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MAIN PAPER

Adaptive learning in human–android interactions: an anthropological analysis of play and ritual

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Abstract
Using anthropological theory, this paper examines human–android interactions (HAI) as an emerging aspect of android science. These interactions are described in terms of adaptive learning (which is largely subconscious). This article is based on the observations reported and supplementary data from two studies that took place in Japan with a teleoperated android robot called *Telenoid* in the socialization of school children and older adults. We argue that interacting with androids brings about a special context, an interval, and a space/time for reflection and imagination that was not there before. During the interaction something happens. There is adaptive learning and as a result, both children and older adults accepted Telenoid, and the children and older adults accepted each other. Using frames of play and ritual, we make sense and 'capture' moments of adaptive learning, and the feedback that elicits a social response from all study participants that results in self-efficacy and socialization. While "ritual" refers to the application of what has been learned and "play" means that there are no obvious consequences of what has been learned. This analysis illuminates new understanding about the uncanny valley, cultural robotics and the therapeutic potential of HAI. This has implications for the acceptance of androids in 'socialized roles' and gives us insight into the subconscious adaptive learning processes that must take place within humans to accept androids into our society. This approach aims to provides a clearer conceptual basis and vocabulary for further research of android and humanoid development.

Keywords Android science · Adaptive learning · Anthropology · Cultural robotics · Ritual and play · The uncanny valley

1 Introduction

This article analyzes human–android interactions as an emerging aspect of android science within an interdisciplinary research framework that originates in Japan (MacDorman and Ishiguro 2006; Ishiguro and Nishio 2007). The android science developed by professor and roboticist, Hiroshi Ishiguro, argues that when we engage with an android robot that possesses human-like and animate characteristics, we react and behave as if it is human. The 'android' in this sense, is distinct from a mechanical looking humanoid robot (i.e., Sony's Qrio or Honda's Asimo) even though they both share a human-like appearance.

As defined by MacDorman and Ishiguro (2006): "It is not enough for an android to have a head, two arms, a torso, and perhaps two legs. It must be human-like down to the look and feel of the skin, teeth, and hair. Its behavior should also approximate human behavior. People should be able to subconsciously respond to the android as human" (*ibid*., pg. 322). Thus, "the ability to sustain human-like relationships with people would be a milestone in the development of androids" (*ibid*., p. 299).

Yamazaki et al, (2013) conducted two studies we further explore in this article. In their research with school children and older adults with dementia, they used a teleoperated android robot called *Telenoid*. As we see later, the children and the older adults formed and sustained human-like relationships with the android. It further facilitated the relationship that developed between the children and older adults, and we explain how this might have happened later.

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Straub (2016) found, in a field-study using another android robot called Geminoid HI-1, that the human-like appearance and the social presence embodied in the robot facilitated a shift in reactions of humans interacting with the Geminoid HI-1. The reactions ranged from a realization that the robot is a reactive mechanical device to ascribing social agency to the android. Based on the Goffman theory of situational framing, the study described how the participants (users of the android) attributed a "co-referential sense of a social setting" (*ibid.*, p.555) to the android. The users moved from a co-location level, where both the users and android are present in a shared space but do not engage with each other, to a higher level of sociality of co-presence, where both are accessible to each other and engaged in reciprocal interactions.

Further, humanoids, as a result of their human-like appearance and behavior, are distinguishable in their interactions with humans, as opposed to interactions that humans have with machines and computers. This is because interacting with humanoids causes "a fundamental change in the meaning of social interaction and the nature of human communication in society" (Zaho 2006, p.401). Human–Humanoid Interactions (HHI) advance the level of interface exchange as "humanoid social robots are not user-friendly computers that operate as machines; rather, they are user friendly computers that operate as humans" (*ibid.*, p. 402).

Thus, as discussed by MacDorman and Ishiguro (2006), the more human-like the robot becomes (i.e., the more android), the greater the human-directed expectations elicited from the human participants. We assume that these expectations, that are largely subconscious, are moments of adaptive learning. In other words, when interacting with humans both humanoids and androids do something to their surroundings and to human participants. When they do something, a cognitive, mental, emotional and social process of making sense of what just happened begins and adaptive learning occurs. The process of making sense includes varying reactions of verbal and non-verbal, subconscious and unconscious—such as curiosity, wonder, laughter, disgust, and fear—in their effort to rationalize what they already know, feel or do not know (as some reactions are uncertain and unexpected). The experiential process of adaptive learning is a situated event (something that is happening here and now) that brings about a special context, an interval, and a space/time for reflection and imagination. This special context is a departure which can free participants, even momentarily, from everyday reality and offers the possibility of a different type of existence—a potential of being.

From the theory of mind perspective (or mentalizing in developmental psychology), adaptive learning processes include human ability to comprehend and make sense of the world by "adding sequences together, putting them into context and relating them to other similar events or their own experiences, feelings, mental states" (Bianco and Ognibene 2019, p. 2).[1]

In this paper, we rethink human–android interactions (HAI) by focusing on moments of adaptive learning within the anthropological framework of "play and ritual"—an interdisciplinary direction that has not yet been explored sufficiently in human–robot interactions (HRI). In this context, "ritual" in this article refers to the application of what has been learned in the process of adaptive learning (how the HAI experience has induced a change after the interaction has ended) versus "play" where there are no obvious consequences of what has been learned (thus, play here is apparently without any visible consequence after the interaction has ended).

In anthropological circles, there is debate about the exact definitions of play and ritual, where they begin and end, merge or contrast with each other (see, for example, Shapiro 2020), but, for the purposes of this article, we use both frames to understand and 'capture' moments of adaptive learning, that are largely subconscious human-directed expectations elicited within HAI. We further propose that our analysis might be applied to the study of humanoids and HHI.

1.1 What androids do?

In the following profoundly significant piece of self-refection, Prof. Ishiguro describes the interaction between him and an android (built and programed as his twin in terms of appearance and behavior) (Ishiguro and Nishio 2007):

> "When I (Hiroshi Ishiguro, the person on whom the geminoid prototype was based) first saw HI-1 sitting still, it was like looking in a mirror. However, when it began moving, it looked like somebody else, and I could not recognize it as myself. This was strange, since we copied my movements to HI-1, and others

[1] Inspired by developmental psychology and human infant mentalizing abilities, Bianco and Ognibene (2019) describe the brain processes responsible for the development of mentalizing abilities in humans: "with the aim of transferring such features to social robots" (p.6). They argue that this human ability of adaptive learning is still limited in robotic systems and their Deep Neural Networks. The authors propose an adaptive Theory of Mind system as a solution at an architectural level that supports robots in active learning and the contextualization of everyday social scenarios to achieve optimal understanding (understanding at the level that a human would understand). Their suggestion is based on the integration between teleological and simulation models: "while the teleological model might be useful to predict mental states…the simulation model may become valuable when humans start learning from experience and relating to other people" (p.7). The integration of these two models will result in adaptive learning which in this article will be described in terms of the anthropological frames of play and ritual.

> who know me well say the robot accurately represents my characteristics. This means that we do not objectively recognize our unconscious movements ourselves. While operating HI-1 with the operation interface, I found myself unconsciously adapting my movements to the geminoid's movements. The current geminoid cannot move as freely as I can. I felt that, not only the geminoid but also my own body was restricted to the movements that HI-1 can make. In less than 5 min both the visitors and I could quickly adapt to conversation through the geminoid. The visitors recognized and accepted the geminoid as me while we were talking to each other. When a visitor touched HI-1, especially around its face, I got a strong feeling of being touched myself. This is strange, as the system currently provides no tactile feedback. Just by watching the monitors and interacting with visitors, I got this feeling". (*ibid.*, p.140)

Prof. Ishiguro looked at himself watching back, as if looking in a mirror at his double and twin android, his potential self, and the potential of being multiplied and expanded. The Geminoid HI-1 android and Prof. Ishiguro mirror one another, and by that unfold a space/time that was not there before. The interaction has recursively altered and generated another actuality through the virtuality/actuality (imagined/realness) of the android. In his interaction with the android, his movements, feelings, sense of awareness and his experiences, as well as those of his visitors, resonate with the android as with a mirror image, and created a shared emotional experience. These recursive experiences with an anthropomorphized android create a unique interface quality—that of amplifying the mirroring effect between human and android, android and human, and both with their inner and external worlds (their subconscious and their surroundings). This mirroring effect forms a socially interactive processual relationship of somatic mimesis in which one subconsciously follows the other in guided actions. This may transform and unfold an emotional process in an attempt to embody the mirrored other. This mirroring effect is a moment of adaptive learning that comprises largely subconscious human-directed expectations, and only through Prof. Ishiguro does self-reflection become visible and evident.[2] As Prof. Ishiguro explains, "we do not objectively recognize our unconscious movements ourselves".

Resonance is a crucial communication medium in social interactions that allows participants to communicate beyond words, to synchronize and engage with other's compelling concerns and address meanings in spite of cultural chasms and gaps: "resonance evokes shared human experience, what people across place and time can have in common. Where culture separates, resonance bridges" (Wikan 1992, p. 476).[3] Resonance generates effects that enable communication with androids.[4]

The mirroring effect, which is largely subconscious, can be described as a dynamic of a "Möbius Strip" (Handelman 1998, p. xxiii) where the inside of the strip continuously turns into its own outside in a process of self-transforming interactions, e.g., from the inside of Prof. Ishiguro's being to his potential avatar and back, and with his visitors and their surroundings up to the moment of his feeling of being touched at the HI-1 interface (while it is actually the robot that is touched).[5] The Möbius metaphor illustrates that the interaction with the android is self-transformative. It does something. Adaptive learning has taken place.

In this paper, we argue that accessing the dynamic interactions with android robots through the embodied process of transformation (e.g., Prof. Ishiguro and the visitors' shared emotional experience), offers points of access to different models of selfness, human-ness (humanity) and robot-ness (e.g., Prof. Ishiguro describes the new movements he cannot recognize in himself and how he re-adjusts his movements in accordance with Geminoid HI-1, or the new conversation model that emerges when the visitors recognize and accept Geminoid HI-1 as him, or a new understanding of remotely being touched).

This endeavor brings to the fore empirical questions that examine the dynamic interactions and effects between human and android as the main locus of investigation. As a result, our understanding of the social agency of androids may be expanded and new directions for HAI analysis may be pursued. We use the play and ritual frames to provide

[2] In psychoanalysis, the mirroring effects in social interactions contribute to self-development, growth and having a sense of being in the world. Both psychoanalysts Winnicott (1971) and Kohut (1977) describe how infants develop a sense of having or being a self from the primary caregiver's empathic mirroring responses and how finding themselves in parental reflections provides a sense of the self.

[3] As discussed by Wikan (1992, p. 476): "Resonance evokes shared human experience, what people across place and time can have in common. Where culture separates, resonance bridges—from a lived realization that this is the only practicable way. It [resonance] does not deny difference: Hinduism, Buddhism, and Islam are…completely different [from one another]. But it renders difference relatively insignificant in the face of that which counts more for certain purposes: shared human potential."

[4] Lomas et al. (2022) argued that designers can make use of the untapped potential of resonance to shape successful and desirable interactions in AI and HRI. The sentient and reactionary aspects of resonance are notable. The interactions with androids produce feelings that are nonverbally reciprocal through resonance.

[5] The discussion of Kim and Kim (2013) of humanoid as the "cultural other," as a mirror for the self, serves as evidence to our argument.

contextual insights into two field studies with an android robot.

We argue that interacting with androids triggers adaptive learning that brings about a special context, an interval, and a space/time for reflection and imagination that was not there before. Rethinking through frames of play and ritual, focuses our study on dynamic interactions and transformations as a locus of the social rather than focusing on the robot's or the human user's social appearance and behavior. While there is no doubt that coding of pre-existing knowledge and categories to the appearance and behavior of the robot as part of design processes is important, the interactions that follow are much more important, and comprise the dynamic processes of mirroring, imagination, make-believe, testing and tinkering, which are the communicative qualities of play and ritual.

1.2 The meanings of play, ritual and the fold

Play and ritual are types of "public events" (Handelman 1998). These events act upon the world in ways that may be consequential because they present, re-present or transform social and moral orders and bring about adaptive learning. Interactions in the frame of a play are meaningful because of the power of shared make-believe.[6]

Make-believe makes the play a situated event, a space/time interval that is distinctive and suspends everyday activities and beliefs about the android and/or about the human (i.e., we know that we are interacting with an android and not with a human, but we may believe that humans and androids resemble one another sufficiently to substitute for each other).

If the interactions are playful, to some extent these interactions do not have consequences for our everyday life, but we may still ask questions that relate (consciously and unconsciously) to everyday life expectations elicited within HAI: what does the interaction mean? Is it real or imagined? true or false? uncanny or ordinary? fun or serious? Is it human or non-human? What do the interactions with androids convey about the human self, the person they represent, about humanity? Where should we draw the line of what is human? When do non-playful interactions with humans become obscured (or dehumanized?), especially if the human is imagined and constructed to be "the other"?

The human-to-human interaction of older adults or older adults with dementia is an illustrative example that may be referred to as an "extra-cultural category at the brink of humanity" (Hazan 2011, p.5). Hazan (2011) argues that there is a failure of meaningful dialog between researchers and subjects who are considered as "others" or who belong to "extra-cultural phenomena" that we cannot understand, explain, or make sense of.

Because of the ambiguity of the interaction, playing with the other or playing the other in human–human interactions generates a "potential space" for change. BenEzer (2012, p. 336) takes Winnicott's psychoanalytic claim that communication is possible only in play and suggests that this is facilitated by the willingness to "play the other," and to test ideas, beliefs and attitudes of the other culture in real or imagined situations of playing (BenEzer 2012):

> "Within this context (Winnicott would say "within potential space") one plays with the idea of being the other while knowing that one is not" (Ogden, 1985, p. 138) … In this process, the "other" helps create, crystallize, and sharpen the identity of both participants in the encounter. As a result, both may experience personal growth. Playing the other enriches and expands the boundaries of the person/self while, at the same time, strengthening them by sharpening the differences between them". (*ibid.*, p.336)

This potential space, as described by Winnicott (1971), is an intermediate space of experiencing that is not fantasy and not yet reality, where imagination, symbolization, and creativity are possible because it allows the here and now individual to try out new solutions and experiences.

This psychoanalytic insight reinforces the importance of play as a complex border-zone that simultaneously generates paradoxical meanings about the self and the other and possible alternative meanings (it has the potential to expose inner contradictions). In HRI, this may be translated into the uncanny feeling that arises when interacting with androids (Mori 1970). The uncanny valley feeling emerges from the difficulty in evaluating whether something (an android) is inanimate or animate, human or non-human. This feeling is integral to the dynamic of the interaction and marks the cognitive and emotional unfolding and organization of this special event and context.

This underlines the conditions of uncertainty and duality associated with play when something is both one thing and another at the same time and opens up human possibilities that might be embedded in androids due to the uncanny valley. Play is a dynamic medium that facilities the imagination of the actual and the alternative through the breaching of boundaries, and social and ontological orders.

[6] As set out in Bateson's (1972) concepts of framing and meta-communication, play and ritual are significant communication media. These concepts become central to the study of ritual as a form of non-verbal communication in human interaction, and to study how play is set apart from the everyday. When participants are in play, they frame and convey the meta-message that "This is Play" (Bateson 1972). The notion of meta-communications (meta-messages) draws the boundaries and defines the recursive dynamics of the interaction. For more timely discussion about Bateson's ecology of the mind theory on the development of AI and robotics, see Galanos (2017).

Rituals, like play, suspend routines with their unique symbols and performative interactions while conveying a serious message that tries to resolve the paradox and to reintegrate participants into a social order (i.e., what was learned during the ritual become everyday norms). In theory, interactions as rituals operate as a feedback loop that re-adjusts sociopolitical order and set new sociocultural and ecological processes in new directions (Kapferer 2005).[7]

As described by Kapferer (2005), the ritual may act to slow down the emergent and uncontrollable uncertainties of living, to enable participants of the ritual to realize themselves and to reset their existence in the new space–time of the everyday. According to Handelman (1998), there are two types of rituals that represent two different types of learning and implementation: rituals that mirror and rituals that model. The first type are rituals that act to mirror and reaffirm moral and social orders powerfully and subconsciously as seen during national events and ceremonies—the Remembrance and Independence Day effect (*ibid.*, p. 162). In the second type, rituals serve to model transitional moments in personal and collective experiences, such as rites of passage like weddings or initiation rituals (*ibid.*, p. 32). While it seems that play and ritual are distinctive frames, there is no clear-cut distinction, and they may merge into a single event (Shapiro 2020).

The interaction in which the play and ritual are framed, in Deleuze's terms (1994), is a virtuality that may generate actuality, horizons of being and becoming in the folding and unfolding of the Möbius strip. In describing the "fold", Deleuze (1994) draws our attention to the hidden and invisible processes that are reduced in detail and size through folding, so that what is folded still comprises everything else that is not visible and perceivable using human senses. Through the process of unfolding (or altering angles of perception) some hidden connections become visible.

An illustration of folding is closing an open book or box (reducing the book in size and detail). Unfolding involves opening of the book and zooming in on the book and its chapters.[8] A further example of the fold is Telenoid, the android described in the studies below. The design of Telenoid is such that the user sees, in the closed book (the fold), a design with a minimum of diversity that facilitates identifying with Telenoid (Nørskov and Yamazaki 2018) but in the open book (unfolded), the Telenoid is of infinite possibility because of its dual qualities.

The folded book or box still has infinite content (that can unfold), but this is not always perceptible to the human senses (because it exists outside causal connections or rational thought). Within the fold, every possibility already lies inside the fold, but these possibilities are not revealed in their entirety at any moment. Thus, in the process of unfolding, unpredictable effects and new connections may occur, and connections become rearranged so that only some parts are visible at any moment and new cultural models might emerge as alternatives that do something.

In Table 1 we summarize the frames and concepts referred to in the following analysis. It is hoped that this approach will provide a clearer conceptual basis and vocabulary for further research of ecological, ethical, social, philosophical, cultural, and engineering questions raised by android and humanoid development.

2 Methods used in two studies of HAI

2.1 Android robot

We revisited and unfolded two field studies where HAIs were investigated via the teleoperated android robot called "Telenoid" in an elementary school and an old-age care facility in Japan.[9] These studies are significant in their setup (in a non-laboratory setting while the participants operate the android) which enables us to observe moments of adaptive learning.

Telenoid, a teleoperated android robot developed by Hiroshi Ishiguro Laboratories (ATR) is designed to provide its operator, who controls the robot remotely via a computer in a Wizard of Oz setup, with an embodiment and tangible entity.[10] In this setup, the operator's voice (tone, pitch, volume and emphasis) is transmitted while the robot's lips move in time and the operator's neck movements are mimicked. To some extent, it is also possible for the operator to move the robot's arms. As discussed by Nørskov and Yamazaki (2018), in an effort to maximize the telepresence and to accommodate the operator's individual traits, the design of the robot deliberately embodies a minimal humanoid shape. This design deliberately excludes any individual human feature that might "distract the imagination of the interlocutor"

[7] An example is the practice of folding paper swans by caregivers from the Philippines (Mazuz 2013) that creates a microsystem of adjustment which sustains the human–human dynamic. In this microsystem there are processes and domains necessary to changes in rhythm and synchrony to interact and work together. This emphasizes the sentience and resonance evident in human interaction.

[8] This logic of folding and unfolding is also relevant to visual encoding and how to represent complex data and variables in information visualizations while making reductions transparent. See Brüggemann et al. (2020).

[9] See also Yamazaki et al. (2012, 2019) for more experiments with Telenoid and older adult participants with dementia.

[10] The Wizard of Oz method enables remote operation of a robot by a human rather than robot systems. In this case, Telenoid was operated by the children and mimicked the operator's voice and movements.

Table 1 A table summary of the frames and concepts

Who is in the study?	Telenoid and operator Child and older adult participants
What is happening in the study?	Real and imagined interactions Adaptive learning
What was observed?	Make-believe Verbal and non-verbal communication Responses (reciprocity) Individual and group behavior, changes in behavior and dynamic, the assumption of Role-play Resonance Self-efficacy
Concepts used to explain what is observed All the concepts are features of play and ritual frames	A special context, an interval, and a space/time for reflection and imagination, a complex border-zone Embodiment Mirroring Intersubjective experiences Duality (paradox and duality which explains the uncanny valley- when something is one thing and another at once) Folding and unfolding Transformation Feedback loop

(Nørskov and Yamazaki 2018, p. 239) and also facilitates the identification of the user with the robot (i.e., in theory, anyone should be able to identify with the robot).

In both studies (Yamazaki et al. 2013), Telenoid was used as a teleoperation so that the teleoperator was in control of the robot's head motions, voice, and head-turn behavior. The children both operated the robot as their embodied figure and responded to it in performing tasks set for them. These tasks were instructions given by a teacher and researchers to the child teleoperator. Interactions with the robot took place over 2 days.

2.2 Methods in case study 1

The first two-day field study began in a classroom in an elementary school of twenty-eight children ($n = 28$, aged 9–10 years in age). As the researchers set up for the study, the class was introduced to Telenoid, and children worked with each other to become familiar with the android. As the study began, the children were divided into six groups (4–5 participants in each group) all of whom sat in their groups awaiting their turn with Telenoid.

One child from each group was assigned the teleoperator of the Telenoid and was taken to an adjacent room, while the robot remained in the classroom with the other children. The teleoperator was instructed by the researchers and teacher to operate it to complete a number of tasks with his/her classmates. Each group had 10 min interaction with it, and groups rotated. Cameras in both rooms recorded each 10-min interaction. For the purposes of our analysis in this article, we focus on the interactions that took place within each group.

2.2.1 Observations in case study 1

We describe the observations of the original researchers using the example of a single group. In this group, a child started operating the robot. To accomplish the tasks he was assigned, the child was observed to take on the 'form' of the robot (as if he was Telenoid). What the children in class saw was an android with the voice, facial expression and body movements of their classmate, the operator—the Telenoid. As the interactions unfolded, however, the teleoperator realizing the difficulty of his mission, exaggerated his movements to overcome the restricted movements of the android, raised his voice to become better understood, and emphasized words and actions—he embodied Telenoid. Thus, the mirroring effect included largely subconscious verbal and non-verbal gestures—the teleoperator was learning and adapting. As its left–right motion was the opposite of the operators, the operator made continual corrections and adjustments as he learned to "embody" Telenoid.

The children in the group responded to the robot as "a special entity" at once human and non-human. They nicknamed it "Telebow" as it became a member of the group. Their interactions with the robot evolved as they learned by practice, trial and error, and through their reciprocal interactions. Interacting with Telebow led to actions of a different nature from the ordinary (subconscious actions) among classmates, between Telenoid and the group (and the teleoperator) that united them in completing their tasks.

2.3 Methods in case study 2

In this second case study the researchers used Telenoid remotely to study interactions between the robot (once again operated by children) and older adults with dementia who live in a care facility. Sixteen children (aged 9–10 years) and 10 residents with mild to moderate dementia (with a mean age of 92 years) took part in the study.

2.3.1 Observations in case study 2

At the beginning of the study the children were observed to be nervous and reticent to communicate with the unfamiliar older adults. In this context, Telenoid as an embodied medium, helped the children initiate chatter and continue communication with the older adults. Telenoid provided a buffer between the children and older adults not simply to hide behind initially, but to "get closer" to the older adults while the older adults held Telenoid—touching, hugging, and caressing it—the android serving as an avatar for the children.

The children then began to interact spontaneously—without instruction—through Telenoid. While waiting their turns, the children learned from each other as operators, exchanging opinions about their strategies to communicate (what works, what to try). Examples of the children's comments are below (Yamazaki et al. 2013):

> "I did not feel embarrassed as much as face-to-face." "It was easier to talk through Telenoid because I could see her, but she couldn't see me." "Telenoid is convenient because it lets me ask what I couldn't face-to-face." "While I was talking through Telenoid, it became fun to talk, and I want to talk with a senior citizen again." "It was fun to talk through Telenoid, and I was glad that I could see so many smiles on the elderly." and "The grandma was always laughing, so it was fun." Most of the children felt more relaxed talking through Telenoid than during direct face-to-face communication and had positive impressions about the older adults with dementia". (*ibid.*, p.14)

The older adult participants were much more talkative than usual. Telenoid was perceived to be a growing human child. Some older adults spoke to it, saying (Yamazaki et al. 2013):

> "Hello, boy. You seem about to smile. You are so cute!", or asked "Can I hold you?, and remarked, "Oh, you are so heavy! When you were a little child, you were probably lighter". Other participants said, "You are getting quite heavy, aren't you? But that's OK. That's natural because you are growing up." Some participants perceived Telenoid to be a girl, saying, "You do not have to worry about it. It'll be about a year before you look like a girl…. When your hair grows longer, you'll look more feminine". (*ibid.*, p.15)

In interviews with facility personnel, one staff member said (Yamazaki et al. 2013), "The resident seniors engaged in more informal conversations than face-to-face with visitors. Even if the visitors were children, the elderly would become really tired. We should create situations where they can talk to something like a doll when it's hard to contact people." (*ibid.*) As described also by Yamazaki et al. (2013):

> "Most senior participants had positive impressions of Telenoid when they first met it, even though, ironically, their caretakers had a negative one. Since the staff members first thought that Telenoid was creepy, they thought it might be difficult for the older adults to accept it. They were surprised, however, that the residents thought it was cute. Sometimes the older adults thought Telenoid was a doll and sometimes they thought it was a baby. Their caretakers were impressed that they were enthusiastic about holding/hugging Telenoid and were willing to talk with it." (*ibid.*)

3 Discussion

With a reflection on the significance of these studies, this paper aims to offer the conceptual frameworks of play and ritual for the analysis of human–android interactions. These frameworks facilitate an understanding of the experiences and adaptive learning that happen among humans and androids (which are largely subconscious). The process of adaptive learning here is described in the terms of mirroring effects, responsiveness, resonance and self-efficacy, and they are explained using the concepts of duality, folding and unfolding. Each of these concepts, however, is complex and the interactions described in this paper are confined to the Telenoid and participants (including the child operator of the android) in the classroom. Interactions between the classroom participants and observers are not described, and the wider context of these anthropological concepts is beyond the scope of this paper.

3.1 The main observations of HAI in the two studies

Human–android interactions (HAI) become real social experiences that actually do something and evoke transformations among the participants and their surroundings through adaptive learning. By analyzing the interactions described using frames of play and ritual, we are able to capture moments of adaptive learning that happen dynamically in real time.

Four moments of adaptive learning were transformational and these, and their implications are discussed below:

1. Telenoid was accepted by cognitive impaired older adult participants who touched and showed signs of affection toward the android
2. Within each group children accepted the android as a "special entity"
3. The distance between the older adults and the children was overcome through their interaction through the android
4. Adaptive learning resulted in self-efficacy and socialization

As we look at these four observations together, key to the analysis of the interactions is that all participants encountered a new social situation, and their interactions took place in a space/time that is a departure from their daily reality. This is an instant of realism in make-believe where make-believe is unfolded in practice—the development of dynamic interactions and the reciprocity of sentiments between people. The robot here is an intermediary, a proxy or a facilitator of the interaction between humans. Although Telenoid is a "special entity" ("the other") to the children, this does not preclude embodiment by the child operator. Indeed, the process of embodiment is progressive as adaptive learning takes place and each child operator exaggerates his/her movements to make the android more effective in communicating instructions to classmates. This acceptance of "the other" takes place in a space/time that permits make-believe and imagination. The importance of this space/time is that interactions that are unlikely or difficult in reality do happen in this space/time. If the interactions are possible in the space/time interval, one may argue that they may be possible in reality.

This has implications for the acceptance of androids in "socialized roles" in society (as potential carers of older adults, as play mates for children) and gives us insight into the subconscious adaptive learning processes that must take place within humans to accept androids into our society—trusting them with the most vulnerable members of our society.

3.2 Analyzing HAI in terms of play

In the classroom "play" happened. There was mimicry, make-believe, mirroring and the embodiment of Telenoid. Duality explains how the children embodied the robot and how the older adults related to it as neither a boy nor a girl, neither young nor old, neither animate nor inanimate, both an object and a subject (Telebow, a baby, a doll). These concepts were integral to playfulness, imagination and interplay that allowed responsiveness, resonance and self-efficacy to happen. Playfulness and make-believe were powerful communication media within which the participants were able to suspend their conventional communicative intentions to make something happen and allow duality to exist. Part of the make-believe happens when one of the participants 'dresses in a disguise' using Telenoid. This allows the child to behave differently in class—a departure from what is expected of them within the context of the classroom.

The participants' lived experiences were part of a complex and challenging social situation: they (even the operator) allowed themselves to become immersed in a situation that is unconventional, uncanny and uncertain. In spite of this uncertainty, they continued to communicate, interact and engage—they learned and adapted. This adapted learning was key to continuing the interaction, responsiveness and developing self-efficacy.[11] This adaptive learning process also called by Ingold (1997) as a 'guided rediscovery' which involves a purposeful alignment of the learner's attention "to the movements of others, and a harmonization of that attention with the novices [learner's] own movements so as to achieve the kind of rhythmic adjustment or resonance that is the hallmark of fluent performance" (*ibid.*, p. 111).

We argue that, in terms of play, interactions of humans with androids bring about a special context, an interval, space/time for imagination that was not there before and does not exist thereafter. Throughout the interactions the participants became personally engaged, emotionally charged and physically active. What seems to matter is the participants' efficacy, their presumption that their activities are meaningful and make sense to others because they evoke responsiveness and resonance.

In terms of resonance, during the interactions among classmates, Telenoid emotionally *vibes* as much with the other classmates as it does with the operator. The synchronicity also builds unity toward a shared outcome—that of successful communication. The vibe, according to Lomas et al. (2022), is "a pervasive cultural construct used to describe how people perceive the shared affective experience and esthetic expectations of a group, a place, a product, a brand, a robot, etc.…the vibe emerges from interpersonal resonance effects". (*ibid.*, p. 4).

3.3 Analyzing HAI in terms of ritual

Firm conclusions about how adaptive learning is applied in this research are not possible as the participants have not been followed up or observed further. Nevertheless, ritual as an anthropological concept is relevant in the explanation of

[11] Self-efficacy in this context refers to the confidence that grows in people in their interactions with each other as a result of the reciprocation of actions and feelings in the group.

the feedback loop. In terms of ritual, there is a change that exists after the interaction. This change, a result of adaptive learning, feeds back to the participant and influences their subsequent interaction. The process, whether it is happening subconsciously or unconsciously, is key to adaptive learning and is continually present as all interactions are dynamic.

As the interactions unfold, hidden connections, categories and meanings of the social order that are beyond the self and the present situation become visible, including cooperation, care, companionship, childhood and adulthood. The categories extend into the wider—real and imagined—social order while presenting alternative models. Here we may unfold these categories in the current changing political, economic, and social circumstances of, e.g., Japan as a super-aged society, where the nation's population is shrinking and aging rapidly. Thus, in this context what is the role of children, older adults and robots—who will care for them? Does HAI in Japan transform sociocultural and ecological processes in relation to the new age-grade changes in a super-aged society?

Over the last two years and as a result of the caregiver shortage, the Japanese government has allowed the entry of foreign care-workers to look after older adults as well as encouraging the development of robots as caregivers.[12] In Japan, which is a relatively racially homogeneous society, foreign caregivers are considered as the "racial other" (Iwata and Nemoto 2017). Does HAI in Japan constitute a new space to test the idea and role of "the other" or to experiment with new forms of interaction with "the others"—whether the racial other, the robot other, the older adult other, or the older adult with dementia other?

In these interactions, emphasis is placed on the sharing of common experiences or a common experience that entails the negation of individuality and denial of uniqueness of each participant (because any child was potentially able to operate and become Telenoid). The children unite as group members. The older adults become caregivers of Telenoid. Using the android, the children and the older adults had repeated experiences of being the "other" where the children cared for the adults, Telenoid and each other, the adults cared for the Telenoid, children and each other, and everybody cared for everyone else. Thus, here a new model of being Japanese in terms of reciprocity and mutual assistance may emerge.

The interactions described are all intertwined and have societal implications in a super-aged society which is evolving a new social and moral order, family dynamic, and increasingly integrating robots into the everyday.

[12] Retrieved from: https://www.migrationpolicy.org/article/japan-labor-migration-reforms-breaking-past (February 23rd, 2022).

3.4 Implications of HAI

The transformations we discussed have three interconnected implications to be considered in furthering the study of HAI:

1- **The uncanny valley** is where the robot takes us as we enter an unfamiliar and potentially threatening space. That threat exists in our thoughts and imagination which are largely subconscious, not just in the reality of how we look at robots, their features and movements, and in how we see them living and working with us, indeed, doing our work. The more the robot resembles the human, the greater the threat—the deeper the uncanny valley. In anthropological terms, studying the uncanny valley takes us to new intervals of space/time that allow us to explore this valley and confront our fears, duality, and paradoxes. Play and ritual provide the frames in which to analyze these difficult concepts.

2- **Redefining "culture" in HAI**: The prevailing approach to the study of culture in robotics is largely limited to the view that culture is a pre-known set of rules of what is appropriate and acceptable behavior (Ornelas et al. 2022).[13] This is what is coded into a robot, not the adapted learning that emerges from human–robot dynamic interactions—cultural learning and change. This prevailing definition limits our understanding of culture to the background that exists outside and in advance of our interactions with robots. These cultures are localized and have predefined norms. Examples of such rule-based cultural encoding may be seen in the writings of Trovato et al. (2011), where historical and geographical contexts such as Euro-American, Judeo-Christian, Japanese Shinto and Buddhist cultures are used as the logic that shapes the way in which robots are accepted and used. While there is no doubt that in designing the robot, coding of pre-existing knowledge and Japanese culture influences the appearance and behavior of the robot, the interactions with humans that follow are far beyond existing cultural norms. Thus, while prevailing cultural expectations explain cross-cultural differences in HAI in the context of either the conditions in which the interactions occur, or the users' or the engineers' cultural background, we suggest that something new has happened, there has been a transformation, a new culture has been generated. This new culture continuously folds and unfolds. It will be interesting

[13] Ornelas et al. (2022), call for new directions in cultural robotics and argue that culture is an emergent phenomenon that develops from interactions between agents in their own social setting and the environment. Thus, robots must become participants in the process that leads to the emergence of culture and robots should have capacities to successfully engage in such interactions.

to explore further how HAI influences different models of human-ness and robot-ness or human/robot-ness (or even Japanese-ness or child-ness, or elderly-ness). Unfolding HAI generates unexpected combinations of different and opposite social and cultural orders, ethics, models, categories, and boundaries.

3- **The study of the therapeutic potential of HAI**: When an android interacts with humans, it unfolds a special context of play and ritual, and it is this context that has therapeutic potential. Play as a creative experience (Winnicott 1971, p. 54) creates a safe space (as discussed above, an intermediate space of experiencing that is not fantasy and is not yet reality) that allows self-discovery and adjustment. These are necessary to form a new relationship with the world. This relationship is not simply necessary for survival, but it is essential to the changes that are continuously required of us to deal successfully with challenging situations and a changing world, and to work with others and the other toward cohesion and socialization. Further research is needed to explore how different types of androids and humanoids will interact and what space/times they will produce. Paraphrasing the anthropologist Claude Levi-Strauss (1966), animals and objects are "good to think with," androids are good to imagine with.[14]

3.5 Questions and future directions

The concepts of ritual and play are as applicable to the study of group interactions as they are to the study of an individual's interaction with a robot, a human or the 'other'. Expanding anthropological study using the frames described in this research could yield important information about what it takes for androids to become 'accepted' and 'trusted', to become part of the everyday. AI and robotics researchers may consider a detailed study of ritualized and playful practices of the unfolding changes that constitute everyday experiential and adaptive learning and the broader dynamics in society.

Processes of learning in HAI are complex and involve uncertain and unexpected human instinctive reactions as well as rationalization. These deserve scholarly attention. Existing models of how cognition and learning take place are enriched by an understanding of the processes of mirroring, responsiveness, resonance and self-efficacy in HAI so that dynamic interactions between androids and humans may be studied in terms of the dimensions of their depth and evolution.

Further research into the long-term implications of adaptive learning is important: what happens after the android becomes normalized and routinized through learning? How might it influence future android interactions and influence possibilities for socialization?

Learning involves the deeper incorporation of insights, feelings, and realization. These consciously and unconsciously direct perception and action. Studying the long-term effects engineers expect individuals and society to embody through their interactions with robots will give us valuable insights into HAI but also into human social interactions.

Android development and human interactions raise many complex and ethical issues that require detailed study. This article describes anthropological tools used in the study of HAI in small groups. These tools will be of value as AI and android technology advances and becomes incorporated into everyday life and large communities.

4 Conclusion

Androids are good to imagine with. They create situations and set up dynamics with continuously changing interactions. Through the frames of play and ritual, we are able to analyze these dynamic interactions and the adaptive learning that takes place. Through duality, we explain how something can be both one and the other at the same time (which is the basis of the uncanny valley—the unfit of familiarity and human likeness). Through a study of responsiveness, resonance and self-efficacy, we are able to observe the effects of make-believe and imagination that are necessary to create interaction and maintain a social situation, and even achieve outcomes, such as the accomplishment of a task, team cohesion and collaboration. As we tackle the global challenges of aging communities, migration and HRI in an increasingly digital world, studying human–android interactions creates a space for us to study how the other becomes integrated into existing cultures and how cultures continuously fold and unfold.

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[14] In this phrase, Lévi-Strauss (1966) argued that animal are not only good to eat but also good to think with [bonnes à penser], as for examples animal totems of different clans are a concrete and abbreviated way of stating the relationship between clans as analogous to the relationship between the two animal species. This example provides a sense of how materiality and objects (totems) matters not because of casual or functionalist explanation but because it reconstructs a system of classification and relationships. Thus, people shape and recode the material object world as part of their repertoire of dynamic interactions and make them meaningful and valuable as vehicles of meaning making that protect moral categories.

Data availability Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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