Normative Affordances Through and By Technology: Technological Mediation and Human Enhancement

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Abstract

Human activity is fundamentally embedded in and constituted by technology. In this regard, technology influences not only how people experience the world, but also which possibilities for action offered by the environment (affordances) can be perceived and ultimately acted upon. As having socio-cultural and normative aspects, affordances are deeply relational to the technological human form of life. Postphenomenology describes several human-technology relations and their perception and action mediating effects. Therefore, it provides a suitable framework to examine how technology mediates the perception of affordances and leads to different behavioral outcomes. Technology can reveal hitherto hidden affordances but can also result in the manipulation and concealment of action possibilities. Both aspects can be deliberately controlled by using a particular technology and/or interfering with the technological hermeneutic process. Technological mal-functions, limitations, purposeful corruption, or human error can disrupt the hermeneutic qualities of technology and may lead to false conclusions about affordances and respective maladaptive behavioral outcomes. Technology can also be applied to humans to form "better" versions of them. One consequence of these so-called Human Enhancement technologies is the emergence of different affordances for the enhanced individual and the possible establishment of new affordances inside a form of life. Manipulating the perception and emergence of affordances through technological mediation or Human Enhancement can have severe political and ethical consequences. It is necessary to engage in an open debate about the perception and action mediating power of technology and the human reliance on them in our current and future form of life.

Keywords

Affordances, Ethics, Human Enhancement, Postphenomenology, Technology.

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I. Introduction

Throughout their existence, members of the genus Homo - exploiting the rich landscape of material opportunities - have constantly altered the face of the Earth. From the first combination of different materials for the purpose of constructing composite tools to today's particle accelerators: Human activity cannot be separated from its embodiment through and with technical means [1]. The presence of technology not only shapes activity in the human lifeworld, but also influences human perception at various levels (individual/cultural), in a way that "is more than a formal change; the way world is experienced is changed ontologically" [1, p. 47].

Concerning an animal's perception of its environment, Gibson [2] states that its perceptual system is optimized to process visual features that enable ecologically important behaviors. Subsequently, he defines the concept of *affordances*. Initially, affordances describe what an environment offers to an animal. In the following scientific discussion, the concept was extended to take human activity in the material world into account [3]. Nowadays, affordances are conceived as possibilities for action and, in the case of humans, these possibilities are deeply embedded in socio-cultural and socio-material relations [4]–[6] and thereby connected to the notion of Wittgenstein's *form of life*:

> Affordances are possibilities for action the environment offers to a form of life, and an ecological niche is a network of interrelated affordances available in a particular form of life on the basis of the abilities manifested in its practices—its stable ways of doing things. [5, p. 330]

Imagine a form of life as a set of lived practices and available common behavioral patterns. It structures and enables our activities but simultaneously consists of these aspects. It "lives in use" [7]. Using technologies is a stable and regular way of human's meaningful engagement with the world, reciprocally and skillfully shaping it and the possibilities of action afforded by it [1],[7]–[11]. Hence, technologies and their normative use are part of the human form of life, that shapes and structures our interactions with existing and

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future technologies [7]. Most importantly, the ability to make a correct epistemic judgment is also part of a form of life [12].

Perception and realization of affordances depend on the practices and abilities in a form of life [5]. Technology in its use actively shapes human perception and thus influences which affordances can emerge and are realized in the human form of life. Hence, technologies are part of the human ecological niche; the way we live [2],[5]. In other words: By influencing the perception of affordances, technology influences which patterns of behavior emerge from these possibilities, become widely available, and eventually manifest themselves in concrete practice. What is important here is that adopting these behavioral patterns is not just a matter of social persuasion and convention but begins much earlier: In the mediated perception and notion of what is possible in the first place.

Given the ubiquitous influence of human technology and our general dependence on it for survival, the technological form of life comes with an array of ethical issues: "Technologies help to determine how people act, so that it is not only people but also things who give answers to the classical moral question, 'How to live?'" [13, p. 236]. Thus, the way human beings live simultaneously shapes moral behavior and the normative notion of certain standards [7],[14]. Furthermore, affordances relate to the value of technologies [15],[16]. The value is determined by the affordances, their possible realization, the user's intentions, and other contextual parameters [15]. The context here could be a form of life that partially determines which affordances can be realized in the first place. In addition, the significance of affordances arises from past experience and forward-looking expectations [17]. To be realized an affordance must relate to this specific form of life. The same form of life that produced the technology in question. This recursive process is why a form of life and all the possible technological engagements it incorporates can be understood as a "river-bed," as something that is in steady flux but at the same time provides structure and stability [7].

Given the close connection between affordances and everyday phenomenology [6], we must turn towards these factors that shape the regular perception of the human lifeworld. Most notably, this lifeworld is a technological one [1]. In it, the influence of technology on human perception and action is constitutive, enhancing, and mediating [1],[11],[13]. This means that human perception of affordances is deeply connected to the mediational processes of technology. Hence, the form of life and the available affordances depend on how technology alters human perception. To fully understand the consequences of different human-technology relations, we will use the approach of *postphenomenology* and its perspective on technological mediation of human experience to demonstrate how technology can change the perception of affordances and eventually a form of life.

II. Marrying Postphenomenology and Affordances

Postphenomenology is concerned with how technology influences the human experience of the lifeworld. Postphenomenological research is interested in the technological transformation and mediation of human experience, perception, and action and the related embodied perspective [1],[18]–[20].

According to Don Ihde [1], human beings and technology engage in different formalizable relationships [1],[20],[21]. Among others, one example are so-called hermeneutic relations, in which technology translates information about the world into a "text" that is understandable by human beings.

Hermeneutic relation: Human → (Technology – World)

Here the perceptual focus is *upon* the technology. Ihde employs a thermostat as an example here. By "reading" its "text" (units of temperature), we are able to perceive an aspect of the world, even without directly experiencing it. Note the first connection to a given form of life and its skills and abilities. The affordance of the thermostat in terms of reading and insight into the temperature requires knowledge of the relation of the present symbols (usually numbers), the measurement unit (usually degrees of Celsius or Fahrenheit), and the respective embodied experience of temperature. If one part of this tripartite relationship is unknown, we cannot make sense of the hermeneutic text. As most of the world measures temperature in Celsius, we also encounter the cultural and spatial aspects of the form of life. For someone unfamiliar with the mathematical relationship between Fahrenheit and Celsius, 50 °F is incomprehensible.

Additionally, Ihde describes the so-called alterity relation. When engaging with technology, artifacts, depending on their perceived automatism and interactional potential, are sometimes experienced as an "(Quasi)-Other," which steps to the foreground and becomes an interactional partner and the focus of the experience. But unlike the hermeneutic relationship, there may be no connection to the outside world at all, or the same world may withdraw to the background. The minus inside the parentheses formalizes this.

Alterity relation: Human → Technology – (–World)

Alterity relations are constituted by relating *to* technology in a specific way. An example is the deliberately anthropomorphized assistant, such as Apple's "Siri." When somebody asks this software about the weather, questioners relate to this technology as to somebody other who knows about the weather. This interactional component between a so perceived quasi-other and the human user distinguishes the alterity relation from the mere hermeneutic relation. However, demarcations between the different relations are complicated, and Ihde acknowledges the emergence of descriptive grey areas.

Phenomenology sees itself first and foremost as a movement that investigates the relationship between human beings and their lifeworld, rather than being a mere description of reality [13]. Postphenomenology seeks to investigate technological mediation "from within," using insights to shape intentions and actions [22]. As possibilities of action, affordances are fundamentally relational [5],[6],[15],[23],[24], especially towards a particular form of life [5] and individual skills and abilities [12]. Therefore, a postphenomenological perspective could shed light on human beings' relations with their environment and the actions afforded. This becomes evident, considering how affordances can contribute to the postphenomenological notion of multistability, meaning flexible but finite possibilities for using an artifact [25].

Postphenomenology is not only concerned with the mediation of perception but also with the mediation of action. Here technology is simultaneously inviting and inhibiting [13]. As affordances can be conceived as invitations for behavior [26], the important connection of this concept to technology and its perception and action mediating character becomes even clearer.

Using technology, humans relate to the world in different ways. These relations depend on the affordances perceived and the emerging actions. Furthermore, these relations and the resulting affordances shape our future engagement with the environment. This is the diachronic dimension of affordances: They reflect our past and future [17]. Therefore, the theory of affordances, combined with a postphenomenological perspective, can contribute to our understanding of how different technological mediations translate into different stable patterns of behavior and become a part of the human form of life.

III. An Example of the Perception of Affordances Through Technological Mediation

Imagine a vast and empty horizontal almost entirely bounded by impassable cliffs. The ground is covered with grass, and approximately 300 meters away from where your stand is a podium topped with a gold-filled pot. The only way to get there is a direct passage over the plane. Luckily, there are no physical obstacles. This situation now has various affordances: For someone seeking imminent monetary fortune, the most relevant one may be the possibility of crossing the plane and taking the gold. Unfortunately, the whole plane is heavily contaminated by gamma radiation. Attempting to cross it would be inevitably fatal for any human. With a wavelength of < 10 pm, gamma radiation is invisible to the human visual system. This is an example of hidden affordances [27], as the described landscape may prima facie afford safe passage to the pot of gold but, in fact, bears severe health danger. Note that the original conception of affordances was not only concerned with beneficial offers but also with maladaptive ones [2].

There are several possibilities for gaining knowledge about the hidden affordance of the plane. Once one person started crossing it and suffered from terminal radiation sickness, other observers could make assumptions concerning the hitherto imperceptible hazard and thus about the hidden affordances. However, they would not be able to tell what exactly caused the person's death, though they might a suspect a deadly invisible and mysterious hazard on the plane. At some point, they may (correctly) conclude that traversing the terrain is impossible and therefore refrain from further attempts. These conclusions and the resulting normative call to inhibit crossing behavior would be drawn through a tragic instance of observational learning.

Given the human communicational abilities, eye-witnesses of the deadly crossing attempt could tell other humans about the danger and thus influence their notion of affordances even without them perceiving the plane on their own. Cultural transmission preserves knowledge about the mysterious yet dangerous plane. Some foolhardy adventurers may try to cross it from time to time, but their attempts would always have the same fatal result. Here the normative dimension of affordances and epistemic judgments becomes evident again: The normative standards of how to engage with specific affordances are tied to individual skills and abilities in a given situation [12] but also to socio-cultural and -material practices and customs [5] (for a slightly different view, see [28]) and therefore a form of life [7]. The existence of such a form of life makes the practice possible in the first place [7],[29]. Hence, the ability to recognize the "correct" affordance of the deceptively safe plane is tied to socio-cultural transmission, shaping the expectations of the plane, which are then re-enacted in concrete practice other community members can draw from [6]. Accordingly, affordances cannot be integrated into a given affordance landscape without shared attention and a mutual understanding of the meaning and embodied experience.

The notion of expectations is crucial. In the realm of so-called "cultural affordances," expectations are tied to "conventional affordances," which require a correct inference by the perceiver [6]. The set of shared expectations creates a "local ontology" interwoven with concrete practices and socio-material reality [6]. Engagement with the material environment is an essential condition for the emergence of customs, practices, and meaning [10],[11]. If someone placed a warning sign at the edge of the plane, the normative aspect of the conventional affordance would also be communicated socio-materially. The meaning of this material sign is enactively embedded in past engagement with its content and modulation of attention [6],[11]. The social practice relating to the material sign can therefore help to define a set of local and relevant affordances from the whole available landscape of affordances [6]. Once sufficiently adopted and recognized, culturally transmitted information becomes a part of a specific form of life and would thus enable its sufficiently skilled members to detect relating affordance even without experiencing the radiation first hand.

Another means of assessing the hidden affordances of the plane is science. Here one must note that science is embodied in technology [1],[20], meaning that scientific insights heavily depend on the available technology that produces them and vice versa. Scientific observation is socio-materially augmented perception [30].

In our example, one way to learn about the hidden hazard on the plane would be to discover and formulate the physical principle of radioactivity and its maladaptive effect on biological tissue. But this is only the first step. Even if known that there is such thing as radioactivity, it is not clear if it is the cause of the plane's danger. One way to find out is technological aid, specifically a Geiger counter. Using this technological device constitutes a hermeneutic relationship with the plane. It allows for the perception of an environmental feature through technology and reveals a hitherto hidden affordance.

$$Human \rightarrow (Geiger\ counter - World)$$

The Geiger counter transforms the information in a way perceivable by humans. Feeling the adverse effect of the radiation is sufficient to refrain from trying to cross the plane but insufficient for understanding what causes this experience. Furthermore, the Geiger counter can deliver the relevant information before feeling the radiation directly. We can simply "read" it from a screen without exposing ourselves to lethal danger.

Affordances are always specific to the particular animal and depend on their bodily condition [2],[31]. This fact must be accounted for in the technologically mediated perception of the environment. As scientific instruments possess the ability to perceive what may be hidden from humans, the detections resulting from this "instrumental realism" [32] must be compatible with the human condition: "for embodied humans whose observations are those of bodily-perceptual creatures, […] the information, data, or image must be transformed, translated, into what is open to our *anthropological constant, an embodied human*" [32, p. 113, italics from the original]. In other words, the technologically retrieved information about the world must be presented in a sensory and cognitively comprehensible way to humans. Once again, converging with the concept of conventional affordances and their requirement of correct inference regarding certain expectations [6], the notion of instrumental realism requires scientists, engineers, and designers to think about the technological mediation processes within the scientific endeavor when integrating their findings in the expectations and predictions of their models and theories. Furthermore, they must acknowledge the emergence of a combined human and technological "composite intentionality" in the hermeneutic relationship between humans and technology [21].

In a recent study on the fMRI-supported neuropsychiatric diagnostic process, de Boer and colleagues showed how this imaging technology mediates researchers' notion of brain complexity and materializes deduced diagnostic labels in concrete experimental diagnostic practice [33]. The establishment of an ontological link between a scientific measurement and a diagnosis shapes expectations and materializes an affordance for future use. Regardless if this concerns a deadly dose of radiation or psychiatric diagnosis: What matters is the socio-material commitment of scientifically retrieved information with its alleged meaning by applying skillful inference and deduction. This is no arbitrary process. People will still suffer from radiation sickness, even without knowing what the Geiger counter display means, and observers may expect the same outcome. Importantly, any materialization of conventional affordances inherent to a local ontology must ensure the appropriateness of certain expectations and

the ability to draw correct inferences from them [6]. So we can use the insights of the scientific process to not fall for the false expectation that every plane bears a hidden danger. The diachronic nature of meaningful affordances [17] becomes evident when we consider how the scientific measurement only makes sense in light of past scientific insights and how it will shape our future engagement with possible observation targets.

Perception of affordances is not limited to the visual modality. The Geiger counter not only visibly displays the presence of radiation through its display but may also produce the characteristic sound. While reading a display may require knowledge about reference values and thresholds, this iconic and technologically produced sound functions as a cultural proxy for radiation danger. Technology enables us to perceive certain information previously inaccessible and integrate them in a translated form into our socio-cultural framework. This eventually relates to a form of life in the sense that:

> particular mediations by particular artefacts are part of [...] forms of life that exceed what happens at the level of the phenomenology and hermeneutics of individual use and interaction, or rather, that connects this phenomenology and hermeneutics to larger wholes and structures at the level of [...] cultures (forms of life). [7, p. 1516]

Even if only a minority of people ever had direct contact with a Geiger counter or a deadly dose of gamma radiation, they usually know, given the necessary cultural transmission, what the sound means; what to expect when hearing it [6]. Any deduced affordances are then preserved so that the knowledge about them is partially separated from directly perceiving the environmental context they emerged from.

To be fully comprehensible, the radiation measurement's visual and auditive representation must be hermeneutically translated [1]. The technologically produced stimuli must be interpreted in a "correct" way to evade the threat. This "know-how" is again transmitted culturally and distributed differently in any given population. This observation emphasizes the normative and socio-cultural dimensions of a form of life, either in terms of affordances [5],[6], technology usage [7], or particular skills and abilities [12]. As we can see, not only the ability to produce technology but also its scientific application, the transmission of knowledge gained through technology, and the normative affordance realization are deeply intertwined with their constitutive socio-cultural sphere and form of life [5],[7],[12]. Due to the cultural transmission of (technological) knowledge, human beings can spatiotemporally extend the individually acquired knowledge about affordances. This knowledge is partially obtained by the products of this sphere, i.e., skills or technologies [5],[12]. Yet, neither skills nor technologies alone create affordances. Affordances exist even if never realized or perceived by a single individual [5],[15]. Instead, they emerge from the possibility of detection and realization inside a form of life and the skills and abilities it includes as a whole [5],[12]. The whole set of available affordances constitutes the rich landscape of affordances, while the individual situational relevant possibilities of action structure this landscape into the "*field of relevant affordance*" [12]. Applying technology skillfully toward a particular object constitutes one possible relation from which the perception and eventual realization of detected affordances can emerge. At the same time, it can restructure the landscape of affordances in dependency on the technology's characteristics. The Geiger counter can neither perceive the color of the grass nor understand the ascribed value of the 79 proton element in the pot. For this device, only the gamma radiation affords to be "seen." And because this technology is part of our form of life and is attuned to our bodily capabilities, we can "see" through it and detect a highly relevant life-or-death affordance and the related expectations of a painful death.

Imagine that at some spots radiation is so low that crossing the plane is possible. In other words, a hidden and invisible maze. This maze has different affordances than the contaminated ground next to it. Even without a Geiger counter, humans can figure out the exact route by continuing to send people on the plane and eventually realizing that some places are safer than others. However, this would require an even more fatal trial-and-error process than the initial acquisition of knowledge about the plane. The use of the Geiger counter reduces possible costs. People recognize that radiation seems to fall off at the maze entrance based on the counter's display and sound. This observation alters the affordance perception of the place and directly invites action [13] at specific locations.

While the adverse effect of the radiation may be felt firsthand as an example of "natural meaning," technologically retrieved meaning, requiring correct inferences and cultural customs, may be called "non-natural" [6]. To correctly use the Geiger counter, one must perform several skillful translations, typical for the hermeneutic human-technology relationship. First, the visual display or sound must be translated into an internal danger measurement. Then this measurement must be assessed in terms of potential damage. Lastly, the affordance must be identified as relevant, evoking a state of action readiness, characterized by an organism's wish to engage in relational modulation toward their environment [12]. Note that we can identify action readiness also at the beginning of the process. The relevant affordance of the gold (spending it) in conjunction with the hidden hazard evokes the wish to change one's relation to the environment using the hermeneutic capabilities of the Geiger counter. This counter, in its instrumental realism, also performs a translation. Information about detected radiation is translated into electrical and, finally, visual and auditory information.

Let us now increase the complexity of the scenario. Assume that one has access to the Geiger counter 3000: A more sophisticated AI-powered follow-on model that can scan the entire aircraft at once and produce a detailed map with visual information about the non-hazardous path through the plane. In addition, a flashing display shows the words "Safe passage possible" and a calm voice navigates the user during the crossing. Here, the number of translations and the conducting agent differs. In the case of the ordinary Geiger counter, users must deduce certain facts themselves. They need a specific level of expertise and knowledge to arrive at the correct conclusions about the affordances of the plane. The Geiger counter 3000, however, translates the measurement of the radiation itself and directly produces a normative outcome and straightforward guide for one's actions. Using it still requires skill, but these are different from its predecessor.

Furthermore, the Geiger counter 3000 translates more information. It displays not only local information about radiation but also a spatially extended representation of the plane in front. Additionally, it gives direct navigational advice based on its perception of the affordance and in concordance with its programming. This may result in a relational shift towards an *alterity relation.* The Geiger counter 3000 is now experienced as another, equipped with certain hermeneutic capabilities that give explicit navigational and normative advice based on its perception of the world. In this way, its ability to engage with collective and shared attention is enhanced, and so is its impact on mediating expectations, relevance, and normative aspects of affordances [6]. The alterity relation differs from a simple map. Maps must be read by humans and can be more easily ignored. However, even though the Geiger counter 3000 enters the social realm of affordances and their communication, given its limited intentionality, determined by its technological structure, "its otherness remains a quasi-otherness, and its genuine usefulness still belongs to the borders of its hermeneutic capacities" [1, p. 106].

One step further to contemporary praxis is the reliance on personalized algorithms, which can also be conceived as "others." These pieces of software can profoundly shape human decision-making and give rise to individual epistemic structures that do not inevitably lead to what is most beneficial for the user [34]. Remember that correct epistemic judgments are part of a form of life [12]. So the choice of the Geiger counter 3000 and the algorithm, given an alterity relation, is evaluated in their usefulness in leading to correct epistemic conclusions in a form of life. This a posteriori evaluation, however, does not make them immune from leading to potentially catastrophic mistakes.

However, the epistemic usefulness of technology is not only a matter of the instrument and the kind of relationship but also concerns human factors. This is exemplified in a memorable but fictional scene in the TV Series "Chernobyl" [35], retelling the story of the eponymous nuclear power plant catastrophe. After the reactor accident, the technical staff tries to determine how much radiation is leaking. Their Geiger counter shows 3.6 Roentgen, which is laconically assessed as "not great, not terrible" by the chief technician in charge. However, the value of 3.6 Roentgen shown on the counter is the highest the instrument can display. A second measurement with a more potent counter reveals the radiation to be, in fact, 15,000 Roentgen. The hermeneutic relationship now has an *enigma* between technology and the world [1]. The instrument does not correctly refer to the factual world and a false affordance [27] is deduced by its interpreters. The relationship between humans and the world has become increasingly *opaque* [1]. By reading the information presented, the technical personnel is led to believe a false normative assertion, namely that there is no lethal hazard when in fact, there is. Their expectations of the conventional affordance [6] do not match the physical reality. This is where we must recognize the complex relationship between artificial hermeneutic text and the human reader: Humans rely on the information presented by the Geiger counter. They trust the device to refer to the world correctly. The assumption made by the technicians in "Chernobyl" based on the first measurement resulted in the horrible mistake of underestimating the danger by a factor of ~4000. However, it is prima facie the *correct* conclusion based on the information available to them. Although the measurement afforded to be interpreted as harmless, the technician's ability to draw the correct conclusion was limited by the materiality of the measurement instrument and its mediation of relevant information. So who is to blame in this example? The Geiger counter is neither responsible for its limiting construction nor its incorrect use.

Furthermore, it seems unfair to blame the humans who rely on the information provided by the counter. We may, of course, question their motives. The TV series does so by depicting the chief technician as incompetent and politically motivated. But this again opens up a new dimension of aspects to consider when examining conventional affordances, expectations, and human technological capabilities [6]. Especially under the suspicion of political motivation, the rich social dimension of affordances becomes evident. For this to be effective, the relevant social actors do not necessarily need to be physically present to influence engagement with situational affordances [36].

When substantially integrated into individual cognitive processes, interfering with a person's environment can have similar moral significance as interfering with them personally [37]. But does this also apply to interferences with the technology a person uses to relate to the world to access its possibilities of action? In general, the aforementioned perceived usefulness is open to deliberate manipulation. In the case of manipulation, the incorrect assessment of affordances is not rooted in the "natural" inability of the device or reader but the external exploitation of its affordance to be manipulated. If one understands the underlying technological structure and the associated hermeneutic processes, one may use the technological mediation of human perception to shape the behavior of others to their advantage. The crucial thing here is that the human body reflects the individual ecological niche to stay selectively attuned to relevant affordances [12]. Manipulating the artifacts constituting the niche potentially disrupts the coupling between the possibilities that make up the niche and the individual. Humans constructed their niche in a way that eases reasoning and problem solving [38]. Objects and technology can be used in various ways [25], but only a few possibilities have manifested themselves in actual practice. This is because this particular affordance exploitation allows for a normatively better result in a given situation [12]. However, supposing the relevant affordances are not perceivable due to deliberate manipulation, the optimal solution to a given task or problem is also not available. Like other affordances in a form of life, the utilization of such manipulation affordance depends on individual skill and the presence of other artifacts and techniques that afford technological manipulation. For an affordance to be manipulated, the affordance itself must afford manipulation. As affordances reside in the relationship between environment and individual, respectively form of life, these are the targets for any manipulation effort. The moral impact of such manipulation depends on the level of dependency and integration of the artifact, for example, in terms of using them in cognitive tasks [39]. Technologies operating phenomenological transparently and outside the range of human control or consciousness afford new ways of manipulating human behavior [40].

For exemplification, take the artwork "Google Maps Hacks" by Berlin-based artist Simon Weckert (Fig. 1). Weckert used 99 smartphones to change the Google Maps status of a street from empty to blocked by traffic jam [41]. People using Google Maps in the surrounding area were redirected to different routes in order to bypass the virtually "blocked" road. The hermeneutic relationship between the depiction of the street shown on Google Maps and the real world changed. Deduced navigational affordances about the navigability of the specific street - given that the user trusted Google Maps - were altered due to a deliberately established enigmatic relationship. The artist changed the normative aspects of the affordances that were perceived through Google Maps, proofing that a map is indeed not what it depicts [42], but also how this visualization and hermeneutic insights are vulnerable to easy manipulation due to the dynamic integration of real-time information, given knowledge of how the technology works.

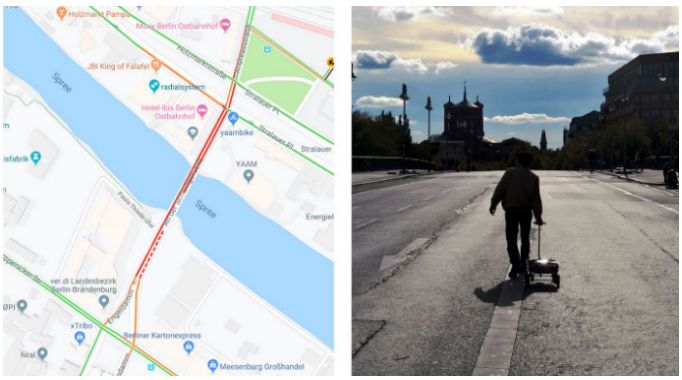

Fig. 1. "Google Maps Hacks" by Simon Weckert. Taken with permission from http://www.simonweckert.com/googlemapshacks.html

Beyond that impressive demonstration of the manipulative potential in our hermeneutic relationships, the exploitation of deduced affordances can have profound political and safety implications. One example is Global Positioning System (GPS) corruption, especially GPS spoofing [43]. All types of vehicles and services rely on GPS to navigate the environment. There are several ways in which GPS signals can be interfered with. The most frequently used type of corruption is

GPS blocking, in which the receiver's antenna is disabled or shielded. As a result, the specific antenna can no longer receive the GPS signal. Another widely used method is GPS jamming, where a different signal is transmitted with a similar frequency but higher strength, which then overlaps with the original signal. Both methods are visible to the receiver as missing GPS signals. There is also the possibility of GPS spoofing. Here, fake GPS signals are provided, indicating a different position in space and time to the user than his actual position [43]. This technology poses a severe threat for any nation or organization reliant on GPS, concentrating (geo-) political power in the hands of the political players capable of GPS corruption.

Prima facie, the misdirection of a vehicle seems to be neglectable. But consider the possible impact if the vessel in question transports military or humanitarian supplies or a political VIP. This example demonstrates that: "navigation systems are indeed instruments for realizing one's intentions and goals, [how] they also embody moral values like safety, transform the experience of our environment, and have unintended consequences on our onboard cognitive capabilities." [39, p. 26]. The moral value of the navigational system is constituted in relation to its affordances [15],[16]. Thus, the ethical severity of any manipulation depends on the same value. Although only affecting a single device, the technological effect of corrupting a single GPS can spread into the (global) sociopolitical sphere and its organizational structures, whose regularities and principles are different and more challenging to predict than in the immediate context of technology [8]. This scenario emphasizes the need for a thorough examination of technology that encompasses not only its primary direct effect on the perception of affordances but also the secondary effects on the techno-political dimensions of the form of life to which those affordances relate. Here some consequences may not be instantaneously apparent. Furthermore, it shows how instrumental realism based on a particular technology can be outwitted by the use of another technology, adding complexity to the human-technology(-technology) relationship. Consequently, technologically sophisticated political players can force other agents into certain types of behavior, not by direct threat or negotiation, but by simply deceiving them about the range of possibilities of action in a given scenario.

Through the conscious and technological establishment of an enigmatic hermeneutic relationship, technologies can not only reveal but also be used to deceive users about the affordances of their environment. This is made feasible by the fact that the affordances themselves can be manipulated, which in turn is only possible because the technologies with which we enter into a hermeneutic relationship are part of a particular form of life and because users expect the device to relate correctly to the environment. Without a GPS device or insufficient skills of using it, one could not be deceived about the affordances as the relevant relation would not be present. Moreover, if we expect the device not to function properly, users will not trust the information it provides to them. By deducing a certain possibility or non-possibility of action as well as the correct way of executing it, people will engage in different patterns of behavior in relation to their socio-material environment and form of life. If picked up by a sufficient amount of people, this engagement will manifest itself in a new practice or will alter an already existing one. Thus, manipulating the perception of affordances using technology can directly influence which affordances are available within a human form of life. The action derived from these interrelated affordances can then change the human ecological niche, i.e., how humans live.

IV. Enhancing the Perspective

It should be clear now how the perception and realization of affordances can be mediated technologically and even manipulated. From there, the question arises of what happens when technological manipulation's power is directed toward humans themselves. Affordances depend on the environment but also the abilities of specific individuals [5],[6],[12]. So, what when these abilities are changed technologically? This touches on the concept of *Human Enhancement;* the effort to create "better" humans through the application of technology [9],[44]. Definitions of Human Enhancement often center around creating new capabilities and capacities through science and technology [45]–[47]. If enhancements and these new capabilities will inevitably lead to "better" humans is subject of controversial debate [48]–[51]. Independent of the claim about its final normative end state, we may examine the concept of Human Enhancement through the lens of affordances. Or, more precisely, how the implementation of technology is connected to the possibilities of action the enhanced person may perceive and realize.

Which capabilities or features of humans are up to enhancement often remains vague. Yet, it appears obvious that improving the capabilities of mind and body goes hand in hand with the emergence of new affordances since they heavily depend on the relationship between the environment, the individual bodily characteristics, and the set of skills [12]. Alternation of one's body is one of the most straightforward ways to change individual affordances. The most infamous means of transformation discussed in the Human Enhancement debate are the so-called NBIC (Nanotechnology, biotechnology, and cognitive science) methods. These enhancement means are rejected or endorsed primarily due to their hypothetical transformative power and consequences on the human condition [51],[52]. The transformative potential of Human Enhancement can be expressed in terms of affordances: as an extension of the human opportunities of action through deliberate and direct manipulation of the human body and mind.

Returning to the example of radiation: there are ongoing discussions about Human Enhancement during space missions to improve resistance against cosmic radiation [53]. This is one of many examples of how technological interventions can adapt the human body to new environments that offer new possibilities of action. This is the opposite of the typical evolutionary strategy of adapting the environment [54]. Instead of the environment, we are adapting ourselves [55].

The debate about Human Enhancement often revolves around whether the technological intervention must be implemented within the human body or can remain external [45],[56]. Regardless of its necessity for definition, the internal implementation of a technological device may realize a so-called *cyborg relation,* which brings forth a new entity equipped with a new *hybrid intentionality* composed of the features of the human and the machine [21]. It is worth noting that the term "cyborg" originally described an individual that used exogenous components to adapt to new and potentially hazardous environments [57], altering the environment's affordance to support survival.

Cyborg relation [21]*:* (*Human*/*Technology*) → *World*

An example of this can be found among the community of "Biohackers," who actively share and promote knowledge about how to self-implant small magnets to gain magnetoreception [58]. Gaining new senses is a clear example of Human Enhancement and allows for detecting and realizing new affordances. These new affordances not only emerge because the technological improvement of human capabilities may enable the respective individual to execute different behavior but also because these special technologies have become part of a certain form of life, enriching it with new skills and abilities. Furthermore, merging technology and human is only possible because the biological tissue and related perceptual processes can be attuned to incorporate other materials and sensory inputs. Technological enhancement is thus related to the possibilities for action that the

environment offers the individual and their constitution, as well as the embedding of that same individual in a larger socio-material structure.

Some argue that the next step in the evolution of *Homo sapiens* will be its merging with technology [59]. Others believe that humans were, in some sense, cyborgs all along [60] or that the aspiration of merging with the machine and transforming human capabilities fulfills a romantic desire [61]. Undoubtedly, the human body and mind themself afford to be changed. Tools afford to be integrated into the human body schema [60],[62], a process moderated by the expertise of the user [63]. Hence, besides the literal embodiment, realized by the spatial implementation of a technology, there are other dimensions of embodiment, depending on the motoric and affective attitude towards the device [64]. Here, the degree of embodiment directly influences action awareness and planning [64] and, therefore, the perception and realization of affordances. Consider, for example, a robotic third thump. Albeit external, it psychologically merges with the body representation of the user [65], who is now able to pick up new affordances from the environment. It is easy to see how the wide dissemination of such a technology would change how humans engage with their environment.

Thinking of humans as "natural born cyborgs" [60], we may even conclude that a considerable proportion of the way humans interact with their environment and eventually reconstruct it to meet their demands is due to the psychological and physiological embodiment of things and the embedding of the human mind and activity into the technological sphere. Adopting the perspective of humans as "profoundly embodied agents," constantly renegotiating the boundaries between environment and body [66], opens up a new and enhanced perspective on affordances. It does not only highlight how affordances emerge from the relationship between (technologized) body and environment but also the transformative nature of technology: Not only do humans perceive and realize affordances *through* technology, but they are granted new ones *by* technology.

V. Affordance in the Technological Form of Life

We provided several examples to demonstrate the transformative power of technology on human perception and action. As stated before, human activity is embedded in and exercised by technology, and it is this (perceptual) activity that is crucial for the perception of affordances in general [2],[24]. This is of particular concern when the transformative power of technologies is directed against the life forms that have constructed them in the first place. Here, the technology not only mediates human perception and action but also directly interferes with its user's psycho-physiological constitution. So-called Human Enhancement technologies are, in some way, already widely used [8],[67],[68] and, therefore, part of the human technological form of life.

Using technology, human beings commit to a specific form of life, comprising stable patterns of behavior [7], which then stands in relation to the possibilities of action afforded to it [5]. Overall affordance modulation research has to consider various intra- and interpersonal contextual factors in relation to the presented task [69]. It has been argued that there are at least two ways of changing the available affordances to an organism: Changing the material environment or altering its form of life or set of abilities [6]. Given the transformative power of technology, both on the level of perception and Human Enhancement, we must add *technological mediation* and *technological alteration of the body* inside a form of life to that list.

Comprehensively and conceptually, technology can bring forth affordances hitherto not perceivable to human beings. Ontologically speaking, these affordances start to exist once they are, in principle, detectable by the skills and abilities of an individual or the general capacities of a form of life [5]. However, the possibility for action does not instantaneously make these affordances relevant to the other individuals engaged in the same form of life. To translate a possibility from the relevant field of affordances to the rich landscape, people must engage in communicative behavior and teaching about the meaning of a particular affordance in a given situation. The remarkable fact of the human form of life is that it only needs one person with the adequate scientific instrument to inform other species members about the hidden danger of a deceptively empty plane. However, it also takes one person equipped with 99 smartphones to fool an entire online community about the affordances of one street, rendering the driving affordance of the same street irrelevant for navigational purposes.

Using technology, humans are changing their relationship with the world and are introducing a new entity in the reciprocal dynamic of this dyade. Technology in the form of a concrete artifact constitutes a new tripartite relationship between this artifact, its environment, and the user and his psychological and physiological characteristics [24]. Given an alterity relation, the artifact becomes a quasi-other and a social proxy in the already socio-cultural sphere of affordance perception. In a more intimate cyborg relationship, humans and technology merge. This process of cyborgization is accompanied by moral concerns and ethical challenges [70]. Some fear that enhancing human capabilities through technological means may even lead to a state of "hyperagency" in which enhancement provides too many opportunities to manipulate internal affairs, which negatively affects how we interact with the world and should therefore be constrained [71]. Seen from the perspective of affordances as connected to the value of a technology [15], some negative attitudes toward Human Enhancement may be due to the possibilities of action the enhancement may provide in a specific context.

Given the necessary expertise and knowledge, every side of the aforementioned tripartite relationship of artifact, human, and environment is susceptible to manipulations. Technological manipulation may lead to the creation of *deceptive affordances*, meaning the conscious misdirection about possibilities of action in a particular setting. Technology can both reveal and veil affordances. This general amplifying and reductive effect of technology may even occur simultaneously and unpreventably [1]. The revealing power of a technology can exceed its veiling effect. However, it is essential to remember this co-dependency when assessing hermeneutic technological relationships and the perception and actions that emerge from them.

Overall, "[t]he impact of technological mediation, [...] results not only from the roles human beings allow technologies to play in their lives but also from the characteristics of technologies that help to shape their mediating roles" [14, p. 89]. Deliberately designed technological mediations due to the actions they may elicit are, therefore, of severe moral concern [14]. Depending on the particular technology, technological mediation could already be part of a specific form of life, interwoven in the regular ways of doing things and engaging with technology on a more general level. Interestingly this can go so far that humans are not even aware of the mediation [13]. If done effectively and sustained, the manipulation of technological mediation can change not only a particular behavior but also a form of life [7]. Accordingly, to understand any ongoing change, we must examine the use of the specific technology in its form of life and thus the affordances it offers to this form and the dynamic changes within this relationship. This is where we must consider a variety of socio-technological forces and be aware of the very nature of a successful manipulation, the unawareness of it happening. The more we rely on technology and its hermeneutic qualities and the enhancement of our capabilities, the more severe the possible damage of any affordance manipulation.

However, in an open debate about the ethical implications of the normative nature of affordances and the technological mediation of their perception, one must understand that withdrawing from the pervasive influence of technology is impossible. Any regulation of technology happens "from within" not only in terms of the actual mediation process but also in a specific form of life [7],[14]. Drawing on the metaphor of a form of life as a river bed [7] and the role affordances may play in assessing the value of a technology [15],[16], it is this form of life that brings forth the technology in question in the first place. By using certain possibilities of action, the material environment is manipulated to create new technology. This technology then influences the perception and realization of present and hidden affordances. While doing so, the affordances of the particular technology in a given context may constitute its value [15], thus prompting eventual regulation based on this value. Therefore, potentially disruptive technologies establish a new normativity or influence existing ones [25]. In other words, by connecting affordances to the concept of the (technological) form of life, scholars can shine new light on how technologies alter perception and action. It opens up a new perspective on how humans regularly do things and how the things humans regularly do recursively influence how humans (will) live.

This is not only an abstract philosophical issue but also concerns the political implication of technological mediation of the perception of affordances. Here, the recourse to the framework of postphenomenology is suitable as it "may not have an inherent *politics*, but it certainly is *political* in that it paves the way for phenomenologically informed interventions" [18, p. 530, italics from the original]. We must, therefore, further examine how technological mediation influences our form of life, the related affordances, and, thus, the whole spectrum of how we engage with the world normatively and perceptually. Even if an artifact is not intentionally designed for manipulation purposes, the affordances of an artifact can make up its moral value [15],[16],[25]. We must face how human behavior is interwoven with the material environment to which humans uphold a recursive relationship. That is, humans use technologies to gain new insights about themselves but also the same environment. A side effect of this improved understanding is not only progress in the romantic quest for positive epistemic knowledge but also insights into how we can influence the behavior of others.

Moreover, we learn new ways of manipulating ourselves. Human Enhancement technologies afford to change aspects of the human body and mind. The ethical debate about these technologies [37], [38], [55]–[57] can benefit from a point of view rooted in an affordance approach. Considering that an ecological niche can be conceived as a set of affordances in a specific environment to a particular time [6] and that the human environment is accumulated with technology of all scopes, kinds, and varying complexities [1],[8],[72], we conclude that technologically induced alteration through Human Enhancement is already part of the human niche. Altering ourselves with technology is part of how we live, and in light of the aforementioned ethical debate about the benefits or drawbacks of Human Enhancement in general, it also addresses the question Verbeek [13] posed for technologies in general: "How to live?"

VI. Conclusion

The human form of life is technological, and technology can change it. By linking the concept of affordances to the mediating perspective of postphenomenology, we can reveal crucial aspects in our understanding of how the perception of affordances functions in a technological context and eventually influences the human form of life and ecological niche. Moreover, new affordances can also arise when humans alter themselves by means of technology.

We have emphasized not only the role of the used technology but also the need for compatibility with the characteristics of its human user and the hermeneutic act of "reading" the provided information. Going one step further, the merging of humans and technology, constituting a new entity, is accompanied by new affordances. Whether the process of cyborgization will eventually lead to a form of sophisticated cyborg-life remains an open question. Considering our heavy reliance on technology in virtually every aspect of our lives, technology affords various ways of manipulation. Not only in terms of manipulating the environment or oneself, but also by deceiving humans about what they can do in a given situation.

In the original conception of Spider-Man, Peter Parker obtained the ability to shoot his webs not through the bite of the radioactive spider but rather through self-build, wrist-attached "web-shooters." This enhancing cyborg relationship between technology and teenage boy suddenly brought new affordances to the mind of Peter Parker. Skyscrapers now afforded the attachment of spider webs, and street canyons afforded swinging. This concluding anecdote is meant not only to exemplify the perception and action transformative power of human enhancement technologies but to serve as a reminder that with great power comes great responsibility.

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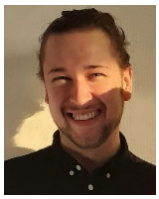

Clemens Bartnik

Clemens obtained his Master in Psychology (M.Sc.) working towards quantitative comparison of visual saliency maps of convolutional neural networks and those of human beings, where he was supervised by Ute Schmid (University of Bamberg). And is now a second year PhD candidate in the Video & Image Sense Lab at the Informatics Institute of the University of Amsterdam, under the supervision of Iris Groen and Cees Snoek. His research focuses on leveraging computational modeling and neuroimaging techniques to understand representations of navigational affordances in the human visual system and computational models. He is inspired by the idea to combine the successes of state-of-the-art computer vision algorithms with classical approaches of measuring human behavior and neuroimaging to better understand how we perceive the world around us.