The 18th IEEE International Symposium on
Robot and Human Interactive Communication
Toyama, Japan, Sept. 27-Oct. 2, 2009



# Development of a Head Rotation Interface by Using Hanger Reflex

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*Abstract*— **When a head is equipped with a hanger made of wire sideways, and its temporal region is sandwiched by the hanger, the head rotates unexpectedly. We named the phenomenon "Hanger Reflex", and we have studied this phenomenon to understand its mechanism and to show the possibility of utilizing the phenomenon as a human interface. However, to use it as an interface, pain sensation induced by the hanger becomes a practical problem. In this paper, we determined the necessary conditions of the Hanger Reflex, and we developed an interface that can induce head rotation by using the Hanger Reflex, without giving pain to the user.**

## I. I. INTRODUCTION

Recently, many computer-human interfaces that display information to the user have been proposed. Although most of them display information to the user via "noticeable" means, such as light, sounds, and so forth, some new works proposed to display information via unnoticeable means, while still, the user's activity is affected by the information. This type of interface may be regarded as "unconscious interface". The user does not notice the existence of the interface ultimately, and the ability of the interface subjectively becomes the ability of the user, which will be a new relationship between human and environment.

One example of the unconscious interface is achieved by using GVS (Galvanic Vestibular Stimulation) [1]. GVS induces a sensation of virtual acceleration as vestibular information when a small electric current is passed between the mastoid processes. A user's equilibratoy sense is unconsciously operated. This type of interfaces can be regarded as a conductor for human, and can be seen as a new navigation interface.

A phenomenon called Hanger Reflex can be regarded as another possible means to be used for an unconscious navigation interface that resembles the GVS interface. Hanger Reflex is the phenomenon that the head rotates unexpectedly when a head is equipped with a hanger made of wire sideways, and its temporal region is sandwiched by the hanger (Figure 1). We named the phenomenon "Hanger Reflex", and we have studied this phenomenon to understand its mechanism and to reproduce the phenomenon [2].

The principles of Hanger Reflex have never been explained so far. In Hanger Reflex, the stimulus that user is applied is simply pressure, and its effect is only head rotation. This simplicity predominates against GVS-Interface by two points; that electrical current to user's head is unnecessary and there is no risk of dizziness. However, if we equip the hanger with our head we get pain which is a serious problem for practical use..

In this paper, we will show the development of a interface that can induce head rotation by using the Hanger Reflex, without giving pain to the user.

Figure 1. Hanger Reflex

## II. HANGER REFLEX

In this section, our previous work of the Hanger Reflex is summarized.

### A. The Phenomenon

When a head is equipped with a clothes hanger made of wire sideways, and its temporal region is sandwiched by the hanger, the head rotates unexpectedly. Because of the involuntary rotational movement, it seems that this phenomenon is a kind of reflex triggered by pressure to temporal region. Thus we named this phenomenon "Hanger Reflex" tentatively. The hanger reflex is widely known to public, because it has been featured on some TV programs as a mysterious phenomenon that can be experienced with daily commodities.

A TV program explained the mechanism as a kind of reflex to avoid a head from pain caused by the hanger [5]. However, it seems that this explanation fully describe the phenomenon. If this explanation is correct, when a person equipped with a hanger feels pain from left side, his/her head should rotate to the right side. However, it was reported that the direction of rotation are different among individuals. Furthermore, if the Hanger Reflex is physiological reaction, it is unlikely that such a difference among individuals should occur. In conclusion, the phenomenon was not fully explained so far.

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### B. *Measurement of the Pressure Distribution*

In our previous work, we have measured pressure distribution of the head when the reflex has occurred by one participant. First, she equipped a hanger with the head and adjusted its position so that the hanger reflex occurred. Next, we inserted a force sensor, and measured the pressure distribution (Figure 2).

We measured with the following four conditions: 1) the hook of the hanger was on the left side, and the head rotated to the left, 2) the hook of the hanger was on the right side, and the head rotated to the left, 3) the hook of the hanger was on the left side, and the head rotated to the right, 4) the hook of the hanger was on the right side, and the head rotated to the right. We measured each condition five times and averaged the result.

Figure 3 and Figure 4 give the results of the experiment. Three pressure peaks by three sides of the hanger were observed in all conditions, and among them, two pressure peaks are in common for each rotation direction. From the results, we have proposed two hypotheses. The first hypothesis is that the direction of rotation is determined by the two pressure peaks both at the head's frontal temporal region and its counter occipital region. The second hypothesis is that the direction of rotation is determined by the position of the pressure peak "either" at the head's frontal temporal region or its counter occipital region.

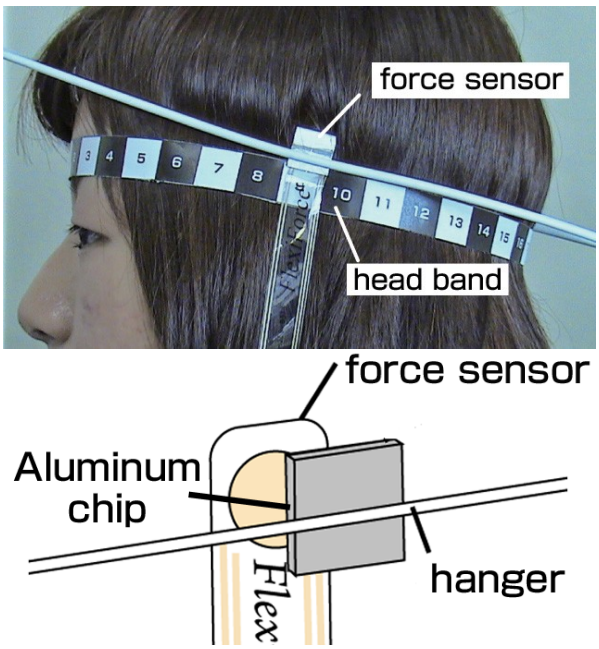


Figure 2. Pressure Distribution Measurement for Hanger Reflex [2]

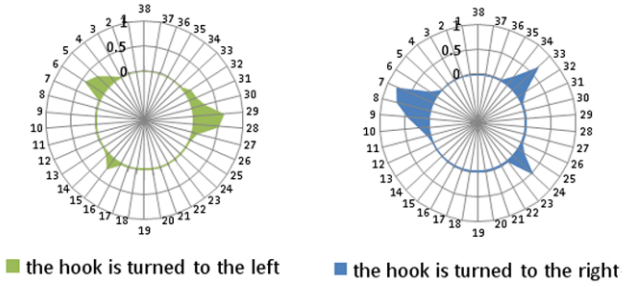


Figure 3. Pressure distribution [N] when the head rotated to the left [2]

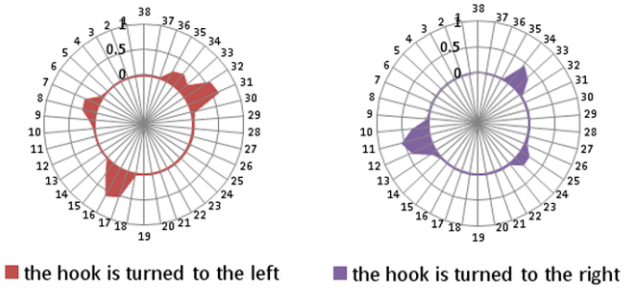


Figure 4. Pressure distribution [N] when the head rotated to the right [2]

### C. *Two Point Hanger*

In the first hypothesis, we have speculated that Hanger Reflex is caused by stimuli to the head's frontal temporal region and the occipital of its counter side. Because, two common pressure peaks were seen in the results as inFigure 5.

Thus, to verify this hypothesis, we made "Two Point Hanger" by deforming the original hanger (Figure 6). This Two Point Hanger can press the two points. As a preliminary experiment, we put the hanger to six participants, and the results were positive. What a head is equipped with the Two Point Hanger, all participants' head rotated with "no" pain. This is quite a positive result, because it was our first time to observe the Hanger Reflex without any discomfort, which is an indispensable part for practical use.

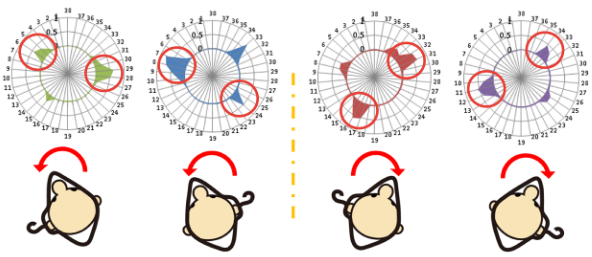

Figure 5. Two Common Peeks of the pressure distribution

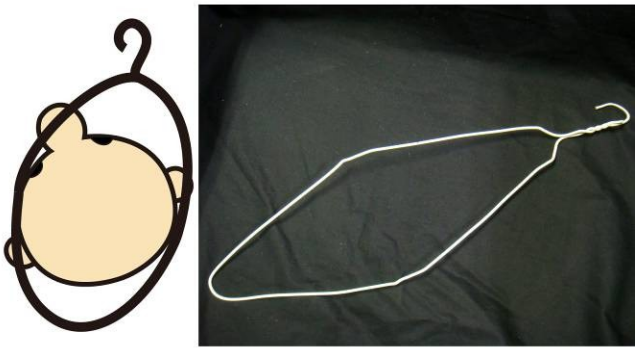

Figure 6. Two Point hanger

### D. One Point Hanger

The results of Two Point Hanger suggest that the direction of head's rotation is sufficiently determined by the two pressure peaks, but the possibility that single peak is a necessary condition remains. Then, we experimented whether a single stimulus either at the head's frontal temporal region or the occipital of its counter side can cause Hanger Reflex.

We inserted a plastic board between the hook of a hanger and the head, so that two contact points were hindered, and the head is stimulated by a single point. The situation is as Figure 7. Please note that to avoid effects on head rotation, application of external force was not the option.

Six participants (three men, three women, ages 21-23) participated in this experiment. We put the hanger with the plastic board to their head and observed whether hanger reflex would occur.

The results indicated that the participant's head rotated under both conditions; frontal temporal region and the occipital region. At the same time, the stimulation of the head's frontal temporal region caused stronger Hanger Reflex. We have also observed that when the head's frontal temporal region was stimulated, all participants' head turned "to" the direction of the stimulus.

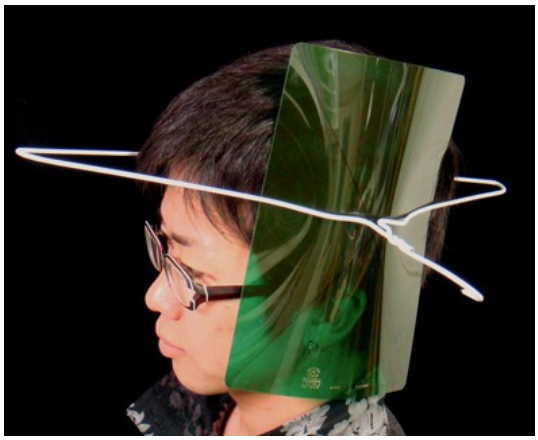

Figure 7. One Point Hanger Experiment

## III. INITIAL TRIAL: ONE POINT STIMULATOR

The result of the previous two experiments showed the possibility that a point stimulus to a frontal temporal region of the head, can cause Hanger Reflex without using a real hanger. We proceeded to verify this possibility by fabricating a simple wearable system which is possible to push a head locally.

### A. System Structure

The prototype system is shown in Figure 8 and Figure 9. A gear motor was attached to the head belt made of polyethylene, which was taken from a crash helmet. A linear actuator composed of DC motor and gear box pushes the head vertically. The motor was controlled by a microprocessor (Renesas, H8-3048). Diameter of the skin contact point was 2.0 cm.

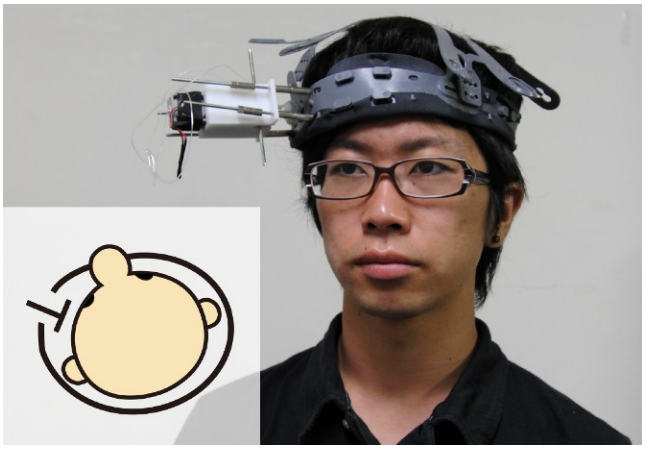

Figure 8. One Point Stimulator

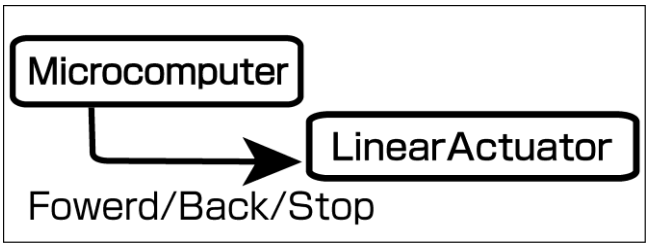


Figure 9. Block Diagram of One Point Stimulator

### B. Experiment & Result

We tested the prototype with 6 participants, and confirmed that the Hanger Reflex was observed. However, there were two problems. The first problem was that, unless the screw hits a certain small region, the head occasionally did not move at all. The second problem was that, the stimulus by this machine was extremely painful.

### C. Possible Reason of the Failure

This experiment told us that something is different from real hanger and our device. There are obviously four apparent physical differences between the real hanger and

our device.

First point is the shape of the contact point. The real hanger stimulated with “line”, while our device stimulated with “spot”.

Second point is pressure distribution. In real hanger, pressure is solely applied to separate three points, while our device is tightened to the head and gives constant sensation of pressure in all circumferences.

Third point is elasticity. Although the real hanger is made of iron wire, it has certain softness so that relatively uniform pressure was applied in broad area, while in our device, pressure distribution was concentrated.

Fourth point is weight. The real hanger is light enough not to hinder head rotation, while our device was quite heavy.

Based on these observations, we set the conditions of next prototype as follows.

First, the apparatus should never give pain to the user as Two-Points Hanger, which will be achieved by using force sensor to control the pressure.

Second, the device should hold the head by merely three points like a real hanger.

Third, the device should use line shaped contactor.

Forth, the contactor should have certain elasticity to avoid concentration of pressure.

Lastly, the device should be as light as possible.

## IV. SECOND TRIAL: LINE STIMULATOR

From these reflections, we made a Line Stimulator that reproduces Hanger Reflex. The appearance of Line Stimulator is shown in Figure 10. The body of apparatus is hanged by thread from ceiling and free to rotate, thus user’s head receive no external force.

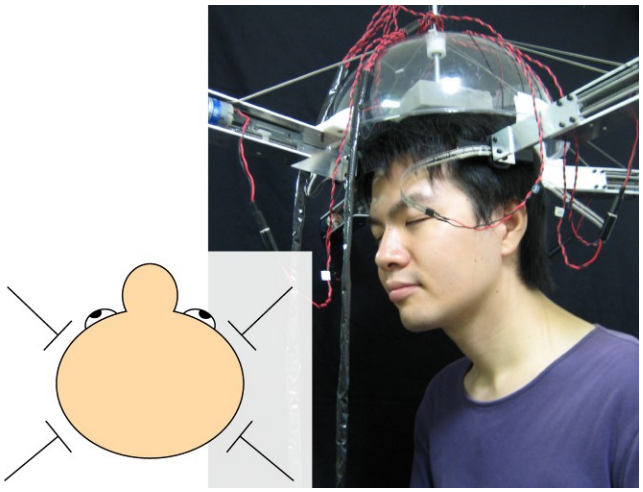

Figure 10. Line Stimulator

### *A. System Structure*

We used four linear actuators (47A-LA-100T, TSUKASA ELECTRIC., LTD.) to press the head from four points. The pressure sensor (Nitta Co., FlexiForceA201-1) was assembled between the actuator and a contactor to directly measure the pressure (Figure 11). These units composed of actuator and pressure sensor were mounted on a hemispherical shell. The actuators and pressure sensors were connected to a microcomputer (Renesas, H8-3048F). Figure 12 shows the system structure.

The contactors were made of Bakelite boards (100 x6 x2 [mm]), and its surface was covered by rubber to increase friction. The Bakelite board was chosen so that the same elasticity was achieved as a real hanger.

Preliminary experiment with this device verified that this stimulator can easily generate the Hanger Reflex. Therefore, we can say that at least one or some points that we have observed in section 3.3 is correct. In the near future, we will further proceed to narrow down the necessary conditions.

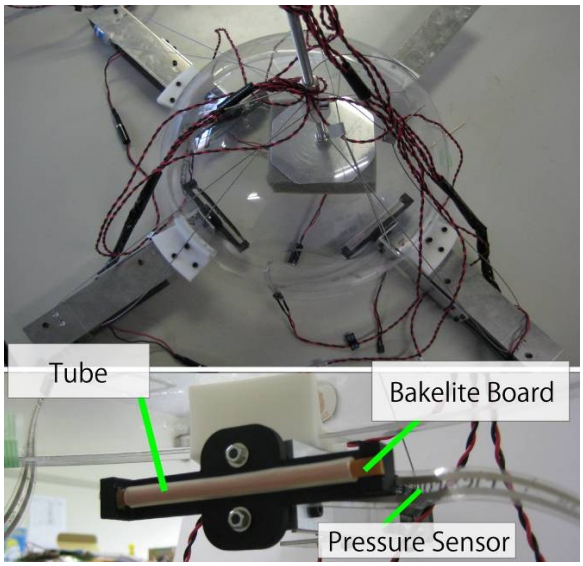


Figure 11. Detail of Line Stimulator

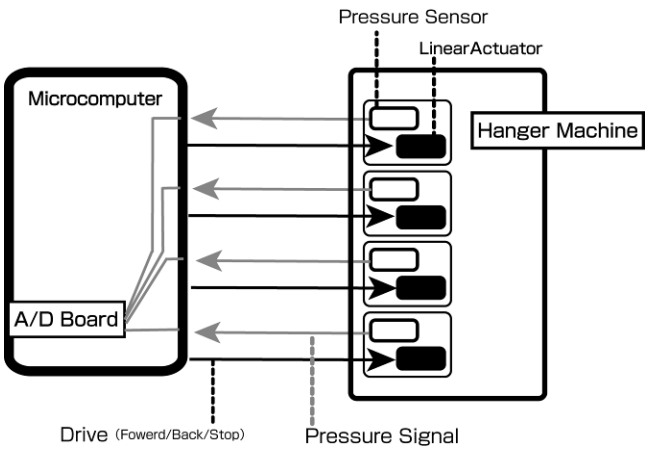


Figure 12. Block Diagram of Line Stimulator

## V. PAINLESS STIMULATION

We have observed that in Hanger Reflex using real hanger, pain occasionally occurred. This pain is a fundamental problem for practical use of the Hanger Reflex as an interface. On the other hand, in the Two Point Hanger case that we have seen in section 2.3, the pain rarely occurred. It suggest us a possibility that we can make a Hanger Reflex interface without pain. Of course, from the viewpoint of our final goal, "unconscious interface", the sensation itself should be minimum and ultimately it should be diminished. But currently it does not seem possible. In the next experiment, we verified that our prototype can generate Hanger Reflex without pain.

### *A. Procedure*

The purpose of the experiment was to find the minimum pressure to rotate head.

This experiment was conducted by 3 participants. The participant sat and relaxed, and he shut his eyes. First, all of 4 units pressed the head with equal pressure. One unit either front right one or front left one was then pulled out. The device was herewith held the head by three points, just like a real hanger (Figure 13). The force was presented from 3N to 9N by 1N. In each force and pressure location, the participant answered "if he felt pain or not", while we observed if the head rotated or not.

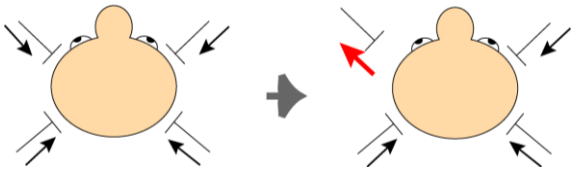

Figure 13. Concept of Line Stimulator

### *B. Result*

The results are shown in Figure 14.

From this result, we observed that the head rotated from 4N, while the participant reported pain from 6N. Therefore, there was a certain area from 4N to 5N that the head rotated without pain.

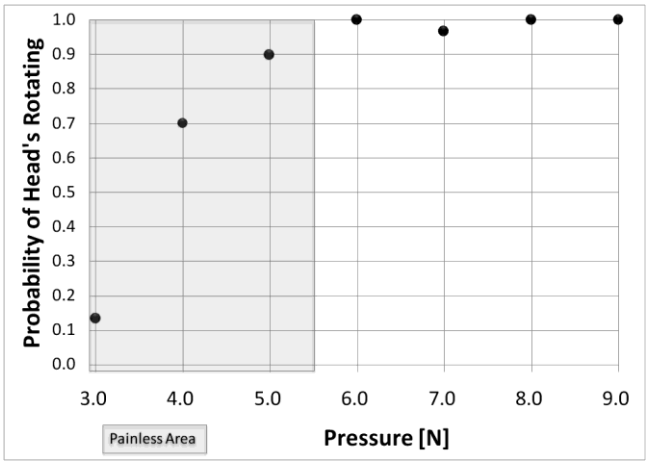


Figure 14. Results of Experiment

## VI. CONCLUSION

In this paper, we investigated the conditions of Hanger Reflex and sought ways to reproduce the phenomenon without pain.

We speculated that a point stimulus to a frontal temporal region of the head can cause Hanger Reflex without using a hanger, and this hypothesis was partially verified. However, it sometimes failed, and we speculated that some apparent difference between the real hanger and our device was the cause. Finally we fabricated a new prototype interface that is composed of line contactors, which stably generated the phenomenon.

Then, we investigated the possibility of Hanger Reflex without pain, which was realized.

Currently, we did not narrow down the possible factors of the Hanger Reflex. Furthermore, our current experiments were simply based on "rotate or not", while we observed that occasionally the phenomenon is quite strong and sometimes weak. We should quantify the strength of the phenomenon.

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