Technology and More-Than-Human Design

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As digital technologies such as big data, the internet of things, machine learning, and artificial intelligence increasingly challenge and even disrupt the everyday job of design—not to mention everyday life—there comes a need to raise critical questions about the ways we design.

Design as we currently know it and practice it was born out of the logic of industrial production. Although initially mimicking the form and expression that were characteristic of craft and making by hand, it soon became obvious that making by machine required something else. In places such as the Bauhaus, ideas about a unity of art and technology started to evolve. Over time, design came to develop methods meant to ensure that a product was "right" by working iteratively with prototypes and minimizing the risk of mass replicating faults and shortcomings, and to form an industrial aesthetic celebrating (rather than hiding) what "new" machines and technologies brought to the making of everyday things.

Contemporary technologies of networked computational things and artificial intelligence, as well as the data capitalism they have made possible, differ from the logic of industrial production. Not only that, they fundamentally challenge the conceptual space designers have created to cope with complexity. For instance, with runtime assembly of networked services, constant atomic updates, and agile development processes, the boundary between production and consumption is almost fully dismantled. No longer is the design process something that happens before production; rather, we see a complete intertwining of development and deployment, sometimes as frequent as daily releases. It appears that this characteristic of a constant becoming is going to be further accelerated by technologies that actively "learn" while in use, changing and adapting over time at an even more fundamental level than is currently the case.

As is already evident, not least in the public debate around what to consider a fair and secure use of data, this emerging technological landscape brings up many issues we need to tackle. One of them is that we might be reaching the limits of what our current

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primary framework for design can cope with—that is, the boundaries of what can be conceived within the frames of human- and user-centered design. In what follows, we discuss what happens if human-centered design is unable to effectively give form to this new technology, why this might be the case, and where we could look for alternatives.

The Expanding Universe of Design

As the concept of what is a product evolves and the way it is built changes, design is expanding. As design shifts toward more fluid flows of interaction between people and processes, as well as between people and the systems of things mediating such processes, new logics blur the boundaries of what "industry" or "economy" a product serves.[1] A connected health device like an Apple Watch is not just a product service that helps people track and monitor their diet, for example; it is part of broader processes of preventive care, and it may find itself in a new sector, such as the insurance industry, connected horizontally to products that could never have been connected before. In this expanding universe of design, digital assistants such as Alexa and Google Home, drones that deliver purchases within minutes of placing an order, Ethereum tokens and smart contracts, are autonomous or semi-autonomous entities that increasingly do business with humans and with each other, across previously separate spheres of life[2]—sometimes resulting in societal effects that are either unintended or undesirable in a democratic society.

As already exposed by the tech scandals of the past few years,[3] this poses significant challenges to the field of design. As an expression of this moment of crisis, we have witnessed in recent years a proliferation of design manifestos calling for a shift toward the development of more honest data-driven products and services. As suggested in an extensive review,[4] designers and developers are increasingly writing manifestos to express "frustration and uncertainty" as they struggle to negotiate the possibilities that data technologies offer and the ethical concerns they bring about. While providing potential roadmaps for a better future, these manifestos also "express a deep concern and even fear of the state of the world and the role of technology in it."[5]

In response to this growing anxiety among designers, not to mention the public, companies are growing concerned with how to anticipate the unintended outcomes of the systems they design and rushing to prove their ethics bona fides through lists of principles for a good and more humane technology.[6] The acknowledgment that making data technology more ethical requires adherence to principles of responsible innovation across public and private sectors usually translates into legislative frameworks[7] and methods

1 Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Competition," *Harvard Business Review* 92 (2014): 64–88.

2 Majid Iqbal, *Thinking in Services: Encoding and Expressing Strategy through Design* (Amsterdam: BIS Publishers, 2018).

3 A sample of high-profile scandals that made the headlines in 2017 and 2018 include Uber pricing surges, Facebook affair with Cambridge Analytica, and Amazon algorithmic warehouse management.

4 Ester Fritsch, Irina Shklovski, and Rachel Douglas-Jones, "Calling for a Revolution: An Analysis of IoT Manifestos," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (New York: ACM Press, 2018), Paper No. 302.

5 Fritsch, Shklovski, and Douglas-Jones, "Calling for a Revolution," 1.

6 AI principles and initiatives rolled out by corporations include documents by Google (https://www.blog.google/technology/ai/ai-principles/), Microsoft (https://www.microsoft.com/en-us/ai/our-approach-to-ai), IBM (https://www.ibm.com/blogs/policy/trust-principles/), Intel (https://blogs.intel.com/policy/files/2017/10/Intel-Artificial-Intelligence-Public-Policy-White-Paper-2017.pdf), and Salesforce (https://www.salesforce.org/ai-good-principles-believe/).

7 Cf. General Data Protection Regulation (EU) 2016/679 ("GDPR") for data privacy regulation (https://eugdpr.org/) and the European Commission draft on "Ethics Guidelines for Trustworthy AI" (https://ec.europa.eu/futurium/en/ai-alliance-consultation/guidelines). See also the public-private initiative Partnership on AI (https://www.partnershiponai.org/).

for explicitly incorporating ethical considerations into policy making, business decisions, and everyday design processes.[8] But these outcomes do not tackle the urgent need for a fundamental rethinking of design as practice.

The radical rupture these technologies bring to design is often hidden by making them appear in familiar forms. The smart watch mentioned above is a useful illustration. While nothing like a clock of the past, it still enters into our life in the form of this familiar thing, and we happily wear it as if it were a mechanical wristwatch. Indeed, we still experience these technologies as *things* with a clear presence and tangibility—yet, they are just one element within a system of decentralized interactions that makes them very different from what things used to be like.[9]

So far, we have considered producers and consumers, designers and users to be people—although the boundaries between these roles have been shifting significantly. What is about to happen is that we might have to consider other actors here, next to people. As the Google assistants, Fitbits, and Airbnb algorithms of our future become increasingly sensitive to context, and their design begins to evolve based on what they "learn" through their encounters with the world (us and each other), they will begin to express agency and become active in a way we have never seen before.[10] What futures this might lead to is an open question, but if we intend to make informed choices about what we want to happen and shape this technology towards desirable outcomes, there is now a need to fundamentally reframe the conceptual space of how we design.

Developing design methodologies and tools to unlock data technology for design is necessary but not sufficient. Given what is at stake, we also need to ask more radical questions. In what follows, we begin exploring the idea that maybe we will not design *for* these technologies but *with* them. Taking the idea of machine agency and artificial intelligence seriously, we would like to explore what happens if we think of networked computational things not only as designed artifacts or technological enablers but also in terms of agents in a design space where they actually participate.

It is important to clarify, though. Approaches such as participatory design primarily stem from ideas about democratic processes and fundamental human rights, whereas the notion of participation referred to here has nothing to do with technology acquiring rights or a position in that sense.[11] Rather, it is about the observation that if things "learn," "act," "change," and more, then relating to them as passive tools more or less hides what they are actually capable of. Although thinking about technological things as "participants" in many ways is deeply unsettling—there

8 See AI Now "Algorithmic Accountability Policy Toolkit" (https://ainowinstitute.org/aap-toolkit.pdf), the "Ethical OS Toolkit" (https://ethicalos.org/), and the more general "Ethics for Designers" framework (https://www.ethicsfordesigners.com/tools).

9 Johan Redström and Heather Wiltse, *Changing Things: The Future of Objects in a Digital World* (London: Bloomsbury, 2018).

10 Elisa Giaccardi, Chris Speed, Nazli Cila, and Melissa Caldwell, "Things as Co Ethnographers: Implications of a Thing Perspective for Design and Anthropology," in *Design Anthropological Futures,* eds. Rachel Charlotte Smith, Kasper Tang Vangkilde, Mette Gislev Kjaersgaard, Ton Otto, Joachim Halse, and Thomas Binder (London: Bloomsbury, 2016), 235–48.

11 In this article, the issue of technology and more-than-human design discussed here also differs from another central reason for moving design beyond its human-centered view, that is, that we live together with other species and thus have a responsibility to address matters beyond our own needs and wishes.

are reasons there is no shortage of science fictions telling us stories of technology moving beyond passive obedience—we believe we need this significant shift in perspective to escape existing ways of relating to technology as something that is determined by our intentions only, as we use it. In other words, if we follow the idea of machine agency and artificial intelligence far enough, we have to revisit the idea of human-centered design. Not because humans matter less but because it is no longer exclusively humans that act, design, make use, change, and thus create new possibilities. To explore the futures we might face, we need to inquire into what a more-than-human world might look like, and what happens when technology is not just material but participant.

The Paradox of Human-Centered Design

Today, most of the designing that happens in the industrial and technological sectors rests in some way on a notion of human-centered design. This is not necessarily in the sense that someone's actual needs, desires, dreams, and hopes govern the design process, but in the sense that the things designed are meant to present themselves to their users as primarily "useful" things—as things to be used for a particular purpose.

In other words, even when designing a piece of complex technology, we primarily want to make it appear as a straightforward tool: something standing by to be ready for us when we need it. It may be that this way of relating to the world is so basic to us that we can consider it the very character of what technology is to us—what Martin Heidegger described as a "standing reserve."[12] From a perspective of dealing with complexity, human-centered design (no matter the scale of the design) is conceptually grounded in the relationship between a person and a tool. It is no coincidence that Heidegger's highly influential example is a hammer: it both clearly illustrates the difference between the tool in active use and the tool passively waiting to be used (the hammer doesn't do anything on its own) and powerfully encapsulates an image of use as an extension of human capacity (in the case of the hammer, almost literally an extension of the arm and the hand).

Today we design and use technologies that involve systems and networked components, sometimes with millions of people using them simultaneously. But if we look for central design ideals and the designs that exemplify them, the absolute majority relates to a use scenario wherein the interaction between one person and one device is cardinal. For instance, think of ideas such as the "personal computer," the "user interface," or the tracking of individuals implemented by current services and platforms to know precisely which individual is using them at what moment. When we design

12 Martin Heidegger, "The Question Concerning Technology," in *The Question Concerning Technology and Other Essays* (New York: Harper & Row, 1993).

systems and services, we still tend to place the one-to-one interaction, the sequence of touchpoints a user will encounter and interact with, at the center of how we give form and expression to the design. Even social media is completely based on individual access points, where one person interacts with one touchpoint, such as an app on the personal device.[13] The primary framework of human-centered design implies a perspective on the world in which technology is something "standing by" for us to use according to our own purposes.

It is therefore not particularly surprising that in response to the disruptive impact of algorithmic logic on society, we would see reactions that call for placing the human even more firmly at the center, along with normative frameworks for how data has to be selected and what level of autonomy should be programmed into autonomous devices. Although there certainly is a need for control mechanisms and regulations to safeguard societal needs and values, human-centered design is approaching a paradox as it becomes increasingly difficult to maintain design ideals and forms where the only "real" agency present and experienced in the design situation is the one held by the "user." How can designers effectively care for people and open up futures that can help humans flourish when how things "learn" and "change"—their real actions—are meant to be hidden in favor of a seamless user experience?[14] When designers are not equipped to understand, account for, and anticipate how such things "participate" on their own terms—with their uniquely artificial perspectives and capabilities—in the expanded and decentralized work of design that is engendered by data technology?

Despite this contemporary paradox, humans still hold a central place in the current design research agenda with the tools and methods of user-centered design and participatory design. In this arrangement, the relationship between humans and objects is unidirectional: only humans make things—tools with a clear encoded function. All we need is to study some more and iterate until we get it "right": the right functionality, the best possible user experience, the most effective multistakeholder collaboration.

Emerging Fundamentals of More-Than-Human Design

The perspective of human-centered design implies that the interaction between a person (or multiple people) and a technology forms the basis for how the designed artifact should be presented. As we expand beyond this one-to-one setting, this particular instrumental relation is no longer the only one to consider. A thing has to relate to a number of other things (which it actually already does, it's just that we are typically not meant to see this when we

13 Christoffel Kuenen, "Aesthetics of Being Together" (PhD thesis, Umeå University, 2018).

14 Holly Robbins, "Materializing Technologies: Surfacing Focal Things and Practices with Design" (PhD thesis, Delft University of Technology, 2018).

use it; we don't see the many different connections our smartphone constantly makes, or the many different services it communicates with to share data). It is also evident that a thing's design needs to acknowledge that not all people use it for the same reason (incidentally, this is also already obvious, as the example of how Cambridge Analytica used Facebook clearly illustrates). In other words, instead of optimizing the expression of a one-to-one relationship between a technology and its user(s), a more-than-human centered design will have to be based on how to manage, present, and negotiate many different relations in parallel—without a particular one being privileged above all others.

In unfolding a future in which networked computational things come to expression by being actively implicated in doing the stuff that includes design, we need to start accounting for their worldview, for the set of values, principles, and logics that determine what actions they take based on what data. How do things connect and relate to each other and to us? In how many ecosystems are they virtually imbricated, and with what capacity for responding to human values and aspirations? In this process, humans and nonhumans alike are embodied as full participants. As doing design increasingly becomes a decentralized and probabilistic process that collapses distinctions between design and use, subject and object, producer and produced, design ought to be predicated on what it *might become* as opposed to what it should be.

There is emerging design work focused on nonanthropocentric perspectives and forms of engagement that promote opportunities to encounter the world in ways that were not previously possible.[15] This body of research indicates a growing need for understanding the agency and roles that humans and nonhuman can play in everyday life and the new capacities for action configured at the intersection of humans and nonhumans. But the understanding of what foundations are needed for developing a design research and education program that aesthetically explores and ethically reorients designers toward more-than-human practices of designing in a world informed by algorithmic logic remains largely implicit.

Taking a more-than-human orientation does not detract us from being human or caring for people in approaches to design. But how do we build the foundations of such a new design practice? Let us consider a few key challenges.

From Ethical Know-What to Ethical Know-How

As the overall impact of these new technologies on everyday life becomes increasingly apparent, it has also become obvious that previous frameworks for dealing with ethical issues do not suffice. The range of ethical issues already in view will require all

15 See design work variously concerned with the entanglement and reciprocity of nonhuman actions and human purposes: Laura Devendorf and Kimiko Ryokai, "Being the Machine: Reconfiguring Agency and Control in Hybrid Fabrication," in *Proceedings of the 2015 CHI Conference on Human Factors in Computing Systems* (New York: ACM Press, 2015), 2477–86; Jodi Forlizzi and Carl DiSalvo, "Service Robots in the Domestic Environment: A Study of the Roomba Vacuum in the Home," in *Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction* (New York: ACM Press, 2006), 258–65; Lucian Leahu and Phoebe Sengers, "Freaky: Collaborative Enactments of Emotion," in *Proceedings of the 18th ACM Conference Companion on Computer Supported Cooperative Work* (New York: ACM Press, 2015), 17–20; Alex S. Taylor, "What Lines, Rats, and Sheep Can Tell Us," *Design Issues* 33, no. 3 (Summer 2017): 25–36. See also work concerned with decentering human agency and more-than-human participation in urban contexts: Maria Luce Lupetti, Roy Bendor, and Elisa Giaccardi, "Robot Citizenship: A Design Perspective," *DeSForM 2019: Beyond Intelligence,* Boston, MA, October 9–11, 2019; Carl DiSalvo and Jonathan Lukens "Nonathropocentrism and the Nonhuman in Design: Possibilities for Designing New Forms of Engagement with and through Technology," in *From Social Butterfly to Engaged Citizen: Urban Informatics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement,* ed. Marcus Foth, Laura Forlano, Christine Satchell, and Martin Gibbs (Cambridge, MA: MIT Press, 2011). Particularly with reference to sustainable coexistence with other species, see: Rachel Clarke, Sara Heitlinger, Ann Light, Laura Forlano, Marcus Foth, and Carl DiSalvo, "More-Than-Human Participation: Design for Sustainable Smart City Futures," *Interactions* 26, no. 3 (2019): 60–63; Laura Forlano, "Decentering the Human in the Design of Collaborative Cities," Design Issues 32, no. 3 (Summer 2016): 42–54; Anne Galloway, "Emergent Media Technologies, Speculation, Expectation, and Human/Nonhuman Relations," *Journal of Broadcasting & Electronic Media* 57, no. 1 (2013): 53–65.

our instruments for governing how to live well with technology, including new legal frameworks and revised professional codes of conduct. But design is not just about accountability—design needs to be anticipatory, able to craft desirable relations between people and emerging technologies, and thus proactive in the associated processes of research and development. Developing this capacity represents a fundamental challenge to existing design practice. Certainly, there will still be a need for efficient functionality, rational use of materials, and overall the making of useful and valuable things—but the central relation between ethics and aesthetics is here quite different compared to what it used to be in the industrial age that called design as we know it into being.

The issue of ethics has always been a central concern in design because it has formed the basis for what is considered "good," "useful," and even "beautiful." There are many reasons for this, but of special importance to the present is a deep concern for knowing *what* the thing is, and how it comes to be this thing: *what* priorities to make, *what* properties to look for, what qualities to achieve, and so on and so forth. In this, ethics becomes central because it forms the foundation of such decisions: to design is to make something for someone. We can see it in various ideas, such as the notion that designed artifacts, more than anything, should be useful—because our primary relation to them is not as artworks but as things that help us achieve various tasks (in a very generous sense of the word). We can see it in the idea that artifacts should not try to mimic something they are not—for example, in the concept of honesty about materials and forms of making, which was a strong reaction against the early days of mass production, when things were often made to look as if they were instead made by hand or with different materials than was actually the case (both of which led to poor copies at best). If we look across the ideas that have come to form industrial design as we know it, especially in the technical domains, the aspects that come forth the strongest are ideals such as simplicity, transparency, honesty, and effectiveness; all of these say something about the importance of things telling us what they are and what they can do for us. However, recent attempts to certify the trustworthiness of connected devices as a way to urge companies to use responsible data practices are laudable but locked into old design ideals and ultimately impractical.[16] This is precisely where and why our prevalent ethical orientation in design does not cope well with the situation we are in now.

One reason behind the offset of the previous alignment of ethics-aesthetics is that the current set of issues are no longer "centered" around the user, and thus not around just one set of intentions or ideas about purpose and use. Previous human-centered approaches fail to support us in this situation primarily because

16 The Trustable Technology Mark (https://trustabletech.org/) is a trustmark for the internet of things aimed to empower consumers to make informed decisions. It also enables companies to prove that their connected products are trustworthy.

their focus on the user's intent orients the whole process toward what makes sense to the person using that thing, at that moment. For instance, when it comes to transparency, what is important is that the workings of a machine are presented in a way that is aligned with the intended user behavior. The more complex the machine, the bigger the difference, as in the case of graphical user interfaces based on metaphors that have little or no bearing on how the machine actually operates from a computational point of view. Over time, we have become accustomed to this relation to technology. We don't want to care about how it works; we just want it to work so that we can do *what* we intend to. That we do not or cannot see what a machine is actually doing may or may not be a significant ethical issue—but when it is combined with increasingly advanced and intelligent automation, it is less obvious where to draw the line between which decisions and actions are to be hidden and which ones need human attention. It is becoming increasingly clear that our attitude of not wanting to care about what the thing does has created a substantial blind spot in how we let things into our lives.

But what happens when there is no longer just one user or aspect/purpose of use involved? Consider something like Facebook, for instance. On one hand, it makes itself present as a way of sharing events and experiences with friends online; on the other hand, it presents itself as marketing platform and elsewhere as a tool for gathering enormous amounts of data about people. Unlike our previous everyday things, this is not just one thing but a fluid assemblage[17] that makes itself present as different things to different people. Much of what we now find deeply problematic comes about as a result of the interactions among these different aspects of use: what appeared in one way from one point of view is in fact something quite different from another. If then we add that these assemblages also trade data with each other to adjust, optimize, and evolve, it becomes clear that these interactions between things are indeed the very basis for how they operate.

Taking a step back to look at the overall picture emerging, we can see that the primary ethical-aesthetic dimension related to what things are, and how they come to present themselves as such, is not primarily about functionality in the local sense anymore—it is about the interactions between us and our things, and indeed between our things and other things, without us being aware of the exchanges taking place. While ideas such as honesty and transparency might still apply, we will have to find out how those ideas might apply to knowing *how* to shape, govern, and care for decentralized interactions rather than just knowing *what* local functionalities to look for.

17 Redström and Wiltse, *Changing Things.*

From Delegation to Co-performance

We all agree that things need to be designed so that they can perform next to people—doing the stuff that includes design—in ways that are sensitive and responsive to the human condition, in other words, in the interest of people and the environment. However, ideas of full "transparency," "explainability," and "trustworthiness" of how networked computational things operate and relate assumes a centrality of human agency and intentionality—only humans make and use things and can therefore control them. As we have previously argued though, things make and use things, too, and according to logics and scales that escape human awareness. We then might argue that, for some transparency, explainability, and trustworthiness to be in place, things will need to be designed so they can continue to generate affordance and value in ways that can be negotiated as appropriate under circumstances of use that are always meant to change. In other words, the point of gravity for an ethical uptake of design is not to be located in the delegated functionality of the thing to be used (i.e., the *what* of intended use) but in the *co-performance* of people and things (i.e., the *how* of the relation).[18]

As people and things become mutually compromised in such world-making relationship, designers need a finer understanding of the situated and recursive relations that may occur among the "people who make things," the "things that make other things," and the "things that make people." In the case of Facebook, for example, designers would need to find new handles for people to understand, correlate, and adjust how events and experiences are made and shared (the "people who make things"); how shared events and experiences call attention to other possible events and experiences (the "things that make other things," such as advertisements); and the curatorial algorithms that take over identity (the "things that make people").

In terms of how these things present themselves, things will need to be designed so that their form—how they come to expression to us as a playlist, a set of recommendations, or a navigation route—can change and so can their value in the broader constellation of other things they are connected to. For this, the aesthetics of immanence of networked computational things require dimensions of openness: things need to be designed so that they can become "some-thing else" (e.g., a different route to a familiar place). It requires also dimensions of variety: things need to be designed so they can become "some-thing more" in terms of their value in different contexts of use (e.g., a set of sensors and actuators variously deployed in the home for automation purposes). And of course it requires dimensions of configurability, so that one

18 The notion of co-performance has been introduced in interaction design by Lenneke Kuijer and Elisa Giaccardi to conceptualize how agency is configured in social practice between humans and nonhumans; Lenneke Kuijer and Elisa Giaccardi, "Co-performance: Conceptualizing the Role of Artificial Agency in the Design of Everyday Life," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (New York: ACM Press, 2018), Paper No. 125. This notion has been expanded in Elisa Giaccardi, "Histories and Futures of Research through Design: From Prototypes to Connected Things," *International Journal of Design* 13, no. 3 (2019) and in Elisa Giaccardi, "Casting Things as Partners in Design: Towards a More-Than-Human Design Practice," in *Relating to Things: Design, Technology and the Artificial,* ed. Heather Wiltse (London: Bloomsbury 2020), to consider how connected things participate in design work alongside people—thus moving past the limitations of examining and analytically predicting the practices that are (or will be) performed by autonomous devices after design and allowing us to conceive of and mobilize the artificial performances of things as part of a decentralized design practice that blurs and loops design time and use time.

thing can become "more things" by horizontally connecting to other products and services across a broader ecosystem (e.g., a connected health device being a device for tracking and monitoring what you eat and how much you move and also being a device for preventive care).[19]

From Functionality to Responsiveness

Realigning aesthetics and ethics in relation to the co-performance of networked computational things brings to the fore matters of growing codependencies among humans and nonhumans and calls for a fundamental reconceptualization of design practice.

Because networked computational things are unstable, they need to be designed so they can become and remain appropriate in the interest of people and the environment. But because the locus of design has shifted from the centrality of only humans making things to include things actively present in their doing, designing networked computational things with an ethical orientation today requires understanding how people (designers and users alike) and things (with their own logics and agentive force) are fundamentally "implicated." To paraphrase Karen Barad, things connect and respond to one another—just like people—and in this responsiveness, they are also "response-able."[20] In this sense, if we are to bring aesthetics and ethics together on a new ground, it is not so much the interaction that joins things up into assemblages that matters ("and . . . and . . . and"), but the "contrapuntal relations" ("with . . . with . . . with") that join things with one another and us together with them.[21] Responsibility is then not about locating right response but the ability to respond—in other words, "a matter of inviting, welcoming, and enabling the response of the Other."[22] It is not about functionality (e.g., the fairest machine learning model or the most explainable algorithm); it is about the relations and interactions that enable us to situate, tune, and negotiate those ethical responses and assessments recursively in both design and use.

What might it mean for designers to develop a capacity for response to be shared between decentralized entities—human and nonhuman alike? One way to look at this capacity, and how to design for it, is to consider how things relate (i.e., their "contrapuntal relations," "with . . . with . . . with"). For things that exchange data and connect, affordance and performance are the results of mutual arrangements—that is, how things fulfill the "needs" of other things (including humans). According to Iqbal,[23] a thing's affordance (or "need to be") translates into the possibility/capability for some action to be performed. Similarly, a thing's performance (or "need to have") translates into a possibility/capability for some level of access or relation to other things. Indeed, accord-

19 Moving closer to the issues discussed in this article, design ideals of resourcefulness, openness, and variety have been explored in the Resourceful Ageing project to contest mainstream data-driven design practices and suggest alternative principles and logics for how to design responsibly "with" the internet of things and machine learning algorithms. See Elisa Giaccardi and Iohanna Nicenboim (eds.), *Resourceful Ageing: Empowering Older People to Age Resourcefully with the Internet of Things* (Delft, The Netherlands: Delft University of Technology, 2018). The project has received a Next Generation Internet 2019 Award by the European Commission for outstanding contribution to better digital life.

20 Karen Barad, "On Touching—The Inhuman That Therefore I Am," *Differences: A Journal of Feminist Cultural Studies* 23, no. 3 (2012): 206–23.

21 Tim Ingold, *Correspondences* (Aberdeen, UK: University of Aberdeen Press, 2017).

22 Barad, "On Touching," 81.

23 Iqbal, *Thinking in Services.*

ing to the original definition of James Gibson (1979),[24] affordance is a relational concept, one that concerns the properties of a relation, not those of the object. Performance is to be intended as a relational concept, too, as an expression of relations located at the "improvisatory edge of practice in the moment it is carried out."[25] For example, the ATM needs to verify the bank balance, convert a portion of it into currency notes, and then dispense them from its safe. As a thing, the bank balance "needs to be(come)" currency notes, and in response (for the ATM to enable that performance) the account to which the ATM is connected "needs to have" enough balance.[26] Put simply, to understand how things relate and connect, we ought to understand what they do and want to do (the "with . . . with . . . with").

As things begin to actively create a more complex landscape of affordances, and with a growing degree of autonomy, learning how to design with the internet of things, machine learning, and artificial intelligence for enabling performances in the interest of people and the environment will require broadening our views and balancing human and nonhuman perspectives. Only in this way may design become anticipatory instead of reactive. Instead of waiting for a better understanding of the impact of algorithmic logics on current regulations and for a review of legal frameworks and professional ethics, designers might already move forward by thinking of networked computational things as responsive entities that need to be designed and evaluated against the human values, social norms, nuanced interests, and aspirations of the specific context in which they come to operate and "respond."

New Design Practices

If designing is to make some-thing for some-one, then the possible futures discussed here are likely to bring about design practices quite different from those that emerged as a response to industrialization. With the shift from hand making to machine production, the issue of control became central: first, the loss of it, not making oneself; then, reclaiming it by means of the prototype, through the "thing" governing what to produce. As a result, much of design mastery revolves around making the prototype (including the process behind it), similar to how craft revolves around the unity of the work resulting in the final artifact. While the role of the prototype has changed over time—from being a concrete thing to be replicated to including all sorts of things that allow the design process to proceed and the intended outcome to be anticipated—making prototypes of various degrees of refinement has remained a central skill as a way of finding out what and how to design. As evident from the foregoing discussion, this central role of using

24 James J. Gibson, *The Ecological Approach to Visual Perception* (Boston, MA: Houghton Mifflin, 1979).

25 Edward L. Schieffelin, "Problematizing Performance," in *Ritual, Performance, Media*, ed. Felicia Hughes-Freeland (London: Routledge, 1997), 194–207.

26 Iqbal, *Thinking in Services*.

prototypes for control, whether to govern process or anticipate outcome, is fundamentally changing[27]—and so will some of the core skills of designers.

Understanding what people want or need and making changes to the design to ensure the best possible outcome and user experience are at the core of what is often referred to in current user-centered design practices as "good design." But in a more-than-human world of design and designing, outcomes and experiences are the result of a dynamic interplay between people and networked computational things, as well as between things and other things. There is a relatively higher level of uncertainty in the coming together of all the elements of this more complex and fluid landscape of affordances and performances. Indeed, this coming together is not necessarily something we control and thus prototype in that sense, but something we cultivate, nourish, and feed. If the core skills of prototyping a product were about narrowing down, isolating the key design decisions, and then presenting in material form an outstanding synthesis worthy of mass production, then the ethos of what is now emerging is much more akin to taking care of something[28]—realizing that not one single intention or perspective will be defining but that the overall process and its outcome will depend on how we deal with the diversity arising from complex interactions.

This will require a design practice that discerns and integrates different capabilities, uniquely human and uniquely artificial, into appropriate co-performances and makes explicit and contestable the decisions that are delegated from everyday practice to development practice. Design methods must become apt to understand and repair inappropriate actions by things, anticipate possible consequences, and consider the contextual significance of the data used—overcoming the rupture between design time and use time characteristic of industrial design but no longer effective.

But to effectively counteract the technological determinism currently dominating so many of our narratives, we ultimately need to make the shift from thinking about an inevitable future to being open to a critical and creative conversation about possible futures (in significant plural). To do this, we need to conceptually equip our design theory and methodologies for new alignments, move past the blind spots of human-centered design, and address the expanding universe of algorithms, forms of intelligence, and forms of life that are entering design practice, casting them as partners in a more-than-human design practice.[29]

27 Elisa Giaccardi, "Histories and Futures of Research Through Design: From Prototypes to Connected Things," *International Journal of Design* 13, no. 3 (2019).

28 About emerging notions of living aesthetics, mutualistic care and habitability in biodesign, see Elvin Karana, Bahar Barati, and Elisa Giaccardi, "Living Artefacts: Conceptualizing Livingness as a Material Quality in Everyday Artefacts," *International Journal of Design* (forthcoming).

29 Giaccardi, "Casting Things as Partners in Design: Towards a More-Than-Human Design Practice" (2020).