



The Role of Human Creativity in Human-Technology Relations

Vincent Blok¹

Received: 5 February 2022 / Accepted: 23 June 2022 / Published online: 4 July 2022
© The Author(s) 2022

Abstract

One of the pressing issues in philosophy of technology is the role of human creativity in human-technology relations. We first observe that a techno-centric orientation of philosophy of technology leaves open the role and contribution of human creativity in technological evolution, while an anthropocentric orientation leaves open the role of the technical milieu in technological evolution. Subsequently, we develop a concept of creation as deviation and responsiveness in response to affordances in the environment, inspired by the affordance theory by James Gibson. With this concept of creation as deviative responsiveness, we articulate the human contribution to human-technology creation, namely, our intentional deviation of the inhibiting forces of the currently dominant niche or meaningful world of human-technology relations, in order to become responsive to new affordances in human-technology creation that constitute a new niche or world of human-technology relations.

Keywords Creation · Human creativity · Innovation · Philosophy of technology · Technological evolution

1 Introduction

One of the pressing issues in philosophy of technology is the role of human creativity in human-technology relations. Traditionally, the process of creation is understood out of the subject of creation, i.e., the craftsman who makes the artifact (Aristotle, 1980). Philosophers like Heidegger criticized this conception of technology as human activity (Heidegger, 1977). His deterministic conception of the essence of technology is criticized as well because technological evolution is not a unidirectional development that makes the world adapt to it (Feenberg, 2005). This criticism does not necessarily imply an anthropocentric orientation in which humanity is the primary agent in technological evolution.

✉ Vincent Blok
info@vincentblok.nl

¹ Philosophy Group, Wageningen University, Hollandseweg 1, 6707, KN, Wageningen, The Netherlands

Technological evolution is for instance determined by previous stages of development, interdependencies with other technological developments, and by universal technical tendencies which are independent of humanity. They are rather operationalized in concrete technologies in relation to particular arrangements of the world in which these technologies appear (Leroi-Gourhan, 1945; Stiegler, 1998). In this way, the technological world we currently live in is created by a succession of interrelated inventions or innovations since the industrial revolution (Blok, 2022a).¹ Such a techno-centric orientation of creation does not mean, however, that the human becomes the “object” of creation and is “invented” by technological evolution, as McLuhan (1964) seems to suggest. That would imply a deterministic conception of technology as well which leaves no room for human creativity. In a way, human creativity is *involved* in the invention, co-evolution, and operation of new emerging technologies, and, therefore, the process of creation is not *without* the involvement of human creativity. But even if we argue for such an involvement of human creativity in technological evolution, we need to conceptualize a progressive understanding of the role of human creativity in this creative process.

Although creation and creativity are not limited to innovation, as poetry is for instance definitely the product of creation but not yet to be considered as innovation, we focus on creation processes in the context of innovation in this article. With this, we continue earlier work on a non-anthropocentric and materialistic concept of creation (Blok, 2022b) and ask for the specific role of human creativity in human-technology creation.² We distinguish between genetically programmed biological evolution and non-genetically programmed technological evolution, without assuming a priori a continuity between the two processes of creation, and limit our reflections to the human creation involved in technological evolution.³

The consideration of the role of human creativity in invention and technological evolution is legitimate, as the philosophical tradition from Greek philosophy onwards estimates creativity as human condition. We can think of Plato’s acknowledgement of the special capabilities of artists to foresee things ordinary people cannot see in the *Phaedrus* (Plato, 2017). We can also think of Arendt’s idea of the *new beginning* of human action in *The Human Condition* (Arendt, 1958). It is the human as artist who creates new worlds, whether it is *New Babylon* by Constant or the new world inaugurated by Picasso’s *Demaiselles d’Avignon* and the *Gutenberg Galaxy* inaugurated by the printing press. It seems, therefore, that we cannot omit a reflection on the human condition in technological invention and creativity.

¹ Although philosophers of technology seem to prefer to speak about invention instead of innovation, as innovation is mainly seen as commercialization of inventions in a free market economy; we use these concepts interchangeably in this article. On the one hand, philosophy consists in the explorative confrontation with prevailing views in science and society (XXXX, 2020), and innovation can definitely be seen as an emblem of our time (Godin, 2015). On the other hand, although innovation is often associated with the commercialization of technology, the concept can also cover the conceptuality associated with the notion of invention (Godin, 2015).

² This article is developed as a stand-alone contribution that does not require the reader to read the earlier article on the ontology of creation first. We do not summarize this earlier contribution here but open a complementary question that is independently developed.

³ The further analysis of the commonality or difference between natural and technological evolution is beyond the scope of this article, in which we want to focus on creation in human-*technology* creation.

An answer to this question is also relevant for contemporary debates in philosophy of technology. Postphenomenology for instance significantly advanced our knowledge of how technologies mediate human experience of the technological world we are intentionally involved in (Verbeek, 2005). Although it assumes a reciprocal relation between human experience and the world that is experienced, its starting point is found in the availability of “technologies in their particularities” and the practical *use* of these technologies in various technological practices (Ihde, 2009: 21–22), while the process of their *invention* and evolution, just like the role of human creativity in this invention, is less developed (Blok, 2021). Postphenomenology focusses for instance on the question how a new-to-the-world artifact like Google Glass mediates our experience of the world we live in (Kudina & Verbeek, 2019), while it is this mediated experience of the world that gives rise to new inventions like the integration of augmented and virtual reality. While current debates in human technology relations focus on given technologies and their use, our contribution focusses on the process of their invention and evolution to provide a complementary perspective on the role of human creativity in human-technology creation.

In the “[The Role of Human Creativity in Philosophy of Technology](#)” section, we ask how philosophers of technology tend to conceptualize the role of human creativity in human-technology relations. We observe that a techno-centric orientation leaves open the role and contribution of human creativity in technological evolution, while an anthropocentric orientation leaves open the role of the technical milieu in technological evolution. We subsequently develop a concept of creation as responsive action and behavior in response to affordances in the environment, inspired by the affordance theory by James Gibson in the “[Creativity as Responsiveness](#)” section. As it will turn out that creation as responsiveness is a necessary but not yet sufficient condition to leave the familiarity of currently dominant human-technology relations behind and to engage in new-to-the-world human-technology creations, we introduce the notion of creation as deviation from the established world of human-technology relations in the “[Creativity as Dissent and Deviation](#)” section. With the concept of creation as deviative responsiveness, we articulate the particular *human* contribution to human-technology creation. This contribution is found in his or her intentional deviation of the inhibiting forces of the currently dominant niche or meaningful world of human-technology relations. This deviation enables the innovator to become responsive to new affordances in human-technology creation that constitute a new niche or world of human-technology relations. In the “[Conclusions](#)” section, we draw our conclusions.

2 The Role of Human Creativity in Philosophy of Technology

In this section, we first ask how philosophy of technology tends to conceptualize the role of human creativity in human-technology relations. A complicating issue is that philosophers of technology tend to discuss innovation in terms of invention, but not in terms of creativity and creation. Although an author like Simondon sometimes explicitly refers to the “creative force” of humans (Simondon, 2017: 120), he mainly describes their acts in terms of intention and use (Simondon, 2017: 71). Because the role of human creativity in invention is less developed in the literature, we reconstruct entry points for our reflection on creation by introducing one position which stresses the role of technology (McLuhan),

one that highlights the human factor as operator and user (Simondon), and one that purely focusses on the human-technology relation itself (postphenomenology). We take the conceptuality of these philosophers of technology—invention and use for instance—to reflect on creation and creativity, without claiming that these philosophers themselves reflected on creativity.

Many philosophers of technology, ranging from Don Ihde to Marshall McLuhan, agree that technologies mediate experience and constitute a new world in which human beings are intentionally involved. This implies that human beings are not the subject of the creation of new technologies, as they are constituted by these technologies as well, or more precise, that subject and object are mutually constituted (Verbeek, 2005: 129–130). The light bulb for instance does not only mediate experience but also constitutes a new meaning of central human categories like work and leisure as well, for instance opportunities to extend the working day, to work at night, and to enjoy leisure time in the evening. Human creativity is not the subject of the invention of the light bulb, but the invention of the light bulb mediates a new world which is no longer determined by the rhythm of day and night, including a new meaning of human creativity that can be employed during leisure time in the evening and gives rise to hobbies as central human category.

Although McLuhan acknowledges the *relational* aspect of human-technology relations when he sees technologies as extensions of our living and acting in the world, his understanding of the role of humans in this relation is ambiguous. On the one hand, he has an anthropocentric orientation when he sees technology as an “utterance” of the human subject. On the other hand, he has a techno-centric orientation when he sees technology as “active logos” that transform both humans and their world (McLuhan & McLuhan, 1998: 98). Although McLuhan is ambiguous in his assessment of technology as *utterance* of the human subject on the one hand and as *determining* the human subject on the other, the following quote indicates that in the end, he tends to a techno-centric orientation:

“Physiologically, man in the normal use of technology (or his variously extended body) is perpetually modified by it and in turn finds ever new ways of modifying his technology. Man becomes, as it were, the sex organs of the machine world, as the bee of the plant world, enabling it to fecundate and to evolve ever new forms” (McLuhan, 1964: 51).

If human beings are the sex organ of technology, he or she is primarily understood as function serving the reproduction, evolution, and dissemination of technology. Humanity is primarily determined by technology and only serves its evolution, while it remains unclear what the precise role and contribution of human creativity are in this “fertilization” of technology.

The role of human creativity is more explicitly reflected upon in Simondon’s philosophy of technology. Just like McLuhan, he stresses the human-technology relation, i.e., a “reality rich in human efforts and natural forces, and which constitutes a world of technical objects as mediators between man and nature” (Simondon, 2017: 15). At the same time, he acknowledges the specific role of humanity in human-technology relations, i.e., as inventor of technical artifacts, as solver of compatibility problems between technical artifacts, as coordinator and organizer of technological artifacts that constitute a technological world—a factory, a lab, etc.—as translator of information between technical artifacts, and as the one who provides meaning to the information stemming from these

artifacts. “The true nature of man is not to be a tool bearer – and thus a competitor of the machine, but man’s nature is that of the inventor of technical and living objects capable of resolving problems...” (Simondon, 2017: xvi). The reason for his appreciation of the human factor in technology is because he rejects the ideal of the full automaticity of technology—which requires a closed system that operates in a predetermined way towards perfunctory results—and envisions the evolution of “open” machines that are sensitive for outside information from other machines and constitute an interconnected world of technologies (e.g., a lab, a factory). According to Simondon, “open” machines require human beings as organizer and operator of interrelated technologies that constitute such an interconnected technological world (Simondon, 2017: 17). He compares the role of human beings as managers of these technological worlds with a conductor who directs an orchestra: “Man thus has the function of being the permanent coordinator and inventor of the machines that surround him. He is *among* the machines that operate with him” (Simondon, 2017: 18).

Do these quotes not indicate that Simondon, contrary to McLuhan’s tendency towards a techno-centric orientation, tends to an anthropocentric orientation? Does he in the end adhere to the traditional idea of the human as subject of creation? Simondon is ambiguous in this. On the one hand, he describes technological evolution as conditioned by a technical and natural milieu. The evolution of the internal combustion engine is conditioned by the availability of fuel and by the thermal operating limit of the metals and alloys from which the combustion chamber is made. These conditions of the evolution of the combustion engine are relatively independent of human intentions (Simondon, 2017: 59). On the other hand, he seems to reserve a special role of the human as inventor and director. According to Simondon, technological evolution is not directly driven by technical beings, but indirectly by the human desire for change. This desire for change is not a desire to be creative, but creativity is one way in which this desire can be satisfied; humanity seeks new solutions that are more satisfactory than those they already possess, and they function as inventor and user of these technologies (Simondon, 2017: 71). For this reason, the origin of technological evolution is found in a definite act of invention, a “synthetic act” of the inventor that constitutes a “technical essence” that remains stable across the technological evolution (Simondon, 2017: 46).⁴

⁴ This conceptualization shows a tension in Simondon’s work. On the one hand, he is very critical about Aristotle’s understanding of *techne* and the essentialist orientation in his conceptualization (Bardin, 2018; Simondon, 2020). On the other hand, in his work on the mode of existence of technical objects (Simondon, 2017), he seems to conceive technology as invention of a new-to-the-world essence or idea of an artifact—i.e., the idea of the first combustion engine—that is *present* in the engineer’s mind as knowledge of this idea of the combustion engine and is re-presented by each and every instantiation of this idea in the subsequent evolution of the steam engine. This reads pretty much in line with Aristotle’s understanding of *techne* (Aristotle, 1980). The idea of the existence of a metaphysical idea of new-to-the-world technologies that remain the same throughout their evolution can be challenged based on Wittgenstein’s criticism of the existence of such essences. If we talk about the combustion engine, language seduces us to assume a general idea or essence of “the” combustion engine represented in each and every instantiation of the combustion engine. But if we look at the evolution of the combustion engine in history, we do not find such an essence, but at most family resemblances between the various combustion engines. The further discussion of this tension and how it can be solved is beyond the scope of this article.

With this, an ambiguity occurs in Simondon's philosophy of technology: although he acknowledges the *relationality* of human-technology relations when he sees the technical milieu as conditioning technological innovations, he tends to an anthropocentric orientation as he sees the human as "inventor and user" (Simondon, 2017: 71) and "creative force" (Simondon, 2017: 120). Human creativity is *embedded* in the technical milieu, but as such an embedded subject, humanity at the same time has a special role as the subject of creation. If the embedded subject is the inventor of technology, invention is primarily determined by the human desire for change, while it remains unclear what the specific role of the technological milieu is in modifying this technology.

Verbeek's account of the relationality of human-technology relations has the advantage that it more explicitly avoids such an anthropocentric or techno-centric orientation and, inspired by Latour, sees humans and technologies as "bound up with each other in a network of relations" (Verbeek, 2005: 149). The problem of an actor network theory approach is, however, that agency is distributed to the sociotechnical network. This makes it hard to conceive the particular role of human creativity in technological design. In the meantime, much progress is made to move beyond a computational and representationist concept of agency by the introduction of enactivism (Varela et al., 1991), the affordance theory (Gibson, 1977), and material engagement theory (Malafouris, 2013; Aydin, 2019) to conceptualize the dynamic interaction between a human agent and its environment. Even if we accept that the technological world we currently live in is created by a dynamic sociotechnical network in which human creativity is involved in the emergence of new-to-the-world innovations and even if we accept that this creativity cannot be distributed to the agency of humans or artifacts as knots in these sociotechnical networks, this does not absolve us from the question about the role of human creativity in this process of invention. The innovations stemming from the dynamics of the sociotechnical network do not evolve automatically and randomly but are in a way intentional.

3 Creativity as Responsiveness

As we agree with the original intuition of the relationality of human-technology relations (see "[The Role of Human Creativity in Philosophy of Technology](#)" section), our point of departure is the idea that technological inventions impact being and thinking at once and can therefore not be understood as initiated by thinking as subject of this creation. At the same time, although humans are not the creative subject of innovation, the innovation of our living and acting in the world is also not an automatic process as it requires human action and behavior; our living and acting in the world *participate* in innovation, for instance in their operation, regulation, and usage. How can we conceptualize human participation in the process of creation if we reject a unilateral techno-centric or anthropocentric orientation?

Innovation is not the same as technology (Blok, 2021). A relational account of technology takes the *familiarity* with the artifact as point of departure; human existence is always already intentionally involved in a meaningful world in which he or she knows how to use these artifacts. But the creative process involved in the

invention of new-to-the-world artifacts like machine learning or deep learning techniques should take the *un*-known and *un*-familiarity of these innovations as point of departure. The innovation of AI is not guided by a technical essence created by the human subject. On the one hand, if we reflect on the history of technological evolution, it turns out to be hard to identify a technilineal most recent common ancestor (TRCA) of AI. Every ancestor or primitive AI application turns out to have a predecessor, just like every mitochondrial Eve as matrilineal most recent common ancestor (MRCA) turns out to have a mother, i.e., turns out *not* to be the MRCA of all human beings. On the other hand, we cannot oversee the disruption of the world due to new-to-the-world inventions like AI that change the world completely in the course of its evolution. The reason is that we can only linearly extrapolate from the known and familiar to the future (Blom, 2021). Philipp Blom provides the example of Diderot and d’Alembert, who describe a *pompe à fue* in their *Encyclopedeia*, a machine that moves and provides warmth. They compare this new and unfamiliar artifact with the familiar—an animal—and do not realize they actually describe the steam engine that will disrupt society as a whole in a few generations (Blom, 2021). If we consider the implications of AI, we tend to extrapolate from the known and familiar to the future while it is very hard to conceive the societal disruption it involves.

Although humanity definitely contributes to the creation involved in innovation, this contribution has not to be found at a cognitive level. Innovation concerns the unknown and unfamiliar and our knowledge of what we create is principally limited. Familiarity is performatively constituted in our actual engagement with the innovation as creator, user, operator, etc. Innovation is primarily action-oriented and emerges in the ontogenetic process of its creation in which human action and behavior are involved (Godin, 2015), for instance in the “spread of new and improved products and processes in the economy” (Freeman, 1974: 18). We take this action orientation of innovation as point of departure in our conceptualization of the role of human creativity in human-technology relations.

If we build on Simondon’s idea of the human as organizer and operator of the technological world, we can conceptualize the role of human creativity beyond his or her being of an embedded subject. The artifact is not primarily invented by human creativity, but human creativity is *involved* in the dynamic operation of inter-related technologies that constitute a multistable technological world (Ihde, 2009).⁵ There is no subject or object of this act of organizing and operation, as both “I” as operator and the artifact *as* operated are mutually constituted and constitute a socio-technical ecosystem or world. Furthermore, the interaction between the operator and the operated is not primarily cognition-oriented but action-oriented. It is in the act of the operation of the artifact as the operated that the socio-technical ecosystem is constituted.

Because approaches of the mutuality of the human agent and its environment like the material engagement theory tend to have a cognitive orientation, while we stress

⁵ Although the idea of multistability is inspired by Ihde’s work, contrary to his work, we conceive multistability at an ontological level, inspired by our rehabilitation of Heidegger’s early phenomenological insights (Zwier et al., 2016).

the action and behavior orientation in creativity and innovation, we propose an *ecological* conceptualization of the human-technology relation, inspired by the affordance theory of the ecological psychologist James Gibson.⁶ The affordance theory develops an explanation of how the meaning of things and organisms in the environment could be perceived directly (Gibson, 1977) and theorizes the dynamic relation between organisms and their environment.

According to Gibson, organisms do not perceive stimulus information from the outside world, which they process consciously or unconsciously. They perceive affordances in the environment to perform a specific kind of action. The word “affordance,” coined by Gibson himself, indicates the meaning of a thing or organism in the environment, which is detected or picked up by the perceiver and allows him to perform a specific kind of action; the air affords breathing, water affords drinking, a stone affords throwing, etc. (Gibson, 1977). We conceive affordances as opportunities for action that are available in the environment and allow specific types of behavior (Heras-Escribano, 2019).

It is not only the physical environment which harbors affordances according to Gibson: “The other animals of the environment afford, above all, a rich and complex set of interactions, sexual, predatory, nurturing, fighting, play, cooperating, and communicating. What other persons afford, for man, comprise the whole realm of social significance” (Gibson, 1977: 68). Gibson develops an ecological approach to human and non-human agents, focussing on the interconnectedness between engaged agents and a milieu of things and organisms providing affordances as opportunities for this engagement. Although Gibson himself focussed on affordances in the natural environment, research has extended his theory to sociotechnical phenomena (Sanders, 1979). Social phenomena like works of art and artifacts offer affordances as well for organisms able to enjoy, read, and use them. A speed bump in the street for instance *affords* the car driver to slow his or her speed. Organisms are primarily *responsive* to affordances in the environment in their actual behavior, ranging from flying to swimming and from driving to interpreting behavior (Sanders, 1997; Blok, 2014a).

The affordance theory enables us to conceive a robot in a factory as harboring affordances to its operation, coordination, and orchestration. The robot in the factory affords its operation, but the meaning of the robot for the operator is not a characteristic of the machine itself. If we encounter this robot in a factory, we do not perceive a physical object but rather we perceive what we can do with it, for instance its operation. According to the affordance theory, affordances have to be taken with reference to an animal. A rigid and horizontal surface affords support for human beings for instance, but not for fish. In the same way, the robot in the factory affords its operation for the operator but not for people not trained or educated in this area. It can also contain multiple affordances for people, like a tree affords hiding and climbing and drip irrigation technology affords smart agricultural practices but also the practice of hanging the laundry to dry in sub-Saharan countries. This relativity

⁶ The introduction of the affordance theory in this article is based on earlier work that was already published (Blok, 2014b).

of the affordance does not mean that the meaning of the drip irrigation technology depends on the valuation of this object by the subject. According to the affordance theory, affordances come up in the reciprocity of animal and environment. What the predator for instance affords the prey—hiding or fleeing behavior—is reciprocal to what the prey affords the predator—predatory behavior (Gibson, 1977: 76). In the same way, what the robot affords the operator is reciprocal to what the operator affords the robot. This means that the affordance points two ways and therefore cannot be understood as a property of an object nor as a property of the subject who values this object.

“Although an affordance consists of physical properties taken with reference to a certain animal it does not depend on that animal. In this respect an affordance is not like a value which is usually supposed to depend on the observer nor is it like a meaning which is almost always supposed to depend on the observer. An affordance is not what we call a ‘subjective’ quality of a thing. But neither is it what we call an “objective” property of a thing if by that we mean that a physical object has no reference to any animal. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy” (Gibson, 1977: 69–70).

What is the ontological status of the affordance if it is not a property of an object nor a property of a subject? It is clear that Gibson rejected the naturalistic “dichotomy between mental (subjective, meaningful) and physical (objective, meaningless) properties, in favor of the concept of an ecological level of reality at which meanings and purpose are as real as bodies” (Gibson, 1982: 408). Gibson’s rejection of any dualism between subject and object does not only imply that affordances cannot be understood as a property of the environment, but it also implies that “artifacts” and “humans” cannot be the “fundamental entities in our ontology, because they are detached and inherently carry the burden of an objective-subjective dichotomy” (Kadar & Effken 1994: 313). Consequently, we discard any kind of dualist ontology, i.e., any posting of a mental (subject) as opposed to a natural (object). Organisms “that utilize” the natural environment are constituted by their reciprocity to these affordances in the environment, for instance the mutual supportive realities of the environment (materials for making a nest) and the bird which settles itself in this environment to build his nest. With this, it becomes clear that both the artifacts and the human operators are constituted by their mutual affordances and not the other way around. In the mutual affordance of artifacts and the human operators, the artifacts afford their operation, and the operator affords a particular design that enables its operation, its solution of compatibility problems, etc. And in the mutual affordances, the artifacts become that which are operated and organized by the human operator, while the human operator becomes the one who is orchestrating these artifacts, solves problems by improving them, translates information, etc.

The affordance points two ways, which means that the affordance itself receives ontological primacy. An ecological concept of human–technology relations conceives the operation of the robot and the operation by the human operator as the product of the mutual affordance in the human–technology relation. The ontological primacy of the affordance enables an ecological reconceptualization of the

relationality at stake in human-technology relations. Affordances come up in the reciprocity between artifacts and their operation by human operators. This means that an artifact and its operator do not first exist separately from each other as things or organisms in the lab or factory and then have an affordance on each other; if the affordance is not a property of the artifact nor of the human operator, then the mutual affordance comes first, in which the artifact becomes the artifact for the operator and vice versa. In the factory, the robot only *is* in the proper sense of the word in its operation by the human operator. The affordance is in other words not a disposition of an agent, but concerns the *identity* of this agent as operator. Just like the robot only is this robot in its operation, the human as operator only *is* in the proper sense of the word in his or her actual operation of the robot. The affordance explains the material foundation of human cognitive evolution, i.e., the human as operator of the technological world we live in (Clark, 2003). It also explains the interconnectedness and co-constitutive nature of human agency and the environment or world in which we live and act. Agency is relational and always already reciprocal to the world of affordances it is responsive to. Just so, the environment or world is no longer an object but always already an ecosystem of affordances that have been taken advantage of by human and non-human agents. In the ecosystem of affordances, the robot *as* operated and the human *as* operator emerge as emergent constituent of this reciprocity. In this regard, the affordance ontology does not allow a separation of human agency and affordances in the environment.

To explain the inseparability of agents and their environment, Gibson makes use of the ecological concept of a niche. A niche can be seen as a set of environmental features which are suitable for a specific species and in which this species *fits*: “I suggest that a niche is a set of affordances. The natural environment offers many ways of life and a way of life is a set of affordances that are utilized” (Gibson, 1977: 69). Gibson’s concept of the niche shows that the affordance ontology concerns the natural environment which is understood in a non-dualistic and non-anthropocentric way. “We all fit into the substructures of the environment in our various ways for we were all, in fact, formed by them. We were created by the world we live in” (Gibson, 1977: 71). An example of such a niche is the factory as meaningful world in which the human emerges as operator of the robot as the operated. In their operation and being operated, the artifacts and the human operators are interdependent and interconnected in a meaningful world in which they are what they are, i.e., operated and operating in this operation. The ontological status of the affordance is that it constitutes a meaningful world in which the identification of artifacts and human operators is performatively constituted.

Till now, we have discussed an ecological conceptualization of the role of the human *operation* of the artifact in human-technology relations, but not yet the context of human creation in these relations. We can extend the affordance theory beyond our conceptualization of human-technology relations to the creation of the human-technology relation. While for the one, an artifact can have the affordance to operate it, for somebody else, it can have the affordance to improve or innovate.

According to Gibson, the environment is characterized as unlimited richness and complexity: “The environment affords many different kinds of food and many different ways of getting food. [...] These offerings have all been taken advantage of,

which is to say that the niches have been occupied. But, for all we know, there may be many offerings of the environment that have not been taken advantage of, that is, niches not yet occupied” (Gibson, 1977: 69). In first instance, we engage in the actual fit between the human operation of an artifact as the operated that constitutes a multistable niche in which both human operation and the artifact as the operated are responsive to each other. But we have to acknowledge the principal possibility of another affordance that emerges in the environment that the human operator currently did not take advantage of yet and calls for action. The meaning of a machine learning or deep learning technique in an AI application in a factory can be self-evident—it is there in order to support decision-making in car fabrication for instance—but may turn out to be unsuitable in new contexts. For instance, currently available machine learning and deep learning techniques require adjustments in case of their application in the agricultural sector. This is because the natural origin of each individual variety of plants, seeds, vegetables, and fruits turns out to be unique. It is also possible that the AI applications provide another affordance in another time and place, in a different situation. For instance, new complex alloys and advanced production facilities provided new affordances to improve the design and capacity of the steam engine. It is also possible that a completely new affordance appears in the environment that we did not take advantage of yet. This does not hold only for the possibility of invaders in established ecosystems who disrupt existing niches. The invention of the steam engine leads not only to a niche in which the human operator operates this machine, but also to the extinction of forests to fuel the steam engine. The invention and production of steam engines lead to the overconsumption of forests. At the moment wood becomes a scarce product due to deforestation, the remaining forests might provide other affordances, for instance the affordance to conserve forests and wildlife. Also new affordances might emerge, like the affordance to mine coal to feed the steam engine.

With this principal possibility of another affordance in the environment, we encounter first the contingency of the current fit of human–technology relations. Secondly, the affordance theory provides an explanation of human creativity beyond the human as subject of creation, namely, as responsive to affordances in the environment. This idea of human creativity as responsiveness to affordances is in line with experiences of scientists and artists who attribute creativity to divine inspiration or a process of intuition that is not completely under control of the human subject (Solomon, 2009). If we consider the affordance theory in our conceptualization of the human–technology relation and creation, we can argue that both are embedded in the human responsiveness to existing and new emerging affordances in the environment. Human agency consists in our responsiveness to affordances in the environment. This responsiveness can consist in the operation of the artifact for one human agent (operator), while for another, it can have the affordance to improve the artifact or innovate a new-to-the-world artifact. It also explains why not everything is possible in creation. There is no infinity of possible designs of machine learning and deep learning techniques, because its actual invention and evolution are not primarily due to the creative capacities of the human agent. The actual invention and evolution are responsive to a limited number of opportunities provided by the environment with which the human agent and the AI applications co-evolve and in which they remain embedded for their proper operation and functioning.

Like the earth never affords mobile organisms to root themselves in the soil, water does not afford us any longer to make a water mill in the age of steam power and electricity. At the same time, the principal possibility of another affordance means that the environment always transcends our actual responsiveness in human-technology relations and always provides new affordances for human-technology creation. Just like a milking robot affords its operation for the operator but not for people not trained or educated in animal husbandry, it provides new affordances for improvement and innovation for the engineer who is trained in machine-learning techniques. This enables human-technology creation. Human-technology creation must be understood as being *responsive* to new affordances emerging in human-technology relations. Once human-technology creation results in new artifacts to which the human operator is responsive, the unfamiliarity of innovation is lifted by the familiarity of human-technology relations.

With this ecological concept of human-technology creation, we can acknowledge the constitutive role of human action and behavior in technological design, without necessarily adhering to techno-centrism or anthropocentrism. Human creativity is not a passive function serving the invention of technology, as the emergence of the new requires not only the emergence of new or changed affordances in the environment, but also our actual responsiveness to these new emerging affordances in actual action and behavior. The interconnectedness and co-constitutive nature of human agency and the environment in which we live and act move beyond a techno-centric orientation of creation. Human creativity is responsive in the dynamic operation of interrelated technologies that constitute an interconnected technological world and allows human creativity to perform specific behavior as operator, orchestrator, inventor, etc. In our ecological concept of human-technology creation, human creativity is not conceived from the perspective of a subject-environment dialectic, but primarily as *responsive* to affordances that constitute the technological world in which they are embedded and in which they emerge as agent.

4 Creativity as Dissent and Deviation

And yet, the responsiveness of human creativity to new affordances in the environment is insufficient to understand the radical newness of disruptive innovations in human-technology creations like AI. The point of departure of the previous section was the difference between technology (familiarity) and innovation (unfamiliarity). We conceived the familiarity with the artifact in human-technology relations in terms of the human responsiveness to affordances in the environment that constitutes a metastable niche or meaningful world in which the human operator knows how to use these artifacts. We conceived the unfamiliarity in case of human-technology creation in terms of the human responsiveness to *new* affordances that we did not take advantage of yet, which creates an adjusted, improved, or even new-to-the-world artifact that subsequent users can familiarize themselves with in their responsiveness to these newly invented artifacts (see “[Creativity as Responsiveness](#)” section).

It is possible that new affordances emerge in the environment. The low energy conversion efficiency of the steam engine affords for instance innovations with

a higher energy conversion efficiency. In first instance, these affordances can be found in incremental innovations to optimize efficiency. But at a certain moment, and in line with the law of diminishing returns, further investments in such innovations will not result in significant efficiency gains anymore. In that case, efficiency can only be increased by the exploration of new affordances for innovation with a higher energy conversion, for instance electricity. It is questionable however whether creation as responsiveness to new affordances sufficiently explains why innovators leave the familiarity of their responsiveness to currently dominant affordances and engage with the unfamiliarity of new affordances. Of course, sometimes a dominant affordance disappears and forces us to become responsive to other affordances in the environment. For instance, deforestation due to the use of wood as primary source of energy caused the first energy crisis (Nef, 1977). We could say that due to this crisis, the primary responsiveness to affordances in the environment—woodcutting as source of energy—was no longer possible and enforced the human agent to explore other affordances in the environment—coal mining as source of energy for instance. But we know that humans are reluctant to voluntarily leave the comfort zone of their world in order to engage with the radically new. The reluctance to cease our responsiveness to currently dominant affordances may also be economically explained. Dominant actors who benefit most from currently dominant affordances related to (patented) technologies have vested interests to remain the status quo. And if we expect that the intensification of our responsiveness to current affordances—for instance the doubling of the production of computer chips—will decrease its costs—as each doubling of production will optimize the production process according to Wright’s law—we also have good reasons to remain the status quo. In other words, there are all kinds of reasons for the human reluctance to cease their responsiveness to currently dominant affordances in the environment. These dominant affordances constitute a metastable niche of human-technology relations that suits the “fittest to survive” and makes one reluctant to engage in the unfamiliarity of new human-technology creation.

As it is possible that we are responsive to affordances which are not or no longer there or that we hold on specific affordances while others already emerged, we can argue that human creation as responsiveness to affordances in the environment is a necessary but not yet sufficient condition of human-technology creation. What explains that humans leave the familiarity of currently dominant human-technology relations and engage in the unfamiliarity of human-technology creation? Innovation can only be understood if human creativity is not *absorbed* by its responsiveness to currently dominant affordances. Innovation is also characterized by the *deviation* of creation from the established world of human-technology relations.

In the history of innovation, innovation is associated with *dissent* and *revolution* (see Godin, 2015), that is, with the rejection of the familiarity of and contentment with the world in which we are always already intentionally involved. It involves the engagement with the emancipation, creation, and innovation of the radically new. Dissent and revolution indicate that creation does not only involve our responsiveness to new affordances in the environment to create new-to-the-world artifacts, but it also involves an act of *ex-novation*, i.e., an act of deviation from our adaptation to currently dominant human-technology relations

(i.e., the world associated with the steam engine) to make way for new affordances that human creativity did not take advantage of yet (i.e., the world associated with the combustion engine). The duality of creation as deviation and creation as responsiveness explains the discontinuity in the history of innovation between waves of technological developments (Kondratieff and Stolper, 1935). Kondratieff for instance identifies a wave starting around 1845 which is associated with steam power. This wave followed the wave associated with waterpower and gave rise to inventions like the water mill and the emergence of the textile industry. The invention of the steam engine does not only establish a new-to-the-world artifact, namely, the first steam engine, but this creation also concurrently deviates from the human-technology relation or world associated with the water mill (Blok, 2022a). The creation involved in the innovation of the steam engine deviates from the existing human-technology relations associated with the water mill. At the same time, this creation is responsive to new affordances in the environment to create this new-to-the-world artifact and constitute the world of steam.

In innovation economics, this deviation of creation is understood in terms of a creative destruction. Innovations do not only create a new-to-the-world artifact like the steam engine, but with this invention, they at the same time destruct the existing market. According to economists like Joseph Schumpeter (1983), the invention of the steam engine destroyed the market of the water mill and created at the same time a completely new market for the steam engine. Our philosophical reflection on the deviation of creation enables us to reframe the economic concept of innovation as creative destruction in terms of creation as deviative responsiveness. Creation consists the deviation of the currently dominant responsiveness to affordances in human-technology relations in order to become responsive to new affordances in the environment in human-technology creation. In this respect, creation as deviation from currently dominant human-technology relations is the driver for the engagement with human-technology creation by our responsiveness to new affordances in the environment. From this responsiveness to new affordances, a new metastable niche of human-technology relations may emerge, or not.

This addition is important to consider, because our responsiveness to new affordances may fail due to contextual factors. If our creation as deviation from currently dominant human-technology relations comes too early—one can think of the replacement of traditional audio storage formats (LP's, CD's) by Microsoft *Zune*, which never took off, while the iPod was very successful a few years later—or if creation as responsiveness to new affordances comes too early—one can think of Hero of Alexandria (+/– 10–70 AD) who described already the first steam engine—a new metastable niche does not emerge. The human engagement with human-technology creation is not performed once and for all. It consists in the performative experimentation with possible affordances in the environment by engaging in action and behavior in response to these possible affordances (including the engagement with marketing and competition for

instance). Performative experimentation may constitute a new human-technology relation, call for improvements, etc. In the current age of climate change, we have for instance sufficient reason to deviate from fossil fuel-related affordances and performatively experiment with our responsiveness to other affordances related to sun and wind.

With the concept of deviative responsiveness, we encounter the specific human contribution to human-technology creation. While we could argue, inspired by Rousseau, (1973), that other animals are instinctively absorbed in their responsiveness to affordances in the environment. An animal does not deviate from its responsiveness to particular affordances in the environment; a piece of meat will never afford a bird to eat it, like a piece of fruit will never afford a cat to eat it. Contrary to other animals, humans can deviate willingly or not willingly from their responsiveness to affordances in the environment. This deviation of human creation is essential for the human species, although in fact, most human actors are reluctant to leave their comfort zone of the currently dominant affordance to which they are responsive. And yet, some humans deviate from the dominant affordance in their responsiveness to new affordances. In case of such a human deviation of our currently dominant responsiveness to affordances that constitute our niche or world, we experience a *misfit* or *asymmetry* in the actual responsiveness to the affordances in the environment. This experience of a misfit destroys the self-evidence of the established niche of human-technology relations (ex-novation). At the same time, this asymmetry calls for the exploration of our responsiveness to new affordances in human-technology creation (innovation). It co-constitutes a new meaningful world in which we are at home. Or if we frame it in more ecological terms, creation involves ex-novation as feralization⁷ of the current niche of human-technology relations and innovation as domestication of a new or adjusted niche in human-technology creation. Each and every human-technology relation or multi-stable niche is finite as it will be disrupted by human deviation, which in turn will call for human-technology creation as responsiveness to new affordances that constitute a new niche or world.⁸ The evolution of human-technology relations is characterized by the ex-novation as disruption of the equilibrium of the niche of human-technology relations and initiates a quest for a new equilibrium in human-technology creation. In such a human-technology creation, the asymmetry is reduced by our responsiveness to new affordances in the environment and constitutes a new or adjusted equilibrium, which will be the starting point for future creations as deviative responsiveness and so on.

Creation as deviation can manifest itself in many phenomena; one can think of moments of madness, idiocy, and foolishness (Dostojevski); the experience of the human imperfection and forgetfulness (Montaigne); or the natality of human action (Arendt). On the one hand, it connects the human role in human-technology creation

⁷ In biology, feralization concerns the process of rewilding, in which a domestic population is returned to the wild.

⁸ Here we find an explanation for the distinction between creation as revolution and innovation, as the deviation is collective in case of revolution and individual in case of innovation.

with the human condition and defines humanity as creative being. On the other hand, it is clear that human creation as deviation does not rehabilitate the human as subject of creation, for instance the ability of the human subject to *effectuate* our responsiveness to new affordances provided by the environment (Kadar and Effen, 1994). It is vanity to think that humans can create without the emergence of new affordances in the environment or, more precisely, without the eventual emergence of our new responsiveness to new affordances in the environment that constitute a new niche or world in which we are at home.⁹ Human creativity is relational as it is always already responsive to the world of affordances in which it emerges as agent. Like the affordance cuts across the dichotomy of subjective–objective, so has creation to be understood in a relational way. It is not the case that I am the subject that experiences a misfit and sovereignly decides to become responsive to another or new affordances in the environment. Seen from a relational perspective on human-technology creation, we have to say that “I” am not primarily deviative responsive to affordances in the environment, but I am the constituent of “my” creation as deviative responsiveness to affordances in the environment¹⁰; as deviative responsive being, I am constituted as inexhaustible source of creation that is not under human control but remains an unpredictable event of ex-novation and innovation.

Creation as deviative responsiveness enables us to articulate the human role in creation beyond its conception in terms of *hubris*. The classical idea is that the capacity to create is a divine one but stolen by humans. By engaging in creation, humans pretend to be godlike and move beyond human nature. On the one hand, as creation is a relational concept as we have seen, it cannot be attributed to the human subject. On the other hand, creation as deviative responsiveness is not to be understood in relation to the divine but in relation to the world of human-technology relations in which we are always already intentionally involved. Without creation as deviation, creation as responsiveness to new affordances in the environment could never come off the ground. Human deviation deviates from the world of currently dominant human-technology relations and engages in human-technology creation that constitutes a new beginning, a new niche or world.

5 Conclusions

In this article, we raised the question what is the role of human creativity in human-technology creation. Although humanity is not the subject of creation, as technological evolution is for instance determined by previous stages of

⁹ For this reason, we have to reject an anthropocentric concept of creation and introduced a materialistic concept of creation in an earlier contribution, in which human deviation remains embedded (Blok, 2022a). With this, we tend to disagree with Stiegler, who embeds human deviation in the absence of any unique human quality (Stiegler, 1998), while we embed human deviation in the conativity of matter (Blok, 2022a). The further elaboration of this topic is beyond the scope of this article, as it would require a dedicated philosophical anthropology.

¹⁰ The sovereignty of “my” creation as deviative responsiveness is a sovereignty without sovereignty, as Nancy would argue (Nancy, 2007), a “self”-institution that creates the “I” who is involved in human-technology relations.

development and by interdependencies with other technological developments, humans are also not the object of creation. In the “[The Role of Human Creativity in Philosophy of Technology](#)” section, we asked how philosophers of technology tend to conceptualize the role of human creativity in human-technology relations. We observed that a techno-centric orientation leaves open the role and contribution of human creativity in technological evolution, while an anthropocentric orientation leaves open the role of the technical milieu in technological evolution. By taking the original intuition of human-technology relations as starting point for our reflections, we subsequently asked for the human participation in the process of creation of human-technology relations. We developed a concept of creation as responsive action in response to affordances in the environment, inspired by the affordance theory of James Gibson (section two). As it turned out that creation as responsiveness is a necessary but not yet sufficient condition to leave the familiarity of currently dominant human-technology relations behind and to engage in new-to-the-world human-technology creation, we introduced the notion of creation as deviation from the established world of human-technology relations in the “[Creativity as Dissent and Deviation](#)” section. With the concept of creation as deviative responsiveness, we articulate the human contribution to human-technology creation, namely, his or her intentional deviation of the inhibiting forces of the currently dominant niche or meaningful world of human-technology relations in order to become responsive to new affordances in human-technology creation that constitute a new niche or world of human-technology relations.

With our findings, we not only advance theoretical knowledge in philosophy of technology. Creation as deviative responsiveness informs our understanding of the emergence of new technologies in human-technology creation that mediate our human-technology relations. What is more, our concept of creation as deviative responsiveness enabled us to move beyond a negative or hubristic understanding of creation involved in innovation. In the history of innovation (Godin, 2015) and in pessimistic philosophies of technology (Ellul, 1964), the deviation of creation is often understood as alienation or decline. Based on our findings, we can argue that creation as deviative responsiveness is indeed transgressive, but that this transgression is simultaneously positive and negative. The deviation of creation frees itself from the inhibiting forces of the currently dominant niche or meaningful world—the world associated with fossil fuel for instance—and enables us to become responsive to new affordances that constitute a new world based on wind and sun.

With this, our concept of creation as deviative responsiveness can also become relevant in contemporary debates about ethics of technology. The quietism of traditional philosophers of technology—one can think of Heidegger’s concept of human *releasement* (Heidegger, 1989)—is often criticized. In response, it is called for human world-making powers to create a world in which humanity takes care of the sustainability of the life support systems of planet Earth (Hamilton, 2017). While it is questionable whether human beings are the primarily subject of world creation (Blok, 2022b), our reflections in this article provide a concept of creation that moves beyond anthropocentrism but acknowledges the fundamental role of human creativity in human-technology creation that can

support sustainable development. In the face of climate change, what is needed is creation as deviation from the inhibiting forces of the currently dominant fossil fuel–driven human-technology relations. Creation as deviation enables us to become responsive to new affordances in human-technology creation that constitutes a new solar- and wind-driven world of human-technology relations. Creation as deviative responsiveness does not make humans powerless as soon as they deviate from the currently dominant niche or world of human-technology relations. Although creation as deviation confronts us with uncertainty about the future, its freeing from the currently dominant niche or world also makes the innovator free to engage with the experimentation of our responsiveness to new affordances in the environment that might constitute a new sustainable niche or world in the future.¹¹

Funding This work is part of the research program Ethics of Socially Disruptive Technologies, which is funded through the Gravitation program of the Dutch Ministry of Education, Culture, and Science and the Netherlands Organisation for Scientific Research under Grant number 024.004.031.

Declarations

Conflict of Interest The author declares no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Arendt, H. (1958). *The human condition*. Chicago University Press.
- Aristotle (1980) *The physics*. Trans. P.H. Wicksteed and F.M. Cornford. Cambridge/London: Loeb Classical Library/Harvard UP.
- Aydin, C., González Woge, M., & Verbeek, P. P. (2019). Technological environmentalism: Conceptualizing technology as a mediating milieu. *Philosophy & Technology*, 32, 321–338.
- Bardin, A. (2018). Philosophy as political technē: The tradition of invention in Simondon's political thought. *Contemporary Political Theory*, 17, 417–436.
- Blok, V. (2014a). Reconnecting with nature in the age of technology: The Heidegger and radical environmentalism debate revisited. *Environmental Philosophy*, 11(2), 307–332.
- Blok, V. (2014b). Being-in-the-world as being-in-nature: An ecological perspective on being and time. *Studia Phaenomenologica*, 14, 215–236.
- Blok, V. (2021). What is innovation? Laying the ground for a philosophy of innovation. *Technē: Research in Philosophy and Technology*, 25(1), 72–96.

¹¹ I would like to thank Jochem Zwier for our discussions about the human role in creation, and the two anonymous reviewers for their excellent reviews of an earlier draft of this article.

- Blok, V. (2022a). The ontology of creation: Towards a philosophical account of the creation of World in innovation processes. *Foundations of Science*. <https://doi.org/10.1007/s10699-022-09848-y>
- Blok, V. (2022b). The ontology of technology beyond anthropocentrism and determinism: The role of Technologies in the constitution of the (post) anthropocene world. *Foundations of Science*. <https://doi.org/10.1007/s10699-022-09829-1>
- Blom, P. (2021). *Das grosse Welttheater. Von der Macht der Vorstellungskraft in Zeiten des Umbruchs*. DTV.
- Clark, A. (2003). *Natural born cyborgs: Minds technologies and the future of human intelligence*. Oxford University Press.
- Feenberg, A. (2005). Critical theory of technology: An overview. *Tailoring Biotechnologies*, 1(1), 47–64.
- Freeman, C. (1974). *The economics of industrial innovation*. Penguin.
- Gibson, J. J. (1977). “The theory of affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting and knowing* (pp. 67–82). LEA.
- Gibson, J. (1982). “Reasons for realism: Selected essays of J.J. Gibson”. E. Reed & R. Jones., R. (Eds.) Lawrence Erlbaum: Hillsdale.
- Godin, B. (2015). *Innovation contested. The idea of innovation over the centuries*. Routledge.
- Hamilton, C. (2017). *Defiant Earth. The fate of humans in the Anthropocene*. Polity.
- Heidegger, M. (1977). *The question concerning technology and other essays*. Harper and Row.
- Heidegger, M. (1989). *Beiträge zur Philosophie. Vom Ereignis*. Gesamtausgabe Band 65. Frankfurt a.M.: Vittorio Klosterman; *Contributions to Philosophy (from Enowning)*. Trans. by Emad, P., Maly, K. Bloomington and Indianapolis: Indiana UP 1999.
- Heras-Escribano, M. (2019). *The philosophy of affordances*. Palgrave Macmillan.
- Ihde, D. (2009). *Postphenomenology and techno-science: The Peking Lectures*. SUNY Press.
- Kadar, E., & Effken, J. (1994). Heideggerian meditations on an alternative ontology for ecological psychology: A response to Turvey’s (1992) proposal. *Ecological Psychology*, 6(4), 297–341.
- Kondratjev, N., Stolper, W. (1935) “The long waves in economic life”, *Review of Economics and Statistics* 17(6)
- Kudina, O., Verbeek, P.P. (2019) “Ethics from within: Google Glass, the Collinridge dilemma, and the mediated value of privacy”. *Science, technology, and human values* 44(2): 291–314
- Leroi-Gourhan, A. (1945). *Milieu et techniques*. Albin Michel.
- Malafouris, L. (2013). *How things shape the mind: A theory of material engagement*. MIT Press.
- McLuhan, M. (1964). *Understanding media: The extensions of man*. McGraw-Hill.
- McLuhan, M., & McLuhan, E. (1988). *Laws of media: The extensions of man*. Routledge.
- Nancy, J. L. (2007). *The creation of the world or globalization*. SUNY Press.
- Nef, J. U. (1977). An early energy crisis and its consequences. *Scientific American*, 237(5), 140–151.
- Plato (2017) *Euthyphro, apology, crito, Phaedo, phaedrus*. Cambridge/London: Loeb Classical Library/Harvard UP.
- Rousseau, J. J. (1973). *Discourse on the origin of inequality*. Everyman’s library.
- Sanders, J. T. (1997). An ontology of affordances. *Ecological Psychology*, 9(10), 97–112.
- Simondon, G. (2017). *On the mode of existence of technical objects*. Univocal.
- Simondon, G. (2020). *Individuation in light of notions of form and information*. University of Minnesota Press.
- Solomon, M. (2009). Standpoint and creativity. *Hypatia*, 24(4), 226–237.
- Stiegler, B. (1998). *Technics and time 1*. Stanford UP.
- Varela, F., Thompson, E., & Rosch, E. (1991). *The embodied mind*. Yale University Press.
- Verbeek, P. P. (2005). *What things do: Philosophical reflections on technology, agency and design*. Pennsylvania State University Press.
- Zwier, J., Blok, V., & Lemmens, P. (2016). Phenomenology and the empirical turn: A phenomenological analysis of Postphenomenology. *Philosophy & Technology*, 29, 313–333.