Understanding Emotion through Multimedia

Comparison between Hearing-Impaired People and People with Hearing Abilities

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ABSTRACT

We conducted an experiment to determine the abilities of hearing-impaired and normal-hearing people to recognize intended emotions conveyed in four types of stimuli: a drum performance, a drum performance accompanied by a drawing expressing the same intended emotion, and a drum performance accompanied by one of two types of motion pictures. The recognition rate was the highest for a drum performance accompanied by a drawing even though participants in both groups found it difficult to identify the intended emotion because they felt the two stimuli sometimes conveyed different emotions. Visual stimuli were especially effective for performances whose intended emotions were not clear by themselves. The difference in ability to recognize intended emotions between the hearing-impaired and normal-hearing participants was insignificant. The results of this and a series of experiments will enable us to better understand the similarities and differences between how people with different hearing abilities encode and decode emotions in and from sound and visual media. We should then be able to develop a system that will enable hearing-impaired and normal-hearing people to play music together.

Categories and Subject Descriptors

J.5 [**Arts and Humanities**]: Performing arts; J.4 [**Social and Behavioral Sciences**]: Psychology

General Terms

Human Factors

Keywords

Hearing-impairment, Emotion, Recognition, Drum performance

ASSETS'06, October 22–25, 2006, Portland, Oregon, USA.

1. INTRODUCTION

Our six years of teaching hearing-impaired students at the Tsukuba College of Technology, now Tsukuba University of Technology (NUTUT [4]), how to use computers to play music has shown us that many hearing-impaired people are interested in and enjoy playing music, especially with others. As a deaf person who had majored in music, Whittaker described a similarity in musical interests among hearing-impaired people and people with hearing abilities [14].

Thus, we set as our goal the development of a system that will enable hearing-impaired people to play music in an ensemble comprising both hearing-impaired people and people with hearing abilities. Besides widely used with music in performing arts [2], visualized music cues give hearing-impaired people more information about the music. We plan to design the system to assist users with music performance visualization.

We will initially use drums as the primary instrument in our system because they require simpler body movements and less knowledge of music. Moreover, drums are generally easier for people to play, and drum performances are usually easier to recognize than other types of musical performances, such as performances by piano. Playing the drums also has a healing effect [7]. However, the results of a previous experiment showed that following even a simple rhythm and tempo on the basis of visual cues can be somewhat burdensome for hearing-impaired people, particularly having to pay close attention to visual cues to keep up with the rhythm and tempo [9]. We concluded that communicating an intended emotion through drum playing might be the best approach for a performance assistance system because a musical performance that focuses on an emotion favors freedom over accuracy.

Our system will assist users improvising with drum instruments with intended emotions to get the feel of unity. Before we can design our system and construct a prototype, we needed to improve our understanding of how hearing-impaired people interpret drum performances and what types of visual stimuli would be the most useful to them. We thus conducted an experiment to evaluate how well hearing-impaired and normal-hearing people recognize an intended emotion. We used four types of stimuli: a drum performance, a drum performance accompanied by a drawing expressing the same intended emotion, and a drum performance accompanied by one of two types of motion pic-

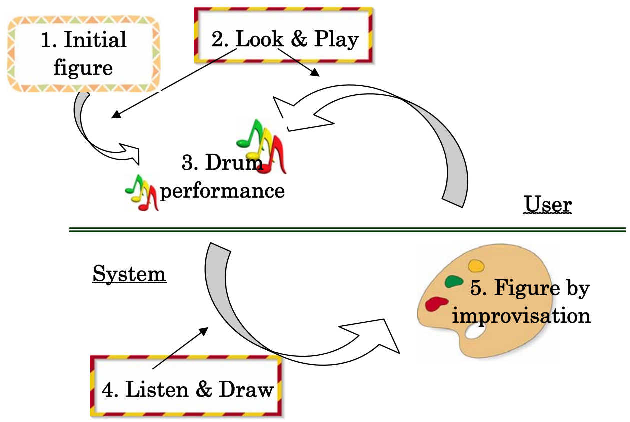

Figure 1: System concept.

tures. The sounds and drawings used in this experiment were generated in previous experiments by both hearing-impaired and normal-hearing people with an intended emotion in mind, so the results of this experiment should show how well the two types of people can identify each other's intended emotions and use those emotions to communicate. Comparison of the recognition rates between the hearing-impaired and normal-hearing participants showed that the highest recognition rate was for a drum performance accompanied by a drawing expressing the same intended emotion although the participants sometimes had difficulty in identifying the intended emotion because they felt the two stimuli sometimes conveyed different emotions.

2. BACKGROUND

2.1 System concept

Our target music performance assistance system, called the "performance enhancement machine" (PEM), will generate visual cues that enable users, even those without any musical training, to enjoy playing the drums and to feel a sense of unity by playing with others. The basic concept is illustrated in Figure 1. All the players simply look at an initial drawing chosen by the leader to determine which emotion is to be emphasized in the performance at first and play their instruments as a group with that emotion in mind. The system analyzes the sounds in their generated performance, identifies the dominant emotion, and generates a representative drawing of it. The players look at the generated drawing to determine which emotion to emphasize and play their instruments again as a group with that emotion in mind. There is thus a cycle of group performance and system drawing, leading to the players harmonizing their performances and playing in better unison. That is, in a sense, PEM is a system that realizes user-machine interaction through emotion.

The generated drawings are simply cues to the users suggesting which emotion to emphasize. They do not specify a performance rule or act as a substitute musical score. The users can play their instruments freely and improvise. Because the cues help clarify the intended emotion, the users can get the feeling of playing in unity.

2.2 Related works

This experiment is one in a series of experiments we are conducting on recognition related to sound and visual information with hearing-impaired people and normal-hearing people. So far, we have conducted experiments on encoding emotions in drum performances [10][11], recognizing the intended emotions in a drum performance [12], and encoding and decoding intended emotions in drawings [8].

In the experiment on recognizing the intended emotion in a drum performance, we found that hearing-impaired listeners did not differentiate between the drum playing of hearing-impaired people, of normal-hearing people with no training in playing drums (amateurs), and professionals. Listeners with normal hearing, on the other hand, could differentiate performances by professionals from those by other performers. There were no significant differences between hearing-impaired and normal-hearing people in recognizing the intended emotions in performances by hearing-impaired people and amateurs.

In our experiment on decoding intended emotions in drawings, hearing-impaired people had better recognition rates than normal-hearing people, although the difference was not significant.

Bresin and his colleague developed a system that renders a musical performance with an intended emotion [5] and Friberg developed a system that analyzes a musical performance and decodes the emotions it expresses [6]. Though Juslin surveyed the recognition of emotion through music [13], little research has been done on understanding intending emotions through drum performances specifically [15] or with hearing-impaired people.

3. EXPERIMENT

3.1 Methods

We used the four basic emotions commonly used in experiments on music perception: joy, fear, anger, and sadness. To determine how well hearing-impaired people and normal-hearing people recognize an intended emotion, we used four types of stimuli generated in a previous experiment: a drum performance, a drum performance accompanied by a drawing expressing the same intended emotion, and a drum performance accompanied by one of two types of motion pictures (Windows Media Player's amoeba effect or fountain effect). The drum performances and drawings were encoded with one of the four emotions by both hearing-impaired and normal-hearing people in our previous experiments.

Subjects either listened to or listened to and watched the presented stimuli and then decided which emotion they felt in the stimuli. As in our other experiments, we focused on comparing the ability of hearing-impaired and normal-hearing subjects to recognize the emotion in the stimuli.

3.2 Material

3.2.1 *Drum performances (sound)*

The drum performances were recorded in previous experiments. We asked three groups of people to play a drum set so as to convey a particular emotion. The three groups were hearing-impaired people [10][11], people with normal hearing abilities who had no training in drum performance (we call them amateurs), and people with normal hearing abilities who are professional drummers. The number of players

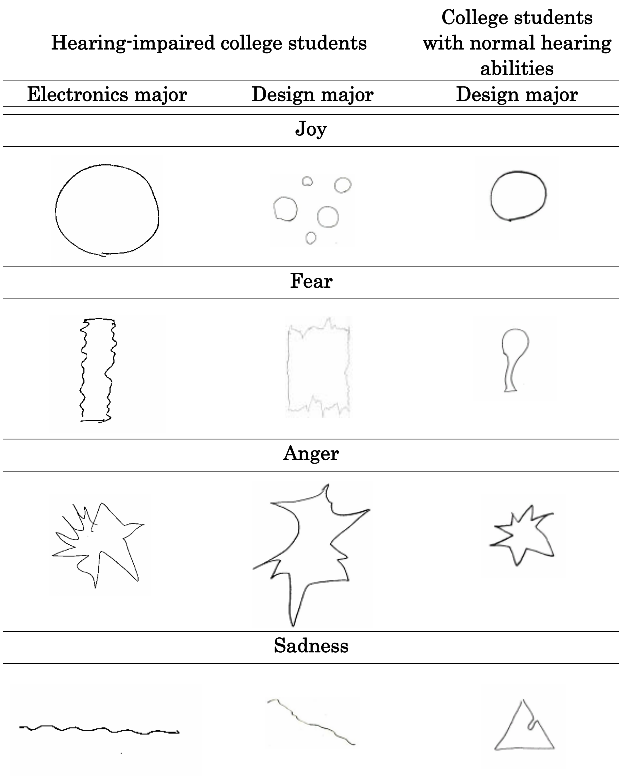

Figure 2: Drawings used as stimuli.

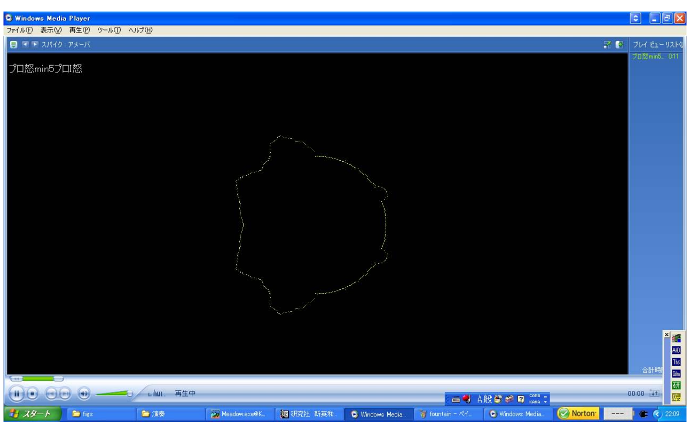

Figure 3: Example amoeba effect.

in each group was 11, 5, and 2, respectively. Since each player did one performance for each of the four emotions, there were 44, 20, and 8 performances per group, respectively. The length of a performance varied from about 10 seconds to over 60 seconds. Hearing-impaired college students played a MIDI drum set, Yamaha DD-55, and their performances were recorded as standard MIDI files (SMFs) with a sequence software system, Yamaha XGWorks. Other performances were played with a tam and recorded into a DAT recorder, Sony TCD-D10 PRO II, through a sound-level meter, RION NL-20.

We calculated the recognition rates for each performance. If the listener perceived the same emotion as that intended by the performer, the trial was scored as correct. For each of the three groups of performers, we identified the performances with the best and worst recognition rates for each emotion. These 24 performances (three groups * four emotions * two qualities) were used as the sound stimuli in the present experiment.

3.2.2 Drum performances paired with drawings (drawing)

We paired each of the 24 drum performances used as sound stimuli with a drawing that conveyed the same emotion. The drawings were also from a previous experiment [8]. We asked three groups of people to draw simple pictures conveying an emotion. The three groups were hearing-impaired college students whose major was electronics, hearing-impaired college students whose major was design, and college students with normal hearing whose major was design. The number of people in the groups was 14, 11, and 7, respectively. From these samples, we chose the one with the highest recognition rate for each emotion for each group in the previous experiment. We excluded drawings that represented concrete objects, such as the sun and tear drops, even though they were with the highest recognition rate. The 12 drawings (three groups * four emotions) are shown in Figure 2.

Except for conveying the same emotion, the parings were random. Since there were 24 performances and only 12 drawings, each drawing was used twice. The drawings were presented using Windows PowerPoint during the first half of a performance and gradually withdrawn during the second half.

3.2.3 Drum performances paired with motion pictures (amoeba and fountain)

We also paired the drum performances with motion pictures: the Windows Media Player amoeba and fountain effects. Although these effects were controlled by and synchronized with the sound data, the resulting animations did not convey any particular emotion themselves. We chose amoeba (Figure 3) because its representations looks a little like some of the drawings we used. We also wanted to use pictures that are quite different in shape and movement from amoeba. We chose fountain (Figure 4) because it uses fewer colors than other pictures that are different from amoeba.

The order of performances was random. The order was the same through the four stimulus categories. The four stimulus categories were presented to subjects in the order of sound, drawing, amoeba, and fountain.

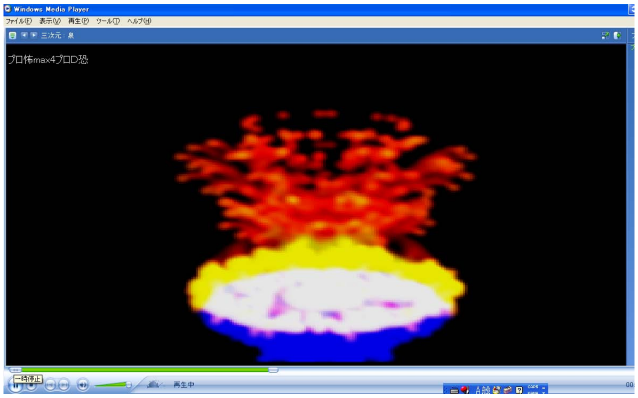

Figure 4: Example fountain effect.

3.3 Subjects

The subjects were hearing-impaired college students and college students with normal hearing. The 11 hearing-impaired subjects comprised 3 men and 8 women[1] (ages 18–22), and the 15 normal-hearing subjects comprised 13 men and 2 women (ages 20–24).

The hearing-impaired subjects were all students in the hearing-impaired division at NUTUT. All had a hearing loss of more than 100 decibels. We surveyed their musical experience in terms of karaoke, music-related games (such as "Dance, Dance, Revolution [1]" and "Drum Master [3]"), dance, and music-related club activity. Of the 11 hearing-impaired subjects, 10 had experience in karaoke, 10 in games, and 7 in dance. Two of them belonged to a dance club and two to a Japanese drum (taiko) club.

3.4 Procedure

The hearing-impaired subjects were tested in a wood-floor gymnasium. They sat on the floor where there was a hearing compensation device (Figure 5). The normal-hearing subjects were tested in a classroom.

We gave the subjects check sheets and instructed them to mark which of the four emotions they recognized from each stimulus. They were presented the 24 stimuli in each category one after the other, about 12 minutes per category, with a 5-minute break between categories. During each break, they prepared a self-judgment report. After viewing the stimuli in all the categories, they summarized how they felt about the experiment.

4. RESULTS

4.1 Recognition rates and ANOVA

We calculated the recognition rates for the stimulus categories and used them for two-way analysis of variance (ANOVA) on arcsine-transformed data. In the following results, significant difference is considered less than a 5 percent probability. We formed three ANOVA analyses where factors were as follows.

1. Intended emotion (four levels: joy, fear, anger, and sadness) and stimulus category (four levels: sound, drawing, amoeba, and fountain).

[1]Three subjects (1 man and 2 women) did not participate in the part of the experiment using the fountain stimulus.

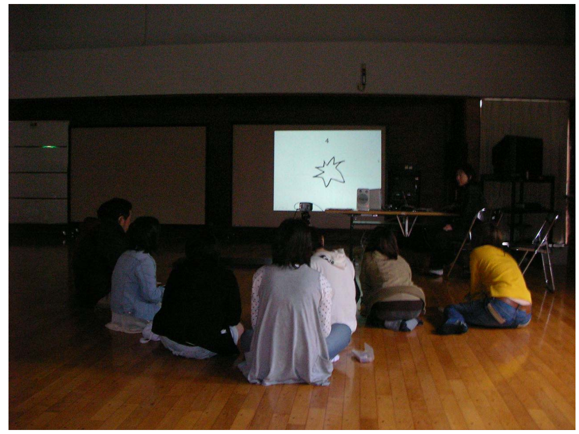

Figure 5: Hearing-impaired subjects being tested on wood floor.

2. Intended emotion (four levels) and subject group (two levels: hearing-impaired and normal hearing).
3. Stimulus category (four levels) and subject group (two levels).

Figure 6 shows the recognition rates for emotions by subject type. Figure 7 shows it for the subject types by stimulus category, and Figure 8 shows it for the subject types by intended emotion. Table 1, 2, and 3 show χ^2 values of each ANOVA above.

From Figure 6, Table 1, and Ryan's procedure, we obtained the following results.

- Fear was the most poorly recognized emotion by both subject groups for all stimuli.
- There was a significant difference in the recognition rates between emotions by both subject groups.
- Although the ordering of the recognition rates by emotion differed between subject groups, Ryan's procedure showed that there was a significant difference between recognizing fear and recognizing the other three emotions in both subject groups.
- The drawing stimuli produced the highest recognition rates for both subject groups regardless of the intended emotions.
- The recognition rates for the hearing-impaired subjects, in descending order, were for the drawing, fountain, sound, and amoeba stimuli. For the normal-hearing subjects, they were for the drawing, fountain, amoeba, and sound stimuli.

  The subjects with normal hearing showed a significant difference in recognition rates between the amoeba and sound stimuli, while the difference for the hearing-impaired subjects was insignificant.
- The recognition rates for the drawing stimuli were significantly higher than for the other three categories for both subject groups.

From Figure 7, Table 2, and Ryan's procedure, we obtained the following results.

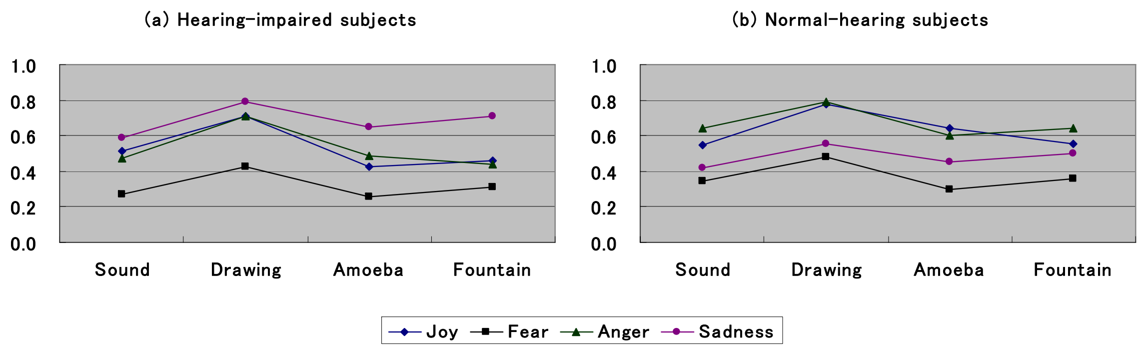

Figure 6: Recognition of emotion by category of stimulus.

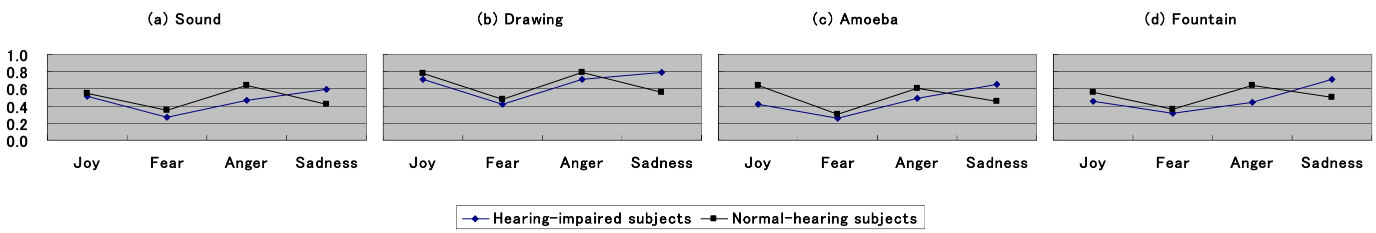

Figure 7: Recognition by subjects for each emotion.

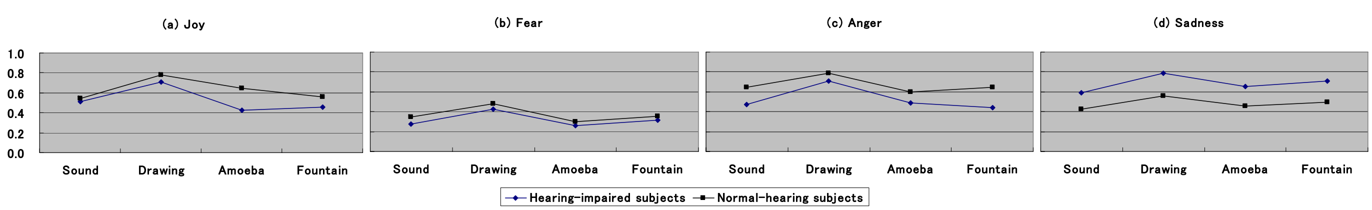

Figure 8: Recognition by subjects for each category of stimulus.

Table 1: χ^2 values of ANOVA (1). Main effects are intended emotion and stimulus category.

	Subjects	
	Hearing impaired	Normal hearing
Main effect (A): Intended emotion	70.82*	87.31*
Main effect (B): Stimulus category	30.27*	27.55*
Interaction of two effects above	5.13	6.05

*: the significance at $p \leq .05$.

Table 2: χ^2 values of ANOVA (2). Main effects are intended emotion and subject group.

	Stimulus categories			
	Sound	Drawing	Amoeba	Fountain
Main effect (A): Intended emotion	24.68*	39.14*	34.34*	21.03*
Main effect (B): Subject group	0.50	0.04	1.34	0.59
Interaction of two effects above	9.69*	12.07*	14.59*	12.12*

*: the significance at $p \leq .05$.

Table 3: χ^2 values of ANOVA (3). Main effects are stimulus category and subject group.

	Intentional emotion			
	Joy	Fear	Anger	Sadness
Main effect (A): Stimulus category	23.75*	10.73*	20.31*	9.70*
Main effect (B): Subject group	6.51*	1.82	12.61*	25.12*
Interaction of two effects above	2.96	0.10	1.31	0.50

*: the significance at $p \leq .05$.

- Ryan's procedure showed that the recognition rates for fear were significantly lower than for the other three emotions for all four types of stimuli, while there were no significant differences between any two of the other three emotions for any types of stimuli.
- For the sound and drawing stimuli, the recognition rates in descending order were for anger, joy, sadness, and fear. For the other two categories (amoeba and fountain), the rates in descending order were sadness, anger, joy, and fear.
- There was no significant difference between subject groups in recognizing intended emotions for all four types of stimuli.

From Figure 8, Table 3, and Ryan's procedure, we obtained the following results.

- Subjects with normal hearing had higher recognition rates for emotions other than sadness than the hearing-impaired subjects.
- There was no significant difference between subject groups in recognizing fear.
- Ryan's procedure showed that recognition with the drawing stimuli differed significantly from the other three types of stimuli for all four emotions. The exception was that there was no significant difference between the drawing and fountain stimuli for recognition of sadness.
- Though the recognition rates differed among emotions by types of stimulus, Ryan's procedure showed that the difference between the amoeba and fountain stimuli was not significant.

4.2 Self-judgment

The post-experiment self-judgment investigated how difficult the subjects found the experiment.

4.2.1 Difficulty

Subjects checked one of the five degrees of difficulty (from 5 for "very easy" to 1 for "very difficult").

- None of the hearing-impaired subjects checked 5 (very easy), two checked 4, three checked 3, five checked 2, and one checked 1 (very difficult.)
- The corresponding numbers for normal-hearing subjects were 0, 2, 1, 10, and 2.
- Less than one-third (3 out of 11) of hearing-impaired subjects felt the experiment was difficult, while about 80% with normal hearing felt it was difficult.

4.2.2 Preferences

The subjects also indicated the types of stimuli in which they felt it was the easiest and the most difficult to recognize the intended emotion (Figure 9). The hearing-impaired subjects strongly preferred motion picture stimuli, while the normal-hearing subjects about equally preferred drawing and motion picture stimuli. The preference for motion picture stimuli among hearing-impaired subjects was indicated with our previous experiment in following tempo and rhythm, even though the stimuli did not yield a good result [9].

4.2.3 Stimulus categories

Seven hearing-impaired subjects and eight normal-hearing subjects indicated that they sometimes recognized different emotions between the performance stimulus and in the drawing stimulus in a drawing category pair, even though the intended emotions were the same. Six hearing-impaired subjects and seven normal-hearing subjects indicated that the emotions in the amoeba stimuli were easier to recognize than those in the drawing stimuli. Six hearing-impaired subjects and seven normal-hearing subjects indicated that the emotions in the fountain stimuli were easier to recognize than those in the amoeba stimuli.

The subjects were asked to specify the easiest and the most difficult emotion to recognize for each stimulus category. More subjects with normal hearing found fear the easiest to recognize and sadness the most difficult to recognize for all the categories than did the hearing-impaired subjects.

5. DISCUSSION

5.1 Recognition of intended emotion

5.1.1 Lowest recognition rate for fear

Since fear had the lowest recognition rate in our previous experiments on recognition of intended emotions with performances and drawings, it is not surprising that fear had the lowest recognition rate for all stimulus categories. The reason for this is not clear. A possible explanation is that fear is not easy to encode into any type of media.

5.1.2 Significant difference in recognition of emotions

Because our previous experiments showed the same result, it was not surprising that there was a significant difference in recognition rates among emotions for all stimulus categories and subject groups. This is a serious problem for our planned system. We need to find a way to improve the recognition rate so as to eliminate significant differences in recognition among emotions.

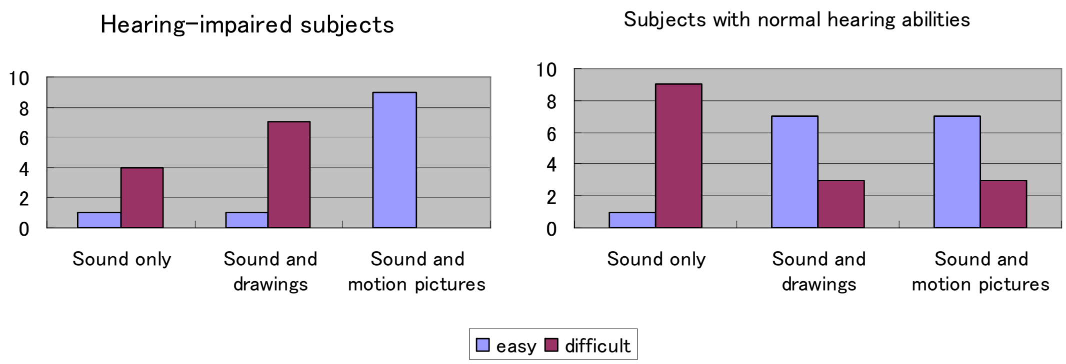

Figure 9: Preferences for types of stimuli.

5.1.3 Higher recognition rate for sadness by hearing-impaired subjects

Only sadness was better recognized by the hearing-impaired subjects, while the three other emotions were better recognized by the normal-hearing subjects. The self-judgment reports show that more hearing-impaired subjects felt it was easy to recognize sadness, though fewer felt it was easy with the fountain stimulus. For all stimulus categories, more subjects with normal hearing found sadness difficult than did hearing-impaired subjects. The self-judgment report results correspond to the recognition rate results, at least in this case.

5.2 Drawing stimulus category

5.2.1 Highest recognition rate

It is noteworthy that 7 out of 11 hearing-impaired subjects and 8 out of 15 normal-hearing subjects mentioned that the emotion they perceived from a performance sometimes differed from the one they perceived from the paired drawing, although the performance and drawing had the same intended emotion.

In spite of that, the recognition rate with the drawing stimuli was the highest of all types for all intended emotions because we used the drawings with the best recognition rate from a previous experiment. Although this may be the reason, we cannot explain why some subjects found a conflict between the sound and visual stimuli or why some of them reported that they used the sound stimulus more than the visual one in deciding which emotion to mark for the drawing category.

5.2.2 Drawing stimulus only

We conducted a supplemental experiment one month later to try and clarify how drawings are recognized. We randomly arranged the same drawings in Figure 2 and asked the same subjects[2] to identify the intended emotion for each drawing. The result with the recognition rate was as follows.

- There was no significant difference in the average recognition rates between both the two groups.
- There was no significant difference in the intended emotion and hearing ability factors in the ANOVA analysis.
- Since we used performance data with the best and worst recognition rates in a previous experiment [12] and drawing data with the best recognition rate in another previous experiment [8], we analyzed the recognition rates by ANOVA where factors were stimulus category (drawing and drawing-only) and best-worst performance data (obtained by splitting the performance data set into the best-recognized and worst-recognized groups). We obtained the following results, which were common to both subject groups.
  - There was a significant difference between the best and worst performances.
  - The subordinate test showed that the simple main effect of the best-worst factor for the drawing stimuli was significant.
  - The subordinate test showed that the simple main effect of the stimulus category factor for the worst performance data was significant.

These results indicate that the recognition rates for the worst performance set increase when subjects listen to them along with visual information. It means that visual stimuli are effective in recognizing emotions for performances whose intended emotions were not clear by themselves.

5.3 Subjects' self-judgment

The self-judgment reports described in 4.2 were not consistent with the recognition rates for the stimulus categories. As described in 4.2.3, the emotions in the amoeba stimuli were easier to recognize than those in the drawing stimuli, and the emotions in the fountain stimuli were easier to recognize than those in the amoeba stimuli. This inconsistency may be due to the way we presented the inquiry. More consistent results might have been obtained if we had asked the participants to simply order the types of stimuli by how easy it was to recognize the emotions in them.

The self-judgment reports were also inconsistent regarding the ease and difficulty of recognizing the four emotions. They showed that fear was not necessarily the most difficult emotion to recognize, in fact, fear was the easiest emotion for the normal-hearing subjects to recognize except in the sound category.

Contrary to our prediction that the fountain stimuli would convey impressions of joy and anger because of its colors

[2]Eight of the 11 hearing-impaired subjects and all 15 of the normal-hearing ones participated.

(red, yellow, blue, and white) and dynamic movements, their presentation did not affect the recognition of emotion. Only one of the 23 subjects reported that she found it difficult to differentiate between joy and anger in the fountain category.

5.4 Future work

Before we can actually build our performance assistance system, we have to more specifically determine how the system will analyze musical performances and use the results to draw pictures expressing the intended emotion ("Listen & Draw" in Figure 1). For that purpose, we need to understand the following things in particular.

- The physical characteristics of performances and drawings that identify the intended emotion. Then we can confirm that the encoding rules between hearing-impaired people and normal-hearing people are similar.

  We will also be able to use the physical characteristics of both types of stimuli to dissolve the significant difference in recognizing emotions.

- The method to map physical characteristics of performances to those of drawings. Then we can make the system artificially generate a drawing expressing the emotion identified in the performance.

- The timing to generate a drawing based on the analysis of a performance. We do not want the system to distract players from their performances by presenting a drawing too early or make them uneasy by presenting it too late. We may have to introduce the basic concepts of music, such as a tempo and a measure, to the system without requiring players understand them.

The further research on the recognition of sound by hearing-impaired people may improve the usability of the system. It includes the following things.

- We will investigate the recognition of intended emotions in performances in relation to the degree of hearing impairment. In the experiment reported here, we simply divided the participants into two groups: hearing impaired and normal hearing. However, there could be gradations in recognition ability related to the degree of impairment and the amount of musical experience.

- We will then investigate how learning to play the drums can change the encoding and decoding processes for hearing-impaired people.

6. CONCLUSIONS

We conducted an experiment to determine the abilities of hearing-impaired and normal-hearing people to recognize intended emotions in four types of stimuli: a drum performance, a drum performance accompanied by a drawing expressing the same intended emotion, and a drum performance accompanied by one of two types of motion pictures. The recognition rate was the highest for a drum performance accompanied by a drawing even though subjects in both groups found it difficult to identify the intended emotion because they felt the two stimuli sometimes conveyed different emotions. Visual stimuli were especially effective for performances whose intended emotions were not clear by themselves. The difference in ability to recognize intended emotions between the hearing-impaired and normal-hearing subjects was insignificant.

After we more specifically determine how the system will analyze musical performances and use the results to draw pictures expressing the intended emotion, we will construct and test a prototype of our performance assistance system.

7. ACKNOWLEDGMENTS

The Japan Society for the Promotion of Science supported this research through a Grant-in-Aid for Scientific Research, Exploratory Research No. 16500138.

8. REFERENCES

[1] Dance Dance Revolution freak. http://www.ddrfreak.com/.

[2] Digital Image Processing with Sound. http://dips.dacreation.com.

[3] Drum Master. http://www.namco.com/games/taiko/.

[4] National University Corporation Tsukuba University of Technology. http://www.tsukuba-tech.ac.jp.

[5] R. Bresin and A. Friberg. Emotional coloring of computer-controlled music performances. *Computer Music Journal*, 24(4):44–63, 2000.

[6] A. Friberg. pDM: an expressive sequencer with real-time control of the KTH music performance rules. *Computer Music Journal*, 30(1):37–48, 2006.

[7] R. L. Friedman. *The Healing Power of the Drum*. White Cliffs Media, 2000.

[8] R. Hiraga, N. Kato, and T. Yamasaki. Understanding emotion through drawings: comparison between people with normal hearing abilities and hearing-impaired people. In *Proceedings of IEEE SMC 2006*, 2006 (to appear).

[9] R. Hiraga and M. Kawashima. Performance visualization for hearing impaired students –a report of the preliminary experiment. In *Proceedings of EISTA 2004*, 2004.

[10] R. Hiraga, T. Yamasaki, and N. Kato. Cognition of emotion on a drum performance by hearing-impaired people. In *Proceeding CD of HCII 2005*, 2005.

[11] R. Hiraga, T. Yamasaki, and N. Kato. Expression of emotion by hearing-impaired people through playing of drum set. In *Proceedings of WMSCI 2005*, 2005.

[12] R. Hiraga, T. Yamasaki, and N. Kato. The recognition of intended emotions for a drum performance: differences and similarities between hearing-impaired people and people with normal hearing abilities. In *Proceedings of ICMPC 2006*, 2006 (to appear).

[13] P. N. Juslin and J. A. Sloboda. edt. *Music and Emotion: Theory and Research*. Oxford University Press, 2001.

[14] P. Whittaker. *Musical potential in the profoundly deaf*. Music and the Deaf, West Yorkshire, BK, 1986.

[15] T. Yamasaki. Emotional communication through performance played by young children. In *Proceedings of ICMPC 2004*, 2004.