Exploring the Influence of Super-Functional Virtual Hands on Embodiment and Perception in Virtual Reality with Children

Anonymous Author(s)

Figure 1: Go-Go Training Task: (a) Participants grab fruit to feed an animal at a set location, followed by (b) Sub-Hand, (c) Normal-Hand, and (d) Super-Hand functions.

ACM Reference Format:
Anonymous Author(s). 2018. Exploring the Influence of Super-Functional Virtual Hands on Embodiment and Perception in Virtual Reality with Children. In *Proceedings of June 03–05,2018 (Conference acronym 'ACM MIG).* ACM, New York, NY, USA, 2 pages. https://doi.org/XXX.XXXX

1 INTRODUCTION

As Virtual reality (VR) technology advances, more researchers are delving into human perceptions via virtual bodies. Many studies have adeptly manipulated the superficial appearance or form of virtual bodies [3, 5]. However, there has been limited research directly addressing the alteration of their functionality [4]. A critical question remains largely unexplored: Can enhancing virtual hand functionality lead to significant changes in how people perceive their real hands? Body size and shape change rapidly during childhood, and this requires equally fast adjustments in body representations during this period. Further, children under 10 years old rely heavily on visual cues to cultivate ownership over novel bodies [1]. We, therefore, hypothesise that children of this age will show enhanced plasticity in body representation, resulting in enhanced ownership over functionally novel bodies.

Virtual reality, and the embodiment of virtual bodies specifically, is a promising experimental tool to investigate how virtual hand function might shape children's subjective embodiment and motor performance, as well as how these domains relate. Consequently, our project aims to dissect this relationship between virtual limb functionality and embodiment in both children and adults. Our primary objective revolves around discerning whether virtual bodies with enhanced functionality (super-functional) are more seamlessly controlled and ownership felt more strongly compared to those with limited (sub-functional) and normal abilities. Central to our approach is the manipulation of the virtual arm's movement gain in relation to the real arm's extension, the previously named "Go-Go technique" [7]. The intention is to create a spectrum ranging from super to sub-functional virtual upper limbs. Platforms like Unity are instrumental in this prototype development journey. Currently, we have concluded data collection in 171 children aged 5 to 10 years old. This poster's objective is to elucidate our methodology, and in doing so, present to psychologists a unique tool - a set of hands which vary in functionality.

Conference acronym 'ACM MIG, Woodstock, NY,

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/XXX.XXXX

2 RELATED WORK

To test whether super-functional virtual bodies will be easier to own and control than sub-functional bodies, we need to select and refine a usable, effective function with different levels (two levels each of super-human and sub-human functions). We achieved this through an interaction design process, designing different suitable tasks and developing prototypes in Unity to test different functions and varying their parameters. We established a series of prototypes to explore and refine these hand functions in Unity, emphasizing their applicability and user interactivity by using different training tasks. Specifically, three VR Techniques were considered.

The **Go-Go interaction technique [7]** essentially provides the user with an extendable arm to reach and manipulate distant objects. As for the "Remote Target Selection" task in this study, participants were asked to remotely grab a decoration(n=10) from a Christmas tree and place it into a red box. A 3D interaction method named **PRISM** [2] offers precise and rapid interaction through scaled manipulation. The objective of PRISM is to elevate user precision and control in virtual settings, mirroring their familiarity with the real world. The tasks include PRISM Rotation (Rotate a red brick until it perfectly aligns with a slightly larger green counterpart) and Transition (Navigate the red brick to ensure its complete placement inside the green brick). **HOOK** [6] is a heuristic methods for selecting the closest high-scored 3D object in dense environments. The task involves selecting a red balloon amidst moving ones and positioning it inside a red box.

3 METHODS

We selected the **Go-Go hand** as the most appropriate virtual hand function, as qualitative feedback from our pilot study showed that participants perceived it as a seamless extension of their own body, rather than a detached tool. We used the Meta Quest 2 for real-time hand tracking, allowing participants to grab and poke without the limitations of controllers. This enhanced user immersion by eliminating the constraints of controller weight and buttons. With three input points from participants, the headset and two hands, ensuring accurate virtual arm length was crucial. To achieve this, we measured participants' arm lengths both in the virtual and real worlds, specifically from the wrist to the humerus, the bone connecting the upper arm to the shoulder. The Inverse Kinematics (IK) system was then used to calibrate shoulder positions, modifying the virtual body's skeleton to more closely reflect the participants' actual anatomical structure. To further increase a sense of embodiment, we customized the colour of the virtual hands to closely mimic participants' actual skin tone and added extendable arms through the IK system. This made the Go-Go hand not only functionally accurate but also visually consistent with users' real-world appearance, aiming to create a more impressive experience.

Linear Super-Hand and Sub-Hand Function: This study evaluates the Go-Go technique's specialized hand functions by comparing four levels of body function (Subfunctional1, Normal, Super1, Super2) across three different age groups. This technique involves scenarios where a 'Super' hand extends reach, while a 'Sub' hand restricts it.

It is essential to note that the previous calculation method for the Go-Go Hand was non-linear(see Equation 1). However, in our experiment design, we aimed to train participants in a satisfying and motivating activity: feeding virtual animals at different levels of super or sub-level Go-Go Hand function. The challenge arises when considering the positions of the animals, which are located at specific distances corresponding to the maximum arm length extension achievable by each participant. These positions are set at 100% of the Max Arm Length, 88% of the Max Arm Length, 64% of the Max Arm Length, and 52% of the Max Arm Length. The issue with the Nonlinear Go-Go Hand function lies in the fact that the maximum arm length gain varies for individuals with different arm lengths.

To maintain consistency in the maximum arm length gain for all participants, regardless of their arm length, we chose to use a linear function relating real to virtual arm length (see Equation 2), which ensures that every participant can reach the target position based on their max arm length, addressing the challenge posed by varying arm lengths. The variable A is the real full arm length. The variable m represents the multiplier for extending the max arm length. We assign different m values (such as 0.8, 1.2, 4, etc.) for the 'Sub' and 'Super' hand functions to achieve varying levels of reach. Like the previous nonlinear function, we chose the threshold value of D as 2/3 of the user's arm length. To reach and manipulate remote objects the user simply extends the hand further than D (R_r > D), and the virtual arm grows. To return to the conventional manipulation the user just brings the hand within the distance R_r < D (see Figure 2).

$$R_v = F(R_r) == \begin{cases} R_r, & \text{if } R_r \leq D \\ R_r + k(R_r - D)^2, & \text{if } R_r > D \end{cases} \tag{1}$$

$$R_v = F(R_r) == \begin{cases} R_r, & \text{if } R_r \leq D \\ D\left(1 - \frac{R_r - D}{A - D}\right) + m \cdot A\left(\frac{R_r - D}{A - D}\right), & \text{if } R_r > D \end{cases} \tag{2}$$

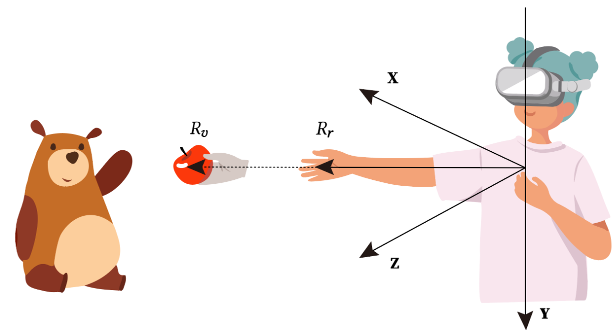

Figure 2: Go-Go hand linear formula; position of real hand is defined by vector R_r; position of virtual hand is defined by vector R_v.

4 CONCLUSION

In conclusion, our research delves deep into the impact of superfunctional virtual hands-on embodiment and perception of virtual reality. This poster's objective is to elucidate our methodology, and in doing so, present to psychologists a unique tool - the ability to vary the functionality of virtual hands. This tool, we believe, can prove indispensable for researchers eager to examine the role of functionality in the embodiment of VR hands. This insight is valuable not only for advancing VR technology but also for furthering our understanding of the intricate relationship between the human mind, body, and virtual experiences.

REFERENCES

[1] Cowie, D., Makin, T. R., and Bremner, A. J. Children's responses to the rubber-hand illusion reveal dissociable pathways in body representation. *Psychological science 24*, 5 (2013), 762–769.

[2] Frees, S., Kessler, G. D., and Kay, E. Prism interaction for enhancing control in immersive virtual environments. *ACM Transactions on Computer-Human Interaction (TOCHI) 14*, 1 (2007), 2–es.

[3] Groom, V., Bailenson, J. N., and Nass, C. The influence of racial embodiment on racial bias in immersive virtual environments. *Social Influence 4*, 3 (2009), 231–248.

[4] Kilteni, K., Normand, J.-M., Sanchez-Vives, M. V., and Slater, M. Extending body space in immersive virtual reality: a very long arm illusion. *PloS one 7*, 7 (2012), e40867.

[5] Lin, L., and Jörg, S. Need a hand? how appearance affects the virtual hand illusion. In *Proceedings of the ACM symposium on applied perception* (2016), pp. 69–76.

[6] Ortega, M. Hook: Heuristics for selecting 3d moving objects in dense target environments. In *2013 IEEE Symposium on 3D User Interfaces (3DUI)* (2013), IEEE, pp. 119–122.

[7] Poupyrev, I., Billinghurst, M., Weghorst, S., and Ichikawa, T. The go-go interaction technique: non-linear mapping for direct manipulation in vr. In *Proceedings of the 9th annual ACM symposium on User interface software and technology* (1996), pp. 79–80.