




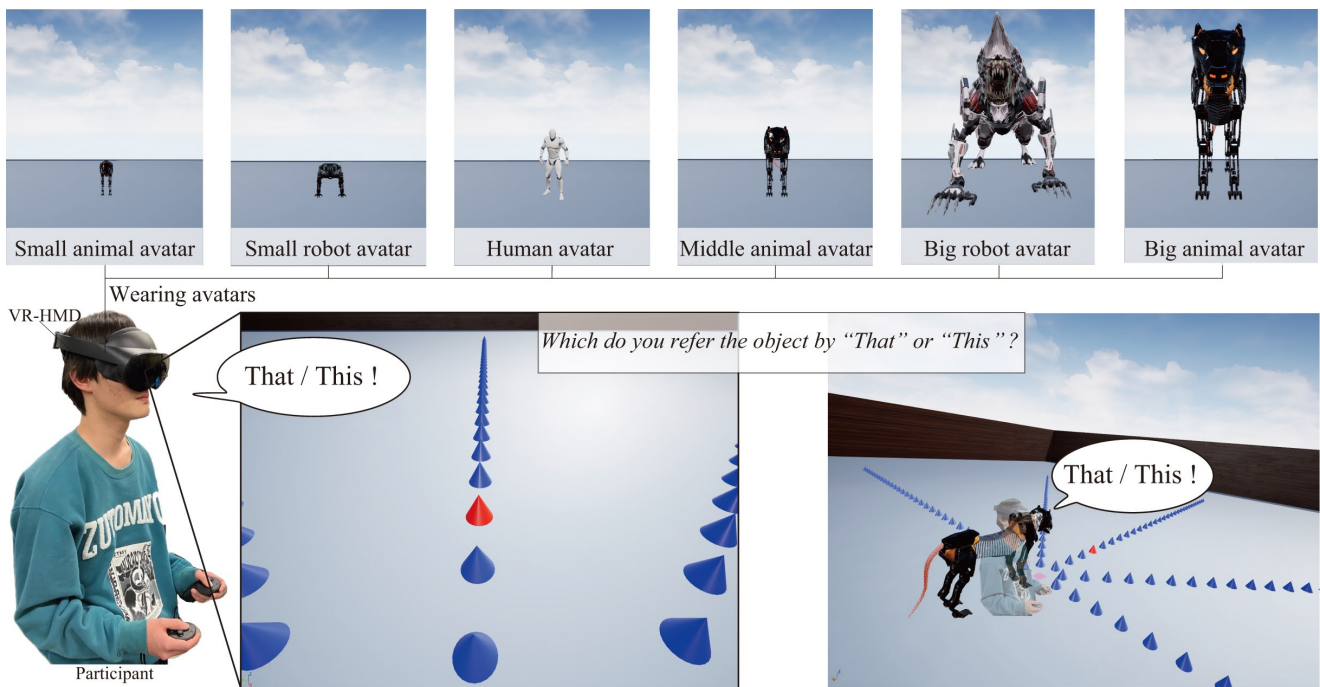


Effect of Physical Extension on the Range of Demonstrative Indicators by Wearing Non-Humanoid Avatars with Different Looks

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※ The demonstrative indicators are spoken in Japanese

Figure 1: Participants can wear VR goggles to wear avatars of different appearances and sizes. Participants wear these avatars and refer to objects in the experimental field using either distal or proximal indicator.

Abstract

Users can interact in virtual reality (VR) spaces through avatars that differ markedly from their real-world looks. These avatars can be customized to any appearance and size, whether they are based on real entities or are entirely fictitious. These avatars include non-humanoid avatars as well. Some non-humanoid avatars do not have hands, in which case the problem arises that they cannot reference using gesture. In this case, the interlocutor must determine the object from the direction of the referent's gaze and the context. Given the impact of avatar characteristics on the visual communication process of joint attention among users, it is essential to elucidate the connection between avatar traits and the range of reference to facilitate smooth interaction. In this study, the influence of avatar looks on the referential range of demonstrative indicators was elucidated. Experiments were conducted in a VR spaces using avatars of different appearances and sizes, with the aim of understanding how these differences impact the ability to refer to objects using both distal and proximal indicators. Specifically, the study aimed to identify the transition point from the proximal to the distal referential field for each type of avatar. This research seeks to deepen the understanding of how avatars, as proxies for humans in VR spaces, influence communication dynamics. Looking forward, it is anticipated that the findings will enhance the VR experience by improving referential communication among avatars of diverse appearances and sizes. This enhancement is expected to foster richer user interactions, thereby contributing to the future growth of the VR market.

CCS Concepts

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

[†] Both authors contributed equally to this research.

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1. Introduction

Demonstrative indicators, including “that” and “this”, are important lexical items across all languages. These indicators are not only present in every language, but they are also among the most frequent words in any given language [Deu05, Die99, SCR*21], and are some of the earliest words acquired after birth [Cla76, CC15]. Furthermore, demonstrative indicators are closely related to the action and often direct attention to objects [Die06].

Moreover, with the increasing opportunities for interaction within virtual reality (VR) spaces, such as stores and events, the nature of these interactions has evolved. In VR spaces, users can customize their appearance and size, ranging from realistic representations to fictional creatures. However, some avatars may lack hands, affecting how users can point or gesture. In physical spaces, pointing and gesturing, accompanied by verbal cues, are common ways to achieve mutual understanding when referring to objects [CWDE11, LGK*13, SKI*06]. Yet, in VR spaces, the feasibility of pointing depends on the avatar’s design, potentially hindering communication. Moreover, the referential range of gestures may vary based on characteristics like the avatar’s appearance and size. However, the relationship between these characteristics and the referential range has yet to be thoroughly explored.

This study aims to elucidate how the appearance and size of an avatar in VR spaces affect the referential range of demonstrative indicators. We created six different avatars varying in appearance and size for use in VR spaces, and participants were asked to use these avatars to refer to objects, thereby examining the influence on the referential range of demonstrative indicators. This paper addresses the following three main research questions (RQs) regarding the impact of the avatar’s appearance on the referential range of demonstrative indicators in VR spaces, as shown in Fig. 2:

- RQ# 1: Does the demonstrative indicator’s referential range change depending on whether the avatar is bipedal or quadrupedal?
- RQ# 2: Does the appearance of the avatar affect the demonstrative indicator’s referential range?
- RQ# 3: Does the size of the avatar affect the demonstrative indicator’s referential range?

By addressing these research questions, this study provides insights into how avatar characteristics influence the use of demonstrative indicators in VR spaces. This research contributes to the understanding of object reference in VR spaces, focusing on demonstrative indicators, and promotes effective communication using demonstrative language in VR spaces.

2. Related Work

2.1. Spatial Demonstrative indicators and Perceptual Space

Demonstrative indicators are often used together with gestures [SCR*21, dKHSK16, CWDE11]. Previous studies on demonstrative indicators have shown a relationship between the space where an object is located peripersonal space (within reach) and extrapersonal space (visible but out of reach) and the use of distal indicators (“that”) and proximal indicators (“this”). Particularly, the research group led by Coventry et al. [CGH14, CVCGF08] found

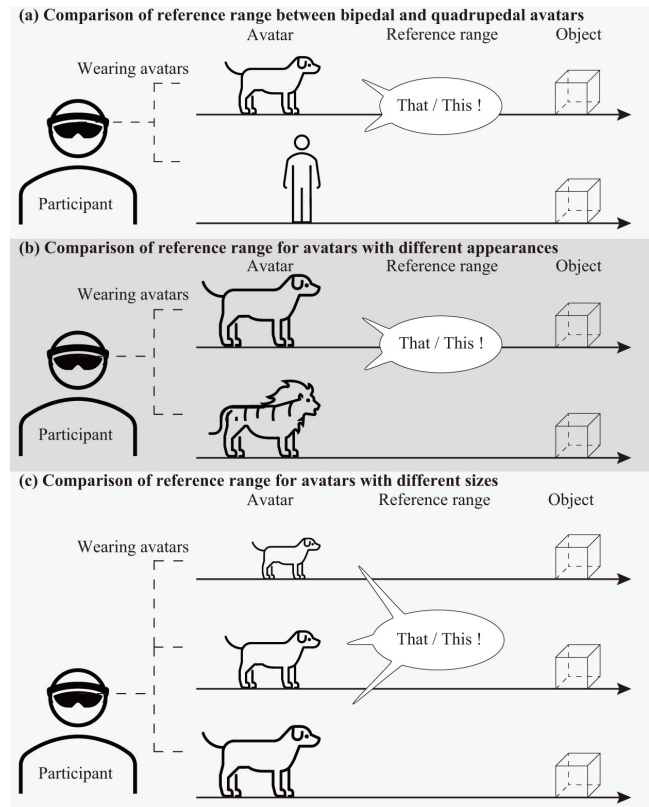


Figure 2: (a)-(c) in the figure correspond to Research Question 1-3, respectively. In (a), the boundary positions of the reference range are compared between a humanoid bipedal avatar and an animaloid quadrupedal avatar using a demonstrative indicator. In (b), the boundary positions of the reference range are compared by the demonstrative indicator between an animal-type quadrupedal avatar and a quadrupedal avatar with a different appearance. In (c), the boundary positions of the reference range are compared by the demonstrative indicator using animal-type quadrupedal avatars with the same appearance but different sizes.

that the frequency of using “this” in English or “este” in Spanish drastically decreases as an object moves into extrapersonal space [MdR07, SZ13]. Furthermore, when using a stick or similar object to point, the range of use for “this” or “este” extends to the end of the stick, aligning with the extension of near space reported by Berti et al. [BF00]. The use of demonstrative indicators is determined by many factors, including the visibility, ownership, and familiarity of the object [CGH14], the position of the interlocutor [CVCGF08, RWVT18], and joint attention [Die14, KÖ06].

However, these studies have primarily focused on situations in real space, and there has not been sufficient investigation into how changes in the appearance and size of speakers in VR spaces affect the use of demonstrative indicators. This research aims to fill this gap in knowledge. It will conduct a detailed investigation into how the appearance and size of speakers in VR spaces influence the use of demonstrative indicators and reveal the impact this has on the

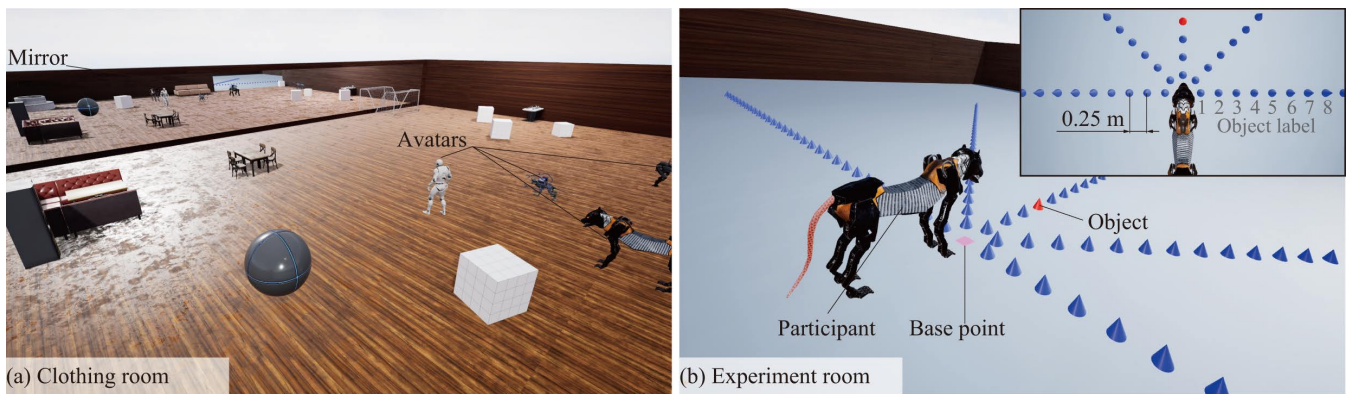


Figure 3: The VR spaces used in this experiment. The experiment was used (a) Clothing room and (b) Experiment room. (a) Clothing room has a mirror for the participants to check their own image. In (b) Experiment room, objects are arranged for participants to refer to during the experiment.

effectiveness of VR communication. Through this investigation, the study aims to understand the patterns of demonstrative indicator use in VR spaces and contribute to the design of more effective communication techniques.

2.2. Avatar Perception and Body Representation in VR spaces

The investigation of human mechanisms through the use of avatars in VR spaces has been an ongoing area of research. In particular, various studies have been conducted on the sense of body ownership of avatars in VR space, referred to as “Virtual Body Ownership (VBO)”. In previous studies on VBO, Botvinick et al. [BC98] examined the effect of the interaction between multisensory inputs and internal models of the body on VBO using the “rubber hand illusion”, in which a rubber hand is made to appear as one’s own hand, and Tsakiris et al. [Tsa10, TH05] extended this concept and established a neurocognitive model of VBO. Lugin et al. [LLL15] showed that VBO can be observed in non-human characters, and Guterstam et al. and Normand et al. [GPE11, NGSS11] demonstrated that the illusion of VBO can be maintained even when virtual body parts are added. Won et al. [WBL15] explored the possibility of VBO in non-human avatars, and Steptoe et al. [SSS13] investigated the effect of body motion on the VBO experience by adding a tail-like moving body part to the avatar. Egeberg et al. and Sikstrom et al. [ELS*16, SDGS14] evaluated the relationship between virtual wing control and sensory feedback in VR games, while Waltemate et al. [WGR*18] demonstrated the impact of customizable avatars on VBO. In addition, Leite et al. and Rhodin et al. [LO12, RTIK*14, RTK*15] conducted experiments on animal avatar control, and Krekhov et al. [KCK18] showed that the illusion of virtual body possession can be applied to animal avatars.

The study by Mine et al. [MONY20] revealed that changes in inter-pupillary distance (IPD) affect the perception of both the body and the external environment. Parastoo et al. [AGFOS19] investigated the effects on walking behavior in real space by varying the velocity gain applied to VR goggle wearers while walking in a VR space, while also changing the eye level. Additionally, Van der Veer et al. [VdVAL*19] investigated the effects of altering eye level in

VR space on the perception of one’s own body parts. These studies involve research on eye level.

However, these studies have focused on the use of avatars, and there have been no studies that directly link the use of avatars to the referents in VR space. In this study, we will clarify the relationship between the use of avatars and the range of referents in VR space, thereby addressing the areas that previous studies have not explored.

3. Experiment

3.1. Study Design

In this paper, we clarify the range of demonstrative indicators that are referred to when a user pretends to be an avatar in a VR space. In this study, we focused on the range of referents by two types of spatial demonstrative indicators: the distal indicator “that” (referred to as “*a-re*” in Japanese) and the proximal indicator “this” (referred to as “*ko-re*” in Japanese). The experimental environment was divided into two rooms: one to enhance the participants’ sense of physical possession of the avatar, and the other to refer to the objects. The experimental environment is shown in Fig. 3. In the room for enhancing the participants’ sense of physical possession of the avatar (Fig. 3 (a)), a large mirror was placed in front of the room so that the participants could see their own image at any time while they were in this room. The participants viewed the scene from a first-person perspective through the avatar. In the object-referring room (Fig. 3 (b)), 30 objects were placed at equal intervals, radiating in five directions from a base point. Each object was a conical marker with a radius of 0.1 m and a height of 0.2 m. The distances between the objects were set to 0.25 m, based on Coventry et al. [CVCGF08]. During the experiment, the objects remained stationary.

Avatars were prepared in a VR space as the experiment, and participants wore a head-mounted display (HMD) and were able to control the avatar using a hand-held controller. The control of the avatars was limited to movement, with no ability to control hand movements or finer foot movements. Six types (Avatar A-F) of dif-

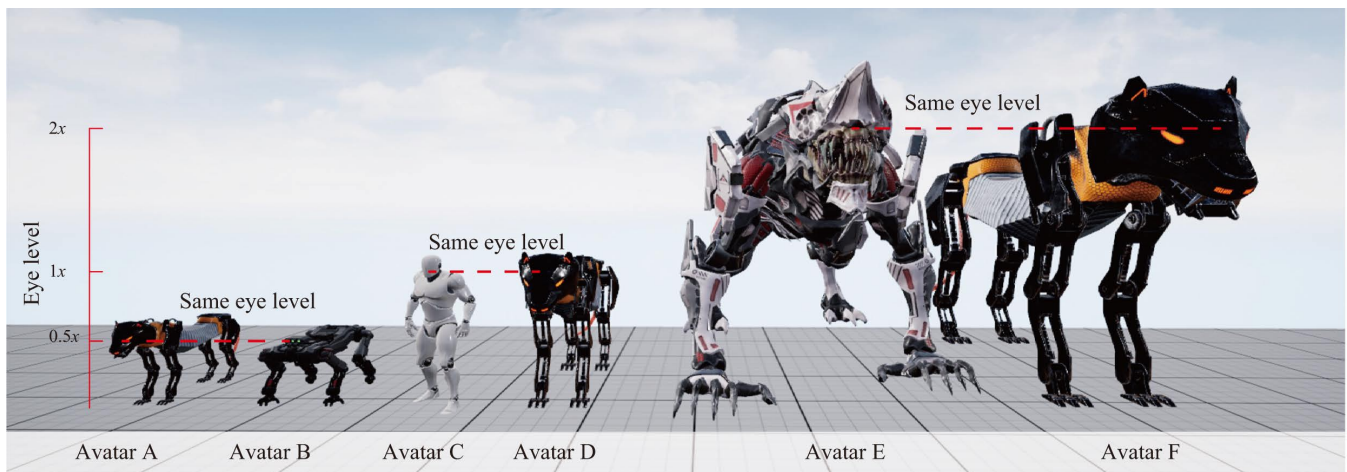


Figure 4: Avatars used in this experiment: Avatars A and B, Avatars C and D, and Avatars E and F have the same eye level, respectively.

ferent appearances and sizes were used in this experiment. These avatars were selected based on criteria such as whether they were bipedal or quadrupedal and whether they represented animal or non-animal forms. The avatars utilized in the experiment are shown in Fig. 4. The configuration of each avatar is as follows:

- Avatar A: Quadruped avatar with the same appearance as Avatar D and half the eye level of Avatar D.
- Avatar B: Quadruped avatar that differs from Avatar D in appearance and is half the size of Avatar D in eye level.
- Avatar C: Humanoid bipedal avatar.
- Avatar D: Quadruped avatar at the eye level as Avatar C.
- Avatar E: Quadruped avatar with a different appearance from Avatar D and with a eye level twice as high as Avatar D.
- Avatar F: Quadruped avatar with the same appearance as Avatar D, but with a eye level twice as high as Avatar D.

The avatars can be divided into three different sizes. This allows us to compare Avatar C and Avatar D to verify whether different gait schemes affect the reference range of the demonstrative indicator; compare Avatar A and Avatar B, as well as Avatar E and Avatar F, to verify whether different appearances affect the referential range of the demonstrative indicator; and compare Avatar A, Avatar D, and Avatar F to verify whether different sizes affect the reference range of the demonstrative indicator. The height of the humanoid avatar used in this study was 1.75 m. In this experiment, we focused solely on the differences in avatar size and appearance, and to eliminate the influence of IPD, the IPD was kept constant across all avatars.

This experiment employed a within-subjects design, allowing each participant to experience all avatar conditions. Additionally, the experimental conditions were presented to participants in a randomized order. The total duration of the experiment was approximately one month.

The environment used in this experiment was built with Unreal Engine 5. An HMD (Meta Quest Pro, Meta Corporation, resolution:

1800 × 1920 for each side, 722 g) was used to present the images in the experiment. The avatars used in this study were obtained from the Unreal Engine Marketplace. The controller was an accessory of the HMD used.

3.2. Participant

This experiment was conducted with 10 participants (8 males and 2 females) between the ages of 21 and 26. All participants had previous experience using a VR-HMD (virtual reality head-mounted display).

In this experiment, we prepared six types of avatars whose appearance and size changed. Therefore, participants who experienced fatigue or changes in physical condition due to changes in perspective or differences in the sense of body ownership were given sufficient rest, and the experiment was not conducted until they had fully recovered.

3.3. Procedure

In this experiment, the participants were asked to wear an HMD and control the avatar with a hand-held controller. This controller allowed only movement, and the hands and feet of the avatar could not be manipulated. First, in order to get a sense of ownership of the avatar, the participants were asked to move freely around the space for 3 minutes while checking their avatar's appearance in a mirror in the space shown in Fig. 3 (a). In the space with mirrors shown in Fig. 3 (a), a ball or a cube was placed in addition to the mirrors to enhance the sense of ownership of the avatar by the participants. Next, the participants were asked to move the avatar to the space shown in Fig. 3 (b) and stand at the base point. Finally, the participants were given a task in which they were asked to refer to an object placed in the VR space using a demonstrative indicator.

Two kinds of demonstrative indicators were used in this experiment: a distal indicator “that” and a proximal indicator “this”. One row of objects in each direction was used as a group, and the experiment was conducted one group at a time, one after the other.

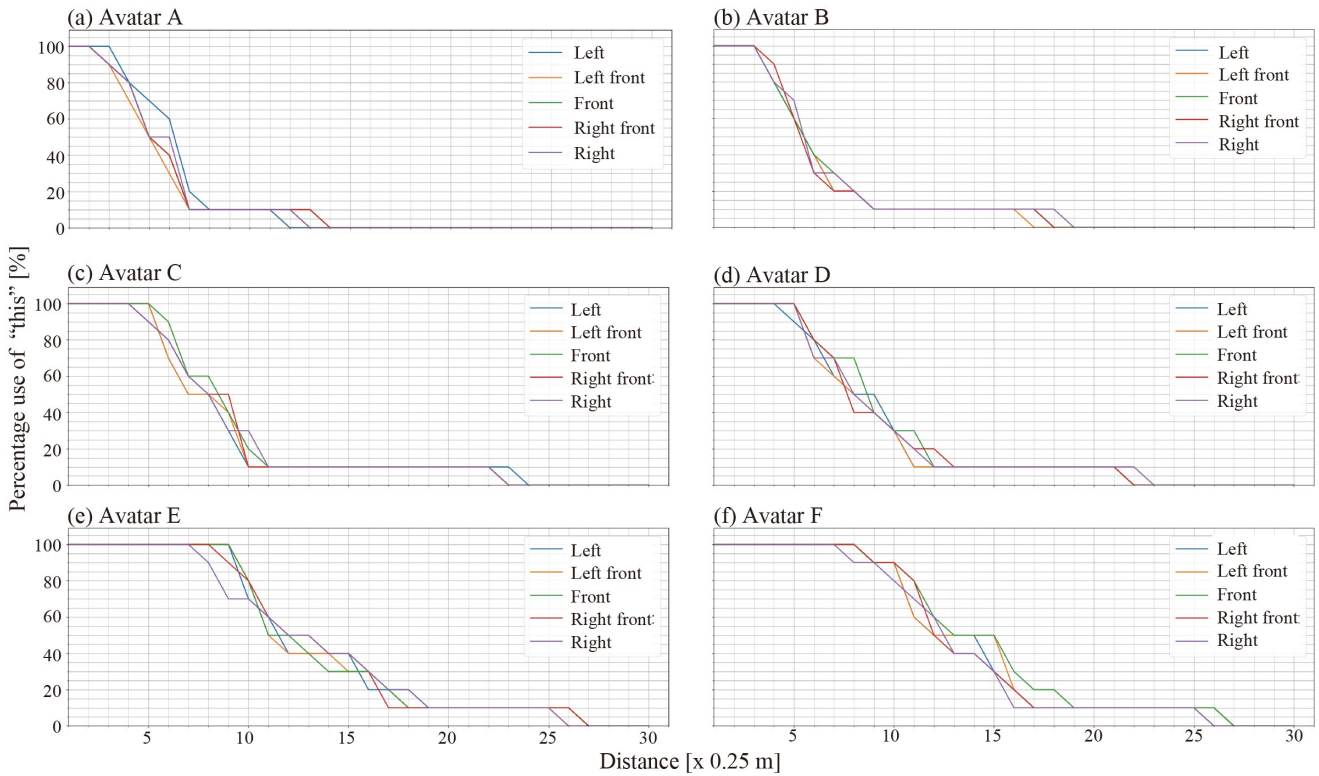


Figure 5: Boundary position of the reference range in five directions for each avatar.

The order of the pairs presented was random for each participant. During the experiment, one object from the group was displayed in red, and participants were asked to answer whether it was “that” or “this” for that object. Participants in the experiment referred to the presented object without using pointing gestures.

In this study, the boundary between the distal indicator “that” and the proximal indicator “this” is defined by the up-down method. In this experiment, the six types of avatars shown in Fig. 4 are referenced in a total of five directions from left to right. In the direction where the object is located, the body orientation is fixed from the reference point where the experimental participant is located, and only the neck is rotated toward the object to gaze at it. When participants referred to target objects at their feet, they tilt their heads downward to view the object. Whether the avatar’s body was visible in this position depended on the type of avatar used. With the humanoid avatar, participants could see parts of the avatar’s legs and body when looking down, closely replicating a human’s typical field of view. For animal-like avatars, participants generally could not see the avatar’s legs even when looking down, though extreme tilting of the head occasionally brought the legs into view. In the case of the machine-type avatar, participants could see a small part of the legs when looking directly downward, but the legs were typically not visible.

Table 1: The result of Friedman’s test for “this” speech rate based on direction for each avatar.

	<i>df</i>	χ^2_F	<i>p</i> – value
Avatar A	4	9.2747	0.05459
Avatar B	4	2.7629	0.5983
Avatar C	4	4.6281	0.3276
Avatar D	4	7.4766	0.1127
Avatar E	4	2.119	0.7139
Avatar F	4	7.9456	0.09359

3.4. Result

3.4.1. Reference range of demonstrative indicator in different directions

This study examined the effect of the avatar’s appearance on the referential range of the demonstrative indicator. This chapter clarifies whether the referential range of the demonstrative indicator changes with direction for each avatar. From the results of “that” and “this” responses given by the participants, the response rate of “this” for each object in each of the five pairs (five directions) was output as a graph for each avatar. The results are shown in Fig. 5. The horizontal axis shows the number of the object closest to the participant as 1 and the farthest one as 30, and the vertical axis shows the percentage of participants who responded “this” to the

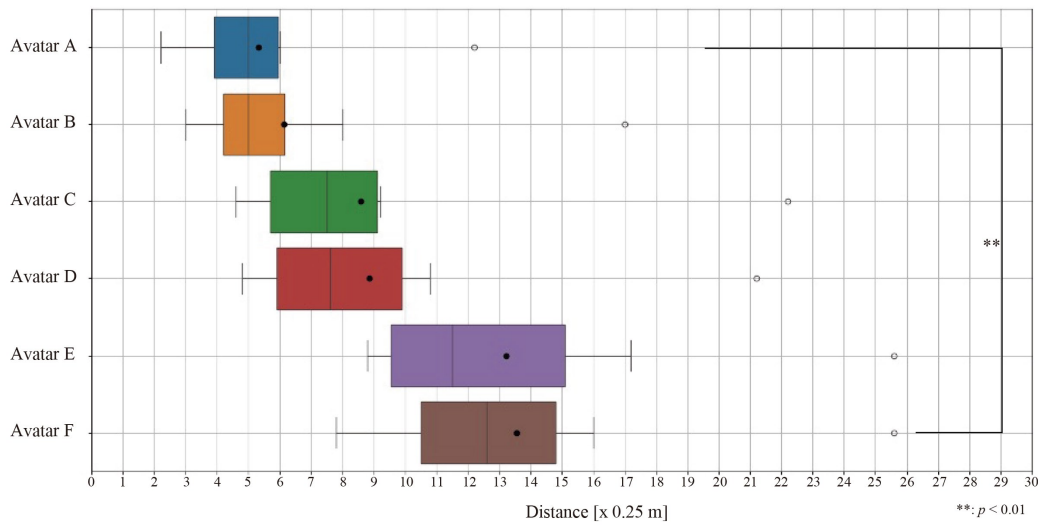


Figure 6: Boundary position of the reference range of the distal and proximal indicators for each avatar.

object of that number. The response rate for each object is the average of all participants.

The data obtained from the experiment were used to examine whether the reference range of the directional indicator changes for each avatar using Friedman’s test. The results are shown in Table 1. The results of Friedman’s test revealed that there was no significant difference in the rate of utterance of “this” by direction. This suggests that the change in the reference range of the demonstrative indicator in VR space is independent of the direction.

3.4.2. Reference range of demonstrative indicator in different Avatar

This experiment reveals changes in the referential range of the demonstrative indicator when the avatar is used by the experimental participants. In this chapter, we clarify the effect of changing the looks of the avatar on the referential range of the demonstrative indicator used by the participants. The results of the experiment are shown in Fig. 6. Figure 6 shows a box-and-whisker diagram of the boundary positions of the distal and proximal indicators for the 10 participants. In this study, the boundary position between distal and proximal indicators is defined as the location of the farthest object to which the participant responded “this”. Since no differences by direction were found in Section 3.4.1, we use the average of the directions at the boundary for each participant as the data.

In this study, the reference ranges of the bipedal and quadrupedal avatar demonstrative indicators were compared by examining the boundary positions of the distal and proximal indicators of Avatar C and Avatar D. Results were obtained by performing a Wilcoxon Signed-Rank Test on the boundary positions of distal and proximal indicators for the bipedal and quadrupedal avatars. The results of the Wilcoxon Signed-Rank Test showed no significant difference in the boundary positions of the reference range of the demonstrative indicators between the bipedal and quadrupedal avatars.

Next, we examined the effect of avatar appearance on the range

of referents of the demonstrative indicator. This experiment was conducted with avatars of the same size but different appearances. Avatar A and Avatar B were the same size but differed in appearance. The Wilcoxon Signed-Rank Test was performed on the boundary positions of the distal and proximal indicators of Avatar A and Avatar B to determine the effect of appearance on the reference range of the indicators. Avatar E and Avatar F also differed in appearance but were the same size. Similarly, the Wilcoxon Signed-Rank Test was performed on the boundary positions of the distal and proximal indicators of Avatar E and Avatar F to examine the effect of appearance on the reference range of the indicators. The results showed that there was no significant difference between these avatars in the boundary position of the referential range of the indicators due to differences in appearance.

In addition, by comparing the boundary positions of the distal and proximal indicators of Avatar A, Avatar D, and Avatar F, we can observe the change in the reference range of the indicators due to the size of the avatar. Since these avatars have the same appearance, it is possible to analyze the change in the reference range of the indicators based purely on the size of the avatar. The results of Friedman’s test were obtained for the boundary positions between distal and proximal indicators depending on the size of the avatar. The results showed significant differences in Friedman’s test ($p < 0.01$). Additionally, to examine the effect of size differences, Kendall’s coefficient of concordance was calculated as an effect size, revealing a large effect ($W = 0.902$). Therefore, for a detailed analysis, a Nemenyi post-hoc test was performed. The results of the Nemenyi post-hoc test revealed a significant difference between Avatar A and Avatar F ($p < 0.01$).

4. Discussion

4.1. General Discussion

In this study, we investigated the effects of the avatar’s appearance and size on the reference range of the demonstrative indicator in

VR space. In this chapter, we will discuss the effects of the avatar's appearance and size on the reference range of the demonstrative indicator based on the results of the experiment.

This experiment first examined whether the reference range of a demonstrative indicator changes depending on the direction in which the referenced object is located. The results indicated that the referential range of demonstrative indicators may not depend on direction. This suggests that when using avatars, the referential range of demonstrative indicators may not vary with direction, and if an object is in front of the avatar, the boundary position of the referential range of the demonstrative indicators may be distributed in a circular pattern centered on the avatar.

Additionally, the avatar is symmetrical in this study. In real space, it has been shown that the reachability of an object is different when a tool is used to point to the object and when no tool is used [CVCGF08]. For left-right asymmetrical avatars, the boundary position of the reference range of the demonstrative indicator might vary with direction due to the difference in reachability between left and right. Therefore, it can be suggested that when using left-right asymmetrical avatars, the boundary position of the reference range of the demonstrative indicator might not form a perfect semicircle.

Next, this study clarified the effects of the avatar's appearance and size on the reference range of the directive. The results showed that the boundary position of the reference range of the demonstrative indicator does not change when the eye level is the same, regardless of whether the avatar is a human-like biped or a canine-like quadruped. This result indicates that, under conditions where no explicit pointing is used, if the eye level remains the same, the boundary position of the reference range of the demonstrative indicator may not vary based on the number of legs. However, in the case of a bipedal avatar, it is possible to extend the boundary position of the referential range of a demonstrative indicator by pointing or using tools [CVCGF08], suggesting that changes in the referential range could be influenced by actions like pointing. In addition, when avatars of different sizes were compared, we observed variations in the boundary position of the referential range of the demonstrative indicator between the largest and smallest avatars used in this experiment. However, no significant difference was observed when comparing the avatar in the middle layer. This suggests a difference in the boundary position of the referential range when the compared avatars have a sufficient disparity in viewing position. Additionally, regarding the boundary position of the referential range of the demonstrative indicator depending on the difference in the avatar's appearance, there was no significant difference in the boundary position of the referential range when the avatars had the same eye level. In this experiment, a dinosaur-type avatar and two large dog-type avatars were compared with two small avatars, a machine-type avatar and a dog-type avatar, respectively. Although these compared avatars differed in appearance (color and shape), the results indicate that these visual factors did not produce a detectable effect on the referential range of the demonstrative indicator, though this may be influenced by factors such as sample size and variability in the data. These results suggest that the reference range of the demonstrative indicator may

be more influenced by the avatar's size (eye level) than by appearance.

4.2. Findings and Insights

This study aims to clarify the differences in the reference range of the instructions for the avatar in the VR space. In order to clarify the differences in the referential range of the demonstrative indicator for the avatar's appearance and size, three research questions were formulated. In this section, we describe the answers to the three research questions and then describe the contribution of this study to VR.

RQ# 1: Does the range of the demonstrative indicator change depending on whether the avatar is bipedal or quadrupedal?

In this study, experiments were conducted and compared using bipedal and quadrupedal avatars at the same eye level. As a result, no significant difference was found in the boundary position of the reference range of the demonstrative indicator between the bipedal and quadrupedal avatars. This result suggests that the leg structure may not substantially affect the referential range of the demonstrative indicator when referring to an object by gaze alone.

RQ# 2: Does the appearance of the avatar change the range of the demonstrative indicator?

In this study, experiments were conducted and compared using quadruped avatars with the same size but different appearances. As a result, no significant difference was observed in the boundary position of the reference range of the demonstrative indicator among the different appearances. This suggests that the boundary position of the reference range of the demonstrative indicator may not vary with the differences in appearance among the avatars used in this study.

RQ# 3: Does the size of the avatar change the range of the demonstrative indicator?

In this study, experiments were conducted using three avatars with the same appearance but different sizes, and a comparison was made. A significant difference was found in the boundary position of the reference range of the demonstrative indicator between the smallest avatar and the largest avatar among the avatars of different sizes prepared in this study. However, no significant difference was detected between the avatar with the middle size and the largest avatar, or between the avatar with the middle size and the smallest avatar. This result suggests that differences in the boundary position of the referential range of the demonstrative indicator may only emerge when the size disparity between avatars is substantial.

These are the answers to the Research Questions in this study. The three Research Questions answered in this study contribute to understanding the characteristics of avatars and the act of referencing in VR space. These findings may support smoother interactions when avatars engage in conversations involving references in VR spaces, potentially improving user interaction quality in VR.

5. Limitation

In this study, experiments were conducted using six types of avatars with different appearances and sizes to clarify the boundary position of the reference range of the demonstrative indicator. Among

them, there were avatars that looked different from humans, such as quadrupeds, and avatars that had a different eye level and differed from the world participants usually see (in terms of object size). Under these circumstances, some participants conducted the experiment on a different day due to fatigue or changes in physical condition. In addition, while many of the participants were provided with appropriate breaks, those who requested more were given additional time to rest. These measures were unavoidable, as the safety of the experimental participants was the primary concern in this study. However, the decline in cognitive ability and judgment due to factors such as fatigue, as well as the dispersion of learning effects across different conditions, remain unresolved issues. We cannot deny the possibility that these factors may have influenced the differences in the reference range of the demonstrative indicators. This is an issue to be addressed in future studies and a point to be noted when conducting similar research.

In this study, experiments were also conducted using six different avatar types with different appearances and sizes. The Proteus effect [YB07] may occur when a human wears an avatar in place of themselves in a VR space. In this experiment, we did not ask the participants about their impressions of the avatar's appearance. Therefore, it is unclear to what extent the Proteus effect occurred because the participants' feelings toward the avatar are unknown. Since demonstrative indicators depend on the reachability of the target object [CC19], the referential scope of demonstrative indicators may vary depending on the perceived appearance of the avatar, even when using avatars of the same size. In order to examine the relationship between the boundary position of the reference range of the distal and proximal indicators and the Proteus effect, we should ask the experimental participants about their impressions of the avatar's appearance and compare them with two avatars of equal eye level but different types. In this study, IPD was not modified. Since changes in IPD can influence perception of both the body and the external environment [MONY20], examining the relationship between IPD variation and the referential range of demonstrative indicators remains an issue for future research.

In addition, in RQ#1, we compared the case where the avatar was bipedal with the case where the avatar was quadrupedal, and in the case where the avatar was bipedal, the reference was made only by gazing, without pointing. In real space, object reference is often performed in conjunction with pointing while gazing, and this gesture may extend the reference range of proximal indicators. In the present study, the bipedal avatar and the quadrupedal avatar used gazing alone for reference in order to maintain consistent conditions. However, if the proximal indicator can be extended by pointing, the boundary position of the reference range of the indicator may differ between the bipedal and quadrupedal avatars. Similarly, a quadrupedal avatar could expand the possibility of extending the proximal indicator by pointing with its forelegs instead of its gaze. Yet, unlike a human-like bipedal avatar, a quadrupedal avatar has a limited range of motion in its forelegs. If pointing beyond the range of motion of a quadrupedal avatar's forelegs were made possible, references could be provided, but this would compromise realism. This is a limitation of the present study because the research focused on gaze-only references and did not clarify the changes in the reference range of the demonstrative indicator when using pointing.

6. Conclusion

This study clarified the influence of the appearance and size of the avatar worn by the user on the reference range of the demonstrative indicator used to refer to objects. In the experiment conducted in this study, six avatars of different appearances and sizes were prepared. The participants were asked to wear these six avatars and refer to objects using two types of demonstrative indicators: distal that corresponds to "that" (referred to as "a-re" in Japanese) and proximal that corresponds to "this" (referred to as "ko-re" in Japanese), in order to obtain the boundary positions of the referential range for each indicator. As a result, significant differences in the boundary positions of the reference range of the demonstrative indicator were found only among the avatars used in this study with different sizes. This result suggests that the use range of the demonstrative indicator differs between small and large avatars, and further research is expected to be necessary for smooth conversation using demonstrative indicators. The avatars used in this study showed no significant difference in the boundary position of the referential range by the demonstrative indicator in the five directions, suggesting that the referential range of the demonstrative indicator may be distributed in a semicircular shape.

The research conducted in this study contributes to understanding the characteristics of avatars in the VR space where users can freely customize their own looks. In addition, smooth communication is expected to be realized by understanding the reference range of avatars in joint attention and reference behavior necessary for common recognition of objects. These findings will be useful for smooth interaction in VR space.

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