STS Encounters

Accessibility statement

This is an accessibility statement for the journal: Encounters.

Conformance status

The Web Content Accessibility Guidelines (WCAG) defines requirements for designers and developers to improve accessibility for people with disabilities. It defines three levels of conformance: Level A, Level AA, and Level AAA. This statement is relevant for volume 10, number 5, 2018 through volume 12, number 1, 2021. Encounters is partially conformant with WCAG 2.1 level AA. Partially conformant means that some parts of the content do not fully conform to the accessibility standard. Despite our best efforts to ensure accessibility, footnotes and graphs may not be accessible for screen readers at this point in time.

Feedback

We welcome your feedback on the accessibility of the journal. Please let us know if you encounter accessibility barriers. You can reach us at:

E-mail: imvko@cc.au.dk
Address: STS Center, Helsingforsgade 14, 8200 Aarhus N

STS Encounters
Research papers from DASTS
SPECIAL ISSUE
Volume 12• Number 1 • 2021

Experiments in Artificial Sociality
Curious robots, relational configurations, and dances of agency

Frederik Vejlin
PhD fellow, Department of Anthropology, Aarhus University

DASTS is the primary academic association for STS in Denmark. Its purpose is to develop the quality and breadth of STS research within Denmark, while generating and developing national and international collaboration.

Abstract

In this article, I explore how experiments with social robots enact and reconfigure more-than-human forms of sociality. I combine recent anthropological discussions of nonhuman sociality with Andy Pickering's work on *dances of agency* (1993, 1995) and John Law's *method assemblages* (2004) to show how human-robot interaction experiments enact open-ended and decentred configurations of entangling relations between humans and robots. I propose the concept of *artificial sociality* to capture both the ongoing enactments and multiple results of such experimental reconfigurations. Using these conceptual tools, I unpack the "curious robot experiment" from my ethnographic fieldwork in a Japanese robotics laboratory and compare the kinds of sociality produced in the two experimental conditions. I argue that the curious robot exemplifies what Pickering calls *technologies of engagement* (2018) by manifesting a form of artificial sociality that augments the unpredictability of dances of agency enacted in (re) configurations of entangling relations.

Introduction

In *Robot Futures*, roboticist Illah Nourbakhsh describes how modern robotics has "invented a new species, part material and part digital, that will eventually have superhuman qualities in both worlds at once, and the question that remains is, how will we share our world with these new creatures, and how will this new ecology change who we are and how we act" (2013, p. xv). For the field of *social* robotics, such questions seem particularly relevant (see Seibt, 2016). Social robots are machines designed to have a form of social intelligence that will enable them to interact with, relate to and understand us humans in humanlike ways (Dautenhahn, 1998). Accordingly, humans ideally treat a social robot "as if it were a person, and ultimately a friend" (Breazeal, 2002, p. xi). In this sense, social robots do not seem particularly *super*human. But this does not render Nourbakhsh's questions less pressing since it still appears critical to ask how we will share our worlds with social robots and how they might change who we are and how we act.

A growing number of scholars in the humanities and social sciences are already grappling with these questions (e.g., Alač, 2016; Robertson, 2017; Šabanović, 2014), often with an unmistakably critical edge (e.g., Jones, 2017; Richardson, 2018). For example, psychologist Sherry Turkle describes our present as the "robotic moment" and argues that we are gradually replacing the intimacy of authentic human relations with the shallow and unfulfilling illusions of connection offered by social robots and similar technologies (Turkle, 2011, pp. 129-133). If we do not recognise how these deceptive technologies endanger the future of human sociality, we risk eroding the essence of humanity (Turkle, 2011, pp. 17-20). In the following, I endeavour to provide a slightly less bleak alternative to Turkle's depressing predictions. Since 2017, I have been doing ethnographic research in robot laboratories in Japan, where I study how roboticists think about, develop and experiment with various kinds of social robots. I also investigate how they use robots to explore what it means to be human (Ishiguro & Nishio, 2007; Ishiguro, 2020).

In this article, I combine ethnographic material with discussions of nonhuman sociality and experimentation in anthropology and STS to explore the design of robots that technologically simulate aspects of human sociality. Further, I ask how such robots, via interaction experiments, are involved in *reconfiguring* the 'thing', human sociality, they were initially intended to reproduce. This raises issues that transcend social robots by inviting us to rethink what it means to be human and what, if anything, distinguishes us from other entities, both natural and artificial (Moore, 2012). Such issues are also central to Turkle's critique of social robots, which echoes a humanist tradition that vigorously upholds a strict dualism between humans and nonhumans and maintains that humans are intrinsically exceptional (see also Jones, 2017; Richardson, 2018).

By design, social robotics disturbs such dualistic distinctions, and this partly explains the apprehension from some parts of the humanities and social sciences. But human exceptionalism is not only challenged by roboticists and their creations. A diverse group of scholars in anthropology, STS, posthumanist philosophy and related disciplines have also grown increasingly dissatisfied with the dualisms of traditional humanism. In response, they have developed alternative ways of recognising and exploring how humans and nonhumans are entangled in intimate and complex webs of relations (e.g., Grusin, 2015; Latour, 2005; Kohn, 2013). My work contributes to this project by showing how experiments in and with social robotics might expand how we think about sociality beyond the human.

Here, I do this by examining a human-robot interaction (HRI) experiment from my fieldwork at the Hiroshi Ishiguro Laboratories (the HIL) in 2017. The experiment was designed to evaluate whether a humanoid robot equipped with an algorithm that simulates 'curiosity' would enable "more humanlike, interesting human-robot interactions" (Doering et al., 2019b, p. 20). Based on a discussion of this experiment, I suggest that researchers in social robotics and their robotic creations might be experimentally enacting new forms of sociality and, in doing so, reconfiguring what sociality is and can be. I propose the concept of *artificial sociality* to capture both the ongoing enactments and multiple results of such experimental reconfigurations[1].

I begin with a brief introduction to social robotics and the assumptions that animate the field. I then review recent anthropological discussions of how sociality is configured in entangling relations between humans and nonhumans. Via Andy Pickering's *dance of agency* (1993, 1995) and John Law's *method assemblages* (2004), I show how understanding experiments performatively helps us see how HRI experiments with social robots produce relational configurations and reconfigurations involving humans, robots and other technologies that enact multiple forms of artificial sociality. I use these conceptual tools to unpack the curious robot experiment and compare the kinds of sociality that emerge in the experiment's two conditions. I argue that the curious robot exemplifies what Pickering calls *technologies of engagement* (2018) by augmenting the unpredictability enacted in relational and experimental dances of agency. Finally, I connect my argument to the work of other scholars with similar interests in more-than-human socialities and human-robot relations.

Social Robotics

In *Designing Sociable Robots* (2002), roboticist Cynthia Breazeal defines social robots as technological systems designed to simulate the cognitive and communicative capacities that enable humans to engage in social interactions and establish intensive, intimate and durable relations with others. Building such machines is a lofty goal. As Breazeal explains:

> [o]ur sociability touches upon the most human of qualities: personality, identity, emotions, empathy, loyalty, friendship, and more. If we are ever to understand human intelligence, human nature, and human identity, we

[1] Hofstede and Liu (2020) and Rezaev et al. (2018) also discuss artificial sociality but in ways that differ substantially from my use of the concept.

cannot ignore our sociality (Breazeal, 2002, p. 239).

Big stuff! But researchers in social robotics face an even more significant challenge. In-depth *scientific* knowledge of the mechanisms that make humanlike sociality possible is required to begin engineering technologies that can even approximate such abilities (Breazeal, 2002; Alač, 2016).[2] However, as several roboticists argue (Breazeal, 2002; Asada et al., 2002; Kuniyoshi, 2019; Nagai, 2019), our current grasp of sociality does not allow us to reverse-engineer its necessary components and simulate them technologically.

Nevertheless, the process of creating such technologies, integrating them in robotic systems and evaluating them in experiments is expected to yield an "uncanny advantage" for producing the in-depth knowledge of sociality we are currently lacking (MacDorman & Ishiguro, 2006a). A brief and partial review of research in social and cognitive robotics[3] shows how robots of varying complexity have been used to explore: the workings of human sociality (Breazeal, 2002; Dautenhahn, 2007), the development of social cognition (Asada et al., 2002), the mechanisms of empathy (Asada, 2015), the role of embodiment for intelligence (Kuniyoshi, 2019; Pfeifer & Bongard, 2006), and even artificial consciousness (Tani, 2017). In this sense, social robotics is a peculiar *scientific* discipline that marries the development of social machines with the creation of experimental approaches that use these machines to investigate *human sociality.*

For example, Karl MacDorman and Hiroshi Ishiguro argue that an android, a robot that is "indistinguishable from humans in its external appearance and behaviour" (MacDorman & Ishiguro, 2006b, p. 289), will elicit the same conscious and subconscious reactions as a human subject would in interaction experiments (MacDorman & Ishiguro, 2006a, p. 298). In such experiments, android subjects might be preferable to humans since they can be programmed to behave consistently across different conditions. Therefore, androids, and potentially other robots, might provide novel occasions for exploring "what it means to be human" since they "offer insights into human behaviour that may be unobtainable by other methods" (MacDorman & Ishiguro, 2006a, pp. 301-302). They do this partly by providing "the unique opportunity to study human affect, cognition, and behaviour when confronted with social agents other than humans" (Bartneck et al., 2020, p. 7).

But this brief introduction leaves the notion of sociality largely unexamined. In the next section, I work through perspectives on more-than-human socialities in anthropology and STS to show the tensions that emerge when compared to the view from social robotics.

Sociality Beyond the Human

It is somewhat ironic that anthropology, the eponymous study of humankind, has recently seen a surge of interest in exploring how human worlds and lives are deeply intertwined with the nonhumans with whom we co-exist (Cerulo, 2009; Tsing, 2013). Although earlier anthropologists recognised how nonhuman beings participate in social life (e.g., Leenhardt, 1947 [1979]; Hallowell, 1960 [2002]), it is only within the last decades that we have become genuinely comfortable with not-quite-human forms of sociality (Long & Moore, 2012; Remme & Sillander, 2017). Indeed, as Anna Tsing asks, "How could it have ever occurred to anyone that living things other than humans are not social?" (2013, p. 27). Accordingly, Tsing (2013, 2016), along with many like-minded thinkers (e.g., Bubandt, 2020; Kohn, 2013; Lien & Pálsson, 2019; Remme & Sillander 2017), have persuasively advanced the claim that human social life always has and always will exist and evolve in intimate and complex entanglements with nonhuman beings.

Although notions of more-than-human sociality are gaining traction within anthropology, they differ from how sociality is understood in social robotics, despite agreeing that genuine sociality is not reserved for humans alone. Compared with contemporary anthropological usage,

[2] Social robotics combines research in engineering, computer science, social and developmental psychology, cognitive science, linguistics et cetera (MacDorman and Ishiguro, 2006a).
[3] For brevity's sake, I do not distinguish between social robotics and cognitive developmental robotics (Asada et al., 2002).

the notion of sociality mobilised in social robotics seems incomplete. In social robotics, human sociality is conceived as something we *possess* as skills and capacities for cognition, communication and interaction (Dautenhahn, 1998). As noted above, roboticists have yet to figure out precisely what these skills are and how to recreate them technologically. But this issue is understood as a scientific puzzle they can solve most productively via technological innovation and experimental evaluation. Once they have determined these mechanisms and have built robots equipped with technologies that can sufficiently simulate them in interactions with humans, they are likely to possess humanlike sociality (Breazeal, 2002, p. 235). Put differently, in social robotics, sociality is a question of what you can do rather than who or what you are.

However, from an anthropological perspective, this seems to ignore a crucial part of sociality, namely the entangling webs of social relations that produce and are produced by our evolved, species-specific capacities for social cognition, communication and interaction (Ingold, 2000, pp. 4-5). As understood in anthropology, the concept of sociality points not only to the possession of such capacities but also to "the relational matrix which constitutes the life of persons" (Strathern, 1996, p. 55), wherein persons are conceived as "simultaneously containing the potential for relationships and always embedded in a matrix of relations with others" (Strathern, 1996, p. 55). In this view, we can simultaneously acknowledge that humans possess *something* that affords them the potential for relationships – the attributes and abilities that roboticists attempt to simulate – while insisting that such abilities grow "in entangling relations with significant others" (Tsing, 2013, p. 27).

Such a notion of relational sociality does not discriminate as to which entities can be relationally entangled. Partly resonant with the view from social robotics, relational sociality is less concerned with intrinsic qualities and assumed abilities. Instead, it attends to how diverse entities *do relations together* and the knotty entanglements such relations grow from and extend. As Alfred Gell notes, "it does not matter, in ascribing 'social agent' status, what a thing (or person) 'is' in itself; what matters is where it stands in a network of social relations" (1998, p. 123). Thus, following Gell and others of a similar persuasion, I understand sociality as an "ongoing relational process which can take a variety of forms" (Remme & Sillander, 2017, p. 9), through which both humans and nonhumans collectively create and inhabit webs of relations that are "intrinsically plastic and malleable, expanding and contracting, including and excluding, continuously" (Remme & Sillander, 2017, p. 20).

This version of relational sociality does not deny that some entities relate differently and that this is partly a result of differences in their respective abilities. But it maintains that such abilities are relational products to be investigated, empirically and conceptually, as they affect ongoing relational entanglements (Šabanović & Chang, 2016, p. 540). Superficially, it seems that social robotics leaves this relational dimension unexplored and ignores how sociality extends beyond the abilities of individuals. But consider Yuji Sone's summary of Hiroshi Ishiguro's take on the relational production of humanity:

> The notion of the human should be defined in terms of one's ability to form relationships, that is to say exteriorised encounters, with other humans, and, further, that these relationships are based upon mechanistic exchanges built of specific gestures and behaviours that can be replicated (Sone, 2017, p. 100 summarising Ishiguro, 2012, p. 49, original references removed).

Despite Ishiguro's somewhat behaviouristic tone, he seems to argue that what we understand as characteristically human, such as sociality, is an *emergent effect of our relations with others*, rather than being derived from intrinsic qualities (Otsuki, 2015, p. 158). But I do not think Ishiguro takes it far enough. Thus, my relational version of sociality emphasises how relations with other beings are partially responsible for producing the abilities that humans (and nonhumans) use to establish and maintain these relations, while also insisting that such entangling relations enact and are enacted by multiple kinds of overlapping socialities.

In short, my argument is that when researchers in social robotics attempt to simulate sociality in robotic systems, the very form of sociality itself is dynamically *transformed* as new relational configurations emerge in interactions between humans and robots. Concomitantly, I propose that the simulations of sociality embodied by social robots will probably not result in perfect replications of existing relational configurations, regardless of how well they reproduce the abilities humans are said to possess. This becomes clearer when considering how social robots are involved in HRI experiments. Luckily, STS scholars have developed tools for showing how experiments in social robotics already rely on relational configurations of humans and nonhumans.

Exploring and Performing Experiments

In the late 1970s, a small revolution rocked the social studies of science as a growing number of researchers started doing fieldwork in laboratories and began investigating what Bruno Latour has aptly described as *science in action* (Sismondo, 2010, pp. 106-107; e.g., Knorr-Cetina, 1981; Latour & Woolgar, 1986[1979]; Latour, 1987). As Karin Knorr-Cetina explains, such laboratory studies "furnished the optics for viewing the process of knowledge production as "constructive" rather than descriptive; in other words, for viewing it as constitutive of the reality knowledge was said to 'represent'" (1995, p. 141). Where earlier work in the sociology of science investigated the *social construction* of scientific knowledge (Sismondo, 2010, p. 54), the laboratory ethnographers instigated a more radical project. Roughly, they studied how collectives of human and nonhuman agencies brought together in scientific laboratories *construct* reality (Law, 2004, pp. 31-32).

This move became most apparent when STS scholars interrogated experimental practices. They argued that experiments do not only produce descriptions of natural phenomena but also *construct* the phenomena in question (Law, 2004, p. 45). To paraphrase Ian Hacking, experiments never just represent reality but always *intervene* in it (1983), insofar as establishing proper experimental conditions requires "control of the variables studied, of the technologies applied, of the experimental design" (Roepstorff & Frith, 2012, p. 103). As a result, scientific experiments looked less like rigorous applications of methodological principles and more like "a complicated practice, a bricolage tinkering with the possible elements to make things work" (Roepstorff & Frith, 2012, p. 103). Importantly, they also revealed experiments to be *more-than-human*, "for as scientists well know it is only through an organized and coordinated effort, using multiple machines and other things as mediators, that different entities become able to reliably 'express themselves'" (Jensen, 2010, p. 7).

Consequently, the realisation that the sciences produce knowledge by constructing the phenomena they only claim to describe emerged alongside a heightened sensitivity to the participation of nonhuman actors in experimental practices. Callon and Latour aptly capture this sensitivity via the *principle of generalised symmetry* (1992). As Casper Bruun Jensen explains:

> Generalized symmetry can be viewed as a methodical insurance policy against taking for granted any preconceived notion of who has the power to act. It thus multiplies the potentially relevant actors and forces attention on their differences and relations. The aspiration is to thereby facilitate a more nuanced analysis of how humans and things (broadly construed) together create, stabilize and change worlds (2010, p. 5).

I hinted at this symmetrical attitude above by suggesting that we should recognise nonhumans as active participants in producing the entangling relations that shape socialities,[4] and the same holds for whom or what we identify as participants in experiments (Pickering,

[4] Jensen clarifies: "Contrary to what is sometimes imputed this has nothing to do with arguing that humans and technologies are somehow 'the same'" (Jensen, 2010, p. 5).

2010, p. 195). When doing experiments, scientists inevitably rely on a whole "realm of instruments, devices, machines, and substances that act, perform, and do things in the material world" (Pickering, 1993, p. 563). To describe how experiments produce configurations of relations between scientists and their nonhuman collaborators, Andy Pickering proposes the image of the *dance of agency*, wherein "material and human agencies are mutually and emergently productive of one another" (Pickering, 1993, p. 576).

As Pickering stresses, such dances of agency are performative, open-ended and decentred. They are performative since "performances are what agents do, whether human or nonhuman", and experiments involve diverse agents doing things together (Pickering, 2010, p. 195). They are open-ended because we never know where the dance will lead; their results are never given. Ideally, experiments traverse the unknown to produce moments of surprisal that reciprocally transform the humans and nonhumans involved (Pickering, 2018, p. 3). Also, by recognising how nonhumans crucially contribute to experiments, we relinquish dualistic control and decentre the human subject (Pickering, 2018, pp. 4-5). In short, dances of agency are "zones of intersection where the nonhuman world enters constitutively into the becoming of the human world and vice versa. They cannot be accounted for by focusing either on the human or the nonhuman alone" (Pickering, 2010, p. 195).

Thinking of experiments as dances of agency seems far from the rigid methodological prescriptivism usually attributed to the scientific method (Law, 2004, p. 40). John Law provides a clear, albeit slightly caricatured, description of this 'standard view':

> If you want to understand reality properly then you need to follow the methodological rules. Reality imposes those rules on us. If we fail to follow them then we will end up with substandard knowledge, knowledge that is distorted or does not represent what it purportedly describes (2004, p. 5).

Law clarifies that he is not advocating for the casual dismissal of 'standard' methods. But, he maintains, when we conceive of methods in this prescriptive register and use them to study things that are "complex, diffuse, and messy," we tend to make an even bigger mess of things (Law, 2004, p. 2). In an example of *redescription* (see Lebner, 2017), he invites us to understand methods as *method assemblages*, as processes "of bundling, of assembling, or better of recursive self-assembling in which the elements put together are not fixed in shape, do not belong to a larger pre-given list but are constructed at least in part as they are entangled together" (Law, 2004, p. 42).

In thinking with method assemblages, we abandon the standard view's anthropocentric quest for experimental control and the associated assumption that reality (in the singular) pre-exists and determines our use of specific methods (Law, 2004, p. 9). Additionally, the relational configurations that constitute method assemblages exhibit the mutual emergence of Pickering's dances of agency by the way in which they "are constructed at least in part as they are entangled together" (Law, 2004, p. 42). But, Law continues, method assemblages do not involve constructivism in the traditional sense, seeing as this often implies singular, fixed and relatively stable representations and associated objects (Law, 2004, pp. 55-56; Mol, 2002, pp. 41-42). Instead, drawing on Annemarie Mol (2002), he prefers the notion of *enactment* since "to talk of enactment is to attend to the continuing practice of crafting" (Law, 2004, p. 56). In contrast to the construction of singularity, enactment results in the production of *multiplicity* as "the permanent possibility of alternative configurations" (Mol, 2002, p. 164). To think with enactment means attending to processes of configuration and reconfiguration without definitive trajectories and stable outcomes that produce complex, multiple and sometimes overlapping entanglements of heterogeneous elements (Law, 2004, p. 42).

In sum, I understand experiments as method assemblages that enact multiple configurations and reconfigurations of relations between humans and nonhumans through open-ended and decentred dances of agency. With this in mind, social robotics and its experiments do not have the appearance envisioned originally by roboticists. That is, when roboticists build social robots and use them in experiments, they are, like other *social* sciences, creating "an extension of – and a reflexive moment in – the continuing elaboration and enactment of social life" (Law & Urry, 2011, p. 392). But the ways in which they enact and transform social realities diverge from the traditional social sciences. On the one hand, social robotics is unapologetically constructivist in that it actively creates new social beings, while on the other hand maintaining that these artificial creations enable them to produce more rigorously scientific representations of existing forms of sociality.

But in light of the above redescription of experiments, a different perspective is possible. Extending my argument from the previous section, I propose that when researchers in social robotics attempt to simulate sociality in robots and use these robots as experimental tools for an artificial science of sociality, they will probably not end up with unaltered reproductions or straightforward descriptions of an existing and singular form of sociality. Instead, robots and roboticists might experimentally enact and reconfigure multiple forms of sociality via performative, open-ended and decentred dances of agency.

At this stage, an empirical example seems appropriate. In the following sections, I analyse an HRI experiment designed to test which of two algorithms, the appropriateness learner and the curiosity learner, would produce the most interesting interactions (Doering et al., 2019b). I then discuss how the concept of artificial sociality, understood as experimental enactments of sociality via relational and decentred dances of agency, might help outline the differences between the two interactions.

Curious Robots

I experienced the curious robot experiments during my 2017 fieldwork at the HIL, a robotics laboratory in the Advanced Telecommunications Research Institute International (ATR) in Japan. The lab's eponymous director, Professor Hiroshi Ishiguro, is internationally (in)famous for his work on the Geminoids, a series of androids made to appear indistinguishable from existing persons. Together with colleagues from ATR, Ishiguro also developed the humanoid robot Robovie, who we will meet below, in the late 1990s (see Kanda et al., 2002). The present experiment was the latest in a series of studies on designing robotic behaviours using machine learning algorithms trained on human interaction data, a strategy the HIL researchers call *data-driven HRI* (Liu et al., 2016):

> By directly capturing behaviour elements, such as utterances, social situations, and transition rules from a large number of real, in situ human-human interactions, it may be possible to easily and automatically collect a set of behaviors and interaction logics [sic] that can be used in a robot (Liu et al., 2016, p. 988).

They started working with data-driven HRI to solve the problem of programming robotic behaviours that can adapt to the unpredictability of social life outside the laboratory (Liu et al., 2016, p. 988). So they turned to machine learning. As Adrian Mackenzie explains, "the techniques of machine learning nearly all pivot around ways of transforming, constructing or imposing some kind of shape on the data and using that shape to discover, decide, classify, rank, cluster, recommend, label or predict what is happening or what will happen" (Mackenzie, 2015, p. 432).[5] For this experiment, the learning algorithm was an artificial neural network trained on interaction data recorded from scripted human interactions staged and recorded at the laboratory.[6] The interaction data was abstracted from the recordings using techniques from their previous work (e.g., Liu et al., 2016). The data, now operational, was subsequently used to train two multilayer perceptron neural networks

[5] This is not the place to critically scrutinise how the algorithmic logics of machine learning influence experimental transformations of sociality (but see Mackenzie, 2015; Seaver, 2017, 2018).

[6] For a clear introduction to neural networks and contemporary issues in AI see Mitchell (2019).

(see Liu et al., 2016 for the data abstraction and Doering et al., 2019b for the entire training process).

For this experiment, the researchers deliberately scripted the interactions used as the training data to exhibit the behaviour they wanted the robot to learn and reproduce (Doering et al., 2019b, pp. 4-6). But the technique ideally scales beyond such scripted interactions. Thanks to current advances in audio-visual and tactile sensor technology, speech recognition and the increasing ubiquity of tracking systems in public spaces, the HIL researchers imagine that "data-driven interaction design based on real-world interactions could soon become a realistic possibility" (Liu et al., 2016, p. 988). For example, "deploying sensor networks in a chain of retail stores could provide hundreds of thousands of example interactions in a manner of months, which could be used to train a robot to perform the role of a shop clerk" (Liu et al., 2016, p. 988).[7] Therefore, it seems fitting that they designed the experiment as a camera shop scenario, with Robovie acting as the shop clerk and the human participants playing the customer.

The experiment compared two conditions where they equipped Robovie with different algorithms programmed to generate learned behaviours according to distinct logics. In the first condition, Robovie's behaviour was generated by a neural network called the *appropriateness learner*, while the second condition layered the *curiosity learner* on top of the appropriateness learner. The appropriateness learner generates actions based on their perceived 'social appropriateness'. After training, the algorithm should enable the robot to "follow the social rules observable in the human-human data" (Doering et al., 2019b, p. 6). When the appropriate robot is confronted with humans performing recognisable actions, the learner selects the top five most appropriate reactions based on the actions pulled from the training data (Doering et al., 2019b, p. 8, 11). The robot then performs the action that most directly replicates what a human would do in the same situation.

The curiosity learner fundamentally reconfigures the logic of replication that animates the appropriateness learner. It does so by exploring and potentially expanding the interactive limitations imposed by training data through the active pursuit of surprisal. The algorithm was inspired by recent research on intrinsic motivation and curiosity, defined by Pierre-Yves Oudeyer and Linda B. Smith as "an epistemic motivational mechanism that pushes an organism to explore activities for the primary sake of gaining information" (2016, p. 2). Moreover, Oudeyer and Kaplan show that curiosity mechanisms can endow robots with "general motivations that push them to explore, manipulate or probe their environment, fostering curiosity and engagement in playful and new activities" (2009, p. 1).

Experimental Interactions

The curiosity experiment was divided into two parts, with each consisting of brief interactions with Robovie followed by a questionnaire and an interview (Doering et al., 2019b, p. 15). As usual in laboratory experiments, the researchers meticulously attempted to manage the human subjects for the sake of comparability. But also to minimize potential disruptions caused by Robovie's occasional incompetence. They told me to treat Robovie as a knowledgeable shopkeeper, despite its frequent failings, and to ignore its appearance and mechanical voice. Additionally, I should not ask Robovie to repeat itself or go 'off script' by asking questions that were too complex or unrelated to the scenario. However, I was encouraged to ask the same questions multiple times or rephrase them slightly to see how it dealt with different and ambiguous questions.

In the first interaction, Robovie promptly welcomed me as I entered the designated area.[8] I walked around the room and started fidgeting with a camera. After a few minutes, Robovie approached me, "Is there anything I can help you with?" As per the instructions, I started asking various questions about the camera, "How much does it cost?" "How

[7] A thorough consideration of the alarming issues that such sensor networks will entail, and what this means for artificial sociality, is beyond the scope of this article.

[8] The following descriptions are based on fieldnotes written after or during the experiment. Some of what Robovie said might not be fully accurate since it was recorded from memory.

many megapixels does it have?" "What is the shutter speed?" When I asked straightforward questions about camera specifications, it provided clear and concise answers. When I upped the ante a bit and asked questions that were a bit trickier, for instance, "What kind of manual settings does the Sony DX500 L220 have?" Robovie's responses would occasionally be completely irrelevant, e.g., talking about the price when asked about the sensor size. When I moved around the room, Robovie would follow me faithfully while listing the specs of nearby cameras. If passivity, predictability and anxiously shadowing the customer are considered appropriate behaviour for a salesclerk in a camera store, Robovie passed the exam.

In comparison, interacting with the curious robot felt substantially different. Here, Robovie was much less predictable, passive and 'socially appropriate'. Instead, it moved around the room haphazardly and randomly asked me quite detailed questions. Once, it asked me the same question seven times in a row while ignoring my increasingly futile replies. This forced the researchers to intervene and restart the robot. Later, as I was moving towards the Canon display, Robovie decided to show me the Sony camera instead, and from its position near the Sony display, it proudly exclaimed, "This one is a fully professional camera. This professional top-end camera comes in black; it works with nary a little noise! It takes fantastic photos, but it has very complex settings." As I was about to leave, Robovie moved to each camera, repeating, "Sorry, this one comes only in black" again and again.

Whereas the appropriate robot was reactive, predictable and frankly dull, interacting with the curious robot was interactive, messy and surprisingly entertaining. I will admit that having a human shopkeeper act as the curious robot did would be disconcerting. Even so, when equipped with the curiosity learner, Robovie's behaviour was much more exciting and enjoyable. Even lively. It is crucial to note that the curiosity learner works, in principle, by adapting the robot's behaviour to the indeterminacy of ongoing and open-ended interactions. It sustains this unpredictability by choosing actions that produce surprising reactions. Therefore, it might be tempting to attribute the production of unpredictable behaviour to the curiosity learner alone. However, as I will show below, the curiosity learner was not exclusively responsible for enacting the surprising sociality I experienced in the experiment.

To understand why, we need a brief look under the algorithm's hood to see how it works. Recall that the curiosity learner is created by stacking an additional neural network on top of the appropriateness learner. The appropriateness learner is programmed to classify and choose behaviours based on a principle of replication – if it successfully replicates what a human would do in a similar situation, then the action is considered socially appropriate (Doering et al., 2019b, pp. 7-8; see also Doering et al., 2019a). But this makes it challenging to deal with ambiguous or uninterested customers. In the case of ambiguity, the robot does not explore alternative actions unless they co-occur with the current human action in the training data (Doering et al., 2019b, p. 20). In the case of uninterested customers who refuse to diversify their interactions, Robovie will produce highly repetitive behaviour, e.g. asking the same question multiple times, because the same robot action will always be the most appropriate when the customer's behaviour stays consistent (Doering et al., 2019b, p. 20).

In contrast, the curiosity learner is animated by what I see as a logic of experimentation, with direct replication being sacrificed for the sake of performing actions with unpredictable results. As one of the researchers told me, the curiosity learner outputs a curiosity score for each available robot action, which is a numerical representation of how confident the algorithm is in predicting how a human will react to the robot. He also told me that "with things like curiosity, the robot can explore a lot of different directions. They might learn things that aren't necessarily useful for one goal, but maybe they are useful in some other way." Further, as Doering and colleagues explain, "the 'curious' robot was able to adapt its behaviors to some individual customer difference (e.g., interested versus uninterested customers) rather than always using the same default behaviors it learned from the off-line training" (2019b, p. 20). Thus, rather than ignoring a customer's lack of interest by resorting to repetitive questions, the curious robot will adapt its behaviour to the current interaction state and leave the customer alone. In this case, actions that might appear useless or inappropriate, such as ignoring the customer, are surprisingly the most curious because they set the stage for further surprisal down the line.

But how does the training data limit these different behavioural logics? In the above, I seem to have ignored the obvious fact that despite their differences, the two algorithms are still trained on the same data. As the HIL researchers explain, "[t]he 'curious' robot can only exhibit behaviours that are perceived as curious if such behaviors occurred in the human-human dataset, from which the robot learns" (Doering et al, 2019b, p. 20). In short, if an action does not occur in the data, then the robot cannot do it. However, by attending to the experiment's open-ended and decentred dimensions, such obvious limitations are redrawn. Even within the boundaries of experimental interactions, the robot requires ongoing relational entanglements to perform *both* appropriate and curious behaviour.

During my fieldwork, I observed a version of the experiment in which the human participant enthusiastically explained how he liked to 'break' robots by purposely testing their interactive limits. In the first condition, he was a stereotypically 'uninterested' customer and refused to treat Robovie as a competent salesclerk. Despite this, Robovie would always have an appropriate action up its sleeve, like repeating the same actions until the customer responded. Robovie seemed to be focused more on 'appropriately' replicating learned behaviour than on following the flow of interaction. As the HIL researchers note, "[g]iven the same situation, the non-curious robot would simply continue to respond with the same 'default' behavior regardless of whether the customer was interested or uninterested, potentially resulting in less ideal interaction than if it had adapted to the individual's needs" (Doering et al., 2019b, p. 20). But something different happened in the second interaction despite the participant behaving with similar indifference. As they report:

> When an uninterested customer continued to ignore the curious robot for some time, the robot would often go back to the service counter, saying "I will be at the service counter if you need any more help." While this was not the most proactive, salesmanlike behavior, it had the highest curiosity value for that particular situation, due to the fact that the robot had "lost curiosity" [...] about previous actions [...] since those actions did not elicit any unanticipated customer responses (Doering et al., 2019b, p. 20).

To put it bluntly, curious robots do not dance with boring humans (Pickering, 2018, p. 7). The curious robot feeds on the indeterminacy that emerges in open-ended interactions, and it prefers being alone to interacting with someone who does not scratch its curiosity itch. But when humans were willing to dance, "the robot would usually continue answering the customer's questions and would not leave the customer alone" (Doering et al., 2019b, p. 20).

It might be said that Robovie is still limited by its training insofar as it can only perform actions that are already present in the data (Doering et al., 2019b, p. 20). When the other participant was completing the post-experiment evaluation, he provocatively said: "I smell scripting." When one experimenter asked him to elaborate, he told her that the "behaviour seemed scripted rather than generated, or at least I hope it was." In some ways, he was not wrong. In the experimental interaction, Robovie cannot ask about the weather or what you had for breakfast because such actions are not present in the training data. But the algorithms do not replicate any single scripted interaction. Doering et al. explain that:

> It is possible that a robot trained on a dataset without curious behaviors can still learn about the humans it interacts with. This is because, at a fundamental level, the mechanism that drives the robot's behaviors will

always result in robot actions that lead to uncertain human responses, such that the robot can learn more about the human (2019b, p. 20).

Surprising Choreographies

Thinking with Pickering's dances of agency, I would say that the algorithms find patterns, or *choreographies*, in the scripted interaction data and, in the case of the appropriate robot, try to replicate the dances these choreographies model. The curiosity learner identifies the same choreographies but *reconfigures* them by executing actions that disturb the learned patterns. In breaking with scripted choreographies, the robot's attempts at maximising surprisal reverberate through the entangling relations that enact and are enacted by the experimental dance of agency. When successful, humans will adapt to the curious robot by accommodating its thirst for uncertainty. Therefore, the actual limits are found not in the training data, but instead in the lack of surprisal that emerges when interactions do not yield novel engagements, like when the curious robot meets boring humans.

In these cases, inaction becomes the most curious action because it primes future interaction for increased surprisal should the customer decide to join the dance. From this perspective, the curious robot exemplifies what Pickering describes as *technologies of engagement*, machines and technologies that overtly embrace and encourage "wild and open-ended dances of human and nonhuman agency in which the nonhuman can always surprise us" (Pickering, 2018, p. 3). He poses this in contrast to *technologies of disengagement*, "free-standing machines" designed to restrict open-ended dances by limiting the scope of nonhuman agency through designed passivity (Pickering, 2018, p. 4). If the curious robot is a technology of engagement, then the appropriate robot is a technology of disengagement, a relational configuration of agencies that neither decentre the human nor afford surprisal.

As technologies of engagement and disengagement, the differences between the algorithms emerge through *how* they participate in dances of agency. The point is not to say that the curious robot is properly social while the appropriate robot is not. But only the curious robot embraces the spirit of open-endedness by reconfiguring the experimental dance of agency. In successfully replicating configurations of patterned interaction, the appropriate robot is "cut off from any performative contact with the world" (Pickering, 2018, p. 2). The appropriate robot is *tamed* by its algorithmic configuration that prevents it from reconfiguring the dance of agency by upholding an asymmetrical dualism that renders it passive and reactive. It only surprises when it "fail[s], and the standard reaction to that is annoyance, not amusement" (Pickering, 2018, p. 4). In contrast, the curious robot reconfigures the interaction by improvising new choreographies in decentred dances of agency that produce multiple and surprising relational entanglements. While the appropriate robot replicates existing configurations and always repeats the same old moves, the curious robot actively encourages indeterminate, open-ended and decentred *reconfigurations*. that transforms the relational choreography by embracing what Pickering calls the "open-ended and exploratory sense of experiment: experimentation as brute finding out. Try and see; what happens if…?" (Pickering, 2016, p. 2).

Nonetheless, there is an additional dimension to the experiment that I have only touched upon superficially and which, initially, seems to suggest a different analysis. Recall how the experimenters encouraged the participants to ignore Robovie's appearance and voice, avoid specific questions, and play along with the scenario by treating Robovie as competent and knowledgeable. These attempts at pre-configuring both human and robot behaviour to fit with the experimental condition might seem to indicate a return of dualistic human-centred control and as such, the curious would appear to be just another example of the 'standard' experiments parodied by John Law above. However, without denying that the experimenters tried to control their participants and streamline the experimental interactions, I contend that the curious robot experiment also reveals the limits of *human* control.

That is, the two versions of the experiment described above not only show how Robovie's algorithmic configurations contributed to enacting different forms of artificial sociality, but also how experiments, as method assemblages involving decentred, performative and open-ended dances of agency, cannot be understood by only looking at the human part of the equation. Although the experimenters tried to make our actions fit the experimental design, they were not entirely successful. Obviously, the other participant seemingly refused the experimenters' requests. Even so, the experiment 'worked' without his compliance. Moreover, even though I tried to follow their instructions, I occasionally forgot in the heat of the moment. For example, I once made the mistake of asking Robovie to compare two cameras, "Is the Sony better than the Canon?" Robovie responded with the Sony camera's megapixels and shutter speed.

These examples of intentional and unintentional resistance might have made it slightly harder to stage the right conditions for providing comparable results and producing proper knowledge. The experimenters might have cursed our blunders or reluctance to follow directions They might even have left out our interactions from the report in Doering et al. (2019b). But the question is whether their attempts at controlling the interaction and our occasional failure to comply changed the enactment of artificial sociality? For the appropriateness learner, it did not seem to make much difference. Even without behavioural guidelines, Robovie would probably continue to replicate supposedly appropriate actions undeterred. In contrast, the curious Robovie actively changed its behaviour by choosing disengagement and inaction when the somewhat apathetic participant did not behave 'ideally'. It behaved as 'designed' even when the participant did not, since the curious robot prefers unpredictable interactions. In other words:

> While the simple Appropriateness Learner can learn the repetitive behaviors, the Curiosity Learner can discover which behaviors are likely to lead to individual variation in customer responses. By guiding the interaction toward these behaviors, the curious robot creates opportunities for interactions to develop in diverse ways, opening up paths in the dialog that have the potential to branch out according to an individual's interests or needs (Doering et al., 2019b, p. 15).

I am trying to make a predictable point. Although the curiosity experiment, like most experiments, involves attempts at controlling the behaviour of the human and nonhuman entities involved, such attempts do not determine how the experiment proceeds in practice. The experimenters' initial effort at steering the participants' behaviour to line up with the experimental design undoubtedly influences the dance of agency to some extent. Nevertheless, experimental dances of agency "cannot be accounted for by focusing either on the human or the nonhuman alone" (Pickering, 2010, p. 195; Suchman, 2012).

The experiments required the active participation of humans and robots, as well as a technological infrastructure of sensors, algorithms, speech synthesisers, actuators, and other tools. When we recognise the complex entanglements of human and nonhuman entities involved, it becomes clear that neither the curiosity learner nor the experimenters were solely responsible for enacting artificial sociality in the experiments above. Accordingly, Robovie's behaviour cannot be fully explained by how the humans involved – participants and experimenters – potentially acted differently across experiments. Instead, I have looked to the zones of intersections and relational reconfigurations produced in the experimental dance of agency. Here, I claim, artificial sociality emerges.

Conclusion

Summing up, I argue that the curious robot provides an example of the experimental phenomenon I propose to call artificial sociality. By technologically replicating human sociality in social robots and developing a new science of sociality, roboticists and robots are experimentally enacting dances of agency that configure and reconfigure entangling relations. This perspective generally seems consistent with existing anthropological theories of more-than-human sociality. However, artificial sociality still looks slightly different in some respects. As the name implies, artificial sociality is deliberately *designed* to simulate human sociality, and it is precisely the seemingly reductive and deceptive artificiality of social robotics that critics deplore (e.g., Jones, 2017; Richardson, 2018; Turkle, 2011).

I should like to make two brief comments at this point. Firstly, by 'defending' artificial sociality, I do not render humans or other living beings somehow *less* social. Instead, I am proposing that sociality is not a zero-sum game and that differences in how humans and nonhumans contribute to the enactment of sociality are contingent effects that result from how they are mutually entangled in relational configurations. Secondly, following Law and Urry (2002), I suggested that as soon as we merely claim to *describe* sociality, we inevitably contribute to its enactment and reconfiguration and that social robotics and the social sciences are equally complicit in intentionally and unintentionally doing so. As I have discussed above, social robots participate in enacting new relational entanglements that experimentally reconfigure the kinds of sociality they are meant to reproduce. It is this experimental dynamic, embodied primarily in the curious robot's designed augmentation of enacted unpredictability, which makes my artificial version slightly unlike existing perspectives on nonhuman socialities.

Still, I am not alone in examining the experimental reconfigurations that social robots potentially produce. Several scholars in anthropology, STS, philosophy and related disciplines are doing important work on social robots. For example, Jennifer Robertson has convincingly shown how Japanese roboticists and politicians *imagineer* reactionary understandings of ethnicity, nationality, gender and kinship in their visions for human-robot coexistence (2007, 2010, 2014, 2017). Staying with Japan, Casper Bruun Jensen and Anders Blok reveal how Japanese *techno-animism* reconfigures robotic entities' ontological nature and challenges modern Western intuition that the spiritual and religious is fundamentally separate from, and opposed to, science and technology (2013, p. 87). In a laboratory context resembling mine, Asli Kemiksiz explores how Japanese roboticists' bricolage of scientific styles leads them to understand their robots as mirrorlike and partial depictions of organic life and humanlike intelligence, since perfect replication "seem[s] too elusive to pursue" (2019, p. 78). In direct dialogue with my present concerns, Selma Šabanović and Wang Lin Chang analyse interactions with the robot PARO and argue that "rather than being a static characteristic of particular people or artifacts, an actor's sociality is continuously in the process of enaction" (2016, p. 540). These pioneering scholars, and many others[9], have been vital in developing my nascent version of artificial sociality.

Finally, I do not intend this article to be an uncritical apology for social robotics. As others have argued (e.g., Suchman, 2007), social robotics often involves reductive visions of human sociality and a lack of appreciation for the contingent complexity and unpredictability of social life outside the laboratory. A more comprehensive account of artificial sociality would carefully evaluate such critical questions, while considering the broader sociocultural and economic implications that social robots likely engender (see Seibt, 2016). However, in the present article, I have bracketed such issues to focus on what we can learn from the experimental practices of social robotics by bringing anthropological discussions of nonhuman sociality to bear on entities who, by design, simulate *human* forms of sociality. In doing so, I hope to set the stage for further experiments with sociality in anthropology, STS, social robotics and beyond.

[9] Notably: Alač (2009, 2016), Katsuno (2011), Otsuki (2015, 2019) and Suchman (2007, 2011). In philosophy, Johanna Seibt's (2017) work is a fascinating attempt at expanding sociality through simulation and process ontology.

References

Alač, M. (2009). Moving android: On social robots and body-in-interaction. Social Studies of Science, 39(4), 491-528.

Alač, M. (2016). Social robots: Things or agents? AI & society, 31(4), 519-535.

Asada, M. (2015). Development of artificial empathy. Neuroscience research, 90, 41-50.

Asada, M., Hosoda, K., Kuniyoshi, Y., Ishiguro, H., Inui, T., Yoshikawa, Y., Ogino, M. & Yoshida, C. (2009). Cognitive developmental robotics: A survey. IEEE transactions on autonomous mental development, 1(1), 12-34.

Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). Human-Robot Interaction: An Introduction. Cambridge University Press.

Breazeal, C. L. (2002). Designing Sociable Robots. The MIT Press.

Bubandt, N. (2019). Coral theory, or what corals can teach anthropology about multispecies sociality [Koralteori, eller hvad koraller kan lære antropologien om multispecies sociality]. Norsk antropologisk tidsskrift, 30(03-04), 186-204. [in Danish]

Cerulo, K. A. (2009). Nonhumans in Social Interaction. Annual Review of Sociology, 35, 531-552.

Callon, M., & Latour, B. (1992). Don't throw the baby out with the bath school! A reply to Collins and Yearley. In A. Pickering (Ed.), Science as practice and culture (pp. 343–369). Chicago University Press.

Dautenhahn, K. (1998). The art of designing socially intelligent agents: Science, fiction, and the human in the loop. Applied artificial intelligence, 12(7-8), 573-617.

Dautenhahn, K. (2007). Socially intelligent robots: dimensions of human–robot interaction." Philosophical transactions of the royal society B: Biological sciences, 362(1480), 679-704.

Doering, M., Glas, D. F., & Ishiguro, H. (2019a). Modeling interaction structure for robot imitation learning of human social behavior. IEEE Transactions on Human-Machine Systems, 49(3): 219-231.

Doering, M., Liu, P., Glas, D. F., Kanda, T., Kulić, D., & Ishiguro, H. (2019b). Curiosity did not kill the robot: A curiosity-based learning system for a shopkeeper robot. ACM Transactions on Human-Robot Interaction (THRI), 8(3): 1-24.

Gell, A. (1998). Art and Agency: An Anthropological Theory. Oxford University Press.

Grusin, R. (Ed.). (2015). The Nonhuman Turn. University of Minnesota Press.

Hacking, I. (1983). Representing and intervening: Introductory topics in the philosophy of natural science. Cambridge University Press.

Hallowell, A. I. (2002). Ojibwa ontology, behavior, and world view. Readings in indigenous religions, 22, 17-49.

Hofstede, G. J., & Liu, C. (2020). To stay or not to stay? Artificial sociality in GRASP world. In H. Verhagen, M. Borit, G. Bravo, & N. Wijermans (Eds.), Advances in Social Simulation: Looking in the Mirror (pp. 217-231). Springer.

Ingold, T. (2000). The perception of the environment: essays on livelihood, dwelling and skill. Routledge.

Ishiguro, H. (2012). Hito to geijutsu to andoroido: Watashi wa naze robotto wo tsukurunoka [The human being, the arts, and the android: Why do I make androids?]. Nihonhyoronsha. [in Japanese]

Ishiguro, H. (2020). How Human is Human? The View from Robotics Research. JPIC.

Ishiguro, H., & Nishio, S. (2007). Building artificial humans to understand humans. Journal of Artificial Organs, 10(3), 133-142.

Jensen, C. B. (2010). Ontologies for developing things: Making Health Care Futures Through Technology. Sense Publishers.

Jensen, C. B., & Blok, A. (2013). Techno-animism in Japan: Shinto Cosmograms, Actor-Network Theory, and the Enabling Powers of Non-Human Agencies. Theory, Culture, & Society, 30(2), 84–115.

Jones, R. A. (2017). What makes a robot 'social'? Social studies of science, 47(4), 556-579.

Kanda, T., Ishiguro, H., Ono, T., Imai, M., & Nakatsu, R. (2002). Development and evaluation of an interactive humanoid robot 'Robovie'". Proceedings 2002 IEEE International Conference on Robotics and Automation, 2, 1848-1855.

Katsuno, H. (2011). The Robot's Heart: Tinkering with Humanity and Intimacy in Robot-Building. Japanese Studies, 31(1), 93-109.

Kemiksiz, A. (2018). Modeled After Life Forms. Japanese Review of Cultural Anthropology, 19(1), 51-82.

Kohn, E. (2013). How forests think: Toward an anthropology beyond the human. University of California Press.

Knorr-Cetina, K. D. (1981). The manufacture of knowledge: An essay on the constructivist and contextual nature of science. Pergamon Press.

Knorr-Cetina, K. (1995). Laboratory Studies: The Cultural Approach to the Study of Science. In S. Jasanoff, G. Markle, J. Peterson & T. Pinch (Eds.), The Handbook of Science and Technology Studies (pp. 140-166). SAGE Publications.

Kuniyoshi, Y. (2019). Fusing autonomy and sociality via embodied emergence and development of behaviour and cognition from foetal period. Philosophical Transactions of the Royal Society B, 374(1771). 20180031.

Latour, B. (1987). Science in action: How to follow scientists and engineers through society. Harvard University Press.

Latour, B. (2005). Reassembling the Social: Introduction to Actor-Network Theory. Oxford University Press.

Latour, B. & Woolgar, S. (1986). Laboratory Life: The Construction of Scientific Facts, 2nd Edition. Princeton University Press.

Law, J. (2004). After Method: Mess in Social Science Research. Routledge.

Law, J., & Urry, J. (2004). Enacting the social. Economy and society, 33(3), 390-410.

Leenhardt, M. ([1947] 1979). Do Kamo: Person and Myth in the Melanesian World. University of Chicago Press.

Liu et al. (2016). Data-Driven HRI: Learning Social Behaviors by Example From Human–Human Interaction. IEEE TRANSACTIONS ON ROBOTICS, 32(4), 988-1008.

Lien, M. E., & Pálsson, G. (2021). Ethnography beyond the human: the 'other-than-human' in ethnographic work. Ethnos, 86(1), 1-20.

Long, N. J., & H. L. Moore. (2012). Sociality Revisited: Setting a New Agenda. Cambridge Anthropology, 30(1), 41-47.

MacDorman, K. F., & H. Ishiguro. (2006a). The uncanny advantage of using androids in cognitive and social science research, Interaction Studies, 7(3), 297-337.

MacDorman, K. F., & Ishiguro, H. (2006b). Toward social mechanisms of android science: A CogSci 2005 workshop. Interaction Studies, 7(2), 289–296.

Mackenzie, A. (2015). The production of prediction: What does machine learning want? European Journal of Cultural Studies, 18(4-5), 429-445.

Mitchell, M. (2019). Artificial intelligence: A guide for thinking humans. Penguin UK.

Mol, A. (2002). The body multiple. Duke University Press.

Moore, H. L. (2012). Avatars and Robots: The Imaginary Present and the Socialities of the Inorganic. Cambridge Anthropology, 30(1), 48-63.

Nagai, Y. (2019). Predictive learning: its key role in early cognitive development. Philosophical Transactions of the Royal Society B, 374(1771). 20180030.

Nourbakhsh, I. (2013). Robot Futures. MIT Press.

Otsuki, G. J. (2015). Human and Machine in Formation: An Ethnographic Study of Communication and Humanness in a Wearable Technology Laboratory in Japan. (Doctoral Thesis, University of Toronto, Toronto, Canada). Retrieved from: https://www.gjotsuki.net/publications/

Otsuki, G. J. (2019). Frame, Game, and Circuit: Truth and the Human in Japanese Human machine Interface Research. Ethnos. Retrieved from: https://www.tandfonline.com/doi/abs/10.1080/00141844.2019.1686047?journalCode=retn20

Oudeyer, P. Y., & Kaplan, F. (2009). What is intrinsic motivation? A typology of computational approaches. Frontiers in neurorobotics, 1(6).

Oudeyer, P. Y., & Smith, L. B. (2016). How evolution may work through curiosity-driven developmental process. Topics in Cognitive Science, 8(2), 492-502.

Pfeifer, R., & Bongard, J. (2006). How the body shapes the way we think: a new view of intelligence. MIT Press.

Pickering, A. (1993). The Mangle of Practice: Agency and Emergence in the Sociology of Science, American Journal of Sociology, 99: 559-89.

Pickering, A. (1995). The Mangle of Practice: Time, Agency, and Science. University of Chicago Press.

Pickering, A. (2010). Material culture and the dance of agency. In D. Hicks and M. C. Beaudry (Eds.), The Oxford handbook of material culture studies (pp. 191-208). Oxford University Press.

Pickering, A. (2013). Living in the material world. In N. Mitev and F. X. de Vaujany (Eds.), Materiality and Space (pp.25-40). Palgrave Macmillan.

Pickering, A. (2016) Art, Science and Experiment. MaHKUscript: Journal of Fine Art Research, 1(1), 1–6.

Pickering, A. (2019). Technologies of Engagement: Cybernetics and the Internet of Things. In French translation as "Techniques de l'engagement: la cybernétique et l'Internet of Things" Zilsel, 5 (Jan 2019). Retrieved from: https://www.researchgate.net/publication/327941338_TECHNOLOGIES_OF_ENGAGEMENT_CYBERNETICS_AND_THE_INTERNET_OF_THINGS

Remme, J. H. Z., & Sillander, K. (Eds.). (2017). Human Nature and Social Life: Perspectives on Extended Sociality. Cambridge University Press.

Rezaev, A. V., Starikov, V. S., & Tregubova, N. D. (2018). Sociological Considerations on Human-Machine Interactions: from Artificial Intelligence to Artificial Sociality. In Proceedings of the International Conference on Industry, Business and Social Sciences (pp. 364-371).

Richardson, K. (2018). Challenging sociality: An anthropology of robots, autism, and attachment. Springer.

Robertson, J. (2007). Robo Sapiens Japanicus: Humanoid Robots and the Posthuman Family. Critical Asian Studies, 39(3), 369-398.

Robertson, J. (2010). Gendering Humanoid Robots: Robo-Sexism in Japan. Body and Society, 16(2), 1-36.

Robertson, J. (2014). Human Rights vs. Robot Rights: Forecasts from Japan. Critical Asian Studies, 46(4), 571-598.

Robertson, J. (2017). Robo Sapiens Japanicus: Robots, Gender, Family, and the Japanese Nation. University of California Press.

Roepstorff, A., & Frith, C. (2012). Neuroanthropology or simply anthropology? Going experimental as method, as object of study, and as research aesthetic. Anthropological Theory, 12(1), 101-111.

Šabanović, S. (2014). Inventing Japan's 'robotics culture': The repeated assembly of science, technology, and culture in social robotics. Social Studies of Science, 44(3), 342-367.

Šabanović, S., & Chang, W. L. (2016). Socializing robots: constructing robotic sociality in the design and use of the assistive robot PARO. AI & Society, 31(4), 537-551.

Seaver, N. (2017). Algorithms as culture: Some tactics for the ethnography of algorithmic systems. Big Data & Society, 4(2). 2053951717738104.

Seaver, N. (2018). What should an anthropology of algorithms do? Cultural anthropology, 33(3), 375-385.

Seibt, J. (2016). Integrative Social Robotics – A new method paradigm to solve the description problem and the regulation problem? In J. Seibt, M. Nørskov, S.S. Andersen (Eds.), What Social Robots Can and Should Do: Proceedings of Robophilosophy 2016 (pp. 104-114). IOS Press.

Seibt, J. (2017). Towards an Ontology of Simulated Social Interaction: Varieties of the "As If" for Robots and Humans. In R. Hakli and J. Seibt (Eds.), Sociality and Normativity for Robots: Philosophical Inquiries into Human-Robot Interactions (pp. 11-40). Springer.

Sismondo, S. (2010). An introduction to science and technology studies. Wiley-Blackwell.

Sone, Y. (2017). Japanese Robot Culture: Performance, Imagination, and Modernity. Palgrave Macmillan US.

Strathern, M. (1996). "The Concept of Society Is Theoretically Obsolete: For the Motion (1)." In T. Ingold (Ed.), Key Debates in Anthropology (pp. 50-55). Routledge.

Suchman, L. (2007). Human-Machine Reconfigurations: Plans and Situated Action, 2nd Edition. Cambridge University Press.

Suchman, L. (2011). Subject objects. Feminist Theory, 12(2), 119-145.

Suchman, L. (2012). Configuration. In C. Lury & N. Wakeford (Eds.), Inventive methods: The happening of the social (pp. 48-60). Routledge.

Tani, J. (2016). Exploring robotic minds: actions, symbols, and consciousness as self-organizing dynamic phenomena. Oxford University Press.

Tsing, A. (2013). "More-than-human sociality: a call for critical description". In K. Hastrup (Ed.), Anthropology and Nature (pp. 37-52). Routledge.

Turkle, S. (2011). Alone Together: Why We Expect More from Technology and Less from Each Other. Basic Books.