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HRI
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Designing for Body Work in HRI

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Abstract — Through this paper, we begin to discuss considerations to design for 'body work' in Human-Robot Interaction. First, we present our motivation for discussing this workspace by sharing our analysis of the use of a telepresence 'Beam' robot by a preschool teacher for inter-generational storytelling sessions in an organizational community setting. Using this case-study and related work, we discuss opportunities and challenges to teleoperation or piloting of robots as body workspace in HRI. We discuss how the different components of teleoperated human-robot interactions, such as the pilot's bodily and sensory association with the robot, the real-world settings, and the interfaces at the user's and robot's end, lead to physical and emotional bodywork for the pilot. To develop our understanding and explicate this workspace, we present our auto-ethnographic imaginaries of piloting Honda's Haru robot and discuss some design considerations, opportunities, and challenges for body workspace in HRI.

Keywords — Bodywork, Tele-operated HRI, workspace, auto-ethnography.

1. INTRODUCTION

Telepresence robots are being used in HRI most commonly in a real-world context for carrying out work remotely, providing care, and in learning and educational contexts. Beyond such in the moment / real-time application, telepresence is being also used to provide behavioural learning for future robots in real-world contexts [4]. Research on the development of teleoperated robots has acknowledged limitations of the current robotic technology in meeting challenges from the unstructured nature of the real world and, in turn, considered teleoperation of robots as a suitable approach for dexterous, complex or unsafe environments. Tele-operation has been recognized as an opportunity for intuitive teleoperation control arising from similarities in embodiment between the humans and social robots [5]. However, the teleoperation workspace, especially in terms of the teleoperator's body, has been less studied. For example, research seldom discussed the physical and emotional experiences of the teleoperator's body after it is used to pilot a complex, dexterous, or dangerous situation.

Prior work in HRI has discussed how teleoperators experience occasional feelings of the robot's bodies as extensions of their own body or share emotional and physical feelings of the robot [3]. While concepts related to embodiment, such as a sense of ownership, agency, and self-location [7], are much studied in HRI, an example where bodywork has been analyzed is - Vertesi's ethnographic account of one of the Nasa's scientists piloting Mars rover [6]. In her work, Vertesi analysed ‘body work' that went into performing robotic gestures to support scientist's visual work of designing interactions of the robot. Vertesi describes how, in this case, gestures became the' embodied imagination' and helped the pilot to make sense of the robot's possible movements or allowed for 'seeing' through the robot's eyes. She describes how well-trained scientists with long-term experience of piloting the robot identified with the robot and its body and were even emotionally connected to the robot as they felt concerned over the robot's short life and its death. She pointed to how, in fact, the robot operation was co-ordination with an entire Rover mission team spread across the world, thus associated with the bodywork of many. Vertesi's ethnographic provided notion of bodywork as piloting or teleoperating, as well as feeling the robot as part of its own body.

Similarly, Herring's [8] experience of piloting telepresence robot provides insight on bodywork as, she discusses how the pilot's presence is represented through the robot's body in the remote space, which advantages the pilot such as to gain attention at times, or at times, puts them at a disadvantage when people in the space perceive the telepresent pilot as the robot. In her work, she points to how the pilot's physical (body) space is expanded through the robot proxies, which calls for thinking further about unintended and secondary consequences that might follow. Through this paper, we hope to begin such a discussion on

considerations for designing for body workspace in HRI. First, we discuss a case study of the use of telepresence Beam robot for intergenerational storytelling to discuss some challenges and opportunities to bodywork. Further, we present auto-ethnographic imaginary of our co-author's pilot of Haru robot [1] to explicate the bodywork space.

2. CASE STUDY: TELE-OPERATION OF A ROBOT FOR INTERGENERATIONAL STORYTELLING

During one of our studies of community-oriented robot use in an Intergenerational setting, we explored the use of 'Beam' telepresence robots for storytelling activity for preschool children and elderly residents with dementia. We encouraged the preschool teacher to conduct her usual IG storytelling activity through the Beam robot. In this community context, asking the teacher to learn to teleoperated a robot would have been unrealistic and would burden the teacher with additional work. So, as an alternative, we provided a co-pilot student researcher who operated the robot while the preschool teacher conducted the storytelling activity. The student operator was directed to coordinate and pilot the robot interactions based on the teacher's instructions and activities. For example, when the teacher indicated wanting to go closer, the student operator would move the robot accordingly. Below we present observations from this teleoperated activity.

2.1. Settings and Observations

The preschool teacher or pilot was seated in front of a laptop next to the student co-pilot, where she could see in- space interactions through the robot's camera. The robot was in a social space in the intergenerational facility. The sessions begin, as usual, with the (telepresent) preschool teacher moving into a space where elders and preschool children were waiting for her to conduct the activity.

In-space, the children and residents received the robot with awe and enthusiasm, as it raised their curiosity about the real location of the teacher. The robot moved around, such as to greet residents and children welcome and goodbye, or while it needed to look around to engage children in interactive storytelling. The robot screen was visible at a certain angle and to only a few people at a time, as opposed to a real person's interactions, which would have been more engaging. However, for the most part, the activity was successfully conducted with the help of other staff members and teachers present in-space. On the pilot's end, the teacher and her co-pilot had to coordinate with each other in real-time based on their shared understanding of the context and activities. The teacher, like her usual storytelling sessions (without robot), had a book in her hand for storytelling activity. Through the storytelling session, she was present on the screen and, at times, brought the book in front of her face to show graphics from the book on the robot's screen. When on-screen, she occasionally used her upper torso and hands to act of the story and engage her audience, as she would otherwise do without the robot.

We observed that being a new user and having little familiarity with the robot meant that the teacher could not identify herself with the robot. The use of a laptop to pilot the robot further hindered her experience of associating the robot, which suggests the importance of a seamless interface for bodywork. Piloting the robot added to her work of storytelling, as she had to ensure the robot's actions represented her interactions. Besides, the bodily dis-associations between the pilot and the Beam robot seemed to reduce the engagement with the robot. For example, when the robot was moving in the space, the co-pilots were seated in front of the laptop, or while the robot was looking around by turning sideways, the co-pilots were required to align themselves to the screen of the laptop.

Previous literature has shown how consistency in the pilot and in-space robot association is an essential factor for better perceptions of telepresence robots by in-space users [2]. In our case, the pilots showed inconsistency in associations with the robot in-space (Figure2). For example, at times, the pilot used the robot's screen as their face, whereas at other times, she projected her face and hand gestures to engage in-space users in the storytelling activity.

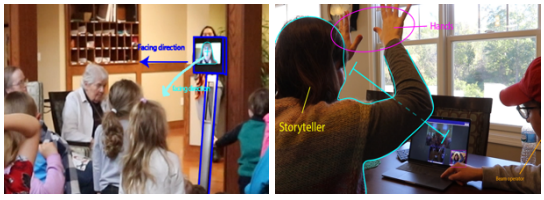

Figure 1. Dis-associations of Beam robot in-space and the pilot's end

2.2. Insights from the Case Study

This study suggested that telepresence constitutes a body- workspace for the pilot, wherein the pilot's body workspace extended from the pilot's end where she used a laptop interface, to the in-space robot's body and the surrounding where she was telepresent. While teleoperating a robot, the pilot's body went through associations and dis-associations with the robot. The pilot engaged in bodywork while representing herself through the robot in-space, accommodating and limiting her interactions to the robot's affordances, and finding strategies to overcome such limitations using her body.

3. EXPLORING BODYWORK THROUGH AUTO-ETHNOGRAPHIC IMAGINARIES

Based on our case of preschool teacher's (co)piloting the Beam robot, we wanted to explore further and explicate bodywork that goes into piloting Honda's Haru robot [1]. Haru robot was designed for multiple purposes and uses, including as an embodied telepresence device to communicate with others through active movement, sound, and LED displays on its eyes. To begin, we decided to reduce complexities in the study of bodywork by eliminating the interface at the pilot's end and instead, imagining the body to be the interface for piloting, such as in case of motion capture. Further, we begin with experiences of our co-authors, who, unlike our previous case of a preschool teacher, was familiar with Haru's affordances to a certain level and had been part of the design team for Haru's interactions for several contexts, including storytelling and in teleoperation. As such, we asked our two co-authors to imagine piloting the Haru robot for interactions.

Author 3 (A3) was not given any specific instruction on how to use the body for piloting, but was asked to show how she would make Haru interact in specific ways such as 'look down' 'rotate its eyes' 'turn its body.' Further, she was asked to film her ethnographic account of using Haru for a short nursery rhyme and discuss her experience. After receiving the auto-ethnographic account from A3, A2 was prompted to counter on any limitations and constraints on body use they would experience. Both A2 and A3 were unaware of each other's accounts through this activity.

3.1. A3's imaginary

A3 was asked to show how she might use her body to pilot specific interactions for Haru; she seemed to somewhat mimic the constraints of the robot on to her body. For example, when she was asked to show how she would make Haru 'look around' and 'look down,' instead of naturally moving her head left and right or up and down in the later case, she moved her entire torso both-ways to look around and bent forward from her back to look down, in an attempt to match Haru degrees of freedom, such as its rotation from the base and movement from the base of the eye-neck.

When asked about how she would rotate Haru's eyes, A3 took a moment and said, *"Well then I would just use my hands... coz I know that I can rotate them (like Haru's eyes)".* She imagined touching her nose to switch on Haru's eye LED lights or blink Haru's eyes by using the' open-close' gesture of her palms. To control Haru's mouth movement, she thought it was obvious she would want to use her lip/mouth movement.

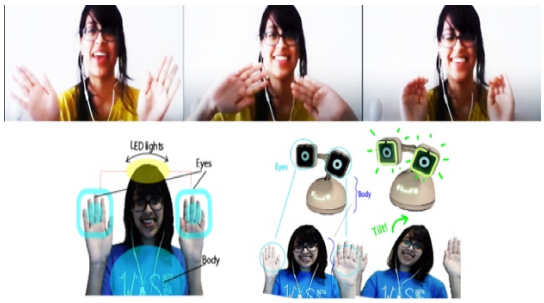

Figure 2. Top: A3's account of Piloting Haru's eye rotation and LEDs; Bottom: A3 playing out her pilot imaginary

Further, when asked to imagine and film her pilot of Haru for a short 30-second story-rhyme, she mentioned: *"I realized if I want to touch my nose (to control eye Led lights), then Haru's eye will move as well, so instead I would do a head wiggle to turn it on and off."* About her experience of playing out the story-rhyme, she said, *"I had to do this 11 times because I kept messing up. I wrote down what I should do, but I kept doing different things because I wanted to use my own eyes at ties, instead of my hands (to rotate Haru's eyes) and sometimes my head will not move along with my shoulders (while imagining to rotate Haru's body). It was hard to remember to distinguish and not accidentally turn on the LEDs".*

She added, *"If I have to do this for 30 minutes in-person, I feel really bad for whomever it would be because it is so hard. I thought it would be easy... I would much rather use a joystick because there are buttons that you can use rather than using your body to remove even the slightest error".*

3.2. Discussion of A3's imaginary

Overall, it seemed that as A3 imagined piloting the robot using her body, she associated her body with the robot's body, while keeping in mind the

affordances of different parts of the robot's body, such as matching the eye rotations with hand rotation. Often, she imposed constraints on her body to associate with the robot's limited affordances, for example, awkwardly moving the entire torso to match robotic movements. However, when asked to playout a pilot of 30- second activity using her body, she found it quite unnatural and strenuous. Keeping this in mind, A2 was prompted to imagine and film piloting Haru using her body, while consciously attempting to break-away from Haru's limitations.

3.3. A2's imaginary

A2 started her pilot imaginary by finding associations between robot's and her own and assigning correspondence. When asked how she would pilot Haru's different interactions, she said, *"I tackled this rather intuitively. First, I thought I should assign my body parts to Haru's body parts for a better association of movements. It occurred to me immediately that using my hands would be the best way to express Haru's eye movement. This way, I can rotate my hands just like Haru's eyes rotate. Then I broadly assigned my torso as Haru's neck-like part and my lower body as Haru's body part."*

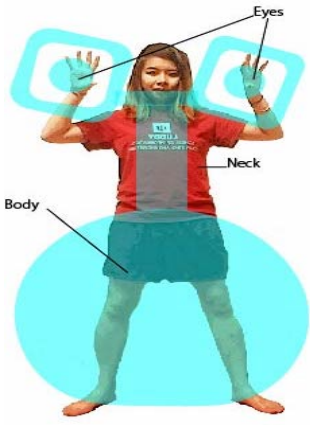

Figure 3. Correspondent body parts

Despite allowing herself such freedom for expression using her entire body, A2 said, *"I attempted to re-interpret and express (Haru's interactions) using my whole body while being aware of its correspondent body parts that I assigned to myself."* She mentioned how her knowledge and perception of Haru's interactions affected her use of her body. She added - *"I was familiar with the different kinds of emotional expressions made by Haru. Throughout this imaginary, I felt compelled to use my entire body to convey stronger emotions that way. As a result, I kept using my legs, opening, closing, and bending them, even though I knew Haru is a static desk robot",* she referred to her imaginary of piloting Haru's mouth expression.

Following the activity, A2 described her imaginary process, *"I see that there are two types of work I did for each expression of emotion. I attempted to imitate Haru's movements and focused on adjusting for our body differences. This work was more technical and specific to piloting certain parts of Haru. I used my hands, for example, to imitate the motions of Haru's eyes. On the other hand, I also interpreted and expressed the emotions of Haru, such as sad, or surprised, for example. This happened rather intuitively and was immensely exaggerated. Instead of attending to Haru's anatomy, I could work on abstract forms of expressions, using my body".*

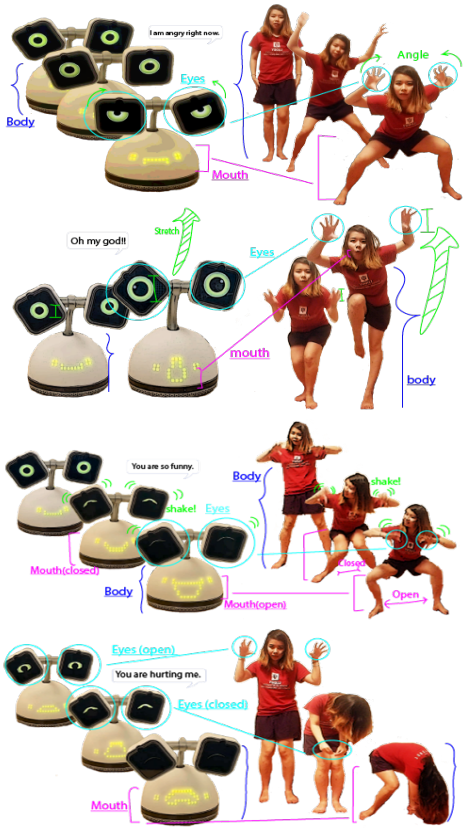

Figure 4. A2 Acting out Haru's emotions

3.4. Discussion of A2's imaginary

While A2, like A3, initially looked for associations between own and robot's body, she seemed to have benefited from not entirely limiting herself to the robot's affordances. Using full-body, A2 seemed to get an advantage from dis-association with Haru's body, as she could then freely use her body to express Haru's emotions.

However, within this freedom, she associated her own and robot body by creating a language of expression for piloting the robot, as shown in A2's account, also suggested that emotional associations were intuitive and intense.

4. OVERALL DISCUSSION

Below, we discuss how 'designing for body work' could change the way we approach the design of robots and HRI.

First, it implies that user's body as controller -- particularly in times when we might be seeing more and more remote interaction happening. An understanding of the body workspace could provide with bodily connection with the robot and provide opportunities to feel more presence in the other space and be affected by what happens there.

Secondly, it changes perspective towards HRI design, as a new version of full-body teleoperation and immersive experience, rather than as an information-based activity through a digital interface. While Vertesi's work suggested how asynchronous body work inspired connection with the robot, our work probes into real-time interactions that could lead the body to feeling more connected to the robot and being present in the other space.

Finally, for design of robotic technologies, our work brings a focus on ways to translate bodily movement to robot movement. It is particularly relevant where the aim would be to make interactions more intuitive, engaging and enjoyable for users and while dealing with robots with non-humanlike morphologies, as in case non-humanoid morphologies and bodily dis-associations with Haru robot used in this paper.

Our case study of the use of Beam robot for storytelling showed how unfamiliarity or short-term use of the robot could lead to a pilot's disassociation with the robot—keeping the style of expressions. Perhaps, different individuals, activities, and settings would benefit from different ways of body associations. For example, A2's full-body use could allow an interactive story-teller or dancer to pilot the robot while also letting them and any people in-space to experience and enjoy their piloting performance.

Based on A2's account of emotional association, we could say that the piloting emotional HRI might provide opportunities and outlets for self-expression for the pilot. However, it could also mean, at times, the pilot's body and mind engage in the work of physical and emotional expression that might or might not correspond with their state. While much research is looking to use' visual motion capture' like techniques to pilot telepresence robots, we call designers to look into critical questions related to the bodywork required for these interactions. How can we design for physical and emotional bodywork required to pilot robots for different users, such as elderly, children, or persons with disabilities? What would be some design considerations for the long-term or duration piloting of robots? How can designers use body and emotional associations and dis-associations between robots and pilots, to the advantage of HRI? How can they better integrate aspects of context into body workspace?

Our discussion brought forth how bodywork could range from being intuitive, like second nature to awkward and challenging to carry out. We begin discussions on how some associations could be evident to the pilot, whereas others would need a learning curve. Our co-author's imaginaries suggested how pilots could tend to limit themselves to the robot affordances or dis-associations between robots, and the pilot's body could be re-designed to create a language of expression.

Above all, our discussion calls for designers to recognize the work of the pilot's and interactor's body into the design of HRI. It suggests how such piloting of robot links bodies of the pilot and robot into an extended hybrid physical and perhaps non-co-located being, where the location of the bodywork becomes unclear as to the pilot, robots, algorithms, and sensors each shape space, and the workspace.

5. CONCLUSION

We presented our case study of using telepresence robots that surfaced issues of bodywork for its pilot. Further, we presented accounts and analysis of our co-author's imaginaries of piloting Honda's Haru robot, to discuss considerations for the design of bodywork in HRI. Through participation in the workshop, we hope to position our work and engage with other participants in a discussion on design explication methods.

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