3.

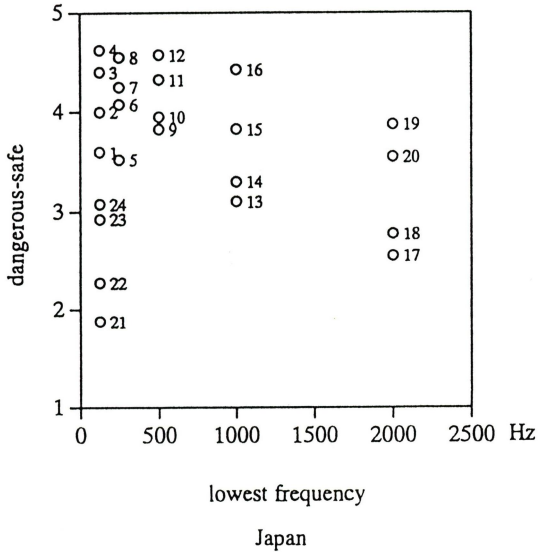
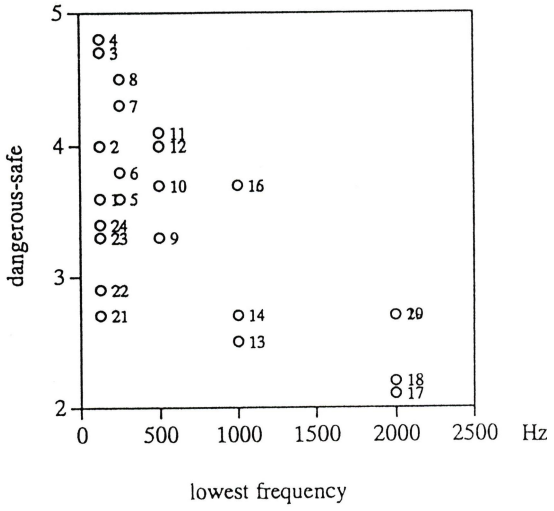
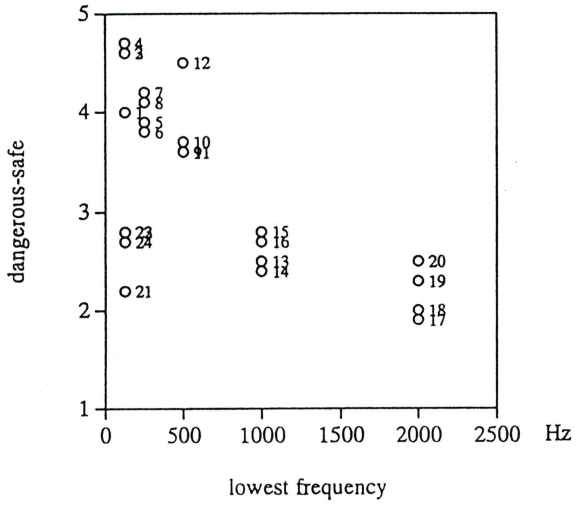


Figure 4.



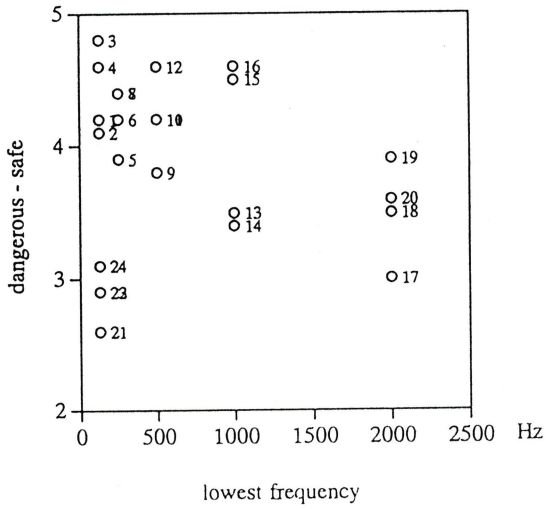
Oldenburg

Figure 5.



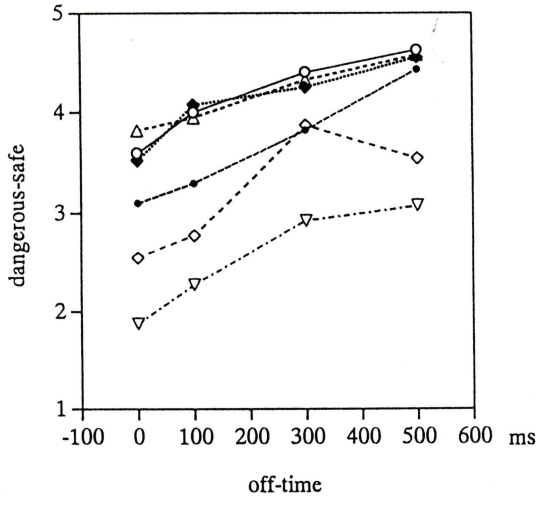
Munich

Figure 6.



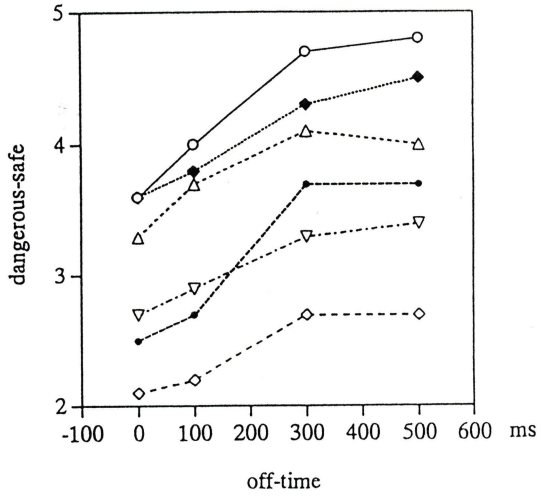
US

Figure 7.



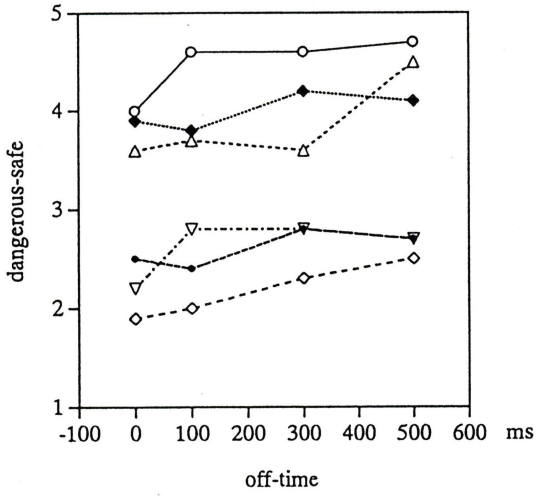
Japan

Figure 8.



Oldenburg

Figure 9.



Munich

Figure 10.

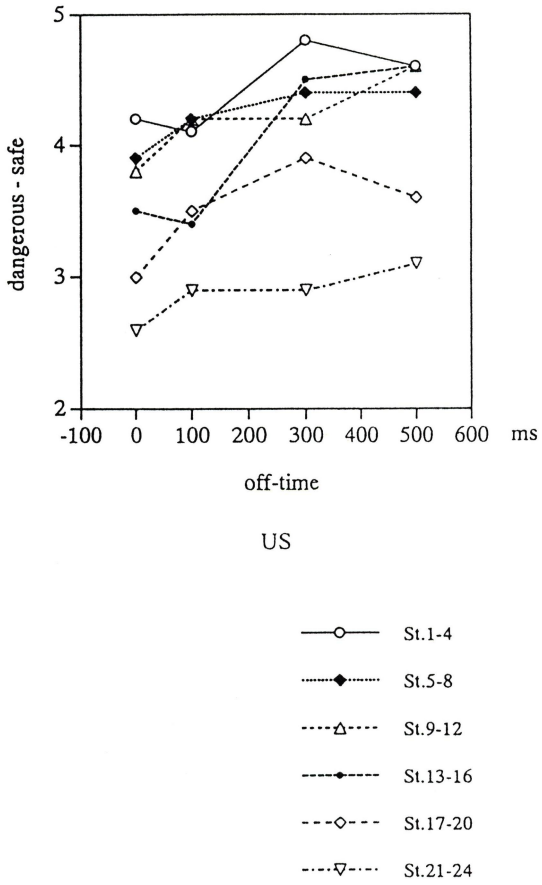

5
4
3
2
dangerous - safe
-100
0
100
200
300
400
500
600
ms
off-time
US
St.1-4
St.5-8
St.9-12
St.13-16
St.17-20
St.21-24

Figure 11.