

## Chapter 2

# SHOJI: A Communication Terminal for Sending and Receiving Ambient Information

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**Abstract** In modern Japan, increased human mobility has resulted in many people being geographically separated from their families and friends. Thus, there is a need for communication devices that can provide a link between geographically separated family members and friends. Although there are two types of communication – instrumental and consummatory – few studies have been conducted on the latter. We have developed a communication terminal that uses the exchange of ambient information as a means to promote consummatory communication. A concept for effectively communicating ambient information was derived from data collected from questionnaires. This concept was used to develop a communication terminal called “SHOJI” that can send and receive ambient information such as the temperature, illumination, light color temperature, and noise level as well as information about the presence or absence of individuals, their movements, and their emotions. We evaluated it experimentally, in which the participants were parents and children living apart. They judged that the information was sufficiently expressed, which indicates that the terminal is useful for exchanging ambient information.

## 2.1 Introduction

In modern Japan, many people live apart from those with whom they have a close relationship, such as family members and romantic partners. Since they are geographically separated, they cannot often meet and communicate directly. Although

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computer network-mediated media communication tools will enable people living apart to interact more frequently, there are various obstacles to efficient media communication. One goal of media communication is to realize *kansei* communication, which conveys human emotions and/or the ambience of their locations.

Human group communication is often classified as either instrumental or consummatory communication [1]. The purpose of instrumental communication is to change the receiver's cognition, emotion, and/or action by communication. Examples of instrumental communication are providing knowledge to others, persuading others, and changing others' actions. The purpose of consummatory communication is communication itself, namely, to share one's experiences, emotions, knowledge, and/or opinions. Examples of consummatory communication are joking, complaining, and talking about mundane things. It is said that most daily communication is consummatory [2].

For both instrumental and consummatory communication to be effective, it is necessary to share communication assumptions between the two parties (Figure 2.1). However, most media communication does not convey nonverbal information such as gestures, eye movement, and facial expression and social information such as age, gender, and job. Most previous studies have focused on instrumental communication; few have focused on ambient information such as human unconscious information and environmental information. To convey the ambient information that tends to be missing in ordinary media communication would be an effective way to improve consummatory communication, which often requires the expression of emotion.

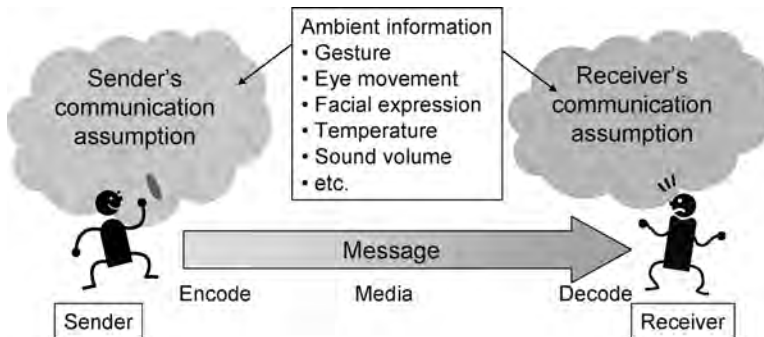


Figure 2.1 Communication model

## 2.2 Ambient Information

### 2.2.1 Definition

In this chapter, ambient information is defined as synthetic information consists of human unconscious information and environmental information. We classify in-

formation related to consummatory communication as either explicit or ambient. Explicit information is the information that the communication sender consciously wants to share with the receiver in consummatory communication. Examples of explicit information are content, the manner of speaking, and gestures used when joking. Ambient information, on the other hand, is implicit information that the communication sender does not want to consciously share with the receiver – for example, talking in a casual manner or muttering to oneself. Moreover, environmental information such as the balmy weather and birds twittering in the morning is also included in the ambient information.

We have investigated the effectiveness of ambient information in supporting consummatory communication. One reason we focused on ambient information is that it is often and easily lost in media communication. The language content of explicit information is easily conveyed by telephone or e-mail. Nonverbal information, such as gestures and facial expressions, can be conveyed using video chat. On the other, motions without conscious intention and soliloquy cannot be conveyed because the sender does not have the intention to do so. In addition, ambient information has rarely been conveyed because conventional media communication tools cannot sufficiently convey this information.

Another reason we focused on ambient information is that it is an extremely effective way to share communication assumptions. On the one hand, explicit information is conveyed only when the sender consciously conveys it. On the other, since ambient information involves many kinds of information that is automatically shared when the sender and receiver are in the same place, people unconsciously send and share such ambient information. This information promotes the sharing of communication assumptions. When most communication assumptions are shared, communication is more effective. Thus, we assume that the sharing of ambient information is useful for smooth consummatory communication.

### 2.2.2 *Related Works*

We can classify existing research on ambient information into two areas: “information that people unconsciously produce”, such as emotion, presence, and motion, and “environmental information”, such as temperature, illumination, and noise.

A previous study related to ambient information focused on *tsunagari* communication [3], which is communication “aimed at fostering a feeling of connection between people living away and maintaining their social relationships”. To validate the concept of *tsunagari* communication, a prototype “Family Planter” terminal was developed. It uses an infrared sensor, an ultrasonic sensor, and a touch sensor to detect users’ presence and motion information. These detected information is conveyed to other Family Planter terminals. Although the effectiveness of *tsunagari* communication had already been examined in experiments with family members and students as participants, only human presence and motion information was conveyed.

There have been previous studies in which ambient information other than presence and motion information have been communicated. For example, Lovelet [4] communicates human temperature information; a digital family portrait [5] conveys information regarding human activity (*e.g.*, opening or closing doors); Lumi Touch [6] transmits information regarding human touch; Peak-A-Drawer [7] is a virtual shared drawer; the Lover's cup [8] is a coffee cup that exchanges the time of drinking between two people in different places; and Meeting Pot [9] is a coffee maker that expresses coffee aroma to a remote office while the device is used.

Other studies have focused on emotion, which is an important communication assumption for consummatory communication. These, however, treated emotional information separately from other ambient information. For example, ComSlipper [10] is a pair of slippers with sensors that express the emotion of the other party; and TCON [11] is a tactile facial form that expresses the emotion of the other party. These studies communicate only a small portion of the various types of ambient information.

### 2.2.3 *Our Approach*

We propose expressing various types of ambient information by using a unified metaphor rather than focusing on specific portions of ambient information. We developed a method for expressing ambient information that helps two parties communicating to intuitively understand the situation of the other party. They can select the portion of ambient information to be transmitted depending on the time and circumstances. This method is expected to protect each party's privacy through the use of a metaphor.

We have now developed a communication terminal for conveying various types of ambient information that we call "SHOJI" (symbolic hosting online jog instrument).

## 2.3 Target Usage

SHOJI can be used for both private and public communication:

- private communication between:
  - family and husband or wife working at a distant location;
  - parents and children;
  - hospital patient and family;
  - romantic partners;
- public communication between:
  - head office and distant plant;
  - office and home of a teleworker.

Private communication is mainly between people who have a close relationship and cannot communicate easily due to their physical separation. For example, when a husband or wife assigned to work at a distant location returns to his or her temporary residence after work, he or she might want to know the living situation back home. Ambient information might enable him or her to feel at ease or motivate them to pick up a telephone and call home.

In public communication, people who work at a distant location could use ambient information to maintain their relationship. Since most communication in work situations is instrumental communication, people contact those working at distant locations by telephone, e-mail, or video conference only when necessary. However, to perform their jobs effectively, it is important for work group members to maintain their relationships by conducting a moderate amount of consummatory communication. Thus, creating communication cues is an important function for a terminal designed to communicate ambient information.

## 2.4 Technical Functional Requirements

Given the situations discussed above, we identified three technical functional requirements:

1. the ability to convey various types of ambient information that are effective in enabling each party to imagine the environment, motion, and state of mind of the other party;
2. the ability to protect the privacy of each party so that they do not feel uncomfortable;
3. the ability to enable people who have different lifestyles to communicate smoothly.

To meet the first technical functional requirement, we use the information that is part of the communication or communication assumption. This includes information about humans and their environments. Since the ambient information communication terminal is used in daily life situations, the information about the two parties should be detectable without imposing any physical restrictions on them. We thus use human presence and motion information. In addition, we attempt to detect emotion, which better represents the ambient information.

To detect emotion without physical restriction, we analyze the voice characteristics from voice information obtained with a microphone and extract the emotion. There are two reasons for detecting only emotion and not voice information itself. The first is to protect privacy. Although it is possible to communicate the voice information obtained from the microphone, users would certainly feel uncomfortable if they thought that their privacy was being invaded.

The second reason is that all the voice information is not always necessary for smooth consummatory communication. It is possible that conveying all the voice information would be bothersome for the users. In addition, one of the features of consummatory communication is sharing emotion. This means that extracting and

conveying only the emotional information rather than all the voice information is more effective for consummatory communication.

In the architectural field, there have been several studies on the effect of environmental information, *i.e.*, room color and illumination. On the basis of these findings, we use sensible temperature (a compound function of temperature and humidity), illumination, noise, and color temperature. These kinds of environmental information are easy to detect, and helpful for users to imagine the other side because they change in a relatively short time. Table 2.1 lists the information detected by the SHOJI ambient information communication terminal.

**Table 2.1** Information detected by the SHOJI terminal

Information	Type
Environment	Sensible temperature
	Illumination
	Noise
	Color temperature (light color)
Human	Presence
	Motion
	Emotion (extracted from voice)

Our solution to the second technical functional requirement, privacy protection, is to enable bi-directional communication of ambient information in an abstract manner. Since the digital expression of acquired information can lead users to feel that their privacy is being invaded, we express the acquired ambient information in a sensuous manner using light and color.

The third technical functional requirement is that people who have different lifestyles should be able to communicate smoothly. One of the potentially disruptive factors in telecommunication is the difference in lifestyles between the two parties. People in remote locations may not spend much time in front of a communication terminal, so they may feel and appear uncomfortable. Thus, the communication terminals must be able to cope with differences in lifestyles.

Our solution is to express not only the present ambient information but also prior ambient information. This means that even though one party may have already gone to bed, the other party can better understand his or her situation from the previous illumination and sensible temperature information.

## 2.5 Questionnaire

### 2.5.1 Overview

As mentioned above, the ambient information sent using the communication terminal should be expressed so that users do not feel that their privacy is being in-

vaded. Our approach is to express information in an abstract and sensuous manner using light and color.

To determine the most appropriate expression method, we conducted a survey by questionnaire. We looked at four methods of expressing ambient information: using light form, using light color, using light brightness, and using motion. We asked participants about the validity of each method. The participants in the first survey were 63 adults (33 men and 30 women). They completed the questionnaire while watching demonstrations of some of the expression methods.

The participants were first told, "Please imagine a situation in which the terminal is placed in your living room and that your parents (or your child) are living apart. An identical terminal is placed in their living room. The terminals detect each room's environmental information such as room temperature, noise level, and illumination level and also detect information about the people in the room such as their entering/leaving and emotions. The terminals exchange this information." The participants completed the questionnaire without further information about the terminal.

### **2.5.2 Results**

First, the participants answered questions about the adequateness of four expression methods representing seven types of ambient information. The description of human presence information was "a measurement that represents whether a person is in the other living room", that of human motion information was "a measurement that represents the speed of human motion in the other living room", and that of emotional information was "a measurement that represents the emotional status of the person in the other living room". The participants then chose the detail of the expression about the expression method that they rated "appropriate".

The questions about appropriateness had a seven-point scale, from "not appropriate" to "appropriate". The participants were asked questions about the further detail of the expression if they answered "appropriate".

Figure 2.2 shows the percentage of respondents who answered "appropriate" for each type of information. The results showed that it was appropriate to express sensible temperature, color temperature, and emotion using color and that it was appropriate to express presence and motion information using light brightness and motion. Color expression was judged appropriate for illumination information by 79% of the participants. Light brightness and motion expression were judged appropriate for illumination information by 73%. There was thus little difference between the two expression methods. There was also little difference between using sound (79%) and light brightness and motion (75%) for noise information.

Next we describe the details of each expression method. The results of information for which only one expression method was judged "appropriate", such as sensible temperature, color temperature, presence, motion, and emotion, showed the explicit tendency in each expression method. Following those results, we determined the detail expression.

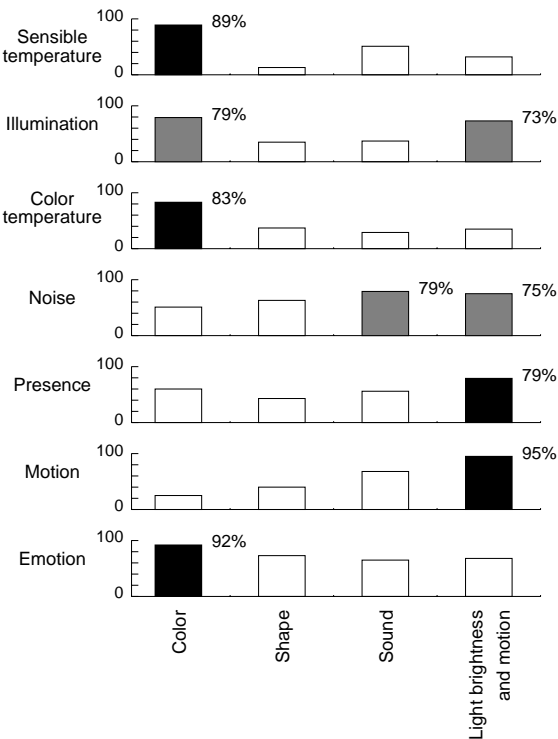


Figure 2.2 Percentage of respondents who answered “appropriate”

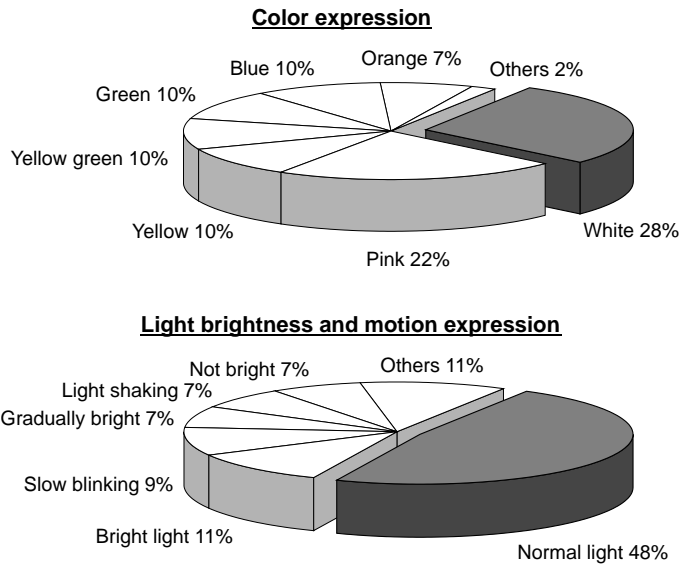


Figure 2.3 Ways of representing illumination information



The results for illumination and noise information were more complex. Figure 2.3 shows the results for color expression and light brightness and motion expression methods about the illumination information. Half of the participants answered “normal bright” for light brightness and motion expression. In contrast, an explicit tendency was not observed for color expression. Thus, we decided to express illumination information using light brightness and motion with normal light. In the same way, since we could observe a more explicit tendency in light and its motion than sound (data not shown), we also expressed noise by using light brightness and motion.

Some participants also stated that the expression of noise information by sound was troublesome in their daily lives. Thus, we decided not to use sound to express noise information.

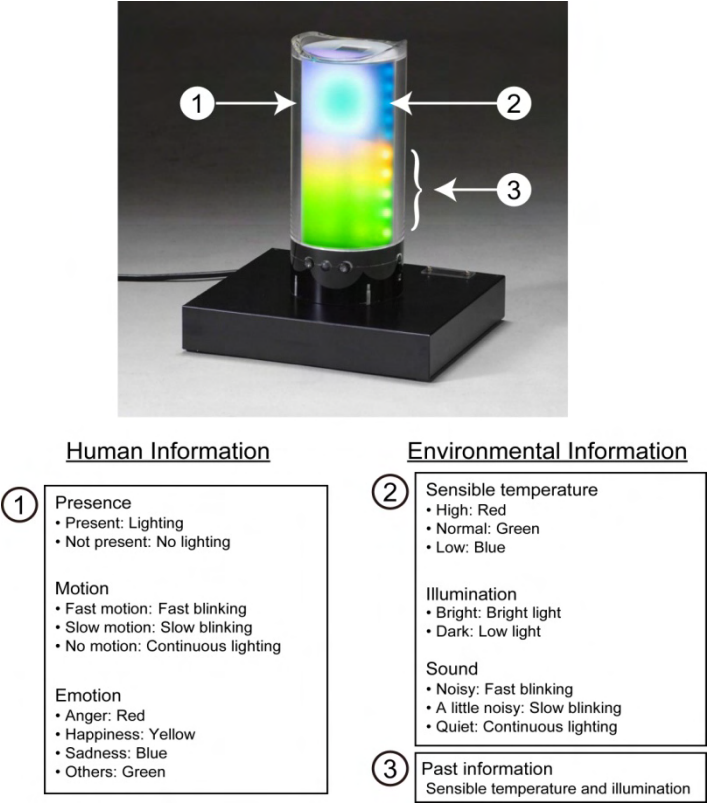
## 2.6 Prototype Terminal

To validate the concept of ambient information communication in which users can feel close to the other party, we developed an experimental terminal. The terminal concept to express ambient information in abstract and sensuous ways is “communication over *shoji*”. A *shoji* is a semitransparent room divider that has been traditionally used in Japan. People can be aware of the ambient information in the next room indirectly from the lights and sounds filtering through the *shoji* screen.

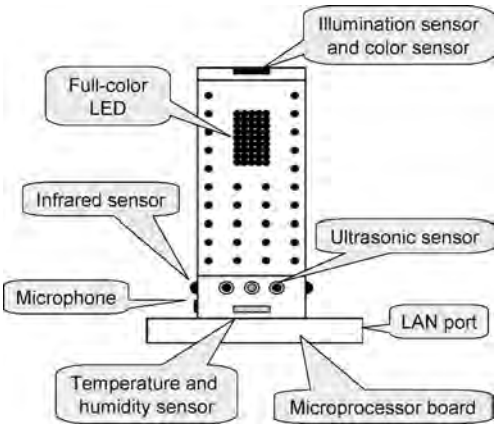
The *shoji* metaphor offers two advantages. The first is that it can be an effective way for people to comprehend an ensemble of information. Since the *shoji* is a common room divider in Japan, we assume that people will intuitively understand the *shoji* metaphor, *i.e.*, a person on one side of the divider will be aware of the environment and activities on the other side.

The second advantage concerns the invasion of privacy. Exchanging large volumes of mundane information often invades a person’s privacy. This often occurs when the transmitted information is one-sided or blatant. Since a *shoji* screen is semitransparent when seen from either side, the exchange of information is reciprocal, and information is transmitted naturally, without any specific effort required to do so.

On the basis of this discussion, we developed our experimental communication terminal, “SHOJI” (symbolic hosting online jog instrument), which is shown in Figure 2.4. The figure also shows how emotional and other cue information is expressed through the terminal. Figure 2.5 shows a schematic of the terminal. It has a microphone, a temperature and humidity sensor, an illumination sensor, three infrared sensors, and an ultrasonic sensor. The terminal is connected to the network through a local area network port. The detected information is transmitted to a predesignated terminal that displays the received information using full-color light-emitting diodes (LEDs). The lights in the center of the terminal present the information about human activities, the lights in the upper portion of the terminal present information about the environment, and the lights in the lower portion show previous information about the environment.



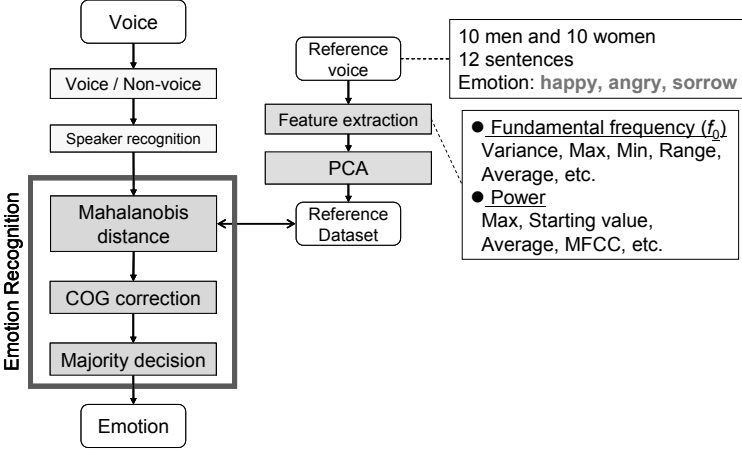
**Figure 2.4** Appearance of the developed terminal “SHOJI” and adequate representation methods found in questionnaires



**Figure 2.5** Schematic of the SHOJI terminal

## 2.7 Emotion Extraction from Voice

In this section, we describe an algorithm for emotion extraction under a real environment. Figure 2.6 shows a flowchart of the proposed algorithm, which consists of three serial recognition processes: voice/non-voice recognition, speaker recognition, and emotion recognition.

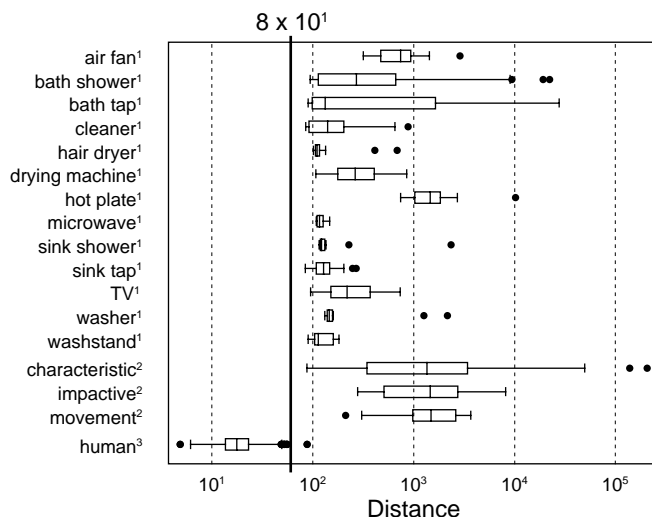


**Figure 2.6** Flowchart for the extraction of emotion from voice data

### 2.7.1 Voice/Non-voice Recognition Process

Since the sounds from the microphone include various kinds of voice, noise, and environmental sounds, the determination of voice/non-voice is necessary prior to the emotion recognition. For the voice/non-voice recognition analysis, we used three datasets (one for voice, two for non-voice). The first dataset was voice data from ten adult men and ten adult women. The second dataset was the domestic sounds database [12]. The third dataset was the Real World Computer Partnership (RWCP) sound scene database in real acoustic environments [13].

In a discriminant analysis, the discrimination function with the modified Mahalanobis distance ( $b = 2$ ) was used [14]. The fundamental frequency ( $f_0$ ), variance and starting value of the power, and the average and variance of the 12-dimension mel-frequency cepstrum coefficient (MFCC) were selected as sound feature values. Figure 2.7 shows the computed Mahalanobis distance between voice and non-voice data. This result suggests that voice data can be discriminated from non-voice data at a distance larger than 80.



**Figure 2.7** Mahalanobis distance between voice and non-voice data (1: AIST database of domestic sounds<sup>3</sup>; 2: RWCP sound scene database<sup>4</sup>; 3: human voice data)

### 2.7.2 Speaker Recognition Process

Since voice features show large natural variations between individuals, it is difficult to recognize the emotion of a specific person when several people are speaking simultaneously. Thus, speaker recognition is also necessary in order to recognize emotion with high accuracy. In a real environment, there will not be any prior reference data for a speaker's voice; therefore, the standard discrimination analysis, which requires reference data, would not be an appropriate method.

In this process, to discriminate between different speakers, we implemented a hierarchical cluster analysis method to accumulate and retain up-to-date reference data. We used Ward's method for the clustering analysis with the cosine distance. The voice data and feature values were the same as in the previous process. The results of clustering for up to ten men or ten women are shown in Figure 2.8. These results suggest that the recognition rate is about 80% when the number of speakers is three or fewer, which is reasonable in a normal-sized family room.

<sup>3</sup> JIS TR S 0001: 2002.

<sup>4</sup> <http://tosa.mri.co.jp/sounddb/indexe.htm>.

“Impactive” is sound caused by the impact of objects such as wood panel [kon, poku] and metal panel [kan, kin]. “Movement” is sound caused by human actions such as clapping hands [pan, pon] and snapping chopsticks together, opening bottle cap [baki, puchi]. “Characteristic” is sounds whose tone describes the type of source, such as bells, coins [chirin, shan], falling books, tearing paper [basa, bi-i].

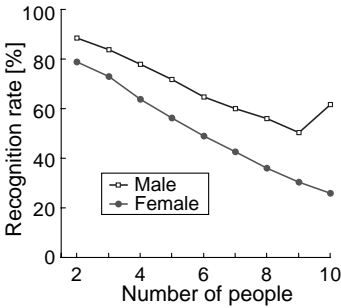


Figure 2.8 Speaker recognition rate obtained by cluster analysis as function of number of people

2.7.3 Emotion Recognition Process

Consequently, emotion recognition was conducted. The voice data from the 20 adults (ten men and ten women) mentioned above was treated as reference data. Each person spoke 12 sentences using three types of emotion (happy, angry, and sad). Three minutes of continuous voice data spoken by 11 other adults (five men and six women) was treated as target data.

In this process, the discrimination function with the modified Mahalanobis distance ( $b = 2$ ) was also used, and the fundamental frequency and power were used as feature values. As a result, the emotion recognition rate was about 70% for men, and about 40% for women (data not shown).

Since human emotions generally do not change significantly over a short time scale, the majority decision process can be applied to this discriminant analysis output. Also, since the center of gravity (COG) in the voice feature space is different for each individual, it is effective to correct the COG once every minute in the discriminant analysis process. Even when starting from an initially low rate, the

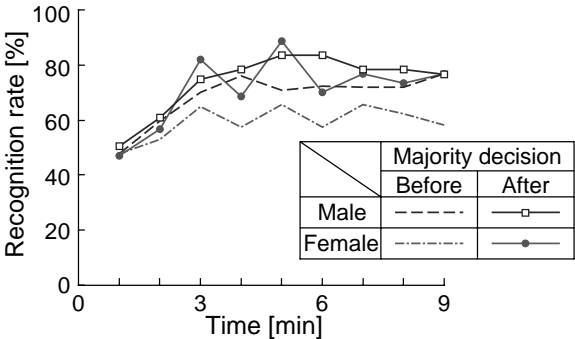


Figure 2.9 Emotion recognition rate using discriminant analysis with majority decision and COG correction

emotion recognition rate improved after a few minutes with the majority decision process and COG correction, resulting in a success rate of about 80% for both men and women in our study (Figure 2.9).

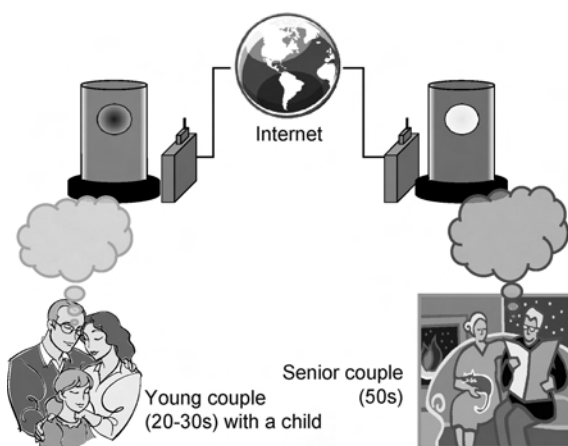
## 2.8 Field Experiment

### 2.8.1 Method

To examine the effectiveness of the concept, we conducted a field experiment using the SHOJI terminal with two couples (Figures 2.10 and 2.11). We set one terminal in each couple's living room where they mainly stayed. The terminals were then connected through the Internet. One couple was aware of the information detected in the other couple's terminal.

Participants were a married couple in their 20s and 30s, and a couple in their 50s who were parents of the wife of the younger couple. The senior couple lived on their own, and the young couple lived with their 6-year-old daughter. The distance between the living room of the young couple and that of the senior couple was about 30 min by train. They were instructed not to be particularly conscious of the terminal and to live as usual for a week.

Interviews were conducted before and after the experiment. In the pre-survey interview, they were asked about their lifestyles and communication frequency with the corresponding couple. In the post-survey interview, they were asked to evaluate the design of the terminal and the appropriateness of the ambient information expression method. They also answered questions about its effect on consummatory communication.



**Figure 2.10** Field experiment using “SHOJI”



**Figure 2.11** Sample photo of SHOJI terminal in living room used for field experiment

### 2.8.2 Results

Since the two couples did not live near each other, they did not meet frequently. The telephone was the most commonly used communication tool, and they talked around 5 h/month by telephone. Most communication was between the two wives.

The evaluation of the design of the terminal and the appropriateness of the ambient information expression method in the post-survey interview are summarized below in the form of responses:

- “I could grasp an overview of the ambient information without close attention to the terminal.”
- “Although at first I could not understand the color expression of emotional information, within a day or so I could figure out the meanings. The expression of temperature information was intuitively easy to understand. Seven types of information were not too much to comprehend.”
- “About the ambient information expressed on the terminal, once I become accustomed to the terminal, I figured out the information at once. However, in the current circumstances, I often forgot the expression method.”
- “The expression by LED was good. The size of the terminal was appropriate. If the display region were smaller, the expression would be harder to understand.”
- “The light of the terminal was too bright at night. I sometimes mistakenly thought that I had forgotten to turn off a light. It would be better to control the light volume of the terminal at night by detecting the illumination of the room.”
- “The terminal was interesting because it was like an *andon* [Japanese indirect illumination made from washi paper, a wooden frame, and a candle]. The color was so beautiful. Washi was good because it was like a night-light.”
- “The change in emotional information was a useful cue to talk with my daughter about the condition of her grandparents.”

The design of the terminal was favorably evaluated by both young and senior couples. Then, although the young couple could easily understand the expression method of overall ambient information, the senior couple pointed out that there was too much information expressed on the terminal. Thus, the evaluation of overall expression method was affected by the participant's age. On the other hands, focusing on seven types of ambient information, both groups had good or not-so-bad evaluations to each expression method. During this experiment, the participants sometimes focused on various types of information depending on their situation. In one instance, they focused on the temperature information, and in another, they took notice of the emotional information.

The evaluation of the effect on consummatory communication is summarized below in the form of responses:

- "The terminal increased the chance to imagine the other side. Though the terminal was a 'machine,' I could feel connected to the other side."
- "The chances to communicate increased. My wife sometimes made a phone call to her mother when she watched the terminal."
- "Since the terminal informed us of the presence of the other side, I could easily contact them. In contrast, since I could judge the condition of my parents by watching the terminal, the number of times we contacted them to determine their condition decreased."
- "Since I could determine whether they were present, it was easy to contact. When I had to contact them, the information on the terminal helped me decide when to phone."
- "When our family ate dinner, we often talked about the other side. Since the terminal gave us information about them, we could not only talk about my family's events but also about the events of the other side."
- "I felt uncomfortable that the other side knew when I got up late. Additionally, I didn't want to convey information when my family was upset in the morning."

All the participants favorably evaluated the effect of the information sharing, which is the purpose of consummatory communication. In particular, the results of the interview showed several advantages, such as "it helps me to contact them by providing information about the situation of the other side", "ambient information leads users to imagine the other side", and "by watching the information on the terminal, users can carry on a pleasant conversation about the other side".

The effect of the terminal was ambiguous concerning the frequency of communication. On the one hand, thinking about the situation of the other side leads to contacting them. On the other hand, since users know the condition of the other side, they may not bother contacting them. Nevertheless, the results also suggest that communication became smoother even if the frequency of communication decreased.

Though the information that users want to convey increased communication effectiveness, there were problems caused by sending information that users did not want to convey. An increase in the information conveyed inevitably leads to an



increase in not only the information that they want to convey but also in the information they do not want to convey. This issue requires further examination.

## 2.9 Conclusion

We have developed a communication terminal called “SHOJI” that conveys ambient information for the purpose of promoting fluent consummatory communication. The concept on which it is based was derived from data collected from questionnaires. SHOJI can send and receive such ambient information as the sensible temperature, illumination, light color temperature, and noise level as well as information about the presence or absence of individuals, their movements, and their emotions. The participants in an experimental evaluation judged that the information was sufficiently expressed, which indicates that the terminal is useful for exchanging ambient information.

We plan to conduct a longer-term field experiment based on the knowledge acquired in this study. In addition, on the basis of an evaluation of the effectiveness of each type of information, we will identify the information that is most effective for conveying ambient information.

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## References

1. Dewey J.: *Experience and Nature*. Dover, New York (1958)
2. Rubin R.B., Perse E.M., Barbato C.A.: Conceptualization and measurement of interpersonal communication motives. *Hum. Comm. Res.* **14**:602–628 (1988)
3. Itoh Y., Miyajima A., Watanabe T.: “TSUNAGARI” communication: fostering a feeling of connection between family members. In: *CHI '02 Extended Abstracts on Human factors in Computing Systems*, pp. 810–811. ACM Press, New York (2002)
4. Fujita H., Nishimoto K.: Lovelet: a heartwarming communication tool for intimate people by constantly conveying situation data. In: *CHI '04 Extended Abstracts on Human factors in Computing Systems*, pp. 1553. ACM Press, New York (2004)
5. Mynatt E.D., Rowan J., Craighill S., Jacobs A.: Digital family portraits: providing peace of mind for extended family members. In: *CHI '01 Extended Abstracts on Human factors in Computing Systems*, pp. 333–340. ACM Press, New York (2001)
6. Chang A., Koerner B., Resner B., Wang X.: Lumi Touch: an emotional communication device. In: *CHI '02 Extended Abstracts on Human factors in Computing Systems*, pp. 313–314. ACM Press, New York (2002)
7. Siio I., Rawan J., Mynatt E.: Peek-A-Drawer: communication by furniture. In: *CHI '02 Extended Abstracts on Human factors in Computing Systems*, pp. 582–583. ACM Press, New York (2002)
8. Chung H., Lee C.H.J., Selker T.: Lover’s cups: drinking interfaces as new communication channels. In: *CHI '06 Extended Abstracts on Human factors in Computing Systems*, pp. 375–380. ACM Press, New York (2006)

9. Siio I., Mima N.: Meeting Pot: coffee aroma transmitter. In: UbiComp'01 – International Conference on Ubiquitous Computing (2001)
10. Chen C.Y., Forlizzi J., Jennings P.: ComSlipper: an expressive design to support awareness and availability. In CHI '06 Extended Abstracts on Human factors in Computing Systems, pp. 369–380. ACM Press (2006)
11. Heesook S., Junyoung L., Junseok P., Youngjae K., Hyunjoon O., Taehwa L.: A tactile emotional interface for instant messenger chat. In: Smith M.J., Salvendy G. (eds) Human Interface and the Management of Information. Interacting in Information Environments, pp. 166–175. Springer, Heidelberg (2007)
12. Kurakata K., Matsushita K., Kuchinomachi Y.: Database of domestic sounds for evaluation of auditory-signal audibility: JIS/TR S 0001. *Acoust. Sci. Tech.* **24**:23–26 (2003)
13. Nakamura S., Hiyane K., Asano F., Endo T.: Sound scene data collection in real acoustical environments. *J. Acoust. Soc. Japan E* **20**:225–231 (1999)
14. Kato N., Abe M., Nemoto Y.: A handwritten character recognition system using modified Mahalanobis distance. *Syst. Comput. Japan* **28**:46–55 (1997)

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