A Basic Study of Hot-and-cold Blower for Realizing Onomatopoeias

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Abstract

The goal of this study is to develop a system for virtually experiencing onomatopoeias, which are echoic or mimetic words. As compared to other languages, Japanese features a large number of onomatopoeias, which serve as a hindrance to foreigners learning Japanese. In order to overcome this hindrance, we present tactile information corresponding to onomatopoeia and prompt its physical understanding. We focus on temperature and wind senses and propose a hot-and-cold blower, which consists of a temperature generator and a blower. Further, we conduct three experiments to verify the effectiveness and correlativity of the proposed system.

Keywords: onomatopoeia, temperature sense, wind sense, tactile interface

1 Introduction

Over the last few decades, the number of people learning Japanese overseas has increased dramatically, going from a mere 130,000 in 1979 to over 3,650,000 in 2009, according to the Japan Foundation[1]. One of the big challenges for these new learners of Japanese is understanding the language's peculiar use of onomatopoeia (i.e. echoic or mimetic words) that sensually express information like sound, texture or movement. The meanings of onomatopoeic words for brightness (pikapika, donyori, etc.) or hardness (fuwafuwa, kachikachi, etc.), for example, are highly abstract and hard to quantify, but because such words are common in Japanese, gaining a good understanding of them is essential to grasping the broader semantics of the language.

A number of efforts have focused on teaching Japanese onomatopoeia more effectively. An online learning support system called ONOMATOPENARAI[2], for example, helps individual learners by illustrating how to use selected onomatopoeic words through example sentences, similar expressions, etc. Another example is the Onomatopoeia Sound Database[3], which provides learners with sound data corresponding to various onomatopoeic vocabularies.

Aside from these self-learning systems, several tools and applications that integrate onomatopoeic keywords have emerged in recent years. Examples include Onomatoperori[4], a cooking application that offers recipe recommendations based on onomatopoeic input, and Onomatopen[5], a painting application that changes brush styles according to spoken onomatopoeic words. The sensual contexts of these applications can make the meaning and application of onomatopoeic keywords more accessible to users.

One range of Japanese onomatopoeia that has not been addressed by such applications is tactile onomatopoeia. This is hardly surprising, since existing applications depend heavily on visual and auditory input and output. Nonetheless, if a system could integrate tactile information to convey the meaning of tactile onomatopoeia directly, it could provide a major boost to intuitive learning of Japanese.

In this study, we propose a system that produces tactile information based on onomatopoeic keywords. Focusing on the user's sense of temperature and wind quality, we integrate a "hot-and-cold blower" device to produce experiences associated with those keywords.

2 Related Work

Systems integrating tactile information have generally used it in one of two ways: (1) as input/output device for system, or (2) as a reinforcement of visual and auditory information. In this section, we limit our discussion to systems that use temperature and wind interfaces.

2.1 Temperature Interface

In this section we take "Themotaxis"[6] and "Thermoesthesia"[7] as examples of the systems using temperature information. Thermotaxis is

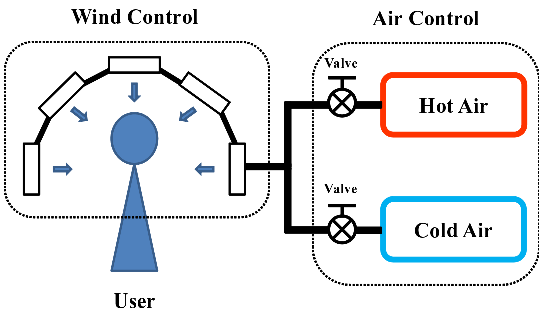

Figure 1. Initial Prototype Design

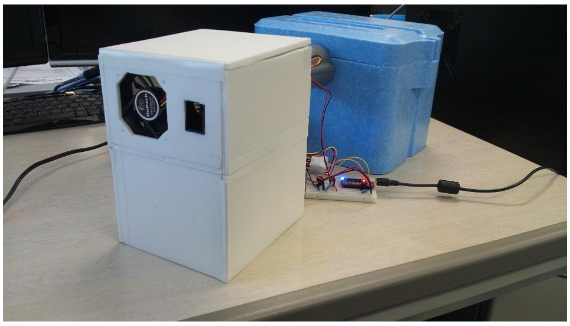

Figure 2. Experimental Device Setup

a system for conducting variable temperature information to users through an earmuff-type wearable device. This system uses temperature information as an input. To control human behavior and their position implicitly by presenting environmental information, two types of Thermotaxis were invented. One, “Thermotaxis: defined,” presents thermal sensation and thus influences standing position of users. The other, “Thermotaxis: society,” creates thermal sensory spots around people and thus encourage uses to gather together or come in comfortable personal distance.

Another system, Thermoesthesia, uses temperature information as a reinforcement of visual and auditory information. The system is designed to let users feel the temperature of warm or cool displayed objects, by directly touching the display surface.

Such interfaces are understood intuitively by most users, even when they convey relatively abstract or emotional meanings (e.g. joy or sorrow) using temperature (e.g. warmth and chill). When visual components are added (e.g. fire and ice) the intuitive is magnified even further.

2.2 Wind Interface

Most systems that make use of wind information do so in combination with visual information, and many integrate audio as well.

The Wind-Surround System[8] uses a set of blowers arranged in circular fashion around the user to reproduce wind environments, while a head-mount display and earphones reproduce corresponding visual and an auditory output. The system is intended to give a more realistic expression of virtual reality (e.g. of a storm, winged flight, etc.)

3 Proposed System

3.1 Basic Design

The hot and cold air currents that a human being feels in everyday life can be described using several key parameters: strength, direction, duration, temperature, and humidity. Our hot-and-cold blower system was designed to reproduce as many of these parameters as possible, so as to cover the greatest number of related onomatopoeic expressions.

We can divide the above parameters into two classes: (1) wind parameters (strength, direction and duration) and (2) air parameters (temperature and humidity). These classes correspond to the subsystems for wind-control and air-control illustrated in Figure 1. In the wind-control subsystem, wind strength, direction, and duration are controlled by adjusting the output of blower fans installed at different positions around the user. In the air-control subsystem, temperature and humidity are controlled by adjusting the apertures of blower-integrated air tanks with different levels of heat and moisture.

In this paper, we focused on two parameters, the strength of wind and temperature, which are supposed to be especially important parameters in hot and cold winds. For this purpose, we made the device which connects wind-control and air-control subsystems through a single short pipe.

3.2 Temperature Generator

Our hot-and-cold blower system, pictured in Figure 2, consists of a temperature generator that feeds temperature-adjusted air to a wind generator, which then blows the air at an adjusted strength.

Many systems that produce temperature-adjusted output make use of Peltier devices, as they are small, produce little noise or vibration, and can control temperature with great accuracy. Unfortunately, Peltier devices would not produce enough heat to sufficiently alter the temperature of air flow used in our system. For this reason, we chose instead to control the temperature of an insulated chamber made of expanded polystyrene casing, using coolants and heating elements. Specifically, we introduced a 1 kilogram mass of dry ice as our coolant and a ceramic fan heater as our heating element.

3.3 Wind Production Device

Our wind-production device used two DC fans: an Owltech OWL-FY0615M as a propeller, and a Sunon GB1205PKV1-8AY.GN as a blower. The propeller fan produces greater air flow than the blower, but a lower static pressure. Using the two in combination, we can reproduce a wider range of wind dynamics.

The output of the two fans is under PWM (Pulse Width Modulation) control via a microcontroller (Gainer Mini) connected by USB. In this way, we can command 256 different levels of wind output through the PC software platform known as "Processing." Since the Gainer Mini microcontroller provides only 5V of electrical power and the fans both require 12V, we incorporated a TOSHIBA transistor (model 2SK2231) to provide additional voltage. The fans will still cease to operate when the PWM value dips below a certain threshold, but they can still reproduce a large range of wind strengths.

3.4 Onomatopoeia for Presentation to Test Subjects

To test our system, we chose a total of 17 wind-related (e.g., pyu-, buo-, etc.) and 13 temperature-related (e.g., hinyari, pokapoka, etc.) words from the Onomatopoeia Dictionary[9]. We then analyzed these words with respect to some parameters (wind, temperature, humidity, contact area, etc.). Since the current prototype of our system only reproduces wind strength and temperature, we left other parameters to the imagination of the subjects and didn't take into consideration.

4 Experimental Evaluation

We carried out several experiments using our prototype device. In all experiments, both cold-wind and hot-wind conditions were reproduced.

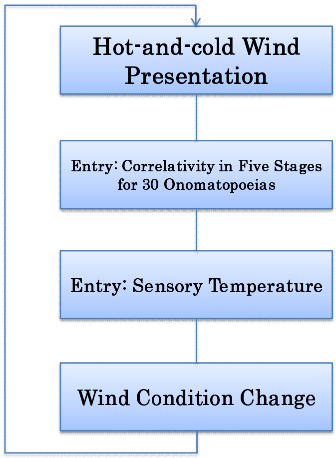

Figure 3. Flowchart of Subject Investigation

The temperature inside the temperature generator was under −30 degrees Celsius for producing cold-wind conditions and around 90 degrees Celsius for producing hot-wind conditions.

4.1 Measurement of Outlet Temperature

To establish what kinds of wind our DC fans were capable of producing, we first measured the output temperature. Placing a thermometer at the blower outlet vent, we carried out ten levels of measurement on each fan unit, starting at a PWM value of 80 (at which level the rotation of a DC fan is stable) and ending with a PWM value of 255 (the maximum output). After running a DC fan for one minute, we recorded the temperature of the thermometer. Because changes of temperature are not immediate, we ran the fan units for exactly one minute prior to measurement, and then waited exactly 5 minutes before the next operation.

Table 1. Wind Patterns Used in Experimental Investigation

Pattern	PWM Value (Propeller Fan)	PWM Value (Blower Fan)
Pattern 1	80	0
Pattern 2	160	0
Pattern 3	255	0
Pattern 4	0	80
Pattern 5	0	160
Pattern 6	0	255

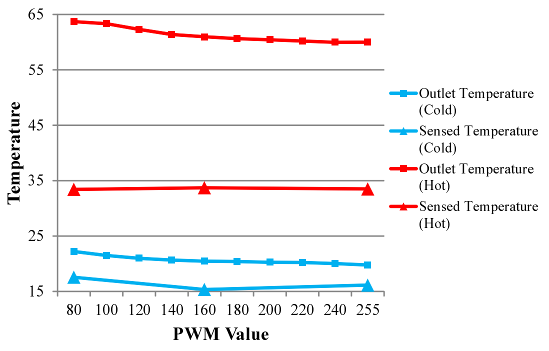

Figure 4. Comparison between Outlet Temperature and Sensed Temperature When Using Propeller Fan

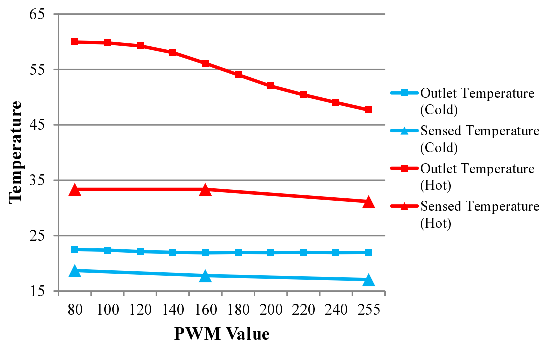

Figure 5. Comparison between Outlet Temperature and Sensed Temperature When Using Blower Fan

4.2 Investigation of Sensory Temperature

Assuming the impression a user has toward hot and cold winds will be greatly affected by the way s/he senses temperature, we sought to gauge sensory-perceptual variations among our subjects. To accomplish this, we decreased the number of wind-sensation patterns to six (three stages of PWM value for each of the fan units), so that the subjects could easily distinguish among them (see Table 1). These 6 patterns were then combined with both hot and cold sensations to produce a total of 12 test wind conditions. Fourteen male and female subjects, all in their twenties, were asked to record their sensations of these conditions.

4.3 Investigation of Correlation of Hot-and-cold Wind Conditions to Onomatopoeia

To investigate how the users correlate hot-and-cold wind conditions to onomatopoeic meanings, we presented each of the fourteen subjects with 30 onomatopoeic words related to wind and temperature, and asked them rate the degree of correlation on a five-point scale. This investigation of correlativity and the above investigation of temperature sensation were carried out at the same time. The combined flow of the two investigations is shown in Figure 3.

5 Discussion of Results

5.1 Outlet Temperature and Sensed Temperature

It is well established that the human sense of temperature is affected by changes in wind and humidity. Accordingly, we compared the outlet temperature of our blower device with the sensed temperature for both the propeller fan and the blower fan (see Figures 4 and 5).

As expected, the greater the wind strength, the lower the sensed temperature was relative to the outlet temperature. Even so, when we compared PWM value 160 to PWM value 255, the sensed temperature did not change significantly even as the outlet temperature changed greatly. We therefore conclude that wind sensation tends to blunt temperature sensation.

5.2 Discussion of Correlativity between Hot and Cold Wind Conditions and Onomatopoeia

We compared the correlativity of wind-related onomatopoeic words (e.g., pyu-, buo-) to the wind conditions produced by both the propeller fan (Figures 6 and 7) and the blower fan (Figures 8 and 9) using the same PWM values. We found that, using the blower fan, the differences in average and variance were rather small, but that, using the propeller fan, the differences in average and variance were, respectively, 2.9 and 1.5 times greater than those using the blower fan. Clearly, correlativity depended greatly on which of the two fan units was used.

For temperature-related onomatopoeic words (e.g., hinyari, pokapoka), we found that the correlativity with reproduced hot and cold temperatures was higher when using the propeller fan (Figure 10) than when using the blower fan (Figure 11). We conclude that the propeller fan unit produced stronger correlations with temperature-related onomatopoeia.

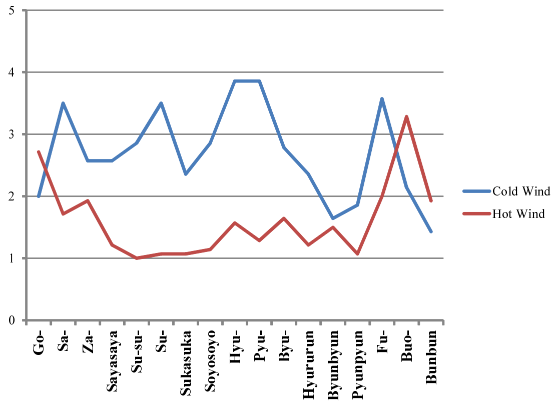

Figure 6. Average Correlativity between Wind-related Onomatopoeia and Pattern 2 Wind Conditions

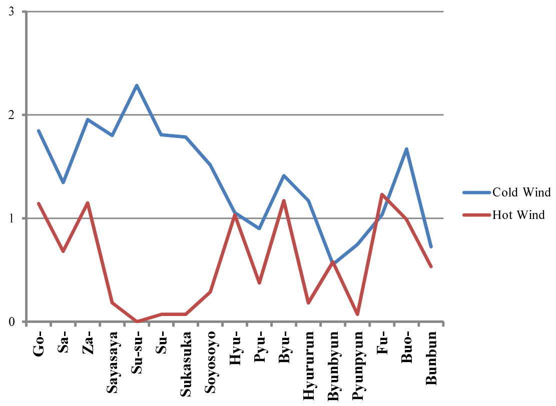

Figure 7. Variance of Correlativity between Wind-related Onomatopoeia and Pattern 2 Wind Conditions

Based on the combined results, we conclude that wind-related onomatopoeia are best conveyed using the blower fan, and temperature-related onomatopoeia are best conveyed using the propeller fan. The combination of the two fans allows us to reproduce wind and temperature conditions with high correlativity to related onomatopoeic words.

5.3 Problems and Solution

One of the challenges facing the system suggested in this paper is the inability to control temperature directly through software. Although heat can be varied by electrical current, cold cannot. In our prototype design, we had planned to accomplish temperature control using a butterfly valve attached to hot and cold air tanks. Unfortunately, problems with the valve coupling prevented proper mounting. To fix these problems, we need to experiment with valves using a different structure (e.g., gate valves).

The problem of excessive system noise, created by the fans and the PWM control, must also be addressed. The best solution may be to provide users with headphones and to present auditory information at the same time as wind information.

6 Conclusion and Future Work

In our investigation of the hot-and-cold blower device proposed in this paper, we found a fairly high correlativity between the hot and cold winds produced by our system and corresponding onomatopoeia.

In future work, we will analyze the feasibility and benefit of adding visual and auditory infor-

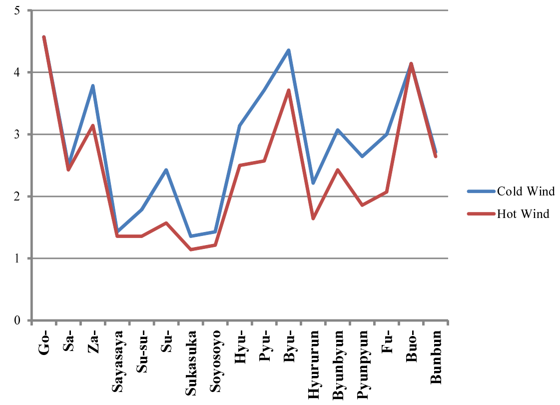

Figure 8. Average Correlativity between Wind-related Onomatopoeia and Pattern 5 Wind Conditions

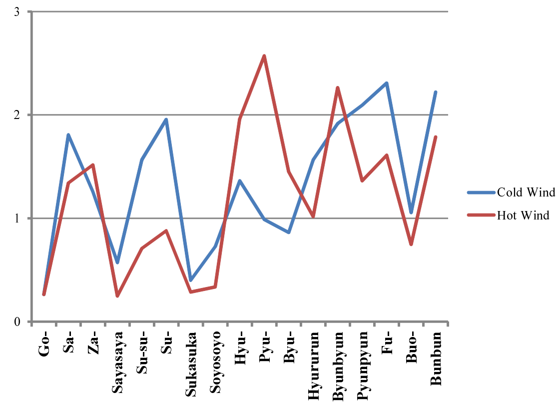

Figure 9. Variance of Correlativity between Wind-related Onomatopoeia and Pattern 5 Wind Conditions

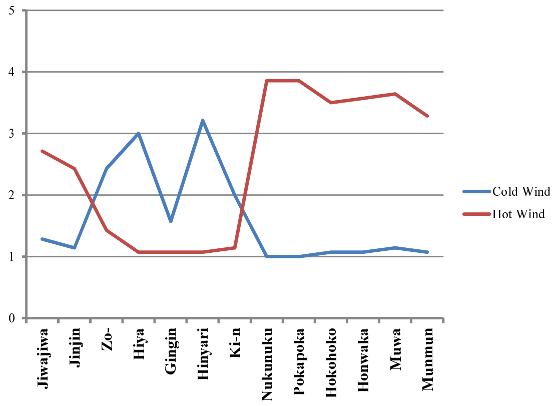

Figure 10. Average Correlativity between Temperature-related Onomatopoeia and Pattern 2 Wind Conditions

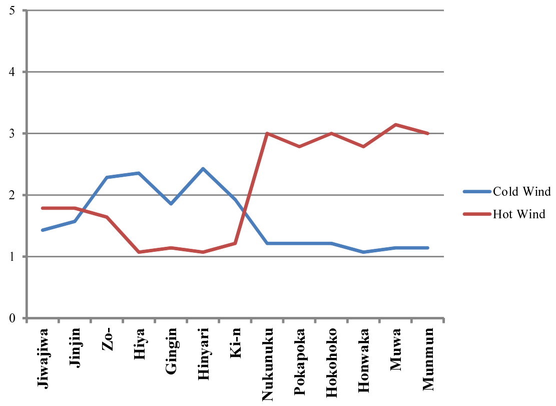

Figure 11. Average of Correlativity between Temperature-related Onomatopoeia and Pattern 5 Wind Conditions

mation to this system. We will also consider a number of presentation metaphors (e.g., intructive picture book that utilizes onomatopoeia as input[10]) that might improve the instructional value of the system.

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