Exploring the Impact of Avatar's Physique on Psychological Impression and Perception of a Gentle Touch Robot*

Taishi Sawabe[1,*], Manuel Mayer[2,*], Masayuki Kanbara[1], Yuichiro Fujimoto[1] and Hirokazu Kato[1]

[1]Nara Institute of Science and Technology (NAIST), 8916-5 Takayamacho, Ikoma-city, Nara, Japan
[2]Media Informatics Group, University of Regensburg, Regensburg, Germany

Abstract
Touch care robots, designed to provide 'tactile touch' and embody the concept of 'humanitude' are a burgeoning trend in contemporary human-robot interaction, particularly in medical settings. Prior studies have indicated that several factors can impact a robot's tactile perception. Within these environments, fully human avatars exhibit a resemblance to robots and can evoke a sensation akin to interacting with a human. To explore this relationship, we conducted a user study with 26 participants, focusing on the impact of avatars with distinct visual characteristics (muscular vs. skinny, male vs. female appearance) on the robot's tactile perception. The results revealed disparities in the influence of visual appearance on haptic perception, as well as gender-based variations in preferences. Additionally, the gender of the user constitutes a crucial factor in the perception of user-robot interaction and warrants consideration.

Keywords
Virtual Reality (VR), Gentle Touch Robot, Avatar's Visual Appearance, Avatar's Physique

1. Introduction

It has been demonstrated that stroking movements have a relaxing effect on the body and mind by mediating the autonomic nervous system and the endocrine system, and there is a technique called touch care, which is medical care that incorporates stroking movements. In general, touch care refers to all care that includes stroking movements and has various effects, such as reducing anxiety and stress and relieving pain. In addition, the stroking movements of touch care are also incorporated into care such as tactile massage and humanitude care, which are practiced in the medical field. Thus, touch care is recognized as a method suitable for reducing anxiety and pain in actual medical and nursing care settings, is an essential type of care, and is expected to remain in high demand. However, the recent shortage of human resources due to a shortage of carers and "caregiver fatigue" among home carers has become a serious problem, and emphasis is being placed on the development of robots that can replace people in providing such touch care.

2. Related Work

A number of relevant studies on robot touch have shown that robots induce positive emotions in humans through touch interactions [1, 2]. The basis for this effect is a multimodal care approach based on philosophical principles known as 'tactile touch' and 'human touch'. They are practiced by humans in nursing and other medical fields. While these methods are practiced by humans in everyday situations, problems related to human resources and nursing infrastructure remain [3, 4]. Therefore, recent research has focused on the development of touch care robots. The aforementioned technological implementation is an example of an attempt to replicate the practice of reducing patient stress and relieving pain through gentle touch interactions. This touch is influenced by various aspects such as stroke speed and speech [5]. While there have been many mechanical and technical studies on touch care robots, few studies have focused on the visual representation of these robots and their impact on patients. Going further into the actual touch care robots, the gender of the avatar as visualized in an augmented reality (AR) environment affected the overall liking [6, 7].

APMAR'23: The 15th Asia-Pacific Workshop on Mixed and Augmented Reality, Aug. 18-19, 2023, Taipei, Taiwan
*Corresponding author.
t.sawabe@is.naist.jp (T. Sawabe); manuel.mayer@stud.uni-regensburg.de (M. Mayer); kanbara@is.naist.jp (M. Kanbara); yfujimoto@is.naist.jp (Y. Fujimoto); kato@is.naist.jp (H. Kato)
http://imdl.naist.jp/people/taishi-sawabe/ (T. Sawabe); http://imdl.naist.jp/people/masayuki-kanbara/ (M. Kanbara); http://imdl.naist.jp/people/yuichiro-fujimoto/ (Y. Fujimoto); http://imdl.naist.jp/people/hirokazukato/ (H. Kato)
0000-0001-9244-479X (T. Sawabe); 0000-0002-8950-9801 (M. Mayer); 0000-0002-1877-996X (M. Kanbara); 0000-0002-8270-2609 (Y. Fujimoto); 0000-0003-3921-2871 (H. Kato)

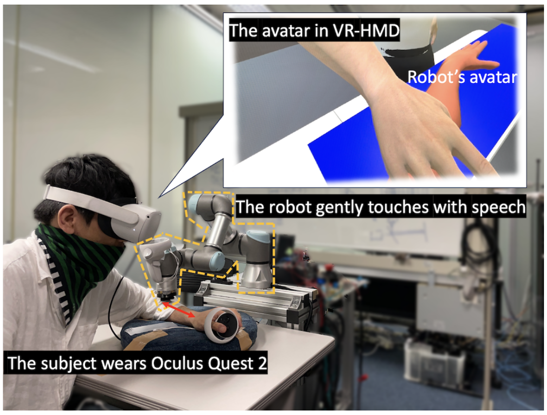

Figure 1: The overview of the gentle touch with robot by using UR3e, and changing physique by using Oculus Quest 2. Above: VR images of the subject through the VR-HMD.

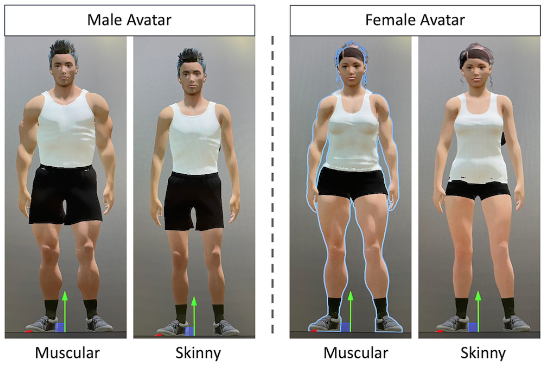

Figure 2: Avatars used in the study. On the left, muscular male avatar and skinny male avatar, and on the right, muscular avatar female and skinny female avatar. This deliberate selection aimed to investigate potential gender-specific variations in the participants' responses and shed light on the intricate relationship between body image and cognitive processing.

3. Robot avatar's physique with a gentle touch

3.1. Overview of the gentle touch robot

We used the Oculus Quest 2 in a virtual reality setup on an Alienware x17 laptop with a built-in NVIDIA GeForce 3080ti. Moreover, Unity 2021.3.13f1 was used for the experimental setup. For the gentle touch, a Universal Robots UR3e with 3D printed end effector is used. The right controller of the Oculus Quest 2 to the last joint of the robot arm to enable hand tracking. Furthermore, All questionnaires except a demographic questionnaire and a final feedback questionnaire were included in the virtual contents. The participant could use a controller to answer the questionnaires inside virtual environment, but we also provided alternative questionnaires outside of virtual reality in case there were any problems.
The touch was performed by the UR3e robot and by tracking the mounted controller synchronized with the avatar's hand movement using Final IK VR which is a high-speed full-body solver dedicated to animating VR avatars. For the touch, the program on the UR3e robot was set to slowly press down until a pressure of 3 [N] was detected. Once this is done, the pressure is held for 3 [sec] and then the arm swipes two times along the participant's arm and back. It then returns to a zero position where it no longer touches the participant's hand. In the virtual environment, the participant could see the avatar's arm move according to the robot's arm in the real world (See Fig. 1).

3.2. Physique of avatars for the robot's different appearance

Four avatars were used: two muscular (male and female) avatars and two skinny (male and female) avatars. The animations were done using Maximo, and the audio voices were using Narkeet. The avatars were created using DAZ Studio according to Kocur et. al [8]. The used avatars can be seen in Fig. 2.

4. Experiments to impress the avatar's physique with a gentle touch

4.1. Overview

This experiment aims to examine how varying visual characteristics of avatars impact both the perception of the touch care robot itself and the perception of touch. For this study, we employed the Godspeed Like-ability Scale along with adjective pairs to assess touch perception. The experiment followed a specific procedure. First, written informed consent and a brief overview of the study procedure were given to the participant. After signing the informed consent form, the participant completed a demographic questionnaire along with some additional questions about visual impairment and cultural background. Once completed, the participant was seated, the Oculus Quest 2 (VR-HMD) was fitted, and the participant was given the left-hand controller. The participant was instructed to place his or her left arm on the cushion in front of two pads once the avatar in the virtual environment had finished introducing himself or herself. When the participant entered the virtual environment, the first avatar walked toward him/her and introduced himself/herself. After placing the hand correctly, the instructor started the robotic touch procedure. The visualization of the touch is seen by the participant in VR as seen in Fig. 1. Following the robotic touch, the avatar left the scene, and the participant regained the ability to move their arm. Subsequently, the participant proceeded to complete the Godspeed Like Ability scale, which assessed their overall perception of the robot and the experience. Upon completing the questionnaire, the next avatar entered the scene. Four distinct avatars were utilized, and their usage was balanced through the implementation of Latin squares. Instead of walking in, the avatars transitioned directly from a resting state to the touch sequence. Following that, the participant was required to answer the questionnaires. Upon concluding the study, participants were provided with a feedback form to gather their subjective impressions regarding their perception of the robot and the robotic touch.

4.2. Participants

We recruited 26 students (21 male, 5 female) between 23 and 37 years old (M = 28.35, SD = 4.65) from our university. We determined the sample size using a prior power analysis and used G*Power (Version. 3.1.9.7) and assumed to conduct a two-way ANOVA with a factor of three levels with an α level of 0.05, power of 0.80, correlation of 0.5, ϵ of 1, and effect size f of 0.25 (medium). The results indicated that 24 participants would be required. The research was conducted in a separate room within the university building. Both demographic and feedback questionnaires were administered anonymously. All participants received a gift card as a token of appreciation for their participation. This study was approved by the Ethics Committee of the Nara Institute of Science and Technology and was conducted according to institutional ethical provisions and the Declaration of Helsinki.

4.3. Evaluation method

Employing a variety of questionnaires is a widely adopted method for assessing human-robot interaction (HRI) scenarios. The Godspeed series is a renowned questionnaire that offers tools for evaluating robot anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety [9]. Each of these tools can be independently utilized, for example, the likeability questionnaire has been employed in various HRI studies [10, 11]. Apart from assessing likeability, an alternative approach to exploring the perception of various attributes is through the use of the semantic differential method, as outlined by Charles Osgood [12]. This method has also been applied in the

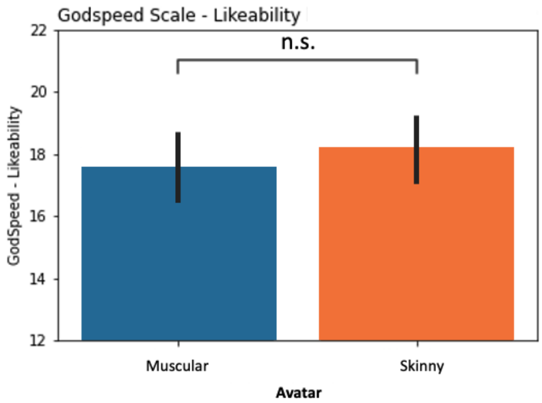

Figure 3: Evaluation of the Godspeed series likeability within Muscular avatar (blue graph) and Skinny avatar (orange graph).

context of robot touches by Yamashita et al., where participants were asked to rate a set of opposing adjectives [13]. Similarly, the same pair of adjectives was employed by other researchers, such as Endo et al., in evaluating their robotic hand [14]. This particular set of adjectives appears suitable for conducting a comprehensive investigation into the variation of individual properties across different stereotypes.

5. Result

From the result no effect on anything regarding Godspeed Likeability Scale. We evaluated each questionnaire using two-way repeated measure ANOVA models. We also calculated linear models. The analysis was done using Python together with the Pandas, Seaborn, and SciPy packages. The Godspeed questionnaire as well as the opposite adjective parts were also evaluated. We also performed evaluations by gender of the participants. Looking at the result, there was no significant effect of F(1) = 0.673 (p = .414), GENDER F(1) = 3.220 (p = .076). An overview of the effects can be seen in Fig. 3 and Fig. 4. Some effects on the touch adjectives: For all participants, dangerous vs safe (Skinny significant more safe than muscular and female significant more safe than male), dislike vs. like (Female significant more like than male), frightening vs. gentle (Skinny significant more gentle than muscular), negative sensation vs positive sensation (Female significant more positive sensation then male), soft vs hard (Male significant more hard then female), unpleasant vs pleasant (Female significant more pleasant then male), undesirable vs desirable (Female significant more desirable then male). For the result of male participants only, machine-like vs human-like (Muscular significant more human-like than skinny), negative

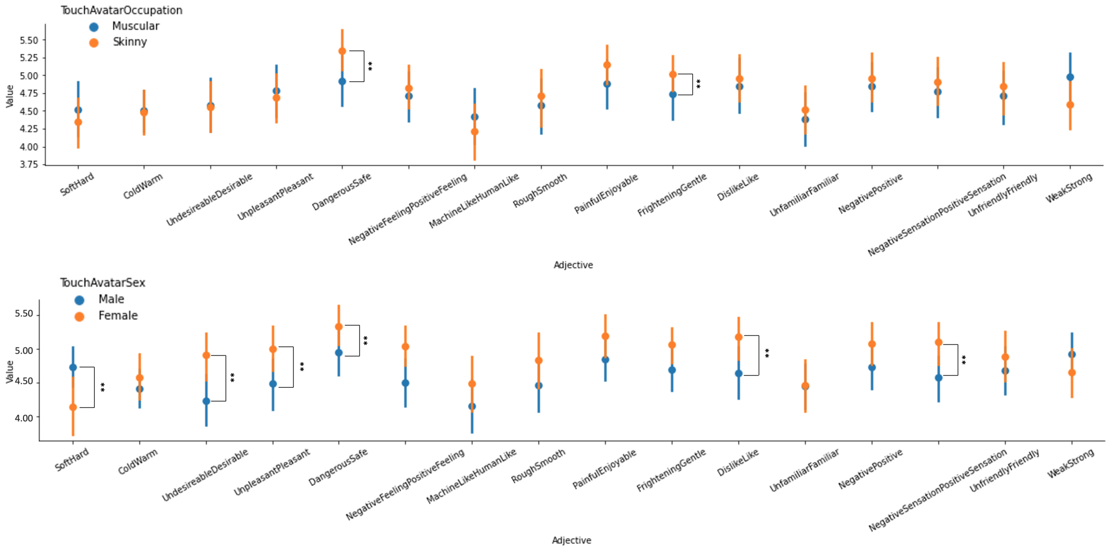

Figure 4: Evaluation of the opposite adjective pairs regarding the perception of the touch in the context of the avatar's physique. The upper graph shows the muscular and skinny results, lower graph shows the Male and Female avatar results.

feelings vs. positive feelings (Female significant more positive feelings than male), painful vs enjoyable (Female significant more enjoyable than male). In the study, we found a significant effect of GENDER $F(1) = 5.265$ ($p = .024$) on the perception of soft vs. hard. We also found a significant effect of GENDER $F(1) = 5.265$ ($p = .024$) in the second part of the study on the perception of dislike vs. like. Additionally, we found a significant effect of GENDER $F(1) = 4.124$ ($p = .045$) in the second part regarding unpleasant vs. pleasant. Regarding frightening vs. gentle, we found a significant effect on GENDER $F(1) = 5.785$ ($p = .028$) in the second part only for female participants. There was also a significant effect on GENDER $F(1) = 6.596$ ($p = .012$) in the second part regarding undesirable vs. desirable. The same was found on GENDER $F(1) = 4.686$ ($p = .033$) for negative vs. positive sensation. We also found a significant effect of GENDER $F(1) = 5.775$ ($p = .018$) in the second part for negative vs. positive feelings.

6. Discussion

In the study, we found that the Skinny avatar has a safer and more gentle impression than the muscular one, and also focuses on gender, the female avatar has more safe, more like, more positive, more pleasant, and more desirable for all participants. An avatar based on although the GENDER did not play a role for the same ability, the muscular and thin avatars influenced the perception of the touch by the GENDER of the avatars in some cases. Returning to our hypothesis while looking at the results of the Godspeed series, we did not find any significance through the series, therefore, the hypothesis of the visual physique of the avatar alters the perception of touch can be rejected since there is no effect on any scale. Specifically with regard to the perception of touch, there is a suggestion that the perception is influenced by the gender of the participant. A passive effect by simply visually observing the avatar could lead to different results. The moment at which a different physique is activated differs from person to person and needs to be further investigated in this context.

7. Conclusion

This study investigates how users perceive touch care robots with different avatars, considering specific visual features' influence on touch and overall perception. 26 participants explored how avatars with varying visual features affected their tactile perception of the robot. Results showed variations in the impact of visual appearance on haptic perception, along with gender-based preference differences. Comparing muscular and skinny avatars, the skinny one created a safer and gentler impression. Thus, the appearance of touch care robots in virtual reality significantly influences user-robot interaction perception. The limited number of female participants compared to males is a study limitation. Future studies should consider cultural, educational, and religious perspectives' influence on perceptions.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Numbers JP19H01124 and JP23H03442.

References

[1] M. Shiomi, A. Nakata, M. Kanbara, N. Hagita, A hug from a robot encourages prosocial behavior, 2017, pp. 418–423. doi:10.1109/ROMAN.2017.8172336.

[2] M. Shiomi, K. Nakagawa, K. Shinozawa, R. Matsumura, H. Ishiguro, N. Hagita, Does a robot's touch encourage human effort?, International Journal of Social Robotics 9 (2017). doi:10.1007/s12369-016-0339-x.

[3] S. Murashima, S. Nagata, J. K. Magilvy, S. Fukui, M. Kayama, Home care nursing in japan: a challenge for providing good care at home, Public Health Nurs 19 (2002) 94–103.

[4] M. Marć, A. Bartosiewicz, J. Burzyńska, Z. Chmiel, P. Januszewicz, A nursing shortage - a prospect of global and local policies, Int Nurs Rev 66 (2018) 9–16.

[5] T. Sawabe, S. Honda, W. Sato, T. Ishikura, M. Kanbara, S. Yoshikawa, Y. Fujimoto, H. Kato, Robot touch with speech boosts positive emotions, Scientific Reports 12 (2022) 6884. URL: https://doi.org/10.1038/s41598-022-10503-6. doi:10.1038/s41598-022-10503-6.

[6] T. Sawabe, S. Honda, Y. Fujimoto, M. Kanbara, H. Kato, Investigation of the human-robot interaction in affective robotics using hri with apparent differences in vr/ar, The 2nd International Workshop on Virtual, Augmented, and Mixed Reality for Human-Robot Interaction (HRI) (2020) 1–4.

[7] K. Tainaka, T. Kodama, I. M. Butaslac, H. Kawase, T. Sawabe, M. Kanbara, Tsundere interaction: Behavior modification by the integrated interaction of cold and kind actions, International Conference on Human-Robot Interaction, ACM/IEEE (2021) 153–156. doi:10.1145/3434074.3447149.

[8] M. Kocur, F. Habler, V. Schwind, P. W. Woźniak, C. Wolff, N. Henze, Physiological and perceptual responses to athletic avatars while cycling in virtual reality, in: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, CHI '21, Association for Computing Machinery, New York, NY, USA, 2021. URL: https://doi.org/10.1145/3411764.3445160. doi:10.1145/3411764.3445160.

[9] C. Bartneck, D. Kulić, E. Croft, S. Zoghbi, Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots, International Journal of Social Robotics 1 (2009) 71–81. URL: https://doi.org/10.1007/s12369-008-0001-3. doi:10.1007/s12369-008-0001-3.

[10] C. Willemse, S. Marchesi, A. Wykowska, Robot faces that follow gaze facilitate attentional engagement and increase their likeability, Frontiers in Psychology 9 (2018). URL: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.00070. doi:10.3389/fpsyg.2018.00070.

[11] E. B. Sandoval, J. Brandstatter, U. Yalcin, C. Bartneck, Robot likeability and reciprocity in human robot interaction: Using ultimatum game to determinate reciprocal likeable robot strategies, International Journal of Social Robotics 13 (2021) 851–862. URL: https://doi.org/10.1007/s12369-020-00658-5. doi:10.1007/s12369-020-00658-5.

[12] C. E. Osgood, The nature and measurement of meaning., Psychological Bulletin 49 (1952) 197–237. URL: https://doi.org/10.1037/h0055737. doi:10.1037/h0055737.

[13] Y. Yamashita, H. Ishihara, T. Ikeda, M. Asada, Investigation of causal relationship between touch sensations of robots and personality impressions by path analysis, International Journal of Social Robotics 11 (2019) 141–150. URL: https://doi.org/10.1007/s12369-018-0483-6. doi:10.1007/s12369-018-0483-6.

[14] N. Endo, T. Kojima, K. Endo, F. Iida, K. Hashimoto, A. Takanishi, Development of Anthropomorphic Soft Robotic Hand WSH-1RII, CISM International Centre for Mechanical Sciences, Courses and Lectures, Springer International Publishing, 2013, pp. 175–182. doi:10.1007/978-3-7091-1379-0_22.