Philos. Technol. (2016) 29:61–78
DOI 10.1007/s13347-014-0186-3

RESEARCH ARTICLE

Taking Stock of Extension Theory of Technology

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Received: 1 September 2014 / Accepted: 22 December 2014 / Published online: 10 January 2015

Abstract In this paper, I will focus on the extension theories of technology. I will identify four influential positions that have been put forward: (1) technology as an extension of the human organism, (2) technology as an extension of the lived body and the senses, (3) technology as an extension of our intentions and desires, and (4) technology as an extension of our faculties and capabilities. I will describe and critically assess these positions one by one and highlight their advantages and their shortcomings and limitations. Along the way, I will explicate some of the differences and similarities between the various approaches. I conclude the paper with some suggestions for future research directions that will be beneficial for advancing theory building and that will drive forward the philosophical refinement of extension theory.

Keywords Technology as extension · Artifacts · Philosophy of technology · Human-technology relations · Instrumentalism · Extended mind · Extension theory

1 Introduction

The focus of this paper is on the extension theory of technology. I will identify four dominant positions that have been put forward in this regard:

1. Technology as an extension of the human organism (Kapp 1877)
2. Technology as an extension of the lived body (Merleau-Ponty 2003; Ihde 1990; De Preester 2011)
3. Technology as an extension of human intentions (Rothenberg 1995)
4. Technology as an extension of human faculties or capabilities (McLuhan 1964; Brey 2000; Lawson 2010)

After a short presentation of each account of technology as an extension, I will stress the advantages of each approach and point out shortcomings. I will also outline links to the other extension accounts.

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Although some authors have already pointed out some of the problems with one extension theory or other (Brey 2000; Kiran and Verbeek 2010); so far, there is no systematic attempt to give a classification and comparison of the four major accounts of technology as extension. This paper fills the gap.

A review of the various extension accounts is important because not all scholars that have come to be associated with the idea of technology as extension are necessarily talking about the same thing. The notion of extension has connotations that not all authors would subscribe to. It is the details that matter, given that extension theory is not a unified theoretical framework, as Heersmink (2012) correctly points out.

The critical review of the various extension theories will help to elucidate the strengths, weaknesses, and limitations of the different approaches that have been presented so far. This will also result in a better grasp on what differentiates and unites the various stances. Slightly more space is devoted to the idea that technology is an extension of our faculties and capabilities as advanced by Brey (2000) and Lawson (2010) because I think that this is the most comprehensive and promising of all the accounts and because it has not yet received a critical evaluation that points to the intrinsic problems of this account.

In the last section, I will take a broader look and consider some general issues pertaining to extension theory, and I will present some future directions of investigation that I think would significantly advance theory building. I will end the paper with a summary and a short conclusion.

2 Extension of the Organism: Your Technology, Your Organs

In this first section, I will briefly describe and then assess the idea that technology is an extension of our organs. Ralph Waldo Emerson expressed the idea poetically in his piece *Works and Days* from 1870: "The human body is the magazine of inventions, the patent-office, where are the models from which every hint was taken. All the tools and engines on earth are only extensions of its limbs and senses." (Emerson in Bosco and Wilson 2007, 79). Although the idea that technology is an extension of the human body can be traced back to Aristotle's[1] claim that the body is our natural tool, it was not until German philosopher of technology Ernst Kapp has presented his account that artifacts and even complex technology are a "projection" of human organs, that this idea found its first proper philosophical elaboration. In what follows, I will give a rough outline of Kapp's account of "Organprojektion," followed by a critique of this understanding of technology as an extension.

The basis of Kapp's philosophy of technology is the idea that our organs are projected into artificial means like tools and instruments. Kapp explicitly claims that the tool is a reproduction (in German, "Nachbild") of the human body (Kapp 1877, 25). With a nod towards Plato, Kapp calls the organism the "Urform" (41) that is considered to be the prototype for all instruments. The "projection" for Kapp is an externalization of an interior, whereas organ-projection means the mechanical reproduction of an organic form. The evolution of technology is due to this projection of the inner workings of the human organism into external artifacts and tools. For Kapp, this

[1] Eudemian Ethics book 7, 1241 b.

process of projection is by no means a conscious or deliberate activity. As Mitcham has put it, the relationship between tool and organ "is more one of unconscious discovery than of conscious invention" (Mitcham 1994, 23). The tool is an unconscious reproduction (projection) of the organic archetype (the Urform).

Kapp considers the hand to be the "innate" and natural tool of human beings. The hand, so Kapp, also serves as a role model for other simple tools like the hammer. In other words, the hand is the organic archetype for the production of tools and instruments. The eye is another example that Kapp uses to drive home his point. While the hand serves as the archetype for various manual tools, the eye is the archetype of every optical apparatus (Kapp 1877, 77). But Kapp goes even further when he claims that the telegraph network is a projection of the human nervous system. The nerves are the "cables" of the animal body, and the telegraph networks are the projected nerves of humanity. One last example: The steam engine is described in analogy to the workings of the human organism. Like the organism, the steam engine circulates energy and needs "food" in form of coal in order to maintain its activity.

It is important to note that the projection of organs is only half of the story. Humans not only "project" their organs into their artificial means but these artificial means also enhance and support the bodily organs (Kapp 1877, 42). I think nobody would doubt that a hammer enhances the bodily strength of the fist.

After this short synopsis of Kapp's main ideas, I will now turn to the problems of his version of extension theory. In order to critically evaluate Kapp's account of technology as organ-projection, I want to make a distinction: I think his account can be read as either an exploration of the genesis of technology or it can be read as an account of the meaning of technology as a vehicle for human self-understanding. While the second reading is a valuable contribution to a deeper understanding of the human-technology relation, the first reading faces some serious problems. I will begin with the second reading that concerns our self-understanding.

2.1 Strengths

On various occasions, Kapp is at pains to point out that tools and machines are not only a reproduction of bodily organs but can also serve as a means for a better understanding of the human organism. He explicitly argues that the "projected" and therefore unconsciously reproduced mechanism that we find in machines can be used to illuminate the inner workings of the organism (Kapp 1877, 26). In other words, technology might serve as a so-called epistemology engine (Ihde and Selinger 2004). The idea here is that we interpret ourselves in the light of our technology. Examples of this perspective (from artifact to organism) are not hard to come by: The eye is often conceived along the lines of telescope and magnifying glass, and William Harvey described the circulatory system after he thought of the heart as a mechanical pump. A more recent example is the attempts by some cognitive scientists to understand and explain cognitive processes in analogy to digital computers (Boden 2006).

I think that the contribution that Kapp makes should be appreciated. He is one of the first thinkers to grasp the role technology plays in our self-understanding. He knew that technology is an important source for the construction of our self-image. Or as the seventeenth century educationalist Johann Amos expressed it: "Fabricando fabricamur"—In creating something, we are also creating ourselves.

I will now turn to the idea that organ-projection can explain the genesis of technology.

2.2 Limitations

According to Kapp, every existing tool must have a corresponding human organ (or some other physiological structure). This naturalistic account of technology revives the old idea of "emanation," which holds that a secondary thing "flows" or proceeds from some primary thing. According to Leibniz, for example, all substances emanate from God (Leibniz 1985, 46f.). I want to propose that the idea of Kapp can be reconstructed as follows: Every tool "emanates" from an external or internal organ of the human body. The upshot of this account is, of course, that if there is an artifact or tool, it necessarily originated from a bodily counterpart. But it does not entail that every organ actually has a counterpart. I will now show that Kapp's thesis thus reconstructed does not withstand empirical scrutiny.

At first glance Kapp's idea of organ-projection is very intuitive. Simple tools like hammers, bowls, and pliers all seem to have a bodily counterpart in our hands, fingers, and teeth. Both hammer and hand can smash something. Both knife and teeth can cut through materials. The functional as well as morphological similarities are obvious. But these similarities do not hold for other artifacts. Consider morphological similarities. Although some tools, like hammer and pliers, are morphologically similar to human organs, there are a lot of artifacts, like books or cellphones[2], that have only a minimal morphological similarity with organs at all.

Now, for the functional similarities, I think that Kapp is correct about the functional similarity between some tools and organs when we understand function in terms of the causal role that something has. Having the same causal role is having the same function. Hence, the knife can have the same function as your teeth with respect to the task of cutting something, because both can be used to cut through material. Your teeth may not be as efficient as the knife but they are nevertheless effective. However, the functional parallel breaks down completely if we look at more complicated artifacts like matches. There is no functional similarity between matches and organs of the human body because there simply is no human organ that has any causal role in emitting light.

To sum up, although the idea of a projection of organs into external means is an intuitive account of how a limited set of simple tools might have developed as a replication of the morphology and functions of some organs, it does not fare well when it comes to complex technical artifacts. Therefore, the explanatory power and appeal of this account is highly limited.

After having reviewed and assessed Kapp's idea that technology is a projection of our organs, I will now turn to the technological extension of the "lived body" and the extension of the senses.

[2] A similar point has been raised by Brey (2000). He gives some counterexamples to the alleged morphological projection of human organs: lighters, telephones, and fishing nets.

3 Not with Your Naked Eyes: Extension of the Lived Body

The idea that at least some artifacts can extend our lived body and our senses has a long tradition, especially within the phenomenological camp. Maurice Merleau-Ponty makes the claim that our body can be extended via the use of tools. He argues that our body is an open system that can incorporate external means. He uses three cases of tool-use to illustrate this idea: Wearing a feathered hat, driving a car, and using a blindman's cane. In all three cases, the artifacts are incorporated into the body: "To get used to a hat, a car or a stick is to be transplanted into them, or conversely, to incorporate them into the bulk of our own body." (Merleau-Ponty 2003, 166). In use, the artifacts withdraw and become parts of the body, thereby being an "extension of bodily synthesis" (ibid., 165). Tools are incorporated into the body, and in cases like the stick and the car, the world is sometimes perceived through these artifacts. The texture of the street is perceived "through" the stick, and the condition of the road is perceived through the car. In these cases, perception is materially extended, and humans are in what Don Ihde has dubbed "embodiment relation" (Ihde 1990, 40) with technology. Although the cane, the car, and also telescopes and glasses are between perceiver and the perceived world, the attention is direction upon the "world" and not at the technology that is employed. In the process of using these tools and instruments, they become transparent (they "withdraw") and extend our sense perception. However, every extension comes at a certain prize because it always involves a *transformation* of experience (Ihde 2002, 93). Consider the telescope: Although your vision is enhanced and the surface of some distant planet or object is brought "closer," the telescope also occludes the surrounding of the object that it brings closer. In the embodiment relation, tools are never neutral because they always "simultaneously magnify or amplify and reduce or place aside what is experienced through them." (Ihde 1990, 76).

3.1 Strengths

I think that the phenomenological accounts of sensory extension and bodily incorporation helps to clarify the experiential structures involved in the use of tools and instruments and sheds light on how we incorporate extra-corporal entities (Besmer 2012). It also showcases the value of attentive phenomenological inquiry into technology for cognitive science. Understanding technology as an extension of the lived body has made an impact on empirical research: De Preester and Tsakiris (2009), for example, draw a distinction between prosthetics and mere tool-use. Only in the former case is the tool incorporated and actually becomes part of the body. Nevertheless, they argue, it is "not easy to maintain an adequate conceptual distinction between a tool that extends the body, and a prosthesis that is incorporated into the body" (309). They also claim that the pre-existing body model (that is, roughly, an implicit representation of the position and posture of our body and its parts) puts certain limits on the possibilities of a bodily extension by non-corporal objects. External objects can replace parts of the body model, but the body model as a whole cannot be extended but only reorganized. In a more recent paper, De Preester (2011) argues for a distinction between what she calls "real re-embodiment" in cases of the incorporation of non-corporal items and "mere" bodily extension via tools. Clark (2007) also defends a distinction between true incorporation into the body schema and mere tool-use.

Despite the empirical value of the idea that technology is an extension of the lived body, there are some problems that need to be addressed.

3.2 Limitations

Obviously, not all artifacts are an extension of the lived body in the sense outlined above, and I do not think that the authors that I have mentioned there hold that *all* artifacts actually extend the living body. The idea that technology extends our senses and lived body describes only a certain limited range of artifacts that can be embodied or incorporated. Hair blowers and hot-water bottles, for example, certainly have unique experiential aspects and might also easily fade into the background of experience, but it is not intelligible how my body or my senses are "extended" when I use them. Similarly, although a book might nurture our intellectual capabilities and an architectural structure may transform how we perceive our surroundings, both do not extend our lived body and enhance our senses in any way[3].

So far I have covered the idea that technology is an extension of our organs and the idea that technology is an extension of our lived body and can extend our senses. In the next section, I will turn to an account of extension that focuses on desires and intentions.

4 Technology as Extension of Our Intentions

According to Rothenberg (1995), it is essentially our *intentions* that are extended in the use of technology. In order to describe this "extension of intentions," Rothenberg uses spatial vocabulary: Intentions are "expanding;" they reach out "from the deciding being to leave a tangible record of the decision in the thing which is done" (15). Desires on the other hand "guide our action toward transformation of the world." (ibid.). So, intentions are considered to be a kind of *intermediary* between desires and the external world. When human beings construct or invent something and subsequently use their creations, so Rothenberg, they "thrust" (16) their intentions upon the world, thereby changing the world into the desired state.

Here is an example that will help to clarify Rothenberg's idea: Imagine you are a farmer whose field is plagued by crows. Your field is an important asset and crucial to feeding your family, so you obviously have a strong desire to keep your crops unharmed and healthy. Your desire to save your crops drives you to seek a solution. You have the intention to transform the world according to your desire. So you deploy a device that keeps the birds away from your field: A scarecrow. According to Rothenberg, this construction "thrusts" or "extends" your intention upon the world. The scarecrow is a tangible outcome of your intention to change the world according to your desire. It is important to note here that your intention could be realized in multiple

[3] It is important to note that cups and books *can* be used as an extension of the senses. We can imagine someone using a book in the same way a blind man uses his cane. Technologies cannot be reduced to a designed intent; rather they are ambiguous and can be embedded in a variety of ways. Or as Ihde (1990) calls it, technologies are "multistable" (144). See also Ihde (2002), 106.

ways. Another more time-consuming and uncomfortable strategy would be to scare the crows away yourself or hire somebody else to do it for you.

4.1 Strengths

One of the advantages of Rothenberg's account is that it directs our attention to desires and how they relate to technology. This brings into view that technology is intimately linked to our affective side, reminding us that our engagement with technology is not merely an intellectual endeavor. In our interaction with technology, we are also affectively invested. Our involvement with technology involves the full range of emotions, desires, and intentions, and a philosophical account of technology should acknowledge this emotional-volitional aspect of technology (McCarthy and Wright 2004).

Rothenberg's idea that technology is an intermediary between the world and our desires and intentions also points to the mediating aspect of technology. Acknowledging that technology is a mediator brings to the fore questions regarding the nature of this mediation and how this mediation shapes the intentions and desires of the people using technology. Which is to say that Rothernberg's account needs to be supplemented with positions developed within the phenomenological tradition, where the reflection on technological mediation is prominent (Verbeek 2008).

In the next section, I will focus on some substantial problems of Rothenberg's account.

4.2 Limitations

Because Rothenberg's usage of "extension" is vague and confusing, it is hard to figure out what he is after when he talks about extension. Just note the different contexts to which he applies the notion of extension: He says that he uses the term to explain, "how intention operates in a dynamic, territory-expanding manner" (Rothenberg 1995, 15). The spatial language that Rothenberg deploys here does not really make it clear how to understand this expansion that allegedly takes place because intentions are not some material objects that might be extended spatially by something like pulling or welding. Reminiscent of Kapp and his idea of organ-projection[4], Rothenberg further claims that only those things can be extended for which we have a "mechanical" understanding (ibid., 15). To illustrate this point, he puts forward examples like the telescope and the microscope, because we possess some understanding and systematic knowledge of the mechanical workings of the eye. He sounds even more like a disciple of Ernst Kapp when he asserts that hand-driven tools like the hammer are a "direct extension of the body" (ibid., 31). On other occasions, Rothenberg seems to have in mind something like a perceptual extension because he claims that instruments like the telescope can extend our perception (ibid., 31). To make things even more complicated and obscure, he introduces a distinction between physical and mental intentions: "The most direct kind of technology is an immediate means for realizing physical or mental intention by extending the forces of the body and the mind." (ibid., 44).

[4] For a more detailed comparison of Kapp and Rothenberg, see Brey (2000).

Going by the gist of his account and in order to avoid the problems just mentioned, Rothenberg's idea might be reformulated like this: Rather than extending human intentionality, technology extends the *means* by which intentions can be realized (Brey 2000). In order to realize our intentions, we come up with and use tools that help us to change the world according to our desire. There are many means to realize a given intention and technology is just one option[5]. More than often, however, we are realizing our intentions with material artifacts.

Now, when reformulated like this, Rothenberg's account seems to be kind of trivial. It is not exactly an original insight that we can change the external world deploying extra-corporal objects. Actions with tools and artifacts are simply a sub-class of "human acts" that leave a mark on the world. So the trivial reading would simply amount to the claim that technology is just another means to realize our intentions- that is to say, another means of how we change the world into a desired state.

Another critical point here is that the desire-intention conception used here might easily lead to the view that technology is merely a neutral means that we use to achieve some desired goal. This view is commonly known as instrumentalism. The charge of instrumentalism against extension theory of technology (Kiran and Verbeek 2010) is a reminder that technology is not neutral and that an account of technology that features desires and intentions needs to be supplemented with a perspective that brings to the fore how technology also shapes this very desires and intentions. Again, a phenomenological perspective that focuses on mediation is a highly promising candidate in this regard.

This brings me to the fourth and last account of technology as an extension.

5 Technology as Extension of Faculties and Capabilities

In *Understanding Media* (1964), Marshall McLuhan popularized the idea that technology can be characterized as an extension of human faculties and capabilities. Unfortunately, McLuhan is not really clear about the concept of extension that he has in mind. Throughout the book, he speaks of various forms of extension: Extension of the senses, extension of our central nervous system due to electronic technologies, and extension of our skin by means of clothes. Despite the conceptual vagueness of his account, I think McLuhan's main claim can be summarized as follows: Technology is not only an extension of human intentions and desires but also an extension of our *capabilities*. For McLuhan, extension is not limited to mere enhancement of a capability. His version of the extension idea pays critical attention to the effects that the use of technology has on us and on our capabilities (Van den Eede 2014, 166). A technology may enhance some of our natural capabilities, but we should not be oblivious to the negative effects of technology on our capabilities. The Internet, for example, is said to have an undesirable effect on our thinking capacities and learning abilities. Some authors have forcefully argued that the Internet turns us into superficial thinkers and suffocates our ability to concentrate and contemplate (Carr 2011).

[5] In some cases, however, technology may be the only way to realize an intention. Think of the desire to propel subatomic particles and the intention to fulfill this desire. Here, the use of a particle accelerator is inevitable.

In the wake of McLuhan's and Rothenberg's ideas, some authors have argued that technology is an enhancement, amplification, or acceleration of the bodily and mental capabilities and faculties that help us to realize our intentions. Two eminent proponents of this view are Brey (2000) and Lawson (2010). First, I will reconstruct Brey's view before I turn to Lawson's account.

Brey (2000) seeks to overcome the vagueness and limitation pertaining to both Rothenberg's and McLuhan's account. His goal is to present a unified account of technology as extension. Implicitly resonating Aristotle's claim that our body is our foremost and natural tool (see section on Kapp above), Brey starts with the observation that nature has endowed us with an original set of tools to realize our intentions. This original tool set consists of the limbs that we control, our sense organs, and our mental faculties. Brey's main thesis is that technology extends our original means by which human intentions are realized. In other words, we can add external means to our original set of tools. Brey defines external means as all means that are not part of this original toolbox. These external means, so Brey, extend the range of actions or tasks that we are capable of performing. According to Brey, the extension of our means to realize our intentions is achieved by either complementary or amplificatory extension.[6] For illustrative purposes, I will only use organs as examples, although Brey also includes mental capabilities in his account:

(1) Complementary extension takes place when the artifact adds a novel capacity. A lighter, for example, adds a new capacity that was not part of our original toolbox.
(2) Amplificatory extension on the other hand takes place when the artifact affects a capacity that already exists. This can happen in three ways:

   (a) A replacement that makes the organ or faculty redundant. Driving a car, for example, makes the legs redundant.
   (b) A supplementation, which refers to performing a function that the organ is also performing but where the artifact adds to the functionality. Clothes, for example, perform the same function as the skin.
   (c) An enhancement, where the functional power of the organ is enhanced because the artifact and the organ cooperate and enter into a symbiotic relationship. Brey's own example is the telescope that extends visual perception because it teams up with our eyes, comprising a functional unit.

Another recent rendering of the idea that technology is an extension of our capabilities and faculties comes from Lawson (2010). He suggests that technical activity is an activity that "harnesses the intrinsic causal powers of material artifacts in order to extend human capabilities." (Lawson 2010, 217). Based on this notion of technical activity, Lawson claims that a *technical artifact* is every artifact that is harnessed in such a technical activity. Technical artifacts can therefore clearly be distinguished from other artifacts such as money or pieces of art because we use the intrinsic causal powers of material artifacts in order to "extend the extrinsic properties or powers of people" (Lawson 2010, 213), while the capability disappears as soon as we cease to engage in

[6] I do not share Lawson's (2008) verdict that Brey leaves his notion of extension unclear.

the technical activity. Therefore, playing with toys and consuming food does not qualify as technical activity.

Despite a lot of differences in the details of their accounts that I am not able to spell out here, there are some crucial similarities between Brey's and Lawson's account of extension: As far as I can see, both Brey and Lawson are in agreement that it is our capabilities and faculties that are extended via technology. Whereas Brey talks about technology as extending our action horizon, Lawson claims that the powers of material artifacts are harnessed in order to expand our scope of possibilities and that technology extends what humans are capable of (Lawson 2008). Lawson further points to the subjective experience of "achieving more" when we are engaged in technical activity. and although Lawson (2010) uses the terms "extrinsic properties" and "powers" that are extended, I take these to refer to capabilities and faculties.

5.1 Strengths

The big advantage of taking technology to be an extension of our faculties and capabilities is that it seamlessly encompasses the other extension theories. This account is comprehensive enough to include simple technical artifacts, without making any dubious claims as to whether the artifacts are morphologically similar to some of our organs. Further, the idea that technology is an extension of our faculties and capabilities is able to incorporate artifacts that extend our lived body and are embodied.

By distinguishing between complementary and amplificatory extension (as Brey does), a capabilities account of extension is also fine-grained enough to specifically consider what is lost and what is gained in the extension. A particular technical artifact maybe a great way to realize your intentions, but this extension might be achieved by rendering the original faculty redundant. In other words, the capabilities account reminds us that extending our capabilities could come with a price. This, again, is an entry point that allows the capabilities approach to integrate the phenomenological insight of the magnification-reduction structure of tools (see Ihde 1990; Section 2 of this paper) and McLuhan's reminder of the negative impact of technology on our capabilities.

Given that faculties and capabilities are not restricted to the bodily realm of organs but include mental faculties and capabilities as well, this account overcomes the limitation of previous extension theories that focused almost exclusively on the body. This opens up a new field of inquiry and invites us to consider the similarities and differences between the extension of bodily and mental faculties and capabilities. The inclusion of mental capabilities also establishes some interesting links to cognitive science[7] that will turn out to be beneficial to both cognitive scientists and extension theorists: First, by using empirical results regarding the effect of technology on our mental capabilities, the extensionist will be enabled to refine his account. It should be of interest to the proponents of extension theory to know what technology extends or

[7] Further advantages of the capabilities account are that it helps to explain the evolutionary trajectory of technology, that it raises the question whether our extension are in line with our desires and what consequences the extension of faculties has for our self-understanding. For more, see Brey (2000).

shapes which mental capability, under which circumstances and how exactly. To give just one example here: There is a small but growing body of evidence on the cognitive benefits of video games (Granic et al. 2014). In a recent study, a team at the University of Rochester could show that video game players are better learners than non-players (Bejjanki et al. 2014).

Second, the cognitive scientist interested in the effect of technology on our mental capabilities may use the concepts of extension theorist as a framework for her experimental design. For example, following McLuhan's idea that we should always expect a numbing of the abilities (Van den Eede 2014, 167), the cognitive scientist may want to investigate what mental capabilities are diminished while other capabilities are enhanced instead of concentrating simply on the positive or negative effects for one capability only.

Despite its many advantages, there are some shortcomings of the capabilities approach that I will consider in the next section.

5.2 Limitations

I want to raise the concern that considering technical artifacts as an addition, replacement, enhancement, or supplementation of our bodily and mental means to realize our intentions cannot really account for what is special about technology. One might ask how is technology a special form of extension? Take Brey's claims that we need a sufficiently restrictive sense of extension and that his version of extension theory does not have counterexamples. I want to suggest that his account does not have any counterexamples because it follows as a conceptual truth that every external means to realize an intention is necessarily either a complementary or amplificatory extension in the sense outlined above. Here is why: If something external is a means to realize our intention, then it is an extension. As soon as something is a means to realize our intention (successfully, one might add), it cannot fail to be an extension. It needs to either add something or take over our abilities. Given that technical artifacts are undeniably external and that they are a means to realize our intentions, it follows that technology is an extension. This, however, does not tell us something about technology specifically but only amounts to the claim that every external means to realize our intentions (successfully) is an extension. Brey acknowledges that a lot of things that are not part of the "standard inventory" that is given to us by Mother Nature can be used to realize our intentions. It is obvious that human beings not only use artifacts to get a job done but also deploy animals and fellow human beings. Humans and animals can serve as external means to realize our intention. So, artifacts are not the only possible external means to realize our intentions, hence the extension of our faculties and capabilities.

In conclusion: The notion of extension of our faculties and capabilities may be a defensible characterization of technology, but only because it is a characterization of every external means to realize our intention. My concern is not that this characterization of technology is wrong but that it is philosophically uninteresting because it does not pick out technology specifically.

I also see another problem for the idea that technology is an extension of our faculties and capabilities in that it leaves unanswered the question which of our faculties and capabilities can be extended. It seems intuitively clear that our capability

to perceive can be enhanced and supplemented by some artifacts. But can our faculty to make moral judgments also be extended? A satisfying account of technology as an extension of faculties needs to give an answer as to whether all of our faculties can be extended or not.

Let me introduce a related issue: It is not clear what precisely is extended in the sense of replacement, amplification, or supplementation. Brey and Lawson do not make clear what they mean when they talk about mental abilities or faculties. As long as it is not clear what a mental capability is, I do not really see how we can make sense of the extension of mental capabilities. Is it the cognitive process that is replaced, or the outcome of the process or is it both? Or are Brey and Lawson referring to a replacement of the neurological underpinnings of a capability? I propose that we should understand what they put forward in terms of *functionalism*. We should think of replication in terms of replication of function. Only the functional roles of the cognitive states and processes need to be replaced in order to properly replace the mental capability. These functional roles can be realized in physical systems other than our brain (Putnam 1973). No replica of the physiological underpinnings of the cognitive capability that is replicated is needed here.

Further, consider cases of extension as supplementation. I have a hard time figuring out what supplementation might mean when it comes to mental abilities. If supplementing a mental capability simply means making a causal contribution to our mental capabilities, then proponents of extension theory will have to specify the bounds of that contribution.[8] Is every artifact that makes some causal contribution to our mental ongoing, however small that contribution may be, to be included in an account of technical activity? I think that it should not be included. Here, I will take a page from the debate of the possibility and limits of extended cognition. Some critics have remarked that the hypothesis that our cognition can be extended beyond our body is prone to "cognitive bloat" (Allen-Hermanson 2012). Cognitive bloat means that proponents of extended cognition cannot provide a line of demarcation between genuine cognition and the tools that facilitate or support cognition. What is missing, in other words, is a criterion of cognition.

What does that have to do with the supplementation of mental capabilities? If an account of extension includes everything that makes a causal contribution to our mental capabilities, then it has to to endorse an absurd number of artifacts simply based on the fact that they causally contribute to our mental capabilities. There are cases where we have no problem to call a technological artifact a supplementation of our powers of the mind. Take the notebook. The notebook is used to write down ideas and experiences or to draw sketches. I think nobody would want to deny that the notebook somehow makes a causal contribution to the creative process of its bearer and for this reason might be called a supplementation of some mental capacities (imagination, creativity, etc.). Now, consider this: The pacemaker also makes *some* causal contribution to the mental capabilities of a person because it keeps the blood circulating which in turn nourishes the brain that is responsible for the mental processes. But do we really want

[8] I take this idea from the debate on extended mind and the bounds of cognition. See, for example, Adams and Aizawa (2008).

to claim that the pacemaker is a supplementation of the mental capabilities of the person? I do not think so. Echoing the problem of the cognitive bloat, I suggest that what is needed here is a clear demarcation between what *constitutes* a mental process from what causally *contributes* to it. As long as that distinction is not at hand, the talk about technology as supplementation of mental capabilities leads to the absurd consequence of encompassing everything that makes a causal contribution.

One last issue: Some material artifacts seem to slip trough the cracks of the theory somehow. For example, the stance that the capabilities approach has on art and other cultural artifacts such as churches or statues is not immediately clear. One could make the case that art also is a means to realize the intention to achieve transcendence or a deeper connection to the world. Even recreational drugs might be considered to be an extension because they help us to realize some of our intentions such as the intention to relax after a hard day or the intention to enter an altered state of mind. However, it is not obvious right away how these artifacts extend our action horizon (Brey) or our extrinsic powers (Lawson).

After the critical review of the four major approaches that consider technology to be an extension, I will canvas some future directions of research that I think would significantly advance extension theory.

6 Future Directions

One thing that is needed to foster extension theory is more in-depth analysis of technological artifacts. As Brey (2000) correctly points out in the last sentence of his paper, the extension perspective is only a starting point. It is certainly not done with the claim that the perspective of technology as an extension is a valuable vantage point that creates novel questions about the human-technology relation. The extension perspective needs to prove that it can shed new light on old questions about technology while at the same time raising new issues. One needs to show how precisely this perspective is useful in explaining technology. In other words, how does the conception of technology as extension hold up in an analysis of various specific technical artifacts? Case studies would be a valuable step to demonstrate the value of the extension perspective.

There is some debate about whether extension theory is just instrumentalism in disguise. Kiran and Verbeek (2010) have claimed that extension theory rests on a false notion of technology because it takes technology to be a neutral means to reach a predefined goal, thereby neglecting that technology also co-shapes how the world appears to us. However, this critique might itself rest on a deliberately strong and superficial reading of extension theory that neglects the differences between authors and approaches. You can be an extensionist while holding that technology is non-neutral and has an impact on subjectivity and affects how we relate to the world (Heersmink 2012). The alternative is not between being a non-instrumentalist and being an extensionist. Given this debate, it would be highly beneficial to have an account of the relation between instrumentalism and extension theory that makes the differences and similarities more precise, while at the same time valuing the things that instrumentalism gets right about our relationship with technology.

Next, I think it would be of great interest to work out the conceptual connections between accounts of technology as extension and accounts of the extended mind. The

proponents of the extended mind thesis claim that a coupled system encompasing cognitive processes and external tools can sometimes constitute cognition (Clark and Chalmers 1998). It would be attractive to illuminate the points of contact between debates regarding extended mind and extension theory of technology, partly because various authors of the extensionist tradition take some artifacts to be an extension of the mind (like McLuhan) or have proposed that some artifacts are an extension of the brain (Feibleman 1967), that libraries are external memory banks, and that computers are external minds (Feibleman 1979, 399). In the previous Section (5.2), I mentioned that extension as a replication of mental capabilities should be regarded as a replication of the function of cognitive processes. Hence, the idea of an extension of mental capabilities has an interesting connection to the parity principle in the extended mind debates.[9] The parity principle is a prescriptive principle that holds that even when a particular process is located outside our skull, we should treat it as cognitive if we would treat this external process as cognitive if it were located in our heads (Menary 2006, 333; Wheeler 2010, 249). In other words, the parity principle is concerned with the functional isomorphism of internal and external processes. However, some authors have argued that the parity principle downplays the differences between external and internal and have opted for the complementary principle. The complementary principle does not focus on the isomorphism of internal and external processes but stresses that cognitive artifacts do not have to be similar to internal processes and can complement them although they are functionally different (Heersmink 2014). It is worth to examine if the extension of mental capabilities is more plausibly conceptualized under the parity or complementary principle. Also, it would be interesting to investigate whether the idea that technology can extend mental capabilities entails one or the other principle. Overall, more conceptual work is necessary to fathom the yet neglected overlap between accounts of extended mind and accounts of technology as an extension. An overlap that I think will yield fruitful results for both sides.

Further, I want to propose that one further important task for extension theorists is to go beyond the favorite paradigm examples of extension theory, that are mostly material artifacts such as tools, and work out whether the digital world, with its possibility of multiple online personas and new opportunities to create narratives of the self (Belk 2013), can be accommodated in the framework of extension theory.

Speaking of going beyond the trodden path, we should not overlook the point that the accounts of technology as extension focus on tools and machines that are more or less under our control. The idea of technology as an extension seems to be tailor-made for artifacts that are used or manipulated by us in one way or another. However, not all artifacts are under our control. Especially with the introduction of autonomous technology and sophisticated robotics on the rise, we are faced with new challenges: What happens if machines are able to develop desires and interests of their own (Neely 2013), do they cease to be extensions or do they remain extension in the sense that other sentient beings can be means to realize some intention? This takes us back to the abovementioned question of what different kinds of extension have in common and how, if at all, an extension with material artifacts differs from an extension that features non-technical biological entities.

[9] I am grateful to an anonymous referee for bringing this to my attention.

Let me dwell on this issue a little more: The lurking danger of extension theory is that it makes it easy to overlook some crucial differences between how certain artifacts are deployed. Conceptualizing technology as either an extension of the senses, an extension of desire, or an extension of the means to realize our intentions makes statements about technology that are very general and might miss subtle differences. Of course, both a cochlear implant and a binocular are extensions of a similar kind because they both are sensory extensions and an extension of our intentions. However, there is an important difference, given that the implant is permanently incorporated whereas the binocular might be only temporarily embodied. They not only differ in their relation to the body and in the way they are used but they also have different existential implications- that is to say, implications for the lives of the "user".

Morality is one of the blind spots in extension theory so far. Extension theorists have been awfully silent about the moral implications of their accounts (except for some scattered remarks here and there). What does it mean for the moral status and the moral standing of machines and artifacts when they are an extension? Further, how does the idea of technology as extension chime with philosophical accounts of the moral standing of technology and moral status ascriptions? I submit that we need to spell out how extension theory helps us to think about the moral dimension of artifacts. It needs to be inquired which moral position may follow from the idea that technology is an extension. I suspect that this can only be done on a case-to-case basis and by working with a clear notion of extension.

Given that at least one of the extension accounts focuses on our capabilities and faculties, I think it would be very rewarding to connect extension theory to the literature of skill acquisition. What I have in mind here are not just the bodily motor skills (Dreyfus 2004, 2002) but also cognitive skills that are acquired or enhanced in the use of artifacts. A narrow notion of skill that considers skill to be a proficiency in the use of artifacts (e.g., Feibleman 1966, 318) has only limited value here, because it neglects all the extensions of our capabilities that do not evaporate once the artifact is put down or turned off (Lawson 2010). Skills seem to extend our action horizon in a particular way, although, of course, they are not external means. More theoretical work needs to be done here because it is not clear whether certain skills count as technically induced extensions of our capabilities or whether, in the language of Brey (2000), they are part of our natural toolbox that can be shaped by technology.

7 Summary and Conclusion

I will now give a short summary of what I have established in this paper:

(1) I have proposed that a characterization of technology as an extension of the human organism as Kapp has presented it is a good reminder to be critical as to how we interpret ourselves through our artifacts. Our self-understanding is mediated by technology. Although intuitive on first glance, the shortcoming of the account is its claim that artifacts always have functional or morphological similarities to some organ. For this reason, it cannot accommodate artifacts and machines that have no similarity to the body.

(2) The account of technology as extension of the lived body and extension of our senses pays close attention to the experiential structure of our use of artifacts and can give us a better understanding of embodiment and incorporation. It also reminds us of the non-neutrality of technology. However, given that a lot of artifacts do not extend the lived body or the senses, the account is limited but can still serve as a valuable supplementation to other extension accounts.
(3) The characterization of technology as extension of our desires and intentions is valuable in that it directs our attention to the oft-neglected affective and volitional aspect of technology. I have introduced the problem that conceptualizing technology as a means to realize our intentions is rather trivial and philosophically not very substantial. I have also proposed that the account should be combined with a phenomenological perspective that takes technological mediation serious and pays attention to how technology shapes our desires and intentions. The combination with a phenomenological perspective can also save the account from drifting into instrumentalism.
(4) The notion that technology is an extension of our mental and bodily capabilities and faculties is the most comprehensive account of technology as extension so far in that it is able to integrate the other accounts. By including mental capabilities, the account also goes beyond the restrictions of the other theories that focus almost exclusively on the body. Concerning mental abilities, I have suggested that the account needs a criterion to distinguish what *constitutes* a mental process from what causally *contributes* to it. Without such a criterion, the account absurdly includes every artifact that makes a causal contribution. I have also raised some concern that the account might be philosophically uninteresting given its notion of extension. The account does not address the question of what makes technology special among the external means to realize our intentions.

Although the different versions of extension theory have different foci, they still bear a lot of similarities that make it hard to disentangle them. For example, Heersmink's (2012) distinction between a weak and a strong version of extension theory is not as clear-cut as he presents it. According to him, the weak version does not make an ontological distinction between humans and artifacts, whereas the stronger version claims that technology is sometimes incorporated and embodied, thereby forming a new symbiotic systematic whole. Heersmink puts Brey (2000) in the camp of the weaker version. However, you will remember that Brey was also concerned with extension as enhancement. In this extension-as-enhancement condition, Brey refers to the symbiosis of technology and humans, and he also explicitly mentions the possible embodiment of technology. So the line between strong and weak reading might not run as clearly between authors. Confusions can be prevented with a clear and detailed picture of what the advocates of technology as extension actually claim. In this paper, I have outlined the strengths and weaknesses of the various accounts of technology as extension. I have also presented some issues for possible future directions of research. My hope is that this will advance theory building and support philosophical refinement.

Acknowledgments I would like to thank Tanja Hentschel and Felicitas Selter for feedback on earlier drafts, as well as one anonymous reviewer for valuable comments.

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