Thermo-Message: Exploring the Potential of Heat as a Modality of Peripheral Expression

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CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
Peripheral expressions using various modalities are considered as possible alternative ways of delivering information in our communication. In this research, we aimed to explore how the thermal expression can be used in the interpersonal communication. Based on the result of the focus group interview, we developed a pair of devices with which the users can exchange a "thermal message" each other. Experience prototyping was conducted with the devices in the real daily life context of the users. We identifed the charateristics of thermal expression, and confirmed the potential of the thermal expression in interpersonal communication.

Keywords
Thermal expression, peripheral expression, modality, interpersonal communication, experience prototyping

ACM Classification Keywords
H.5.2 User Interfaces: Interaction Styles, H.5.2 User Interfaces: User-Centered Design

General Terms
Design

Introduction

The rapid development of information and communication technologies enabled people to have easy and pervasive access to utilize a variety of modalities, including text, voice, image, and video, for their remote communication. Those remote communication features mediated by mobile phones, web services, and applications have become an essential part of our lives, but there are side effects.

Frequent and pervasive remote communication can be obtrusive. As it becomes common to many people, we are expected, by others, sometimes even by ourselves, to respond to the messages that we get with the increased standard in terms of frequency and pervasiveness. Consequently, we are enforced to be notified by too many devices and applications around us. Hansson described this phenomenon as "attention overload" problem [2].

Another problem lies in the limitation of the expression modalities. The technologies embedded in the devices and applications for remote communication support mainly visual and audio media. Although this can deliver the core information, it is still losing the rich contextual information which has important roles in face-to-face communication. Nakashige pointed that this often causes incomplete communication and misunderstanding [4].

In this situation, ambient media is considered as a possible alternative. According to Mark Weiser, calm technology, which is adopted for expressing information in ambient media, can inform without overburdening by enhancing our peripheral reach [6].

Even in this case, most of the previous researches are dealing with visual media for expressing the peripheral information [2,7]. Some other researches [1,3] support the value of other modalities such as audio and tactile, by showing that unique and valuable interactions can be mediated although the bandwidth of the expression modality is low.

We believe that heat can also be used as an expression modality in ambient media for mediating valuable interaction. In more specific, our interest lies in how people could use heat as message in their communication. We expect that understanding this process will give us insights about how heat can deliver information, and also how it can enhance interpersonal interaction with its own unique value.

"Hiya-Atsu" media is one of the few existing examples which discovered the potential of heat as an expression modality [4]. Their study was about providing thermal stimuli on the surface of the mouse, in an expressive manner, with visual images on the computer screen for conveying richer information. Still, their consideration is not covering how to contextualize them in the human to human interaction.

In this research, we aim to explore how heat can be used as an expression modality for mediating valuable interpersonal communication. We had the following research questions:

- How do people endow meaning to the heat and interpret it for their communication?
- What is the value of the thermo-messages and interaction methods?

After the preliminary focus group interview, we developed a pair of interpersonal communication devices with which the users can exchange a "thermal message" each other. Experience prototyping was conducted with the devices in the real daily life context of the users.

Figure 1. The participants of the focus group interview

Preliminary Focus Group Interview

To support our claim and get an idea about our further design direction of the prototype, we conducted a preliminary focus group interview (FGI).

The participants were 5 students (2 male, 3 female) in a graduate school of design, who are trained to capture and crystallize the small differences in our lives from various perspectives. The interview was conducted by the first author for about 30 minutes and recorded with video camera and script writing (Figure 1.). The following topics were discussed:

- Situations in which we felt positive or negative for the thermal sensation
- Information that we can get from thermal sensation in our daily life
- Impressive moments when heat came to us with a special meaning

From the result, we could confirm that we are already sensing and interpreting the heat to get information. One of the participants said that she considered the unusual heat from consumer electronics as a negative signal. In general terms, it means that we have a certain expectation about the heat in a certain situation, and whether the heat matches the expectation or not decides the meaning that we take from the heat.

In addition, we also confirmed that we abundantly have such expectations about our environment. The participants mentioned their prejudice about what is likely to be cold or warm in terms of color, texture and behavior. For example, halogen light, red color, fur, and hugging were said to appeal warmness. This means that we have enough chances to utilize the heat for communication in our lives.

We summarized those as 'general perception about thermal sensation' and 'context dependency'. There were some other interesting issues related to the degrees of perception, homeostasis and synaesthesia. These could be meaningful as findings themselves. Moreover, they became the basis for forming the initial framework for the analysis of the next user study. Those findings will be discussed in the result & discussion section.

Directions for the Prototype Development

Context dependency and other findings imply that the heat generally becomes meaningful and informative in relation with the context it lies in. We expected that observing the experience of users with the prototype in a real context could enhance our understanding about the nature of thermal expression. Therefore the prototype needed to be mobile, easy to use and working in the users' environment.

Prototype Development

A pair of thermal messaging devices was developed. An Arduino board and an Xbee module were the main components for the remote communication, and packed

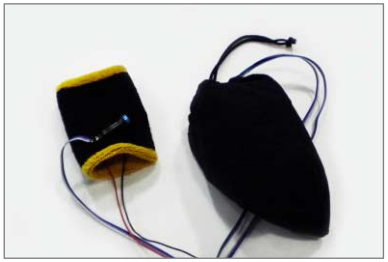

Figure 2. The prototype of the thermal messaging device

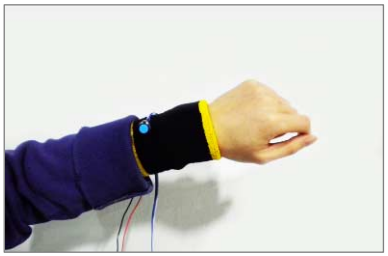

Figure 3. One of the participants is wearing the prototype. A blue button is attached on the wristband.

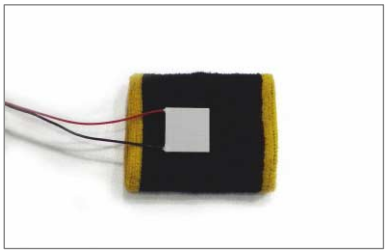

Figure 4. A Peltier device FALC1-07110T150 attached inside the wristband

in a small and soft pouch for better mobility and durability (Figure 2.). The heat was generated from the Peltier device FALC1-07110T150 (Figure 4.) during the time when the button on its pair device is pressed; if you want to send a thermal message to another, you may press the button on your device. The amount of heat was controlled by the on/off time ratio of current supply, so that the user can feel the thermal stimulus within a few seconds but not excessively.

The Peltier device was attached inside a flexible wristband for better contact with the skin and easy wearing (Figure 3.). We expected that the thermal stimulus to the wrist can be relatively acceptable because the wrist is commonly exposed. The sporty wristband can be aesthetically moderate for a large number of people. The button was attached on the wristband for an intuitive feedback.

Experience Prototyping

Two groups of people were recruited and two people were involved in each group. We targeted the people in a close relationship, sharing their physical environment, and communicating frequently. For the diversity of the data, we recruited people with different relationships for each group; mother and daughter for Group 1, colleagues sharing an office room for Group 2.

The participants in each group used the prototype for one day in their living environment, and reported their use experiences. They were asked to write the time and situation every time they use the devices, motivation and intention of the message in case they are senders, interpretation, feeling and reaction about the message in case they are receivers. In the debriefing session, they were asked to suggest other application ideas based on their use experiences.

Result & Discussion

To understand the nature of thermal messaging, the data obtained from both the FGI and experience prototyping were categorized to extract the key issues and patterns regarding thermal expression.

A. Characteristics of Thermal Expression

Mainly from the FGI and the debriefing sessions, we could form a preliminary understanding about the characteristics of thermal expression, i.e. expression delivered by heat. Following seven issues are recommended to be considered when designing thermal expressions.

1. Homeostasis, critical factor to the interpretation

People tend to feel the warmness positive when they are in a cold environment. This seems to be based on the biological needs, e.g. maintenance of body temperature. When they become safe from external factors that can change the body temperature, they feel positive. On the same extent, a radical change of temperature is perceived as a negative sign.

2. Multiple degrees of perception

Heat sensation was found to be not mere binary, i.e. hot and cold. For example, one participant used expressions like 'just lukewarm' and 'favorably warm'. Another participant accentuated the difference between 'being cool' and 'being cold'.

3. General perception about thermal sensation

People mentioned that they feel negative for coldness,

and positive for warmness. There could be some cultural factors which influence their perception.

4. Context dependency

The perception or memorization of the thermal expression is not solely caused by the heat itself. It tends to include the context of the situation in which the person experiences the heat. The heat seems to have hardly any meaning by alone without its context. The participants tried to recall and tell the experience and context first, not just the heat.

5. Synaesthetic complexity

One participant of the FGI mentioned a cup of coffee in a white mug, and the feeling of the warmness with the scent of the coffee and soft texture of the mug. She said that if something else is inside the mug, or the coffee is inside something else, she might feel different. With similar extent to the context dependency, thermal expression tends to be in a part of such synaesthetic complexity.

6. Little obtrusion

The participants of experience prototyping considered that thermal expression has little obtrusion both to the receiver and the people around the receiver. One of them said that she would send the thermo-message at any time she wants to her husband, even though he might be working.

7. Different acceptability on the body parts

People tended to be generous about the thermal stimulus applied to the body parts which are exposed usually, just as hands and wrists, but not to the stomach. Cultural conventions can also be a considerable factor.

B. Values of Thermal Expression

The participants' use behaviors and comments fell into five categories, which confirmed that thermal expressions can be intended and interpreted with various purposes.

1. Playful stimulus

The participants from both groups in experience prototyping reported that they felt the metaphor of physical touch from the thermal expression, which led them to playful use. A large number of their trials were just for fun, which shows that thermal messaging can be appropriate for casual and frequent interactions.

2. Call for action

The prototype was used to call the partner, even to wake up the partner in Group 2. This was functioning as triggering further interactions. One participant from Group 1 suggested that this can be used for the patients to call their caregivers. She said that lukewarm thermal message could mean asking help for ordinary things, and extreme one could mean emergency.

3. Emotional message

Both groups of experience prototyping mentioned that couples or family members can share this system and feel they are always together. As the thermal message has little obtrusion to the partner, it can also be used as a preliminary notifier, before actually making a phone call for casual purposes.

4. Good tidings bad tidings

One participant from Group 1 suggested using this system upon a pre-defined vocabulary between the partners. For example, a long warm signal can mean "I

am thinking about you," and a repeated cold signal can mean "I've got some trouble."

C. Potential of Thermal Expression

Lastly, from the findings of the user study, we would like to highlight the potential of thermal expression in three points, which tell us how and why it can contribute to the improvement of our communication.

1. Unnoticed but casual way of communication

Interpreting the meaning or information from the heat is not a new ability to learn but just an unnoticed way of communication that we already have in our daily life. It is a good example of utilizing peripheral information. Thus we expect that assisting human ability to send and get the heat in distance will lead to better communication.

2. Uniqueness in its emotional value

Heat sensation seems to have its own unique value which cannot be replaced by other sensory stimulus. Just like physical contact, thermal expression can more directly appeal in certain circumstances than the letters or sounds.

3. Diverse situations and purposes for the application

Although the amount of information that heat can deliver is limited, we confirmed from our user study that thermal expression can be applied to diverse situations with diverse purposes. Context dependency and little obtrusion give this flexibility of application.

Conclusion

The result of this study confirmed the potential of the thermal expression in the interpersonal communication. It is not about replacing the type of communications now we commonly use, but rather about augmenting the remote communication by user-driven contextualization of the symbolic and peripheral information.

We expect this research to enhance our understanding about how the thermal expression can improve our communication and how it can be designed. For the further researches, more detailed issues around the characteristics of the thermal expressions can be discussed on the biological, psychological, and emotional perspectives. Designing and evaluating a new prototype with specific use purposes is also expected.

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