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Asymmetric Familiarization with Experience of Different Sized Hand

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Abstract: In the experience of different sized hand, the effect of pre-operation intended to familiarizing oneself with this experience is reported. To measure this effect, the index of degree of immersion (DOI) is proposed, which represents whether the observed behavior is appropriate for the presented hand size. To compare the conditions with or without pre-operation, the DOI is investigated when changing the presented hand size variously. The experimental results show that the pre-operation is effective for familiarizing the presented sized hand, especially larger sized hands.

Keywords: vicarious hand, task for familiarization, asymmetric effect

1. INTRODUCTION

There are many hand-held products such as mobile phones, remote controllers, and digital cameras. The usability of these hand-held products is affected by the shapes of hands to operate them. When designing these products to be user-friendly, especially in terms of shape and layout, it is important for designers to consider the various hand shapes of users. Computational models that assess the usability of products employing various hand shapes have been studied [1][2]. In addition, as with "Through Other Eyes [3]", which is a system for experiencing physical characteristics caused by aging and disabilities, enabling designers to experience product manipulation with hands of various shapes can help designers to explore the usability of users having various hand shapes. In particular, experiencing behavior depending on the size of other people's hand is effective in such helping because behavior usually changes in proportion to hand size. Figure 1 shows the concept of experiencing hands of various shapes. Designers can touch and manipulate products using various hands, which differ from their own.

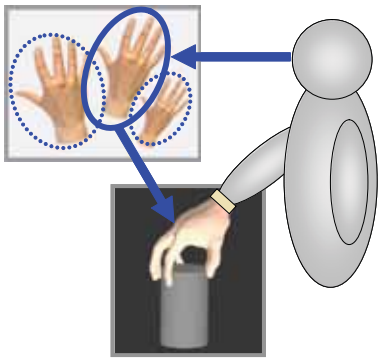

Fig. 1 Concept of experiencing hands of various shapes

For experiencing a part of the functions of products, a number of studies have examined virtual prototyping and augmented prototyping. In these studies, the operating characteristics of a particular user interface [4][5] and the external appearance of products can be controlled [6]. However, few studies have addressed controlling the physical characteristics in the experience.

Thus, the authors have proposed a system that provides the experience of hands of various sizes, which presents hands of various sizes in an environment that appears not to change in size [7][8]. This is achieved in the proposed system by adjusting the optical zoom and actual object size (Fig. 2). For this experience, a pre-operation is needed to familiarize with the presented hand size. In view of aiding design, it shold be simple and easy as much as possible.

As a first step of finding adequate pre-operation, the present paper investigates the effect of pre-operation on the familiarization with different sized hand by comparing the conditions with or without it in various sizes of presented hands.

In Section 2, the method for providing the experience of hands of various sizes is described. In Section 3, the index of measuring the familiarization with this experi-

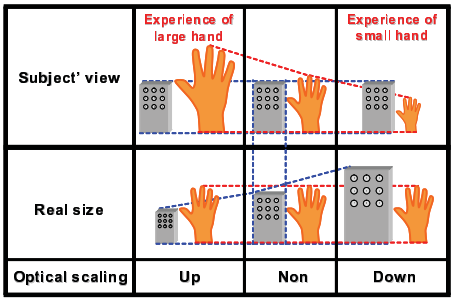

Fig. 2 Relationship among physical size, optical scaling, and the presented hand

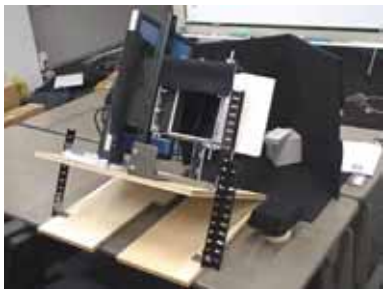

Fig. 3 Proposed system for providing the experience of hands of various sizes

ence is defined. In Section 4, the experimental setup is explained. In Section 5, the effect of pre-operation on the experience of different sized hand is reported. in terms of comparing the conditions with or without pre-operation when changing presented hand size. In Section 6, the conclusion of this study is presented.

2. METHOD FOR PRESENTING THE EXPERIENCE OF HANDS OF VARIOUS SIZES

We have developed a method for providing the experience of hands of various sizes. This experience involves the sensation of hand size being different from one's actual hand size, which occurs when hands of various sizes are presented in an environment that appears to be of constant size. A controlled view of hands and objects is presented to subjects through an optical system with the appropriate scaling.

Figure 2 shows the method employed to realize the desired view using an optical system and analogous objects. The top row shows the desired hand size to be presented. The middle row presents the actual sizes of the hands and the objects, and the bottom row shows the method used to scale the optical system. The scaling rate of the optical system is adjusted to present hands of desired size. The sizes of the objects used in this condition are varied inversely with the magnification of the optical system.

In this way, only the hand size, and not the object size, is changed visually. For instance, the right-hand column shows the method used to present smaller hands. The optical system is scaled down, and analogously large objects are used. However, in order to present larger hands, the optical system is scaled up, and analogously small objects are used, as shown in the left column.

According to studies suggesting the possibility of experiencing hands of various sizes [9][10][11], the consistency of senses, especially vision and somatic sensation, is essential for the experience. In the proposed system, employing an optical system and analogous objects achieves the required consistency.

Figure 3 is a photograph of the developed system. The system consists of analogous objects, a camera with a zoom lens, a computer, a display, and two mirrors (Fig. 4). Images of the right hand and an object captured by the camera are presented to a subject by rendering the images on the display. The camera is a Sony DFW-VL500 (VGA, 30[fps]). The minimal visual delay of the system is 38 [ms], which is due to hardware constraints.

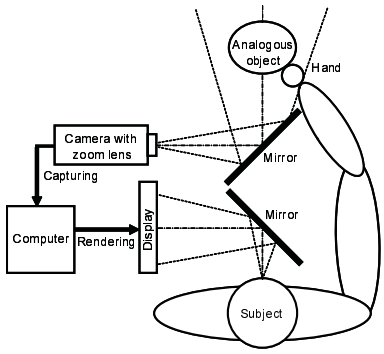

Fig. 4 Configuration of the system for providing the experience of hands of various sizes

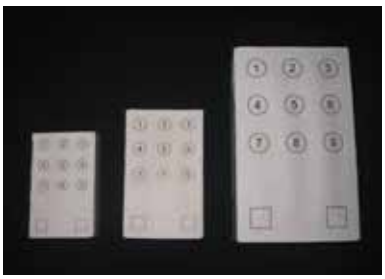

Fig. 5 Objects used for the button-pushing task: 83×50×17[mm] (left), 100×60×20[mm] (middle), 150×90×30[mm] (right)

To familiarize the subjects with the presented hand size, a button-pushing task is performed as a pre-operation. The task involves pushing buttons, which correspond to a four-digit number five times. It is already known that this pre-operation is sufficiently effective for the experience of different sized hand [8].

Figure 5 shows the analogous objects used in this task. In the developed system, the computer displays the numbers to push buttons, and controls the visual delay and the optical scaling of the camera. Figure 6 is an example of the subject's view.

3. MEASUREMENT OF FAMILIARIZATION WITH THE PRESENTED HAND

In this section, we define the index of measuring the familization with the presented hand. To judge whether the experience of different sized hand is successful, a task of grasping equilateral triangular prisms is employed.

According to [12], the grasp strategy are determined by the relationship between hand size and size of equilateral trianguar prism and are classified into four grasp patterns. The grasp strategy depending on hand size can be obtained appropriately to the presented size of hand using our system.

Based on the previous work [8], the probability of ob-

Fig. 6 Example of the subject's view

served grasp patterns has already known when familiarizing oneself with the presented sized hand sufficiently, briefly experiencing different sized hand. Using this information,the probability of the experience of presented sized hand can be calculated.

In fact, when an eauilateral triangular prism is v_j and the ovserved grasp pattern is g_k, the probability of which the experienced hand size is h_i can be calculated as the following equation.

$$p(h_i|v_j, g_k) = \frac{p(g_k|v_j, h_i)p(v_j, h_i)}{\sum_l p(g_k|v_j, h_l)p(v_j, h_l)} \quad (1)$$

where $p(g_k|v_j, h_i)$ has already known as discussed previously and $p(v_j, h_l)$ is determined by experimental setup.

The present paper labels Eq. (1) as "Degree Of Immersion (DOI)," and investigates the effect of pre-operation based on this index.

4. EXPERIMENTAL SETUP FOR INVESTIGATING THE EFFECT OF PRE-OPERATION ON EXPERIENCE OF DIFFERENT SIZED HAND

We examine whether the pre-operation is effective for familiarizing oneself with the experience of different sized hand.

In the both cases of conditions with or without pre-operation, the patterns of grasping equilateral triangular prisms are measured when changing the presented hand size. These conditions are compared in terms of the DOI calculated by using observed grasp patterns.

The scaling rates of the presented hand sizes are 0.67, 1.00, and 1.20, which are labeled Small, Normal, and Large, respectively. These rates were determined by data of the hand length of actual subjects [13][14].

The transitional conditions of presented hand size were determined by couples of these scaling rates. Thus there are six transition conditions in total, which is shown in Table 1. For example, the condition denoted by NS in this table means "to present a **S**mall hand after experiencing **N**ormal hand".

Ten right-handed male subjects participated in this experiment. To cancel the order effect of transitional conditions, five subjects were assigned with the order "(i)-(ii)-(iii)-(iv)-(v)-(vi)" while the others were assigned with the order "(iv)-(v)-(vi)-(i)-(ii)-(iii)".

Table 1 Transitional conditions of hand size

Condition index	Presented hand size	
	Pre-transition	Post-transition
(i) NS (**N**ormal **S**mall)	Normal	Small
(ii) SL (**S**mall **L**arge)	Small	Large
(iii) LN (**L**arge **N**ormal)	Large	Normal
(iv) NL (**N**ormal **L**arge)	Normal	Large
(v) LS (**L**arge **S**mall)	Large	Small
(vi) SN (**S**mall **N**ormal)	Small	Normal

In each experimental condition, the subjects were asked to perform the following tasks.

- Perform the button-pushing task described in Section 2 in pre-transitional sized hand.
- Perform this task in post-transitional sized hand if the experimental condition has a pre-operation.
- Grasp equilateral triangular prisms. This grasp was recorded using a video camera to calculate the DOI in this experimental condition.

5. EXPERIMENTAL RESULT

Figure 7 shows the mean degree of immersion about all experimental conditions. In this figure, the result has the tendency that the DOI of the conditions with pre-operation is higher.

To prove the effects of the two factors, which are pre-operation and transition of presented hand size, on degree of immersion, we used two-way repeated measures ANOVA. The result, which is shown in Table 2, presents that main effects of two factors were confirmed, but there was no interaction between them. According to this result, pre-operation is effective to familiarize with the presented sized hand.

To examine the main effect of transition of hand size on DOI, multiple comparisons between transitional conditions of presented hand size were performed. The results are shown in Figure 8 along with the mean DOI. Significant differences among the transitional conditions

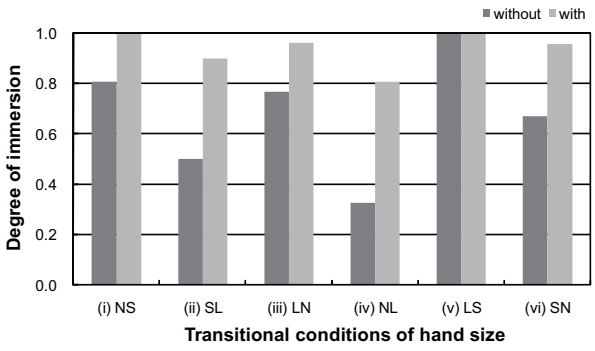

Fig. 7 Mean degree of immersion about all experimental conditions

Table 2 Result of two way repeated ANOVA (*: $p<0.05$)

Dependent variables	Main effect		Interaction
	Pre-operation	Transition	Pre-operation × Transition
Degree of immersion	F(1.0,9.0) = 22.12 *	F(2.9,25.9) = 5.27 *	F(2.5,22.5) = 1.11

show that there are different difficulties of familiarizing with the presented hand in terms of hand sizes, regardless of pre-operation.

These results present the possibility of the different effect of pre-operation about transitional directions. Based on the transitional directions, the conditions shown in Table 1 can be divided into two categories, which are respectively labeled Shrink and Enlarge. Figure 9 shows DOI about the conditions with or without pre-operation and transitional directions with the results of multiple comparisons. In the case of without pre-operation, there was significant difference of DOI about transitional direction, but there was no significant difference of DOI in the case of with pre-operation. Therefore, these results shows that the effect of pre-operation on the experience of different sized hand is asymmetric in terms of transitional direction.

6. CONCLUSION

The effect of pre-operation on the experience of different sized hand was investigated. To measure this effect, the index of degree of immersion into this experience was proposed. The comparison of the conditions with or without pre-operation shows that the pre-operation is effective for familiarizing the presented sized hand, especially larger sized hands.

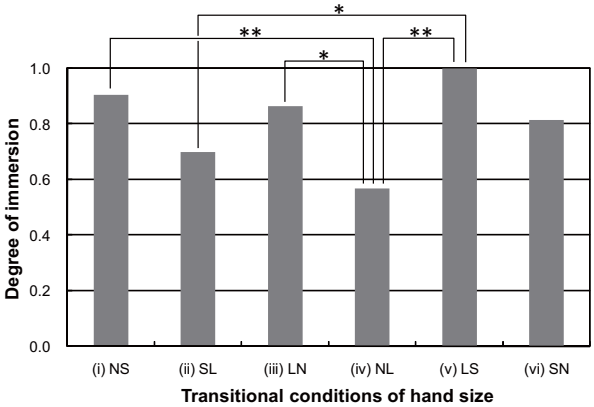

Fig. 8 Mean degree of immersion about transitional conditions of hand size and result of multiple comparisons (**: $p<0.05$, *: $p<0.10$)

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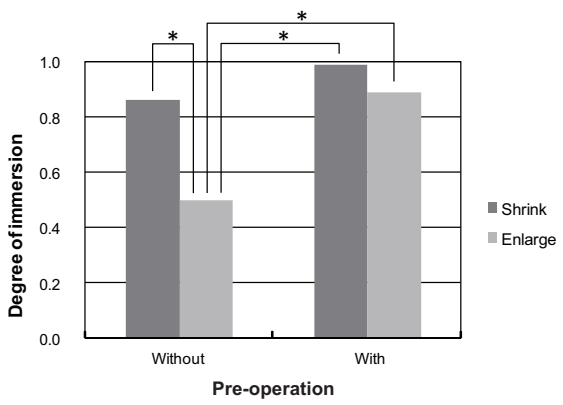

Fig. 9 Comparison of mean degree of immersion about pre-operation and transition direction (*: $p<0.05$)

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