Abstract: A rapid evacuation is important for reducing damage caused by major earthquakes. This research focuses on an emergency alert system applied during an earthquake, specifically, a system that provides an emergency alert interval between two mono sounds. Adequate research has yet to be conducted in this field; therefore, intuition is important. The present research is useful for analyzing ways to reduce the damage caused by large disasters. A total of 36 students participated. To search for an emergency alert interval between two mono sounds, we used an anklet to search for an image. We then revived the association using a factor analysis. As a result, we divided the 10 evaluation factors into three groups and labeled them the unrest factor, impact factor, and hardness factor. The unrest factor was connected to the alert chord, and the impact factor was connected to the sound interval of the alert. Thus, emergency alerts evaluated these two factors.

Keywords: Emergency alert; Mono sound; Factor analysis

1. INTRODUCTION

This research focused on the importance of emergency alerts to inform dangerous situations. Sound has an effect on human behavior, and thus improving emergency sounds can reduce damage. At present, emergency alerts depend on the sensitivity of the composer, and scientific research in this area is useful for society.

This research revealed the influence of sound intervals using the SD method and a Kansei image survey. The test subjects were 18–20 years of age and included both men and women.

2. Research procedure

We conducted three surveys. These research procedures are presented in Figure 1.

3. Preliminary survey

3.1 Aim for preliminary survey

This study surveys people subjectively using an SD based sensitivity survey and investigates which pitch change of an alarm sound can convey danger more effectively. As a preliminary survey, we decided on the definition of the alarm sound, created a sample sound, and conducted a questionnaire survey to examine the differences in each waveform pattern.

According to the research method, sample sounds put out by a PC were heard by the subjects in a salient room. The subjects then answered a questionnaire about the sample sounds. Eight sample sounds were played, and the subjects answered the questionnaire from five levels of evolution for each of six evaluation factors.

3.2 Necessary conditions of emergency alert

We extracted the necessary conditions to satisfy the function of the emergency alert from a previous study:

- Easily hear every generation;
- Possibility of feeling a sense of danger;
- Possibility of classifying other sounds.

Based on these terms, we created 24 types of samples.

3.3 Creating sample sounds
The sample sounds were created under the following conditions: (Figure 2)

1. The sound interval was set using a half tone equal in temperament based on a C note (261.626), with 12 types of combinations created using 2 tones for up to 1 octave.
2. The sound combination was repeated at 120 bpm for 10 s.
3. Two types of tone, a saw-tooth wave and a square wave (from a previous study) were prepared.
4. A sample sound within 250–5000 Hz was created.

Under these conditions, a sample sound was created using waveform generation software.

3.4 Questionnaire

The adjective pairs representing the nature of the danger and the adjectives used in the previous study were applied as the six evaluation factors shown in Figure 3 based on the warning sound conditions listed in Section 3.2.

![Figure 3: Evolution factors of the preliminary survey](image)

A questionnaire survey was conducted using the evaluation factors shown in Figure 4, and subjects were evaluated on a 5-point scale.

3.5 Sample sound

![Figure 4: Questionnaire used during the preliminary survey](image)

In a previous survey, we presented a total of 8 sample sounds from among 24 sample sounds to the subjects, using a wide and narrow combination of sounds, i.e., interval, square, and sawtooth waves.

3.6 Results of preliminary survey

A preliminary survey was conducted with six subjects in June. According to the survey results, a comparison of the average of each evaluation item in each sample sound of the square and sawtooth waves is shown in Figure 6.

![Figure 5: Sample sound used during the preliminary survey](image)

Because the population of the subjects did not reach a statistically significant number this time, we examined whether the error of each waveform was significant using a t-test.

The T and P values are listed, and as the results indicate, the T and P values are 1.6 and 0.14, respectively.

In the results obtained, a P value of > 0.05 indicates the occurrence of no statistically significant difference. Because the difference for each waveform could not be obtained, we created a total of 24 samples from among 12 types of pitch changes for all patterns × 2 types of waveform patterns and conducted the necessary investigation.

In the preliminary survey, the number of evaluation factors was small, and thus it was difficult to find a factor difference. Moreover, because there were five evaluation scales, the difference in each sample could not be determined. The survey used in this study was improved.

![Figure 6: Image profile of square and sawtooth waves](image)

### Table 1: Results of T test in the previous survey

|         | T Value | P Value |
|---------|---------|---------|
| C - C½  | -0.02   | -0.98   |
| C - D   | -0.17   | -0.87   |
4. Main survey

4.1 Outline
Based on the results of the preliminary survey, the survey was conducted by changing the evaluation factor, evaluation scale, number of samples presented, and number of subjects. The outline and conditions of the survey are described below:

4.2 Questionnaire
An evaluation was conducted to clarify the difference in the image between the samples and increase the scale from 5 to 7.

To measure the subjectivity by changing the pitch in detail, four items, i.e., “brightness,” “hardness,” “strength,” and “flashy,” from previous similar studies were added (Figure 7).

4.3 Sample sounds
In this study, we presented 24 pattern sample sounds combining square and sawtooth waves and 12 patterns with pitch changes from C-C# to C-B.

4.4 Experiment environment
The subjects were asked to wear headphones and listen to sample sounds. Subsequently, they were asked to complete the questionnaire.

5. Result

5.1 T test
A T-test was conducted again to narrow down the waveform to one, and the significance of the difference in the alarm sound waveform was examined. As a result, T value = 0.1 and P value = 0.9.

A P value of > 0.05 indicates a lack of statistically significant difference. As a result, the difference between the waveforms was not obtained. Square waves have a faster attack time than sawtooth waves and are characterized by their conspicuousness and can be easily heard.

Therefore, such waves are often used as a notification sound for home appliances. For this reason, the waveform will be narrowed down to a square, and research will proceed with a focus on the change in pitch, which is the main topic. Table 2 shows the T and P values for each sample.

| Sound         | Square Value | Saw Value | P value |
|---------------|--------------|-----------|---------|
| C - C#        | -0.02        | 0.98      |         |
| C - D         | 0.15         | 0.88      |         |
| C - D#        | -0.11        | 0.92      |         |
| C - E         | 0.13         | 0.9       |         |
| C - F         | 0.06         | 0.95      |         |
| C - F#        | 0.14         | 0.89      |         |
| C - G         | -0.03        | 0.98      |         |
| C - G#        | 0.09         | 0.93      |         |
| C - A         | 0.12         | 0.91      |         |
| C - A#        | 0.12         | 0.91      |         |
| C - B         | 0.31         | 0.76      |         |
| C - C         | -0.12        | 0.91      |         |
| Total         | 0.07         | 0.91      |         |

From the questionnaire results combining previous studies and the main research, the image profile, factor loading table of each sample, and a graph of the factor scores were created. JMP software was used for the analysis.

5.2 Image profile
The sample with the maximum average value and the sample with the minimum average value for each adjective evaluation in the questionnaire were extracted and are listed in the graph (Figure 9).

5.3 Factor loading for each sample
Three factors were determined from the questionnaire results using JMP.
Factor 1: [anxiety, scary, unpleasant, dangerous]–restless
Factor 2: [flashy, conspicuous, bright]—impact factor
Factor 3 → [Hard, strong]—Hardness factor.

The factor table at this time is shown in Table 3.

From the factor score table in Table 3, the scores of the restless and impact factors of each sample were calculated. The stiffness factor was excluded because it contributed 8%.

The questionnaire results for each sample were analyzed using the above factors. Figure 10 shows each sample plotted on the factor space with the horizontal axis as the restless factor and the ordinate as the impact factor.

| Evaluation Factor | Factor1 | Factor2 | Factor3 |
|-------------------|---------|---------|---------|
| Anxious           | 0.95    | 0.05    | 0.14    |
| Scared            | 0.94    | 0.01    | 0.28    |
| Unpleasant        | 0.91    | 0.26    | 0.31    |
| Dangerous         | 0.86    | 0.44    | 0.21    |
| Noisy             | 0.16    | 0.91    | 0.26    |
| Stand out         | 0.34    | 0.87    | 0.20    |
| Bright            | 0.40    | 0.85    | 0.05    |
| Noisy             | 0.48    | 0.81    | 0.05    |
| Strong            | 0.23    | 0.77    | 0.45    |
| Hard              | 0.44    | 0.11    | 0.85    |
| eigenvalue        | 5.84    | 2.86    | 0.77    |
| Contribution rate | 61.20   | 27.20   | 8.09    |

From the factor table, the contribution ratio was as follows: first factor of 61.20, second factor of 27.20, and third factor of 8.09. From this, it can be seen that the first factor has an influence of approximately 60%, the second factor has an influence of approximately 30%, and the third factor has an influence of approximately 10% for the alarm sound when repeated twice.

The following results were obtained from the plots in the figure:

- The value of the domestic evaluation was the highest for the restless and impact factors compared to the other samples.
- The first factor of C-E, C-D, and C-D# is the smallest compared to the other samples.
- The first factor evaluation of C-G# and C-F# tended to be higher than that of the other samples.
- The second factor evaluations of C-C, C-A #, and C-A tend to be higher than those of the other samples.

From this, we can see that the first factor, the disturbing factor, is related to the sound of the sound, and the second factor is related to the pitch of the sound.

6. Discussion and conclusion

In the factor loading table, there is an evaluation factor that is dangerous to the disturbing factor, and thus if emphasis is placed on the disturbing factor, an alarm sound that provides a feeling of danger can be created. In addition, because there is an evaluation factor that stands out as an impact factor, it is better to focus on the impact factor to create an alarm sound that can be transmitted.

For the above reasons, it can be stated that the pitch change of C-B is the most appropriate. However, there is the possibility that the sound will create too much anxiety to make a calm judgment, which is a point that needs to be considered.

7. REFERENCES

[1] Sato Kaori, How to hear fire alarm sound when collecting head sound audio in a complex cafe, Journal of Acoustic Society of America, pp. 1-5, 2012

[2] Kyohe Masumura, Study of sound quality for emergency alarm, Symposium on Environmental Engineering, July, pp. 55-57, 2012