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Wider IPD makes people perceive their body to be not so large when large hands are presented

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Abstract

It is known that hand size and the interpupillary distance (IPD), as well as eye height from the ground, are some of the determinants of body size. We investigated the effect of simultaneous changes in hand size and IPD on size perception regarding the body and the external world in virtual reality. We manipulated the hand size and the IPD (normal hand and normal IPD, large hand and normal IPD, large hand and large IPD) while vertically increasing the participants' eye height. Our main results indicated that a wider IPD combined with larger hands made participants perceive their body to be smaller than when the IPD was normal. Thus, the IPD influences the perception of body size when large hands are presented. This is a novel result because it suggests the probability of an interaction effect between the IPD and the hand size, or between the IPD and the presence of hands, on body size perception.

CCS Concepts

• ***Human-centered computing*** → *Virtual reality;*

1. Introduction

The hands of giants are larger than ours, and a giants' interpupillary distance (IPD) would be wider than ours. The size of body parts and the IPD are closely related to the body size. However, understanding the influence of these two elements on size perception of regarding the body and the external world is limited. van der Hoort et al. [vHGE11] showed that participants embodied to a large virtual body perceived objects to be smaller and nearer. Kim and Interrante [KI17] reported that a wider IPD makes people underestimate the size of objects, and indirectly implied that the body size was unchanged. These studies focused on only one of the two variables. Therefore, the effect of simultaneous changes in the size of body parts and IPD on size perception of the body and the external world remains unclear.

We conducted two comparisons to investigate the effect of hand size and IPD changes on the perception of body size and the external world size. Firstly, we manipulated the hand size (large hand vs. normal hand) while vertically increasing the participants' eye height. Secondly, we manipulated the IPD (wide IPD vs. normal IPD) when participants' eye height and hand size was increasing. It was expected that the IPD wouldn't affect body size perception, as suggested by Kim and Interrante [KI17]. Therefore, we assumed that the IPD would not affect the perceived body size regardless of the hand size if there were no interaction between the hand size and the IPD.

2. Method

Participants: Twenty-four people (Mean Age, 22.2 years) participated in the experiment.

Material: The position and movement of the participants' hands were tracked using Leap Motion. Participants saw a virtual body from the first-person perspective through a head-mounted display (HMD: Oculus Rift). A virtual world was developed using Unity.

Conditions: The experiment comprised three conditions. The **Static-hand** condition in which we vertically increased the participants' eye height by up to 12 times while their hand size and IPD were held constant (Figure.1a). The **Large-hand** condition in which we vertically increased the participants' eye height and their hand size by up to 12 times while the IPD (Figure.1b) was fixed. The **Dynamic-IPD** condition in which we proportionally increased the participants' eye height, hand size, and the IPD by up to 12 times (Figure.1c). In all the conditions, the eye height before the manipulation was the average standing height of approximately 1.57m from the ground. Moreover, the participants' hands moved away from the midpoint of their eyes as the hands expanded (Figure.2), to keep the visual angle with the hands constant. This was done to maintain the identical ratio between the distance from the midpoint of the eyes to the hands, and the distance from the hands to the objects in the virtual world in the Large-hand and the Dynamic-IPD condition.

Procedure: Participants were instructed to stand during the experiment. They reported the perceived height of their virtual body

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(pre-Height) when entering the virtual world. Then, the visual information was manipulated in each condition. When these manipulations were completed, the participants were asked to report their perceived height (post-Height) and the perceived eye height from the ground. The perceived height was assumed to reflect the participants' body size in the virtual world, and the perceived eye height from the ground was assumed to represent the scale of the virtual world. The eye height after the manipulation was in the identical position relative to the virtual world under all the conditions, so the perceived eye height from the ground depended on the perceived scale of the world.

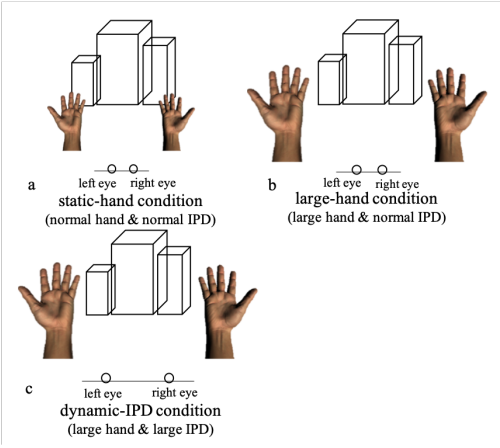

Figure 1: *Experimental conditions*

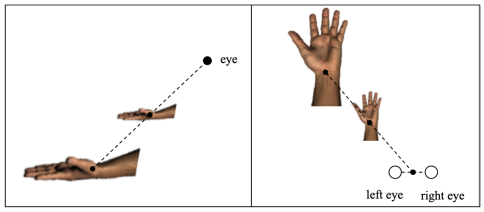

Figure 2: *manipulation of hand size*

3. Results

We defined the enlargement rate as post-Height/pre-Height. We performed Wilcoxon signed-rank test on the enlargement rate and the perceived eye height between each pair of conditions.

Large-hand condition vs. Static-hand condition: The participants perceived that they were getting taller when their virtual hands were expanding compared to the Static-hand condition ($V = 175$, $p < .01$). There was no significant difference in the eye height from the ground between these two conditions ($V = 39$, p = n.s.). Prior studies didn't predict these results. Some procedures were different from prior studies (e.g. the way of manipulation of hand size), and these differences might influence the results.

Large-hand condition vs. Dynamic-IPD condition: The results also indicated that the rate of enlargement was significantly higher in the Large-hand condition compared to the Dynamic-IPD condition ($V = 171$, $p < .05$). The perceived eye height was also significantly higher in the Large-hand compared to the Dynamic-IPD condition ($V = 158$, $p < .05$).

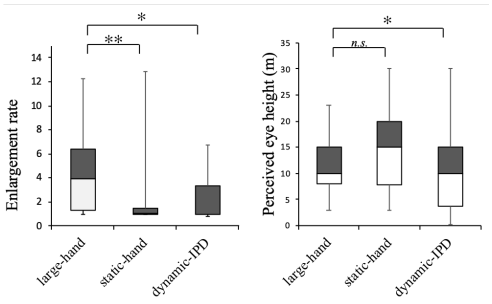

Figure 3: *Enlargement rate and Perceived eye height*

4. Discussion

The main results indicated that participants didn't perceive their body was larger in the Large-hand condition compared to the Dynamic-IPD condition. There would be no significant difference between these two conditions without an interaction between the hand size and the IPD. However, the results indicated that increasing the hand size combined with a wider IPD compared to a fixed IPD resulted in the perception that the participants' body was smaller. This finding does not constitute strong evidence that the effect is caused by an interaction between the hand size and the IPD. Nevertheless, this effect has not been observed in prior studies. Virtual hands have not been presented in prior researches investigating the influence of the IPD on scale perception. This is because a stimulus in which the IPD is increased while the size and the position of the hands are fixed is an awkward experience in which the observers cannot perceive that the virtual hands belong to them. However, if virtual hands were not presented, observers might perceive visual stimuli from the HMD are similar to a video, so they would not perceive that their body was in the virtual world. Therefore, they would not attribute the change in the IPD to changes in their own body. In our research, virtual hands were presented, so that changes in the IPD were likely to be attributed to changes in the participants' body size.

It is interesting that the IPDs of giants are wider than humans. However, if the hands were presented, wider IPD would make people perceive their body to be smaller than fixed IPD. Therefore, the IPD should be fixed while the eye height is increased and the hands enlarged when creating a virtual experience in which people could become giants.

5. References

[KI17] Kim, J. & Interrante, V.: Dwarf or Giant: The Influence of Interpupillary Distance and Eye Height on Size Perception in Virtual Environments. ICAT-EGVE (2017), 153-160.

[vHGE11] van der Hoort, B., Guterstam, A., & Ehrsson, H. H.: Being Barbie: the size of one's own body de-termines the perceived size of the world. PLoSONE (2011), 6:e20195.