# Visualization of environmental sound for the hearing impaired

## -Support by manga technique-

**Hiroshi Arai †**
Department of Art
Kinjo College, Hakusan, Japan
Tel: (+81) 76-276-4411, Email: arahiro@kinjo.ac.jp

**Hidetaka Nambo**
Faculty of Electrical and Computer Engineering, Institute of Science and Engineering
Kanazawa University, Kanazawa, Japan
Tel: (+82) 54-279-2371, Email: nambo@blitz.ec.t.kanazawa-u.ac.jp

**Yuko Shimomura**
Department of Social Work, Faculty of Social Work
Kinjo University, Hakusan, Japan
Tel: (+81) 76-276-4400, Email: shimo@kinjo.ac.jp

**Hiroyuki Kawabe**
Department of Social Work, Faculty of Social Work
Kinjo University, Hakusan, Japan
Tel: (+81) 76-276-4400, Email: kawabe@kinjo.ac.jp

**Shuichi Seto**
Department of Business Administration
Kinjo College, Hakusan, Japan
Tel: (+81) 76-276-4411, Email: seto@kinjo.ac.jp

**Abstract.** Our field of view is about 120 degrees, we receive much information from outside of the field of view from which it is hard to get the information for the hearing impaired. They have poor crisis perception ability as compared to normal persons. Therefore, we have developed a system to visualize environmental sound in order to assist the hearing impaired. Hearing impaired persons can guess sound from movement of objects. For example, contents of talk from lip reading. For environmental sounds, it is hard for them to recognize what happens when the location of the source of sound is unknown. We visualize environmental sound in order to assist the hearing impaired. We take advantage of manga techniques to visualize the environmental sound intuitively. Manga, not using sound, represents sounds in other ways. Thus Manga has powerful potential to describe sound. People who have an affinity for manga can feel a sense of realism even without learning about manga techniques. We can display the environmental sound via manga symbols created by four indicators of sounds, volume, pitch, tone and direction. Concretely speaking, size, speed of movement, font and location of manga symbols are modified by these indicators.

**Keywords:** environmental sound, hearing impaired person, manga technique, HMD.

## 1. INTRODUCTION

It is said that, as a general rule, the bulk of the information that we receive in our daily lives is derived from vision at about 70% and hearing at about 20%. The volume of information is less for hearing as compared to vision, but there is also a large amount of information that cannot be obtained through hearing, and this is an important element in the realm of information sources.

Up to this time, we have developed a note-taking system for support of students with impaired hearing. Along with reduction of the size of the HMD and evolution of VR technology, by means of adding new information within the field of view, we have expanded the breadth of support for hearing impaired persons. Up to this time, we have utilized audio recognition technology to develop our study of added emotional expression in the form of written indicators. In the present study, we have worked toward development of a “system of onomatopoeia visualization” for visualization of environmental sounds in support of hearing impaired persons.

They are made up of (1) investigation relating to conversion of onomatopoeia into writing; (2) construction of a database of environmental sounds; (3) implementation of a system of onomatopoeia visualization; and (4) its verification. By means of visualization of environmental sounds, we can hope for such results for hearing impaired person who cannot hear as (1) detection of danger that lies outside of the field of view, and (2) ability to gain a sense of tele-existence of the unique sounds related to time and season.

## 2. Environmental sounds and Onomatopoeia

In the context of conversion into writing of environmental sounds, they are first converted into onomatopoeia and displayed as such. Onomatopoeia is not included in language and music, but it is used in language to display the sounds of the natural world. Also, while it is not sound itself, it also includes terms that express the condition of things.

Onomatopoeia can be broadly divided into three types. (1) Onomatopoeic words that express sounds emitted by things; (2) particularly prevalent are onomatopoeia that express the cries of animals; (3) mimetic words that express conditions or emotions. Onomatopoeic words are expressions frequently utilized for expression of environmental sounds. It is said that, compared to other national languages, Japanese has a particularly high frequency of their use. [Yamaguchi 02]

Conversion of sounds into words and written expression of atmosphere are found in rich profusion in Japanese manga expression. Such elements as balloons, explications and onomatopoeia are frequently employed in shapes to express tele-existence(fig.1). In this study, for the purpose of analyzing sounds input with a microphone are utilized by converting them into set onomatopoeic words. In addition, in order not to allow the volume of information to become excessive, we have not utilized explications and balloons.

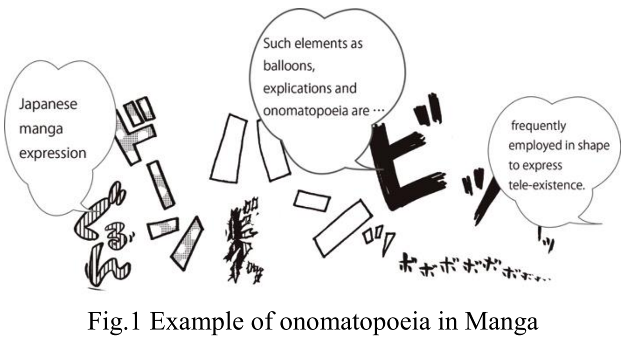


Fig.1 Example of onomatopoeia in Manga

## 3. Questionnaire for conversion of environmenta l sounds into onomatopoeia.

When converting environmental sounds into onomatopoeic words, the problem of wavering (ambivalence) in the orthography depends upon the sensitivities of people who experienced those sounds. In order to delve into this tendency, we carried out a questionnaire investivation.

### 3.1 Experiment 1

We prepared eight types of environmental sound (table.1) for questioning students. We explained to the students that they should convert the sounds into writing in such a way that it would be easy for a third party to comprehend. We had them listen to three repetitions of each sound and write their responses down on the questionnaire sheet. We also had them explain in written words what sound it was that they thought they had heard.

Table1. Sounds used for the questionnaire

| No. | Sample Sounds | No. | Sample Sounds |
|---|---|---|---|
| 1 | Knocking on a door | 5 | clapping hands |
| 2 | Vehicles coming and going on a crowded street | 6 | Cry of a penguin |
| 3 | Opening the lid of a can | 7 | Rain |
| 4 | Warning signal at a railroad crossing | 8 | Cheers with clinking glasses |

### 3.2 Experiment 2

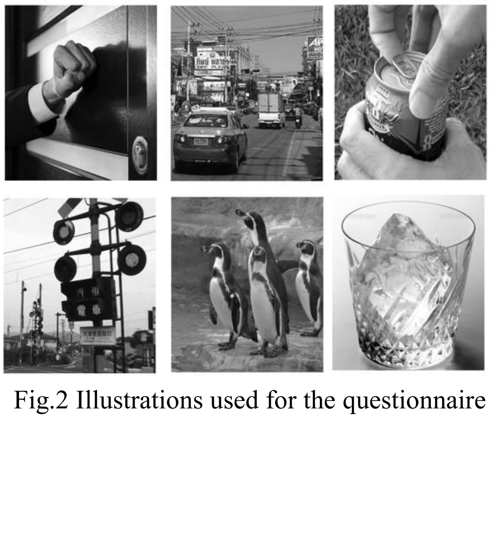

Fig.2 Illustrations used for the questionnaire

In experiment 2, we carried out an experiment with displays of drawings that provided an image of the sound (fig.2).

## 4. Experiment results

Experiment result as follows. The total showed almost the same written expression in the context of the difference between the sounds of double consonants or long sounds, signs and symbols (such as musical notation/exclamation marks/and dotted lines). The portions shown in red indicate the places that demonstrated the influence of the presence or absence of illustrations.

### 4.1 Results 1

The number of questionnaire respondents was 32 people. The types of words for expressing a single sound averaged about 11. The fewest number of words expressing sounds was for Nos. 1 and 5. The closest to the average sounds were seen in Nos. 3,4,7, and 8. The sounds converted into writing that were more numerous than average were seen in Nos. 2 and 6 (table.2).

Table.2 Conversion to written characters of environment sounds (without illustrations)

| No. | Sample Sounds | 1st | | 2nd | | 3rd | | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | Knok | kon' kon' | 17 | tontoɴ | 5 | don'don' | 2 | 7 |
| 2 | Traffic jam | buro ro ro | 5 | za– | 3 | bu ooo n' | 2 | 22 |
| 3 | Lid of the cans | ka shu | 11 | pu shu | 9 | pishi | 2 | 12 |
| 4 | Railroad crossing | kan' kan' | 18 | ka–n' ka–n' | 5 | | | 10 |
| 5 | Applause | pachi pachi | 31 | | | | | 2 |
| 6 | Penguin | hahhahha– | 13 | unkown | 4 | faffa | 2 | 19 |
| 7 | Rain | za– | 11 | ja– | 5 | shaaa– | 4 | 13 |
| 8 | Cheers | karan' | 11 | chi–rin' | 7 | kan' | 3 | 14 |

### 4.2 Results 2

The number of questionnaire respondents was 33 people. The types of words for expressing a single sound averaged about 12, showing very little difference between this and cases in which illustrations were shown. The types of words were the lowest number in Nos. 1,4, and 5. Those closest to the average were seen in Nos. 3,7 and 8. The sounds that elicited the largest number of types were Nos. 2 and 6. The most remarkable differences between questionnaires 1 and 2 were seen in response to sounds

Table.3 Conversion to written characters of environment sounds (with illustrations)

| No. | Sample Sounds | 1st | | 2nd | | 3rd | | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | Knok | don'don' | 15 | kon' kon' | 11 | gon'gon' | 5 | 5 |
| 2 | Traffic jam | buro ro ro | 9 | dou ruru | 2 | bu ooo n' | 2 | 20 |
| 3 | Lid of the cans | ka shu | 12 | pu shu | 11 | | | 12 |
| 4 | Railroad crossing | kan' kan' | 19 | ka–n' ka–n' | 8 | | | 7 |
| 5 | Applause | pachi pachi | 30 | | | | | 4 |
| 6 | Penguin | hahhahha– | 11 | haa haa | 2 | faffa | 2 | 21 |
| 7 | Rain | za– | 15 | zaaaaa | 6 | zaa– zaa– | 3 | 10 |
| 8 | Cheers | karan' | 22 | kakon' | 2 | | | 12 |

were seen in Nos. 1 and 8. In No. 1, the first and second places were interchanged, and in No. 8 there was a sharp reduction in the expression of the second sound (table.3).

### 4.3 Observations

The results of the questionnaire for which only sounds were used, without showing any illustrations, and that in which illustrations were shown are compared in table.3.

Concerning the written expressions of sound No. 1, the greatest number of words expressing the image of hard or strong sounds was "kon-kon" as shown in table.3. However, the results of table.3 in which illustrations were shown, there was a reversal in the number of students who express a low sound as "don-don." In the illustration it is a man's hand that knocks on the door, and he knocks with a tight fist. It is thought that there is a stronger influence on visual information than on the sound as heard by the ears (table.3).

No. 8 is the sound produced when clinking two pieces of glass together. In table.2, next to the imagined sound of pieces of glass clinking together of "karan," the next largest number indicated the sound as "chirin." The students who wrote down this expression of the sound had the image of wind-bells in mind. (table.3) The small wind-bell sound is produced by the wind when the piece of paper attached underneath it is moved by the wind in such a way that it makes the sound of "chirin." It is a handicraft art object that gives the hearer a sense of coolness. In table.3, the image displayed is a drinking glass full of ice. Around half of the respondents chose the sound "karan," while there were hardly any who indicated the sound as "chirin."

When converting sounds to written characters the visual information is a large determining factor in imagining what produces a sound. The generally accepted sound images, including those such as "wanwan" for the barking of a dog and "ba-an" for an explosive sound showed a similar pattern in conversion to writing among all students. This is also true of the No. 5 sound of clapping hands. There were an extremely large number of types of conversion to writing of the juxtaposition of a number of different sound as in No. 2 and sounds that we all have a similar consciousness of as in No. 6.

Based upon this concept, two consciousness methods were seen in the conversion of sounds into written characters. The first was in the case of the majority of people holding the same image of a sound in common. It is possible to express the method of conversion to writing of a number of conversion patterns. The second is the case of images of sounds that people to not hold in common. In this case, it is difficult to obtain a common written expression when precise conversion of sounds to writing is carried out. In addition, there were a large number of small differences in the conversion into signs and symbols of the sounds of double consonants and long sounds. However, since expression is influenced by the sounds heard, there was seen to be a relationship with the volume of the sounds.

## 5. Structuring of a Prototype System

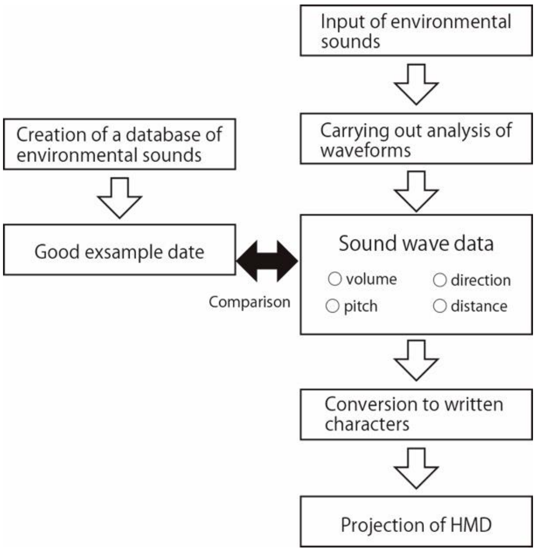


Fig.3 Summary of onomatopoeia system 1

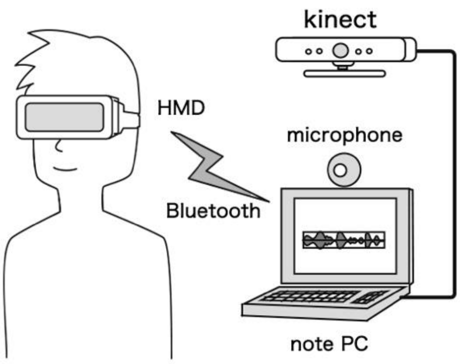


Fig.4 Summary of onomatopoeia system 2

Based upon the above, we devised rules for our system. Environmental sounds that were input through a microphone are converted into waveform data. Environmental sounds are emitted from a different sound principle than phonetic sounds, which can be explained by the fact that they do not contain the same waveforms as the vowels and consonants of phonetics. Thus, in order to recognize environmental sounds, it is necessary to implement special volume extraction and recognition methods that are different from the phonetic recognition method. Therefore, wavelength forms of hypothesized environmental sounds were collected in advance and by means of their similaritities, they were converted into a database for comparison for carrying out conversion into onomatopoeic written characters based upon their similarities.

In addition, the phonetic data was categorized into (1) levels of sound volume and (2) levels of pitch. The sound volume levels were transposed into the size of the written characters. The pitch level of the sound was made to correspond with the written characters.

A Kinect sensor was utilized to determine the direction of the sounds. Concerning the direction of the sounds, it was possible to obtain the approximate direction of the sounds within a right-left radius of 50 degrees centered around the Kinect. Since the distance is also linked to the sound volume, it was also reflected in the size of the written characters.

We began by making efforts toward conversion of environmental sounds in the context of specific direction and angle. Direction and distance is altered along with the shift in position of object, so the depth from both back and front of the objects that are the source of the sounds is expressed in animation of the size and position of the written characters. (fig.5) For now, we use the method of conversion to writing of a number of conversion patterns. And from now on, we will consider experimenting about selection of characters to be used.


Fig.5 Summary of Summary of onomatopoeia

## 6. Conclusion

In the present study, for the purpose of structuring of a system of visualization of environmental sounds for the benefit of people with impaired hearing, we carried out experiments that delved into the rules for onomatopoeic conversion of those environmental sounds. By means of conversion into written characters of eight cited types of environmental sounds, we came to understand the trends of abstract sounds and actual realistic sounds. Also, we came to understand that use of the size of visual information was necessary for conversion of sounds into verbalization of those sounds, and we also grasped the importance of involvement with direction. Visual recognition of environmental sounds not only makes it possible to perceive dangers that come from outside the field of view, but it also makes it possible to obtain a sense of tele-existence from sounds peculiar to season and time. We can hope that our creation of new contents related to HMD and VR will also prove useful to people other than those with impaired hearing.

## REFERENCES


[1] Jun Shigeno, Psychology of the World of Sound, September 10, 2003, Nakanishi Publishers, Inc.

[2] Toshikatsu Yamaguchi, The World of the Intermediate Hearing Impaired and the Seriously Hearing Impaired, August 5, 2003, Hitotsubashi Publishers, Inc.

[3] Hitoshi Ishihara, Kazunori Komatani, Tetsuya Ogat, Hiroshi Okano, Sound-Imitation Word Recognition for Environmental Sounds - Disambiguation in Determining Phonemes of Sound-Imitation Words, Journal of Theses of the Artificial Intelligence Society, Vol. 20 (2005) No. 3 P 229-236

[4] Hoshu Oh, Kunio Kashiwa, Hidenao Nagano, Takeo Igarashi, Method for Visualization of Moving Image Sound in the Context of Onomatopoeic Animation, Workshop on Interactive Systems and Software, Anthology of Theses, December 2013, P165-166

[5] Seto, S., Arai, H., Sugimori, K., Shimomura, Y. and Kawabe, H., Subtitle system visualizing non-verbal expressions in voice for hearing impaired --- Ambient Font ---, Proceeding of the 10th Asia-Pacific Industrial Engineering and Management Systems Conference 2010 (2010)

[6] Seto, S., Arai, H., Sugimori, K., Shimomura, Y. and Kawabe, H., Visualization of Non-verbal Expressions in Voice by using Manga technique- Ambient Font for Hearing Impaired Student -, 11th European Conference for the Advancement of Assistive Technology (2011)