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# Evaluation of Roller-Type Itch-Relief Device Employing Hot and Cold Alternating Stimuli

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**Abstract**

An itch is a significant problem for many diseases and relief of itch without side effect is required. We focused on the fact that painful thermal stimulation inhibits the itch sensation. Based on two well-known phenomena, thermal grill illusion and synthetic heat, which can generate pain or burning sensation without physical damage, we tried to achieve similar effect with harmless-range thermal stimulation. We developed a roller-type itch-relief device. The roller is composed of two parts. One part is set hot and the other is set cold by embedded Peltier devices. When the device is rolled on the user's skin, the skin is exposed to hot and cold stimuli alternatively. We also evaluated the elicited sensation and confirmed that it could partly deliver pain sensation.

**Author Keywords**

Itch; Thermal stimulation

**ACM Classification Keywords**

H5.2. INFORMATION INTERFACES AND PRESENTATION: User Interfaces – haptic I/O, prototyping.

J.3 [LIFE AND MEDICAL SCIENCES]; Health

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## General Terms

Human Factors

## Introduction

An itch is a sensation that is common to many skin diseases such as atopic dermatitis and senile xerosis. It can be relieved temporarily by scratching, but scratching damages the skin, leading to prolonged illness. Therefore, it is important to reduce the itch sensation without damaging the skin. In the treatment of atopic dermatitis, suppressing the itch by the administration of a drug (e.g., a steroid or antihistamine) is now common. However there is a risk of side effects (e.g., adrenal insufficiency, diabetes, and viral skin infection) of drug treatment.

Meanwhile, it is known that painful thermal stimulation inhibits the itch sensation [1]. This may lead to a type of treatment without the risk of serious side effects; however, the heat causing the pain might burn the skin.

The thermal grill illusion (TGI) [2][3] and synthetic heat[4] are well-known perceptual phenomena that induces pain or burning sensation without damaging the skin, by presenting hot and cold stimulation simultaneously to the skin. Therefore, it is likely that presentation of both hot and cold sensation might be used to induce pain-like sensation and relieve itch, while it does not damage the skin.

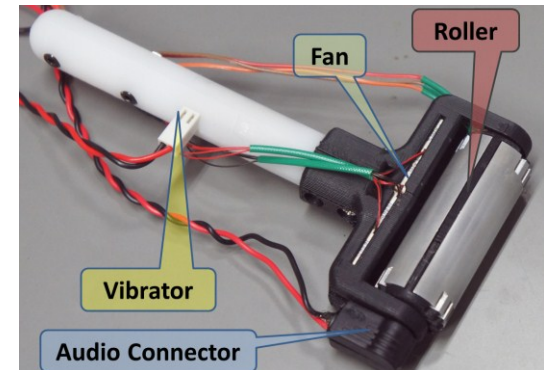
Based on this idea, we have developed and evaluated a roller-type itch-relief device that employs alternate temperature [5]. The roller has embedded Peltier devices. The outer surface of the roller is divided into two parts, one being heated and the other being cooled. It is anticipated that by rolling the roller on the skin,

the skin touches the two parts alternately. User study with the prototype confirmed that itch sensation is reduced. However, the device temperature was not stable and we could not evaluate subjective quality of the elicited sensation.

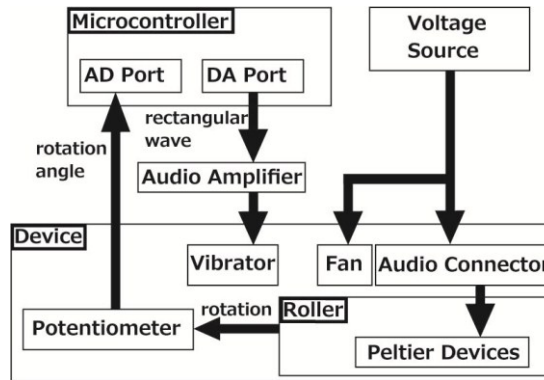
In this paper, after developing a roller-type thermal device with sufficient stability, we verified whether it would bring TGI or other related illusory sensations.

## Device

The system consists of two aluminum parts (outside diameter: 20 mm, length: 50 mm), a potentiometer to measure the rotation angle, a vibrator (Tactile Labs, Haptuator Mark II), two Peltier devices (STS, T150-85-017S), four fans (Sunon, UF3C3-700) a microcontroller (mbed NXP LPC1768), an audio amplifier (Rasteme Systems, SDA202), ABS plastic exterior, and a voltage source (A&D, AD-8723D) (**Figure 1**, **Figure 2**). To connect the current source and the rotating Peltier devices, we used an audio plug and a leaf spring as a rotary joint.



**Figure 1.** Overview of the device



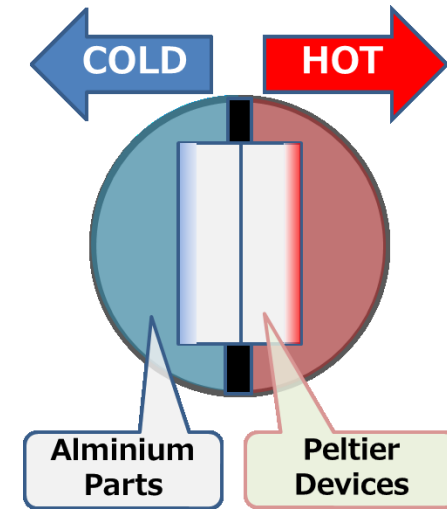
**Figure 2.** System overview

The roller portion is embedded with two Peltier devices, which are piled up to achieve efficient heating and cooling (**Figure 3, Figure 4**). One side of the pile touches and heats one side of the cylinder, while the other side of the pile cools the other side of the cylinder.

Normally, TGI is elicited by hot and cold stimuli presented simultaneously and close to each other. However, this simultaneous stimulation results in large setup and consumes much energy. On the contrary, we presented hot and cold stimuli using single cylinder, which makes the device compact, and at the same time energy-efficient, since single Peltier device works both as a hot and a cold thermal sources. We expected that the TGI to be generated through the presentation of hot and cold stimuli to the skin alternately through the rotation of the roller.

In our first prototype, although we could initially present hot and cold stimuli separately, they gradually became hotter due to the heat of the Peltier device [5]. To overcome this problem, we embedded array of

micro-fans to release heat. The roller was also redesigned to efficiently transmit heat from the Peltier device to the aluminum parts.



**Figure 3.** Cross-section of the roller

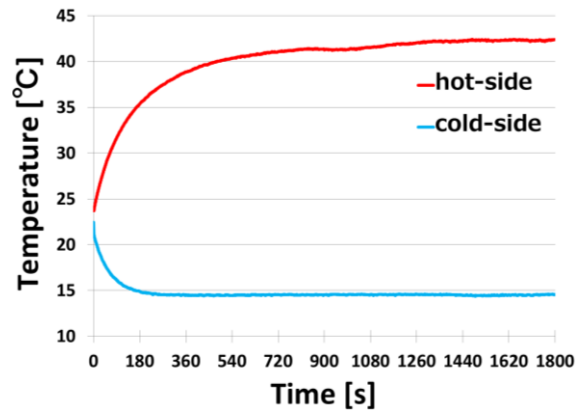


**Figure 4.** Inside of the roller

#### Hardware evaluation

To ensure safety, the temperature of the roller surface must be within a range that does not damage the skin, which is around 44 °C [6][7]. We adjusted the current applied to the Peltier device to keep the roller surface

below 44 °C. **Figure 5** shows the surface temperatures of the two sides of the roller when 0.8 A constant current was applied to the Peltier devices. The room temperature was 23 °C. The measurement was carried out for 30 minutes, and the high-side temperature was maintained below 43 °C, while low-side temperature was below 15 °C (**Figure 5**).



**Figure 5.** Surface temperature of the roller.

## Experiment

We evaluated sensation elicited by hot and cold temperature stimulation. We compared three temperature conditions of the roller and evaluated by questionnaire.

### Participants

8 healthy naive participants (male; 5, female; 3) between 21 and 63 years of age participated in the study. None had atopic eczema or chronic skin disease.

They did not have any prior knowledge of TGI or other related illusions.

### Environment

The experiment was conducted in a room maintained at 25 °C.

### Temperature conditions

Three conditions, "cold only", "hot only" and "alternate temperature" were prepared. The "alternate temperature" is what we mentioned in the previous section, with 40 °C for the hot side and 15 °C for the cold side. In case of "cold only", the temperature of both sides of the roller was set to 5 °C by putting the roller in the refrigerator in advance. In case of "hot only", the temperature of both sides of the roller was set to 45 °C by putting the roller in the body warmer in advance.

### Procedure

Participants were asked to voluntarily roll the device to inner side of their right forearm for 10 seconds per trial. For each trial, they were asked to choose words that described the sensation they felt from the following: cool, cold, warm, hot, stinging, itching, tickling, wet, painful, good feeling, strange feeling. The procedures were repeated 15 times per one participant, five times for each temperature condition. The order of the trials was randomized.

### Result and Discussion

**Figure 6** shows the result of the questionnaire. The horizontal axis shows sensation quality, and the vertical axis shows answer rate.

In "cold only" condition, naturally "cold" was selected most, followed by "cool". "Wet" was also selected, possibly because cold temperature recalled condensation. In "hot only" condition as well, "warm" was selected most, followed by "hot". On the other hand, in "alternate temperature" condition, "cool", "cold", "warm" and "hot" were all selected, naturally because hot and cold stimuli were alternatively presented.

What made the "alternate temperature" condition different from other conditions were "painful" and "strange feeling", which rates were 22.5% and 32.5%, respectively. These are the typical expressions for the known TGI, so we may say that the device could partly deliver TGI, although the rate was not so high.

After the experiment, six out of eight participants commented that hot and cold sensation were perceived simultaneously (not alternately) in the "alternate temperature" condition.

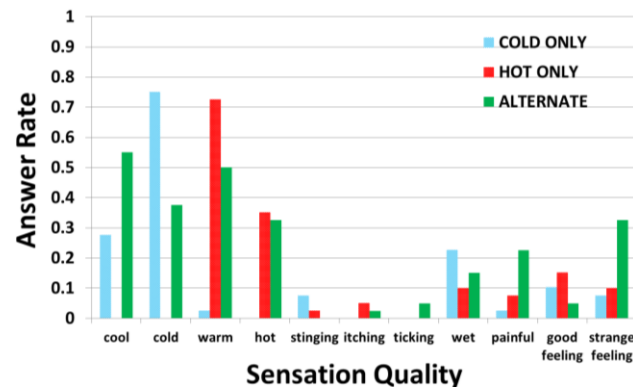


Figure 6. Result of the questionnaire

## Conclusion

To relieve itch sensation, which is a significant problem for many diseases related to skin, we developed roller-type itch-relief device employing hot and cold alternating stimulus. We evaluated the sensation with the developed device, and the result shows that the device could partly deliver pain sensation to naïve participants.

Our next step is a hardware optimization. Currently, the roller diameter is 2.0 cm, resulting in around 3.14 cm interval between the two centers of thermal stimuli, which is relatively larger than the known TGI studies.

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