Interaction Design and Architecture(s) Journal - IxD&A, N.30, 2016, pp. 30-46

Material Practice as a Form of Critique

Julian Stubbe

Department of Sociology, Technische Universität Berlin,
Fraunhoferstr. 33-36, 10587 Berlin, Germany

Abstract. The paper characterizes how material practice becomes a form of critique. Based on a comparison of two presumably distant objects, it delineates how engagement with materiality opposes established forms of knowledge production and representation. One object is a robotic hand, which is made of silicone, and the other object is a media art installation that transforms signals of the Earth's magnetic field into a laser projection. Both objects are not part of a political paradigm; rather, they oppose the state of affairs in a technical domain and evoke thoughts of how technology could be designed differently. The paper delineates three elements of critical material practice: embodiment and imagination instead of linear progress, performance instead of formalized representation, and allegories instead of symbols. These elements stress that material engagement is not only a matter of learning and creating new forms; it also challenges established modes of technoscientific knowledge production and representation.

Keywords: critical making, reflexivity, material practice, media art, robotics

1 Introduction

The aim of this paper is to characterize material practice as a form of critique. It makes an argument from a sociological perspective so as to contribute to the interdisciplinary discussion of "making" within epistemic and aesthetic practice. In particular, the paper addresses how engagement with materialities becomes more than cultural expression or learning. It aims at characterizing how material practice can become an alternative that counteracts established modes of knowledge production. This is how the haptic and behavioral capacities of physical objects are enacted differently than cognitivist forms of knowledge production or formalized modes of scientific representation. Hence, critique is understood here as the questioning and opposing of established forms of knowledge. However, this is not in the sense of critical thinking; rather, critique is a form of critical doing.

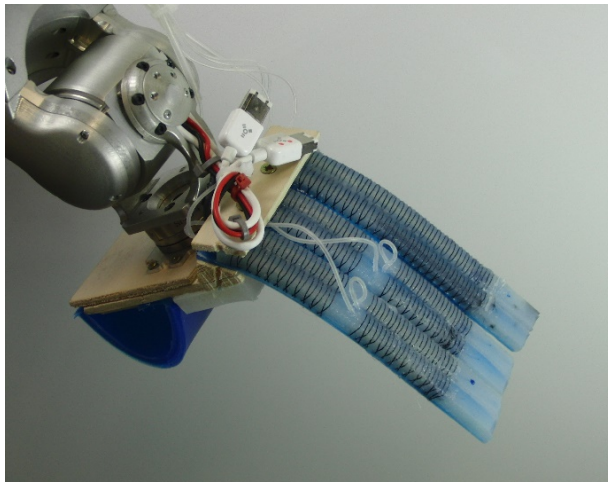

Fig. 1. The RBO Hand (printed under IEEE license).

The intent to address material practice as critique stems from an ethnographic study concerned with the construction of two objects. Both objects have been constructed in very different contexts: one in the scientific context of robotics and the other in media art. As such, they have not been constructed as technologies of Critical Making [1] or Critical Design [2], whose research programs explicitly address making as a normative and political statement. In contrast, both objects do not aim at criticizing society or unjust social effects at large – they stick somewhat to their technical domains.

One object is a robotic hand, which is made of silicone – the RBO Hand (Figure 1). Silicone is not a material commonly used for robotic hands. Most robotic hands are made of solid materials that are electronically steered. More commonly, robotics research is based on standardized hardware that is manufactured by commercial suppliers of scientific infrastructure. In contrast, the RBO Hand is a hardware-driven project that seeks to make use of the unusual characteristics of silicone for robotic grasping. The research aim of designing such a hand was to create a robust robotic grasp that would comply with an item's shape without detailed sensory information. The Hand's development is one current research challenge for a robotics institute; it is mainly being constructed by Raphael Deimel and supervised by the institute's director, Prof. Dr. Oliver Brock [3].

The other object is a media art installation, *Mirage*. To investigate it, I visited an artist's studio and accompanied the artist during his creative process (Figure 2). The installation is an image-generating apparatus that transforms signals from the Earth's magnetic field into a moving laser projection. Its technical structure is complex and consists of different mechanical and electronic elements that are connected to create a distinct kind of physical behavior. All the elements are open and not hidden in casings. Although one can see the elements moving, their complexity makes the exact workings opaque, and one cannot tell how the projection will move next. *Mirage* is one of several installations by the artist Ralf Baecker that render visible technical

processes that usually remain hidden in scientific machinery, as well as in our everyday lifeworld [4].

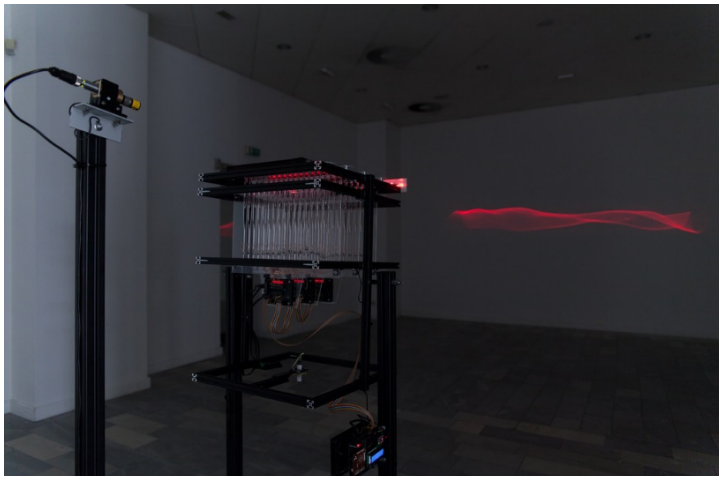

Fig. 2. *Mirage* (printed with permission from Ralf Baecker).

Over the course of approximately two years, I encountered both objects' developments through various situations. I visited experiments in the studio and laboratory, followed mundane tinkering practices, recurrently conducted interviews, went to robotics conferences and art exhibitions, and analyzed discursive documents such as research papers and exhibition catalogs. In sum, the data of my study comprises approximately 20 month of ethnographic observation, 15 interviews, and a body of 20 documents.

On the surface, both objects are very unalike: the RBO Hand is a scientific object, whereas *Mirage* is a piece of art. Furthermore, their outer appearances as well as their technical means of functioning do not have much in common. However, both objects' constructions share a similarity that makes their critical capacity a pressing issue. The RBO Hand and *Mirage* share the enactment of material characteristics in a way that is distinguishable from the state of affairs in their technical domain. This is how both objects create a distinct kind of physical behavior in contrast to formalized modes of knowledge representation, like schematic models, graphs, simulations, or mathematical rules and formulas: those abstract sign systems that are distant from the reality they claim to represent. In what follows, I have compared selected incidents from my fieldwork so as to delineate how engagement with materialities does not stabilize a particular set of knowledge, but, on the contrary, destabilizes ways of producing knowledge, and, furthermore, how that knowledge becomes intelligible and meaningful to others. My main question is: How does turning back to the groundedness of material practice become a form of critique in opposition to formalized modes of knowledge representation?

In what follows, I have first addressed the issue of material practice and critique from a theoretical perspective. I have argued that neither fundamental theories of material practice nor interdisciplinary studies of making address the above question sufficiently. On the one hand, scholars concerned with fundamental processes of

material practice have not capture how engaging with materialities becomes an oppositional stance, whereas, on the other hand, reflections on the critical capacity of design are limited to critical approaches *per se* and do not capture how knowledge representations change through material engagement. The paper's main part consists of three elements that characterize critical material practice: embodiment and imagination instead of linear progress, performance instead of formalized representation, and allegories instead of symbols. I have delineated all three elements by closely comparing the RBO Hand's and *Mirage*'s construction and diverse enactments, whereas I have drawn on additional cases for the third element. I have closed the paper by elaborating upon what we can learn from these cases for the interdisciplinary discussion on making.

2 Material Practice and Critique

Fieldwork does not entirely inspire one to pick up the issue of critique. Making is not only a hot issue in public discourse, but also a pressing matter for academic reflections upon it. Whereas scholars in disciplines like anthropology or sociology deal with the fundamental processes of engaging with materiality, interdisciplinary scholars across design and science and technology studies have proclaimed that making can become a form of societal critique. In the following, I have argued that studies on fundamental processes of engaging with materiality do not capture the statement character that material objects gain when they are constructed in opposition to an established discourse. Interdisciplinary research programs do not capture the specific character of critical material objects and their representations when they are not part of a critical design paradigm *per se*.

Scholars dealing with the fundamental processes of human engagement with materiality have focused on how human subjectivity and embodied interaction with materialities are interrelated. For instance, anthropologist Tim Ingold has focused on making as a particular way of "knowing from the inside" [5]. Ingold, from his experience of an interdisciplinary course consisting of anthropologists, archeologists, artists, and architects, has spoken about how material engagement transforms intellectual appropriations of the world. Through actively doing things, like creating a piece of art as an anthropologist, one achieves a position *within* the world instead of studying it from the outside as a mere theorist. This kind of learning aims not so much at providing facts *about* the world; rather, it enables one to be taught *by* it and learn from the experience of engaging with its physical qualities. In this regard, Ingold regards not only art and architecture as craft, but also his own anthropological work, which actively participates in the material transformation of the world that he seeks to understand. Material practice is a particular way of learning in opposition to cognitivist approaches that separate theoretical and practical epistemologies. Similarly, Richard Sennett has argued from his pragmatist perspective that material practice is part of the human condition [6]. His tradition of thought is rooted in an understanding of human cognition as bodily and materially constituted. Materiality, the body, and interacting with one's environment are integral parts of developing consciousness and identity [7], as well as constituting principles of scientific

reasoning and artistic expression [8, 9]. In this vein, Sennett has argued that thinking and feeling are contained within the process of making. As such, making does not oppose intellectual thought; on the contrary, material and bodily engagement are part of experiencing the world, and, as such, they condition processes of learning and classification [10]. Hence, so Sennett, studying technologies and their cultural meaning must start earlier than considering how it is applied and take the principals of making into account. This strain of thought, which is concerned with the fundamental processes of material practice, is of pivotal concern for the study of making, as it rejects the dualism of the body and mind. However, it does not acknowledge the cultural meaning of material objects when they are constructed in opposition to established modes of knowledge production and representation, particularly in a postmodern context.

In contrast, interdisciplinary approaches, feeding from design as well as science and technology studies, are working with the critical capacity of making and design [11–13]. Their concern with critique stems from reflections upon established modes of technoscientific knowledge production. Philip Agre, for instance, argued that artificial intelligence research has little critical capacity as such, but could benefit from a more critical engagement with the assumption it takes for granted. Nevertheless, speaking from his own socialization, he stated that critical engagement leads to a double identity, with one foot in the technical design work and the other foot in critical reflections upon it, informed by social science [14]. Phoebe Sengers and her colleagues argued in a similar vein that reflections upon blind spots in the design of human computer interaction could open new means of development and bringing technologies closer to people's lives [15]. Such arguments stress that designers should add reflective loops into their work in order to become more self-aware about what values and norms they inscribe into technology. Research programs such as Critical Making or Critical Design take a somewhat different route, as they have proclaimed that engagement with the materialities of technology change how we think of technology. As such, material practice has the capacity to engage critically in societal discourses, as it practically shows that things could be different [16, 17]. Matt Ratto and his colleagues have stressed that arguments that reduce all of science and technology to semiotics seem to lack the power to provide substantive critique [12]. In contrast, their research program has aimed to develop new knowledge as well as social communities and institutions by combining representational work of signs and meaning with the material craft of development and design. Informed by the heuristics of science and technology studies, they have integrated the practical doing of technology with reflections upon it. Nevertheless, the reflections about how material practice becomes a form of critique are limited to those cases that *per se* address problematic societal issues. For example, they report on "tactical media" projects that attempt to destabilize gender roles through manipulated Barbie dolls that reply with hyper-masculine phrases taken from an automated GI Joe doll. Whereas this is certainly a highly progressive endeavor concerning its societal impact, the theoretical reflections have not captured how knowledge representations change when material objects become epistemic agents in their own right.

In what follows, I have aimed at characterizing how material practice is not just a matter of subjective learning, as has been the focus of fundamental theories. I have also focused on how engagement with materialities changes established modes of

knowledge production and representation. In contrast to interdisciplinary approaches on reflective or critical making, I have delineated such critical material practice without drawing on cases from political paradigms *per se* so as to understand how critical knowledge is fostered through deeply engaging with a technical domain.

To capture these facets of material practice, one has to characterize objects in their specific epistemic context as well as the cultural references that signify those objects. I propose using the notion of "aesthetic reflexivity" in order to understand how material objects become a form of critical engagement with technology. Sociologists Scott Lash and John Urry developed the notion of aesthetic reflexivity so as to distinguish cognitivist modes of reflexivity from those based on experience and hermeneutical interpretation. They criticized, for instance, sociologist Anthony Giddens for the hidden cognitivism that underlies his central notion of reflexivity as societal monitoring. According to Lash and Urry, Giddens' understanding of reflexivity conceals the aesthetic dimension of reflexivity, which increasingly signifies the expressive dimension of the modern self, whose sources are signs and allegories instead of information and knowledge. This furthermore entails a misconception of the body, which is not merely a monitored object, but rather a reflexive agent in itself. In this regard, Lash and Urry proposed switching from self-monitoring to self-*interpretation*, which is rooted in hermeneutics [18]. They have emphasized the interpretative character of processing the sense of information instead of simply feeding information back into practice in the sense of a cybernetic causality. As such, their concept brings individual actors and materiality into the discussion of reflexivity; in addition, aesthetic reflexivity stresses social order and consequence, because it regards aesthetics as an integral element of producing order. The pivotal elements of aesthetic reflexivity are embodiment and allegories, and the cultural role of both in late modernity. Both elements have allowed Lash and Urry to pose the diagnosis that aesthetics have become increasingly important in postmodern cultures.

3 Three Elements of Critical Material Practice

In the following, I have used the two elements embodiment and allegories, which Lash und Urry consider central to aesthetic reflexivity, as a heuristic for comparing the RBO Hand and *Mirage*. Unlike Lash and Urry's proposal, I split embodiment into two elements so as to distinguish embodiment as a critical form of knowledge production from performance as a critical form of knowledge representation. Hence, I regard critical material practice as signified by the following three elements: embodiment and imagination instead of linear progress, performance instead of formalized representation, and allegories instead of symbols. Each section is introduced by theoretical remarks.

3.1 Embodiment and Imagination Instead of Linear Progress

The first element of critical material practice refers to the material embodiment of objects. In the following, I have shown that this is not arbitrary, but a specific

epistemic stance that favors exploration and deviation in opposition to sticking to the common path of technological development. My claim is that embodiment and imagination becomes a form of critique when it enables a different way of reasoning than established modes of knowledge production.

For Lash and Urry, embodiment is a central element of aesthetic reflexivity, as they have explained concerning the epistemic role of the human body. The role of the human body in aesthetic reflexivity is particularly different from cognitive modes of reflexivity. Lash and Urry have criticized Giddens—who considers the increasingly individuated body in late modernity—for such hidden cognitivism. Giddens has focused on how the body turns into an object when actors engage with its outer appearance and monitor its physical state. However, this view reiterates a subject-object dualism, says Lash and Urry's critique, which is deemed inappropriate, as the body itself becomes an agent of reflexivity. They have drawn on Marcel Mauss to put forward the argument that bodies are not merely mastered by a cognitive self, but rather, the body makes up the conscious and unconscious mind and constitutes practical forms of reasoning [19]. For Mauss, the body is man's first and most natural instrument. In this vein, their understanding of reflexivity gains an experiential notion in which the body constitutes the very process of knowledge creation.

The RBO Hand's material embodiment fosters this kind of reasoning, which is particularly significant in contrast to established forms of robotics research. In general, robotics is a discipline between science and engineering. Still, the relation between formalized theory and the dirty work of building technologies is ambivalent in robotics. When I spoke with the director of the robotics institute, Oliver Brock, he stressed this ambivalence and laid down his view on progress in robotics and the role of theory building. When asked about the role of mathematical formalization, which is integral to the scientific culture of robotics, he answered with a figure. He said that, for him, robotics research is comparable to the practice of "alchemists." Alchemists used to throw together all kinds of ingredients in hopes of gold. Although, nowadays, their practice has a much more mystical than scientific appeal, they still laid important stepping-stones for modern chemistry. Concerning the RBO Hand, Raphael Deimel, who actually built the Hand, illustrated this approach by explaining, "Basically, we want to create another kind of communication of the Hand." This entails applying only a simple signal, such as inflating/deflating, so as to create complex grasping movements by exploiting the characteristics of the silicone and its interactive compliance with the surrounding environment. Brock's and Deimel's explanations illustrate their stance concerning scientific practice. They claim that procedures should be explorative and create physical behavior. In that sense, building the objects one seeks to investigate and testing an idea in its material form is an epistemic approach that is significant to the work of this project and not given. In this material approach, embodiment constitutes the creation of new knowledge. The step makes theories and concepts possible, not the other way around.

When asked about the idea for *Mirage*, Baecker answered with a "dream story." He told me, "My art surely is conceptual, but it is not concept art with a political statement or so." He gets his ideas from his inquiries into forgotten technologies, mechanical apparatuses, and their combination with contemporary digital technologies. "Sometimes I have a mechanical idea, and then everything comes together," he said. For *Mirage*, he drew on an idea he had been carrying around for a

while. “I wanted to build a machine that hallucinates,” he recapped. Baecker’s figure refers to artificial neural networks whose algorithmic learning is based on a wake-sleep metaphor [20]. Instead of asking how algorithms learn, he re-figured the established notion of artificial intelligence, and asked, “What would their ‘dreams’ look like?” Unlike sleeping or learning, dreams and hallucinations are related to pictures and images created through or within activity. Dreaming and hallucinating are both activities through which images evolve that the mind producing and perceiving them cannot control. Both terms implicate generating images without controlling them. This indicates an interesting tension for an image-generating machine. It indicates that the image that is produced is not a controlled artistic act, but a visual technical process that happens beyond human control and is caused by complex interactions among heterogonous agencies, such as the Earth’s magnetism and digital algorithms. Baecker further described the visual image produced through such contingent technological processes as a “synthesized landscape.” This figure is distinguishable and significant in its reference to a peculiar origin within the hidden life of the machine. In that sense, the “dream” figure connects *Mirage*’s visual aesthetics with a figurative account of a machine’s hidden agencies. Crucial to Baecker’s story is that he has rejected simply programming such a particular kind of algorithm and run a simulation that graphically renders the algorithm via a screen, which would be technically feasible for him. In contrast, he has sought to build the apparatus that embodies the transforming capacity of technical agencies.

Embodied and aesthetic forms of reasoning resonate in Brock and Deimel’s as well as Baecker’s engagement with technology. Both projects employ sensual and interpretative forms of reasoning through their engagement with technological hardware. Embodiment is not a matter of medium in their practice, in the sense of a concept that is inscribed and transmitted through an artifact. Rather, the material qualities of the artifact are engaged in how concepts come about. Nevertheless, both approaches entail an imaginary and figurative element. All the actors refer to larger spheres of meaning when they explain what they are doing. Their objects are not technologies that simply solve the problem at hand; rather, their objects seek to destabilize what is taken for granted in their technical domain. They connect material behavior to imaginary accounts of technologies instead of referring to an instrumental application to explain why all this makes sense. This turn toward embodiment and imagination is a form of critique that allows new forms of aesthetic reasoning, as it counteracts linear technical progress, which simply follows the dominant path.

3.2 Performance Instead of Formalized Representation

The first element of critical material practice leads to the second element that follows, which stresses the specific mode of enacting the significance of an embodied object. This takes the objects into the public, where the differentiating nature of material objects becomes intelligible and meaningful to others.

The issue is a consequence of the embodied nature of both objects. Lash and Urry have explained that the body is an instrument and, hence, a reflexive agent in its own right. This is stressed above, and I have argued that the embodiment of objects marks a critical stance in opposition to formalized abstraction and simulation. However,

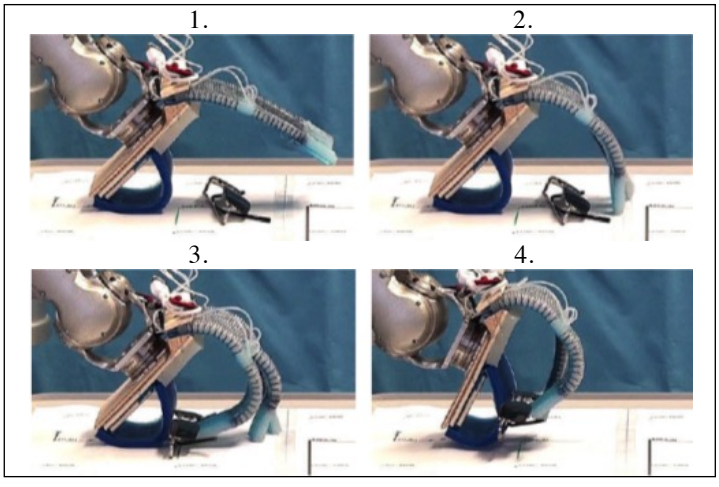

Fig. 3. The RBO Hand performing a surface constrained grasp [25] (printed under IEEE license).

what replaces the established modes of representation in critical material practice? Lash and Urry have argued that aesthetic reasoning is an immediate and physically bounded practice, in opposition to the processing of abstract symbols, which "empty out" categories through their mediated forms of engagement. Lash and Urry have drawn a parallel to engagement with objects and classifications. They have stressed that the hermeneutic tradition they have built on does not engage in legislating or explaining unmediated universals, but in interpreting and understanding the particularity and groundedness of experience. Based on Emile Durkheim and Mauss, they have stressed that all types of classifications and representation are social in nature [21]. As such, classifications and categories are based on experience within a particular lifeworld. They have accused the formalized abstraction of modern science of eliminating the basic premises of categories, which they see in social organization and not in universal principles. Lash and Urry have put forward the argument that modes of classification and representation might as well be of an aesthetic nature when reasoning engages senses, feelings, and interpretation.

The RBO Hand is a technology that contributes to the scientific community of robotic grasping. Within the scientific community, robotic hands are evaluated regarding their performance in grasping items. There are canonized theories about desirable grasps and means of distinguishing between types of robotic grasping [5]. The most desirable robotic grasp is one that maintains control in the face of unknown disturbing forces. "Grasp maintenance" means that the contact forces applied by the hand prevent contact separation and unwanted contact sliding. There are two main types of closure for robotic hands to establish maintained closure: (a) *Form closure* occurs when the palm and fingers wrap around the object, forming a cage with no wriggle room, and (b) *force closure* is a grasp that holds a pen in its fingertips so as to write. These types of closure can be modelled according to a hand's technical specificities. Hence, there are idealized models of grasping allocations for a particular

hand, which makes the grasping performance of common robotic hands comparable [23].

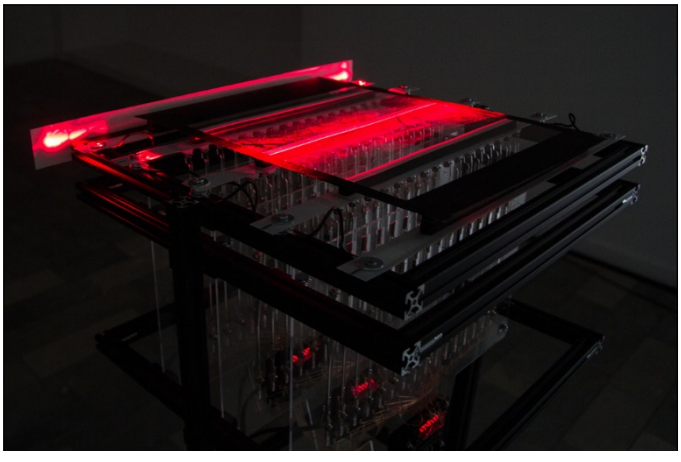

Fig. 4. *Mirage*'s moving mirror foil, actuated by 48 muscle wires. The laser light is reflected from the mirror foil onto the wall (printed with permission from Ralf Baecker).

In their second published research paper, Deimel and Brock explicitly addressed the modeling of the RBO Hand's grasping as difficult due to the nonlinearities of compliant grasping and the large number of degrees of freedom in the actuators [24]. In an interview, Brock emphasized that this had caused difficulties regarding how colleagues perceived the Hand. However, for him, progress was a matter of what a hand could do and not what grasping models a hand realized. The presentation of the grasping results of the RBO Hand somewhat reflects this opinion. All the papers include several pictures of the Hand grasping different items, like a paper cup, tape dispenser, or bottle. The pictures refer to the Hand's capacity to grasp heterogeneous shapes due to its compliant behavior. In contrast, grasp models are described in schematics [23]. By referring to their experiments, Deimel and Brock addressed the RBO Hand's distinct kind of grasping performance, which is based on a form/force closure mix. The significance of the Hand's grasping is in how it makes use of the table in order to pick the item up. In Figure 3, the Hand picks up a pair of sunglasses positioned on a table. The Hand approaches from above, and the grasp is described in four steps: (1) contacting the surface, (2) caging the object, (3) contacting the object, and (4) pitching to lift [25]. The softness of the Hand's silicone material makes the sliding movement possible, as it adapts to the resistance of the table. Instead of sensing its exact position in relation to the table's surface, it simply slides over it without damaging itself, the table, or the sunglasses. Whereas sensor-based grasps regulate their grasping force through data feedback and search for an ideal grasping allocation, the RBO Hand does not need this loop, as the silicone regulates the force of the air pressure by deforming its body according to the sunglasses' shape. This distinct type of grasping is significant in its visual performance instead of in an ideal allocation in a canonized model for robotic grasping.

Mirage's output is a moving image: It is the reflected light of the cross-line laser diode that is projected onto the mirror foil and, from there, toward the wall. The

muscle wire actuates the foil, which makes the reflection move as the light adapts its beam to the continuously changing surface (Figure 4). The laser light is red and produces a focused reflection that does not lighten the dark room, but remains at the wall. Whereas I have discussed the RBO Hand's output in contrast to established grasping in robotics research, *Mirage*'s output does not oppose the established categories that correspond with shared evaluation criteria. Certainly, *Mirage*'s output is described in words, too, but figures like "hallucination" are associative references to its aesthetics and not categories with which its output is evaluated. No classifications such as successful/unsuccessful reflect upon the quality of *Mirage*'s technology.

Nevertheless, more interesting at this point is the installation's open architecture. *Mirage* lays bare the assemblage of its heterogeneous components: the analogue fluxgate magnetometer, circuit boards with microprocessors, the muscle wires that actuate the moving mirror foil, as well as all the springs, screws, and metal parts that keep the components together. Spectators can see how these elements are connected and how they move: the rapidly changing numbers of the algorithm, the muscle wires pulling down the mirror foil, and the foil reflecting the laser light. The complex interactions of all the elements create the silently moving image on the wall. Still, one cannot exactly tell what causes a particular movement or what happens next—*Mirage*'s complexity creates opacity. The peculiar tension between visible components and contingent output is significant in *Mirage*. Baecker told me that his installation should render visible the inner life of its technology. Scientific images created, for example, by telescopes or scanners, are increasingly distant from the reality they claim to represent. Technology is not a naïve medium, but always alienates reality, as it singles out certain phenomena and translates energy into signals. These processes are commonly hidden and black-boxed, particularly when technologies become more complex. In contrast, *Mirage* is open; you can see the elements moving and the laser light slightly touching the mirror foil. As such, *Mirage* performs the technical rendering of an image instead of claiming that its created image is a representation of the Earth's magnetic field.

The point I want to make here is that both technologies are not a matter of stabilizing canonized and formal representations like models or scientific graphs; rather, performing the technology's distinct behavior destabilizes formalized scientific abstraction and the technoscientific sense of representing the world. Instead of re-producing representations, the RBO Hand and *Mirage* perform the increasingly vanishing groundedness of formalized knowledge. Counteracting formalized representations, they perform the disruptive, creative, and critical capacity of engaging with materiality and, as such, criticize devout beliefs in technoscientific representations of knowledge.

3.3 Allegories Instead of Symbols

With the third element of critical material practice, the focus is shifted toward the meaning of objects. Whereas I focused on material embodiment and the distinct efficacy of both objects in the preceding sections, the main issue in the following section is how both objects relate to larger spheres of meaning. The element follows

up on the performative character of both objects, but shows off the limits of disrupting established categories, as well as what signifies the capacity of making objects in critical opposition to technoscientific symbols of progress. I have drawn on two more examples to illustrate this element of critical material practice.

Lash and Urry have claimed that aesthetic reflexivity is signified by a particular mode of meaning-making, which they have seen in allegories instead of symbolic meaning. In claiming that allegories are increasingly important as sources of the self, they have drawn on, in particular, Charles Taylor's account of making the modern identity [26]. The central concern of that discussion relates to the difference between symbol and allegory, which has been the subject matter of philosophical debates since the 18th century. Whereas the symbol is a sign in which form and content unite, the allegory is a sign that calls the unity of form and content into question. In their common semiotic meaning, symbols are signs that resemble or directly connect to the denoted object. This connection is maintained through habits or through sets of associations that ensure its particular interpretation. In contrast, allegories separate form and content; they break with the notion of expressive unity. Allegories transport meaning, but do not represent an idea or object. In this regard, they require interpretation and re-contextualization to be made sense of. One of the most famous allegories is Plato's "Allegory of the Cave." In contrast to Taylor, Lash and Urry have stressed that allegories increasingly fuel late modernity's sense of morality and ethics. This does not mean that symbol and allegory cannot co-exist. The symbol retains an expressivist and romantic tradition, like the call to nature of the Green movement in the 1970s with its utopian symbolism. In contrast, the allegorical mode is more impulsive, anarchistic, and connected to urbanism, globalization, complexity, and heterotopian imaginaries.

Robotics is a field with a dominantly symbolic mode. This is demonstrated in the human as an ideal as well as in how robots represent the humanoid imaginary [27, 28]. Although the RBO Hand embodies a critical stance to the robotic canon, signifying the Hand within the robotics community requires referring to established figures. This established figure is the "human hand," which is considered as the ideal hand and, as such, a role model for robotic hands [29, 30]. Concerning the RBO Hand, referring to the human hand is somewhat of a surprise, because the Hand does not have a classical anthropomorphic design. Nevertheless, at a robotic conference, Deimel opened his talk by showing several video sequences of a human hand grasping a sponge on a table. He clicked back and forth and explained in detail how the human hand grasps the sponge by sliding its fingertips over the table. In so doing, Deimel focused on selected aspects of human grasping and enacted these as desirable and more appropriate for robotic grasping. He went on and used these separated aspects as references to claim that his RBO Hand embodied a similar kind of grasping. Such accounts of the human hand as ideal are typical of robotic grasping research. Even when a technical design follows a minimalist instead of an anthropomorphic approach, the "human hand" remains a symbol of the ideal hand.

The symbolic mode of robotics does not claim that robotic and human capacities match, but that the human hand and desired capacities are one. What the human is can be figured rather differently in robotics and can entail aspects of human embodiment, sociability, and emotions, which are differently reiterated in robotics and artificial intelligence research [27]. The human-likeness, or the "almost human," is a signifier

of the humanoid imaginary in this regard, as robots are repetitively enacted as technologies in the making whose promises always exceed their actual capacities [28]. In this regard, questions of symbols are not so much about how close the robot and the human are, but about how robots represent human-likeness. In this regard, anthropologist Lucy Suchman has critically denoted that she is less worried about "that robotic visions will be realized […] than that the discourses and imaginaries that inspire them will retrench, rather than challenge and hold open for contest, received

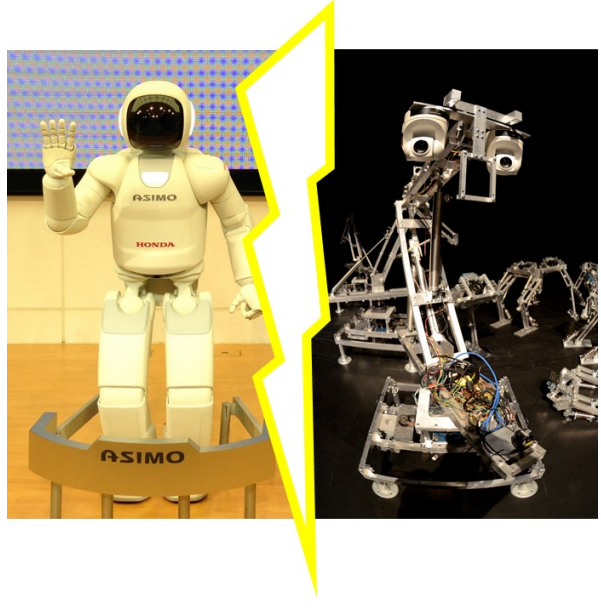

Fig. 5. *What is the difference?* On the left, ASIMO, illustrating the symbolic mode of robotics (my own picture), and on the right, DSM-VI, an example of allegorical meaning (printed with permission from Bill Vorn).

conceptions of humanness" [27]. Exemplary of this concern is the public presentation of ASIMO, one of the most famous humanoid robots, developed by Honda (Figure 5, left side).[1] ASIMO holds regular public showcases at a Honda presentation center in Tokyo. The showcase is a scripted performance of ASIMO's capacities. The robot enters the neatly polished stage accompanied by several hostesses. The stage is immaculate, as, apparently, the robot has sensory problems when the environment is too dusty. The choreography involves the performance of ASIMO's walking and running capacities as well as its ability to dance. The robot appears somewhat handicapped, as its movements are unnaturally precise and somewhat stiff and jerky. At the end of the performance, children have the opportunity to get their picture taken with the robot, for which ASIMO waves into the audience. The point I want to make

[1] Based on my own empirical observations in Tokyo, 2013.

is that ASIMO embodies the humanoid imaginary, not in the sense of equaling human capacities, but as a symbol of technological progress and human-likeness, which it performs through somewhat funny conduct. In this sense, there is no gap between the robot and the humanoid imaginary that narrates its significance.

The more reflexive and critical character of allegorical meaning is shown in Baecker's approach to technology. If one considers his general artistic interest, Baecker's art has a pivotal allegorical element, that is, how he implements technological hardware in order to render visible the technical construction of scientific knowledge. Concerning *Mirage*, I have already addressed parts of this issue, as I have stressed that its performative character opposes the black-boxing of scientific image production. There are several others of Baecker's installations with similar ambitions. For instance, there is his installation *Rechnender Raum*, for which Baecker assembled a large wooden frame, a mesh of strings, mechanical pulleys, and electric motors. The assemblage renders visible the contingency created through increasingly complex connections between technically primitive elements. In a similar vein, *Mirage* is not a representation of the Earth's magnetic field; rather, the complete technical apparatus marks the technical production of scientific images that capture otherwise hidden processes. The figure of a hallucinating machine exaggerates this notion as it counteracts machinic behavior with an unconscious, irrational, and uncontrollable aspect of human life. In this sense, *Mirage* is an installation that marks exactly the technical mediation between the particular (magnetic field) and the general (its image).

Bill Vorn's robotic art is another example of such allegorical meaning, which contrasts the symbolic enactment of humanoids in robotics [31]. In his continuously running project "Robography," Vorn creates robotic creatures that enter into wild and anarchic forms of interaction. One installation is DSM-VI (Figure 5, right side), a robot that expresses "symptoms of 'abnormal' psychological behaviors." The installation's title refers to a scientific document of modern psychiatry: the *Diagnostic and Statistical Manual of Mental Disorders*. Actually, the volume's fifth edition was released in 2013. Hence, the artist has proposed a subsequent sixth edition that is concerned with the "the misery of the machines." This project refigures the notion of the human as an ideal by rendering misery and disease instead of sociability and friendly emotions, which are common features of the human figure in robotics. In so doing, DSM-VI points its finger right at the gap that ASIMO conceals: that between the particular of material technology and the ideal of technoscientific progress.

The meaning of allegories is not intuitive. Whereas ASIMO is fun because kids can recognize it as a humanlike, friendly machine, *Rechnender Raum* and DSM-VI are disruptive and require interpretation. Their aesthetic reflexivity is in how their technologies render visible and simultaneously counteract established borders between art and science, human and technology, and the artifact and the imaginary. Technologies are aesthetically reflexive when they render visible the social and technical construction of institutionalized modes of representation and foster critical engagement with a technoscientific sense of progress and innovation.

4 Conclusions

What can we learn from this comparison regarding the critical capacity of making in general? I have argued that fundamental theories of human engagement with materiality focus on subjective learning, whereas interdisciplinary approaches only capture cases of societal or political critique and, furthermore, do not capture how knowledge representations change through deeply engaging with technology. The delineation of the RBO Hand's and *Mirage*'s multiple enactments, in contrast, shows how engagement with technology becomes a form of critique within a particular technical domain, when objects become reflexive agents in their own right. Drawing on the notion of "aesthetic reflexivity," I have delineated three elements of such critique: embodiment and imagination instead of linear progress, performance instead of formalized representation, and allegories instead of symbols. These elements are a general heuristic for understanding better how material objects are an integral part of social order and, more central here, how they are engaged in re-configuring the order that is taken for granted. As such, the delineated elements are not limited to the two cases presented here and their particular domain; they are of significance for making and reflections upon material practice in general. The elements stress, for instance that makers should consider how their practice entails attributing technologies with meaning and how making fosters new modes of representation. They capture how critique is not necessarily a societal or political statement; they emphasize how creating objects and experiencing the physical quality of objects' behavior is a matter of evoking thoughts of how things, and, in particular, technologies, can be different.

Whereas the close comparison of the RBO Hand and *Mirage* has highlighted that critical practices in science and art share strong similarities due to the material character of objects, differences remain in how sense-making involves re-figuration. In particular, the last element of critical material practice, allegories instead of symbols, shows the limits of critique in specific domains. Critique is unlikely to become a beneficial contribution when it opposes the state of affairs in all technical as well as semiotic regards. People still need to be able to connect to what is new and different about an object to make sense of its opposing character. As such, robotics and media art are different, in the sense that aesthetic reflexivity might be more dominant in art than in science. However, the RBO Hand and its modes of enacting its distinct materialities shows that objects of science are also signified through the affective appeal of experience and efficacy and not only through "emptied-out" abstraction. Critical material practice, in this regard, opposes indulging in an image of technoscientific progress; it is a matter of experiencing and relating to the heterogeneity of imaginaries, literacies, and materialities that are bent, torn apart, whirled, and re-articulated through technological objects.

5 References

1. Ratto M.: Critical Making: Conceptual and Material Studies in Technology and Social Life, The Information Society, 27, pp. 252–260 (2011)
2. Dunne A., Raby F.: Design Noir. The Secret Life of Electronic Objects, Birkhäuser, Basel,

Boston, Berlin, (2001)
3. The Robotics and Biology Laboratory, Techniche Universität Berlin, http://www.robotics.tu-berlin.de/
4. Ralf Baecker's website, http://www.rlfbckr.org/
5. Ingold T.: Making. Anthropology, Archaeology, Art and Architecture, Routledge, New York, (2013)
6. Sennett R.: The Craftsman, Yale University Press, New Haven, London, (2008)
7. Mead G.H.: Mind, Self, and Society. From the Standpoint of a Social Behaviorist, The University of Chicago Press, Chicago and London, (1967)
8. Dewey J.: Logic. The Theory of Inquiry, Henry Holt and Company, New York, (1938)
9. Dewey J.: Art as Experience, Perigee Books, New York, (1980)
10. Lévi-Strauss C.: The Savage Mind, Weidenfeld and Nicolson Ltd., London, (1966)
11. Garcia D., Grootveld M., Lovink G.: The ABC of tactical media, http://waag.org/nl/project/tactical-media-network
12. Ratto M., Wylie S.A., Jalbert K.: Introduction to the Special Forum on Critical Making as Research Program, The Information Society, 30, pp. 85–95 (2014)
13. Oudshoorn N., Rommes E., Stienstra M.: Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies, Science Technology and Human Values, 29, pp. 30–63 (2004)
14. Agre P.E.: Toward a critical technical practice: Lessons learned in trying to reform AI in Bowker, G.C., Star, S.L., Gasser, L., and Turner, W. (eds.) Social science, technical systems, and cooperative work. Beyond the great divide. pp. 131–158. Psychology Press, New York (1997)
15. Sengers P., Boehner K., David S., Kaye J.J.: Reflective Design, Proceedings of the 4th Decennial Conference on Critical Computing. pp. 49–58 (2005)
16. Haraway D.J.: Simians, Cyborgs and Women: The Reinvention of Nature, Routledge, New York, (1991)
17. Hayles N.K.: How We Became Posthuman. Virtual Bodies in Cybernetics, Literature, and Informatics, The University of Chicago Press, Chicago and London, (1999)
18. Lash S.: Reflexive modernization: the aesthetic dimension, Theory Culture and Society, 10, pp. 1–23 (1993)
19. Mauss M.: Techniques of the Body, Economy and Society, 2, pp. 70–88 (1973)
20. Hinton G.E., Dayan P., Frey B.J., Neal R.M.: The "wake-sleep" algorithm for unsupervised neural networks, Science, 268, pp. 1158–1161 (1995)
21. Durkheim E., Mauss M.: Primitive Classification, Cohen & West Ltd., London, (1963)
22. Prattichizzo D., Trinkle J.C.: Grasping in Siciliano, B. and Khatib, O. (eds.) Springer Handbook of Robotics. pp. 671–700. Springer, Berlin, Heidelberg (2008)
23. Melchiorri C., Kaneko M.: Robot Hands in Siciliano, B. and Khatib, O. (eds.) Springer Handbook of Robotics. pp. 345–360. Springer, Berlin, Heidelberg (2008)
24. Deimel R., Brock O.: A Novel Type of Compliant, Underactuated Robotic Hand for Dexterous Grasping, Proceedings of the 2014 Robotics Science and Systems Conference (2014)
25. Deimel R., Brock O.: A Compliant Hand Based on a Novel Pneumatic Actuator, Proceedings of the 2013 IEEE International Conference on Robotics and Automation (ICRA) Karlsruhe, Germany, May 6-10. pp. 2039–2045 (2013)
26. Taylor C.: Sources of the Self. The Making of the Modern Identity, Harvard University Press, Cambridge, Massachusetts, (1989)
27. Suchman L.A.: Human-Machine Reconfigurations. Plans and Situated Actions, 2nd Edition, Cambridge University Press, New York, (2007)
28. Castañeda C., Suchman L.A.: Robot visions, Social Studies of Science, 44, pp. 315–341 (2014)
29. Balasubramanian R., Santos V.J. eds: The Human Hand as an Inspiration for Robot Hand

Development. Springer Tracts in Advanced Robotics Volume 95, Springer, Heidelberg, New York, Dordrecht, London, (2014)
30. Controzzi M., Cipriani C., Carrozza M.C.: Design of Artificial Hands: A Review in Balasubramanian, R. and Editors, V.J.S. (eds.) The Human Hand as an Inspiration for Robot Hand Development. Springer Tracts in Advanced Robotics Volume 95. pp. 219–246. Springer, Heidelberg, New York, Dordrecht, London (2014)
31. Bill Vorn's website, http://billvorn.concordia.ca/menuall.html