Prosthetic Sensorium

JAN CHRISTIAN SCHULZ

janchristian.schulz@googlemail.com

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Abstract

This article investigates the transition of the individual body sensorium into a collective global techno-sensorium extending the perception and mediating the ecological sensitivity of the human. Examples of extended body protheses (e.g. satellites, sensor technologies) and their functioning are used to explain the inter-relationships of a proliferating techno-sensorium that activates environmental protheses such as "biorocks", glacier blankets or anti-forestation listening technologies.

The following work discusses the *intra-actions* and relationships of humans and non-humans within the environment. In co-evolution with their technologies, organisms perform material engagements in which they transform matter into *prosthetic* body extensions, that allow them to expand their *intra-acting* capacities within the world. This work illuminates the developments and impacts of *extending* organisms with a special focus on the humans' expansion of their sensorium and cognitive perception through the media of sensor technologies. Electronic sensors – a primary prosthetic sense in the contemporary era – are joined together into monitoring stations, extended multisensorial bodies floating as buoys in the ocean, integrated within forests, erected on mountains, and jettisoned into planetary orbit. Increasingly connected and complemented by world-spanning network systems like the internet, this *techno-organic sensorium* constitutes an environmental *intra-structure*, allowing the human to perceive the Earth as such, and even to "feel" it on an affective or emotional register. As planetary crises mount, this sensitivity is a necessary precondition for survival, inculcating the possibility of political action and policy change. It acts as the ground for the emergence of *environmental prostheses*: human-made interventions augmenting and supporting dysfunctioning ecosystems and their inhabiting lifeforms. At the same time, these technological assemblages consume massive amounts of material resources and energy, at once expanding knowledge of the planet's delicate ecological relations and contributing to their destruction.

The Naked Body in the Chaos of Lifeforms

Throughout time, the human species – in the same manner as other lifeforms – has developed and sharpened its capacity to sense environmental phenomena in order to survive in harsh environments. Based on the experience connected to the stimuli from the outside world, the human learned to rely on its senses. The ability to detect chemicals in the air (Curnoe 2015), taste potential toxins in the food, hear the presence of a predator, or feel the earth-shaking, constitute a multisensory learning-act that attributes experiences with meaning. Feeding the senses with new experiences was crucial to understanding the environment and navigating through a chaotic world full of potential threats for one's survival. Each form of bodily sensed stimuli affected, and still affects, an organism's decision-making, reaction, and intervention within its surrounding ecosystem. These sense-mediated interlocking feedback loops of living beings establish an *environment* through *intra-action*, a term coined by physicist Karen Barad to describe the mutual constitution of entangled agencies. Compared to *interaction*, which assumes that there are separate individual agencies that precede their interaction, the conception of *intra-action* recognizes that distinct agencies do not precede, but rather emerge through, their *intra-action* (Barad 2007).

Considering an environment as being a space where living entities are *intra-acting* in complex dependencies, the notion of an individual organism separate from its environment dissolves. Instead, the individual might only come into being *through* its environment, in a process that philosopher Alfred North Whitehead calls *concrescence*. Jennifer Gabrys, a researcher on the environment and digital technologies, summarizes Whitehead's theory of *concrescence* describing it as "ways in which actual entities and actual occasions are realized and joined up as distinct and immanent creatures" (Gabrys 2016).

Philosopher Timothy Morton suggests that "what is called environment is just lifeforms and their extended genomic expressions" (Morton 2021), referring to Richard Dawkins' concept of the *Extended Phenotype*. Based on the *theory of evolution by natural selection*,[1] Dawkins states that characteristics of a lifeform's genes express beyond their individual bodies, affecting and shaping their environment. This concept, for example, takes form in the creation of bird's nests [**Fig. 1**; **Fig. 2**] or termite's mounds [**Fig. 3**] and in parasitology, even through "the expression of a parasite's genotype into the phenotype of its host" – manipulating their host's morphology and behavior (Mehlhorn 2008). Morton summarizes, "when you think of things like that, there's really no difference between thinking about what is called an ecosystem and what is called a single lifeform" (Morton 2021).

The applied conceptions of *intra-action* and *concrescence* might only establish an environment *through* organisms sensing their surroundings and reacting according to the sensed *stimuli* – an operation leading to the reciprocity of actions with other enti-

Fig. 1 | *JoaodeBarroemguanandi*, Mauro Halpern. Rufous Hornero in its nest. Their extended phenotype is made out of large thick clay placed on structures like trees, buildings or telecommunication posts. Besides being of use as a breeding site, the enclosed shape of the nest also reduces predation risk

Fig. 2 | *Namibia Webervogel-Gemeinschaftsnest*, Kürschner. The shared nests of the Sociable Weaver are a collectively constructed extended phenotype of the species. They are used over generations and can host hundreds of birds incl. other species

Fig. 3 | *Paesaggio savana con termitai in Guinea-Bissau*. Termite mounds are a collectively constructed extended phenotypes serving as common dwellings for the termite tribe

Fig. 4 | *Prosthetic toe,* Jon Bodsworth

ties. This continuous *intra-play* of lifeforms and their extended phenotypes is mediated by the organism's sensing and responding capacities. The *environment*, then, constitutes by living entities and the transformation processes of matter into their bodily extensions. All these converging agents – organisms and their extensions alike – are effects of their *intra-actions*. According to Lambros Malafouris, professor of Cognitive & Anthropological Archaeology, organisms perform a process of cognitive becoming through "a saturated, situated engagement of thinking and feeling with things and form-generating materials" (Malafouris 2014). Organisms that feel the environment and feel themselves in this environment, do so not least because – as media philosopher Pietro Montani explains – their body and sensorimotor apparatus become *all one* (Montani 2020) with their *extensions*, as a result of material engagements. In an environment that – as a whole – is an effect of *intra-actions*, the exchanges between organisms and matter are a substantial part in the process of an ever-evolving material ecology in which bodily *extensions* are technological *pathways* (Bateson 1987) of mutual *becoming* and *acting* because of their fusing powers capable of linking entities within the environment.

A Cosmos of Extended Phenotypes

On a day in 1997, archaeologists examined an artifact in the cemetery of Sheikh 'Abd el-Qurna at Western Thebes (University of Basel) that researchers from the University of Manchester (University of Manchester 2010) would later describe as likely to be the world's oldest prosthesis. The *Cairo Toe*, crafted out of wood components and bound together with leather thread, was found on the right foot of a female mummy [**Fig. 4**]. Scientific tests dated the prosthesis back to the time between 950 to 710 BCE (Ibidem). Next to being a cosmetic replacement of a missing body part, this prosthesis was designed to help its carrier to walk correctly and to improve their balance.

The term *prostithenai* emerged in Greece in the 16th century and is composed of the prefix *pros* "in addition" and the verb *tithenai* "to place" – today meaning "an artificial part of the body". Following this definition, the *Cairo Toe* represents well what is commonly known to be a prosthesis. However, the term *prosthesis* includes per definition more than only a medical body-replacement. The psychoanalyst Sigmund Freud described the human as a *prosthetic God*, that – through the use of science and technology – creates prosthetic tools that are "perfecting his own organs, whether motor or sensory, or is removing the limits to their functioning" (Freud 1930). Freud displays the human body as fundamentally imperfect and dependent on tools to extend its natural capabilities to protect itself against the forces of nature (Ibidem). These prostheses enhance parts of the body to expand the physical or cognitive capacities of its carrier. In the words of architect Mark Wigley, prostheses are essential foreign elements (Wigley 1991) that reconstruct the human body, transform its limits and extend and convolute its borders.

The concept of a *prosthesis* can essentially be understood as one of an *extension*. However the term *prosthesis* is being used due to its additive, enhancing, and integrative nature as a thing that itself exists in a temporary state of technological evolution and allows an entity to prosthetically expand its capacities of action within its environment. Malafouris sees *things* as "dynamic, perturbatory, mediational means whose presence has the potential of altering the relationships between humans and their environments. New artefacts create novel relations and understandings of the world. New materialities bring about new modes of acting and thinking" (Malafouris 2019). His conception of the mediative capacity of *things*, however, cannot be applied to humans alone but counts for any other entity that is able to extend itself through the means of prostheses. The creation of an extension implies having an intended benefit of some kind for the organism that creates or *carries* it and can therefore be understood as a prosthesis for this entity. From the perspective of other entities that come in contact with that prosthetic intervention and are affected by it, but not intentionally profiting from its enhancing functions, it would not necessarily be perceived as a prosthesis to them. In that case, however, the prosthesis of one or multiple organisms still becomes a *pathway* to other entities as well, mediating certain possibilities of *intra-action* between them.

As supplements for human capabilities, prostheses are often created with the intention to protect or mobilize the body, for the communication of thoughts and ideas, the production and archiving of knowledge, and much more. Considering the expanded definition of *prostheses*, tools like hand axes, created 1.8 million years ago (Columbia Climate School 2011), could already be seen as the earliest prostheses. Playing an essential role in the history of human evolution, Malafouris understands the making of stone tools not as the product of thinking, but as a way of thinking, in which they "bring forth and constrain the organism's possibilities for action and imagination". He further argues: "Our forms of bodily extension and material engagement are not simply external markers of a distinctive humanmental architecture. Rather, they actively and meaningfully participate in the process we call mind" (Malafouris 2019). Continuing this train of thought, the organism's mind stretches beyond its skin into the environment and takes form in the material world.

Next to those early invented stone tools, the aforementioned conception of prostheses would also include the huts found on the archaeological site Terra Amata in Nice, dating back about 380.000 years (Tattersall, DeSalle 2019). Their simple architecture out of a stone circle and branches served as a prosthetic shelter. It extends the *skeleton* of the human bodily structure to protect it from the elements, predators, and other people (Lorek 2018). Likewise other lifeforms', humans' *extended phenotypes* take shape as prosthetic extensions that expand the bounds of the living organism (Feerick 2019) under the influence of their environment. Both determined by and mediated through technology, the organic evolution of the human species continues (Neutra 1954) and materializes within the transformation of raw matter into prostheses that express in myriad variations of extended phenotypes. In this way, "we have always become the humans that we are in interaction with the technologies that we work with", states Peter-Paul Verbeek (2021), philosopher and expert in the ethics of technology.

The media theorist Friedrich Kittler instead, radically detaches technology from its role of prosthetically *serving* the human and declares in an interview, that "one can construct a completely independent history of technology in which one machine replaces another machine, and no machine replaces man" (Bramkamp, Fedianina 2002). Following this notion, Kittler attributes machines with a certain autonomy and grants technology an evolutionary development equal to one of living beings such as humans. In contrast, thinking his idea along the lines of Barad's conception of *intra-action* and Montani's understanding of our relationship with technology as one of reciprocal "feedbacks continuously modify[ing] the practical and cognitive behavior of the human being" (Montani 2020), there can be no autonomously developing entities in this world. Nevertheless, Kittler offers a non-hierarchical way of thinking in which technology is recognized as an agency that has an equal share in the simultaneous evolution and establishment of co-constitutive relationships amongst other lifeforms within the environment.

The notion that a separate *natural* environment exists in parallel with a human-made *artificial* one dissolves when considering that the extended phenotypes of all living things arise from the same process of converting matter into bodily extensions. There is no difference between a spider's woven web to catch prey and prosthetic tools built by humans to hunt other lifeforms for food. Or between a beaver's dam and the human wooden huts in Terra Amata – or even contemporary architecture. If viewed in this way, they may differ only in the sense that the human creates prostheses on a different level of complexity. By virtue of their materialization, humans' prosthetic extended phenotypes coexist with non-human extended phenotypes and collectively establish and constitute the environment.

Some prostheses might serve a collective body more than the individual one and obviously, every prosthesis has its limitations within its operating context and by its material, construction, or aesthetic properties. The extended phenotype of the humans reveals itself in a scaffolding of complex chains of prostheses – each of their links is unique in its performing actions and operational *pathways*, yet depending upon one another to supplement each other's functions. It might need some mental deconstruction work to recognize the purpose of highly intertwined and complex societal ones compared to an individual's endogenous body parts like the lungs, the heart, or the brain. Yet, as distant as these systems might seem from the fleshly organism, they are the product of its mental capacity and were brought into existence by its mind (Feerick 2019; Malafouris 2019). Therefore every human artifact, whether the hand axe, the wheel, architecture, governments, the Internet, or the 7139 worldwide spoken languages (Ethnologue), are to a lesser or greater extent advanced manifestations of the human extended phenotype. All of these prostheses share their enmeshment within the environment as interstitial elements extending, connecting and affecting the actions of humans and non-human entities alike – sometimes they do so in unfolding their function as intermediary agents to such an extreme that they forge mutual or even parasitic and suppressive relationships between other entities.

Constructing a Prosthetic Sensorium

The sensorium mediates the humans' perception of the environment. Over the entire evolutionary history, this sense-apparatus developed through natural adaptation (Krantz 2012) to ensure survival in the best possible way. The interplay of many sensory organs like eyes, mouth, ears, nose, and skin form the humans' sensorium which is responsible for the reception and interpretation of stimuli from the phenomenal world (Ingold 2000). Stimuli, such as light or sound, are the data organized and interpreted by the brain. This data becomes information and constitutes a subjective reality, based on previous experiences and their attributed meaning. This perception of the world determines the behavior of humans; making them responsive, and guides their invention of prostheses. In turn, the prosthetic body augmentations mediate human actions within the environment. In other words, how humans understand and respond to the world is equally enabled and limited by their sensorium.

The sensorium and perceptive register, however, stretches beyond an organism's body through their technological extensions. The anthropologist Tim Ingold concludes Bateson's example of *the Blind Man's Stick*,[2] stating: "It would be more appropriate to envisage mind as extending outwards into the environment along multiple sensory *pathways* of which the cane, in the hands of the blind man, is just one". Bateson, an anthropologist and social scientist, essentially conceives body-extending "objects" as *pathways* through which information can travel. In his understanding, this "includes the *pathways* of sound and light along which travel transforms of differences originally immanent in things and other people – and especially in our own actions" (Bateson 1987).

Incoming sunlight might stimulate – sometimes even overstimulate – one or multiple sensory organs that receive the data. The eyes and the skin activated by the sunlight transform the sensed data through receptor cells into electrochemical signals (Eagleman 2015 quoted in Park; Aldermann 2018) that are sent to the central nervous system. After entering the brain, these signals get processed and actuate the body to react to the sensed signal. This process creates a very personal experience of the surrounding world – an individual reality – that activates a very individual response as a reaction to the sunlight. One kind of reaction to protect the eyes could be the creation of a prosthetic body extension that covers them from the bright light and simultaneously enhances sight [**Fig. 5**].

Seeing the human species as an *intra-acting* organism within the environmental context, one might notice that it relies not only on its own senses to survive. The individual's sensed reality can fuse with the sensing abilities of non-human lifeforms. Observing how other beings behave in specific contexts and interpreting their actions can already be seen as a form of extended human sensing capacities. For example, experiencing that some lifeforms suddenly start to flee might be construed with a correlating danger that can also become a threat for the human – it need not matter whether it is due to a predator or an earthquake approaching. Reading and understanding other

Fig. 5 | *Inuit Snow goggles from Alaska*. Made from carved wood (top) and Caribou antler (bottom), Jaredzimmerman (WMF). Eyewear designed by civilizations in Alaska and Greenlan

Fig. 6 | *Pigeoncameras*, Julius Neubronner, Neubronner's pigeon cameras were meant to be used during the First World War and are an early precursor to drones.

lifeforms' behavior is a form of hijacking their sensing capacities for one's advantage. The coal miners actively practiced this living augmentation throughout the 20th century, using the canary's sensing abilities as a prosthetic utensil to extend theirs. The appropri-

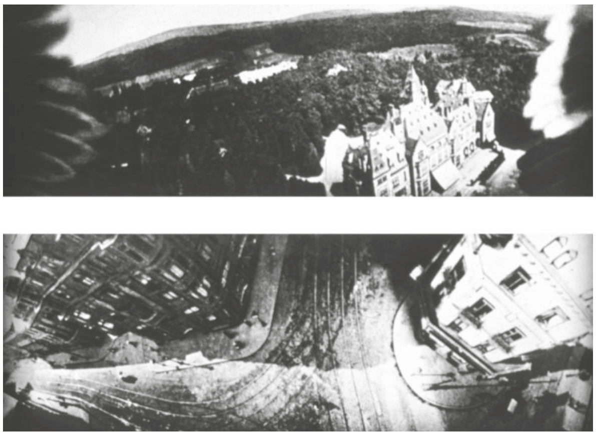

Fig. 7 | *Pigeon wingtips*, Julius Neubronner. Aerial photograph taken by a pigeon

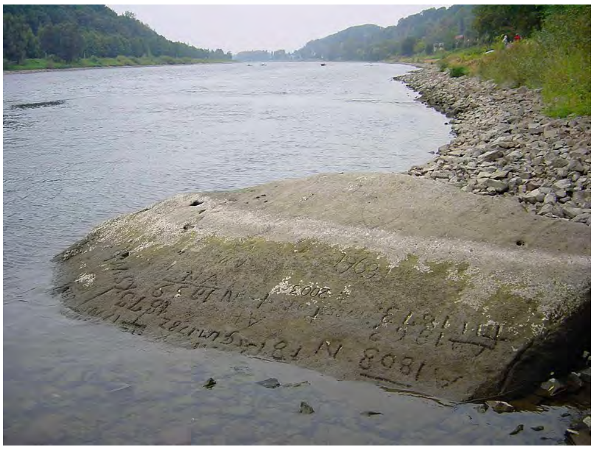

Fig. 8 | Hungerstein Elbe bei Pirna, Hunger Stones are communal monitoring-prostheses that only become visible during droughts when the water level of the rivers begins to fall

Fig. 9 | *Tatev Gazavan*. In the Tatev Monastery in Armenia, the resident monks constructed an eight-meter high prosthetic sense-extension as a response to a devastating earthquake. Erected in 904, the Gavazan obelisk expanded the monks' collective bodily capacity to detect seismic activity, warning them by tilting back and forth when slight seismic oscillations shook the ground. The hinged connection allowed the twelve segments of the octahedral structure to swing like a pendulum, turning back to its original position when when danger was over. (Karakhanian; Abgaryan 2004) The researcher Vazgen Gevorgyan suspects an alternative function of the Gavazan in the form of a celestial compass. Aligned with the Orion belt, it served the monks as a prosthetic astronomical instrument for conducting time calculations, such as the duration of a year (Avetisyan 2018)

ation of non-human capacities to advance the human sense is exercised to the present day. In some cases, hybrids of non-human beings and humans' prosthetic extensions have emerged, such as the augmentation of pigeons with cameras for aerial observation [**Fig. 6**; **Fig. 7**].

It might seem to be a logical consequence that – to understand better the complex system the human finds itself in – prosthetic tools emerging from *material engagement* processes are needed to extend bodily perception and knowledge. Monitoring technologies such as *Hunger Stones* [**Fig. 8**] or the *Gavazan* [**Fig. 9**] are forms of humans' extended sense-organs and mark the early beginnings of a collective prosthetic *techno-organic sensorium*.[3] They are stationary on-site monitoring systems that detect and visualize changes within the local environment, to inform multiple people or even whole regions. Their design is a form of a shared extended phenotype that expands the individual perception of environmental processes to a communal one. Making the sensed data visible, recording, and comparing them, are practices of pattern

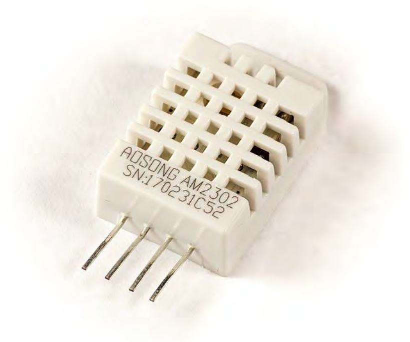

Fig. 10 | *DHT22-Temperatur-Sensor*, Ubahnverleih. Temperature sensor to detect and quantifiy the temperature changes

Fig. 11 | *Garden Wall Weather Station*, MT, U.S. Geological Survey, Monitoring station for weather

recognition that allow for predictions about potentially upcoming threats. However, due to the immobility of these early prosthetic sensing instruments, the collected data was spatially limited to the region. The responding prosthetic interventions to prevent natural hazards or mitigate their destructive power were likewise on a local scale.

Over the centuries, scientists and engineers began to design prosthetic instruments that were handily sized and portable, which enabled them to study changes in the environment wherever their users took them. The invention of tools like thermometers or barometers for measuring atmospheric pressure were starting to augment the human body in the 17th century already. In continuous development, they were later equipped with calibrated scales that facilitated precise measurements of changes in weather conditions and generate quantifiable data. Combining the recorded data of multiple devices extended the humans' *techno-organic sensorium* and made weather forecasts possible, which were crucial for farming practices on land and navigating the sea. Archiving-prostheses such as logbooks supplemented the humans' capacity to store their experiences of environmental phenomena. At the 1853's *First International Marine Conference* held in Brussels, a standardized *Abstract Log* was designed to collaboratively record and exchange international weather data. By founding this international sensing network, the conference marks the origin of a global weather information infrastructure (Edwards 2013). Yet, processing and interpreting the amounts of data promised to create an understanding of environmental phenomena was manual work that required time and effort. The ability to perceive the environment on a grander scale grew in the 20th century with the ongoing advancement of sensing instruments and network technologies. As the shortwave radio transmission untethered telegraphy, the speed and scope of communication webs extended. These infrastructures converge ever more tightly, forming the connective tissues and *circulatory systems* (Ibidem) of the human's expanded *techno-organic-body*.

With each passing decade, prosthetic technological sense-extensions shrunk in size while growing in complexity. Their design has a biological paragon and reveals the close kinship to the human's organic sensory system. Likewise bodily sense-organs, sensors work as electronic devices attuned to register physical input and detect changes within environments. The incoming data is transmitted through cables or antennas functioning like the receptors in an organic sensory transduction process. In the same way, as human senses operate, their technological relatives convert the sensed environmental stimuli into electrical signals, processed by computational *brains*. Contemporary sensors are tiny prosthetic sense-extensions often manufactured out of metal, plastic, glass and ceramic components combined with materials sensitive to specific mechanical or chemical input. They perceive electromagnetic radiation on a vast spectrum of light, making infrared, ultraviolet, or nuclear radiation visible. Sensors *listen* to ultrasound, register temperature [**Fig. 10**] differences to several decimal places, *smell* gases, track moisture levels in soil or air, measure the acceleration of things, estimate the flow of water and its pH level or *feel* the slightest vibrations on the surface of the planet. Joint together as they become multisensorial-bodies floating as buoys in the ocean, integrated within forests, erected on mountains [**Fig. 11**], and placed in orbit to free fall in space. All of them share their connection to extensive communication networks that transmit and distribute the sensed data.

In 1999, the journalist Neil Gross predicted the upcoming century's future of sensor technologies, imagining that "planet earth will don an electronic skin [using] the Internet as a scaffold to support and transmit its sensations" (Gross 1999). Only nine years later, the *Internet of Things* was born when the increasing growth of electronic devices connected to the Internet outnumbered the total number of people living on the earth (Evans 2011). A growing computational power that processes the worldwide data flow enables algorithms to observe anomalies in real-time. They detect specific changes in cloud formations that might indicate the emergence of hurricanes (Tan et al. 2022), reveal pollution sources of algal blooms by tracing color changes in water bodies (Sagan et al. 2020), and point out flooding risks when abnormal dike behavior occurs (Pyayt et al. 2011).

Incessantly designed over time, humans collectively established a *techno-organic sensorium* in the form of a hyperconnected extended phenotype that expands the communal experience to a planetary-scaled one. As a result, the individual reality increasingly becomes part of a *shared reality*[4] – not necessarily only between humans but also with the realities of the sensed entities. With the expansion of humans' prosthetic sensorium, their sensing instruments become increasingly pervasive, seeping into every corner of the Earth and beyond. Their original purpose of augmenting the human capacity to detect potential dangers and understand the interconnections within the environment has not changed to this day. However, compared to past millennia, the dimension of temporospatial perception achieved in the 21st century reveals complex phenomena on Earth and activates accordingly sized prostheses in reaction to the new knowledge.

Fig. 12 | *Lawinenschutz und Hangaufforstung*, Walter Frehner, avalanche barriers lining up along the mountain slope.

The Rise of Environmental Prostheses

Humans dramatically redesign the ecosystem with prostheses that are often thought to sustain the survival of the species in ways that protect them from the forces of *nature*. Compared to sunglasses or raincoats that protect the individual body, spatially increasing issues are mostly responded to with an accordingly-sized prosthesis that is *worn* by a communal body and through which it becomes a collective extended phenotype. These local interventions such as dikes and dams, avalanche barriers [**Fig. 12**], straw mats used to counter desertification, and many more prostheses have a long history and are mainly created to tame and subjugate the environment for collective human advantage.

If the more frequent occurrence of natural hazards had not indicated an imbalanced planetary ecosystem already, the growing distribution of humans' *techno-organic sensorium* vitally substantiated it with significant data. The prosthetic sensorial-extensions enabled the human to transform data from sensed environmental processes into something visible, through a certain level of sensor-input. This revelation extended the perception of humans' inbuilt sensory system and began to influence the way humans think and act (McLuhan, Fiore 1967). According to Ingold, the recordings of the phenomenal world through sensor media create "a reality [that] is given quite independently of our experience of [the environment] and that we can [assumingly] only know or only know correctly through the compilation of datasets drawn from detached observation and measurement and relayed back in the forms of maps, graphs and images" (Ingold 2010: 18). These representational forms translate the environment in an abstract version of it and therefore alter the human-environment-relationship in certain ways that might detach or intensify their relations.

Sparked by early satellite imagery and supported by pervasively expanding *techno-senses*, new forms of knowledge constitute and establish a consciousness that slowly acknowledges the *intra-connectivity* within the environment. This epistemic perception-shift conceives an environment as a world that can only exist in an *intra-dependence* and thus gave rise to what is here coined as *environmental prostheses*.[5]

What defines certain prostheses as *environmental* is the specification that they are a response to the cognition that the environmental equilibrium needs to be preserved in order for the human species to survive. Prostheses, which up to this point had in many cases augmented the human body as protection *against* the environment, now transitioned into prostheses meant to support a dysfunctional ecosystem. *Environmental prostheses* are therefore a form of counteraction that is trying to cope with the consequences caused by humans destructive behavior, such as *Global Warming*. Inventions like *Gazex* that actively manages snowbodies to slide downhill are a violent prosthetic reaction to e.g. foregone human deforestation that in turn caused the slope to be less stable. Although interventions such as these are placed within the environmental body, they are not *environmental prostheses* as they mainly supplement the human body as media for different suppressive purposes. They do not unfold new opportunities for the local ecosystem to thrive, compared to *Biorocks* [**Fig. 13**] which support the preservation and flourishing of lifeforms in the surrounding space.

All prostheses – whether mainly augmenting the human body or the environmental one – coexist next to or *within* each other and are a result of sense- and sensor-mediated human experiences. As prosthetic interventions explicitly activated by and targeted towards environmental phenomena, they share their coming-into-existence through invasive practices of power and control. *Environmental prostheses* are a very special kind of human extended phenotype: they

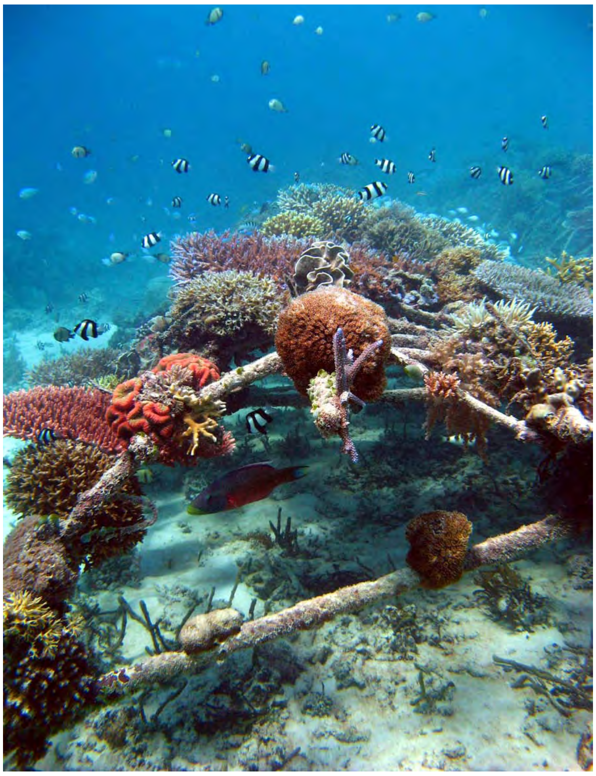

Fig. 13 | *Biorock Reef Indonesia*, U.S. Fish and Wildlife Service Headquarters. Biorocks are a form of environmental prosthesis that makes use of the process of mineral accreation that occurs when low voltage of direct current is put on the metal structure: through an electrolytic reaction a stable substrate of calcium carbonate grows like a rocky coating on the metal frame. The deposited layers of calcium carbonate are become sturdy and fertile grounds for corals and other marine organisms to flourish

are extensions designed by humans, even though they seem to augment the capacities of non-human entities. However, the biosphere appears to profit from these prostheses, these forms of interventions still root to a big extent in the very human intention to mitigate, or slow down [**Fig. 14**], the self-caused imbalances within the environmental system that becomes a threat for its own survival.

Since they co-emerged with their technologies, humans and other organisms are *forming* the Earth's environment through material engagements, expressed in their extended phenotypes. Maybe less perceivable in the past, humans are nowadays im-

Fig. 14 | *Rhonegletscher*, Nikater. To prevent or slow the melting of glaciers, some – often those that serve strategic economic purposes – are augmented with gigantic blankets. These prostheses support the glacier, however they also serves the human as protection-prostheses against potential flooding or water shortages depending on the season. Properly applied within the annual cycle of snow accumulation and snowmelt, the use of glacier blankets can build up snowpack and restore glacier strength

pacting the environment to such an extent that the concept of *terraforming,* as one that comprises the transformation of a planet's environment for the benefit of human life, enters an even vaster dimension in which the Earth becomes substantially inhabitable for other life forms including the human itself. *Environmental prostheses* take an active role in the process of intervening in the relations of terrestrial life – however, they challenge the conception of *terraforming* as one of exclusively human advantage.

Prosthetic actions such as the ones of *Conservation International* currently leading the worldwide largest tropical reforestation effort, aiming to restore 73 million trees in the Brazilian Amazon, are interventions within the environment that pursue to give a living-space for non-human organisms and counter the human-created effects of rising carbon dioxide levels in the atmosphere. Operating on a large spectrum of timescales, some *environmental prostheses* activate a more immediate effect of environmental transformation than others. The demolition of *Glines Canyon Dam* in Washington State as part of the *Elwha River Ecosystem Restoration Project* was the largest dam removal in history. In this case, a previous human intervention within the *intra-active* flow of the ecosystemic life regulated by the river has been removed and therefore becomes a prosthetic action that undoes a previously constructed material barrier of human domination – in a physical sense but also in a relational one.

The emergence of *environmental prostheses* – even though their main goal is a functioning *intra-acting* ecosystem that ultimately supports human survival – also testifies to attachment and care towards the non-human inhabitants of the earth. Something as simple as a bird-house created by the human organism can be seen as a form of *environmental prosthesis* that is not primarily extending the human capacities to expand its body, but the bird one's within the environment. This extension – even though human-made – is not a human-augmenting prosthesis but becomes a *pathway* to *intra-act* and establish a relationship between the human and the bird. *Environmental prostheses* can therefore be seen as a form of *meta-prostheses* as they operate beyond supplementing the mere human body. Some have little effect on the lifeforms around, others express themselves as constructions on national or planetary scales and have the power to influence whole ecosystems. Thinking of an entities phenotypical extension as a prosthesis acknowledges the close and entangled *intra-dependency* within its operating environmental system. Their coalescence inherits a certain kind of fragility in which both the prosthesis and its *carrier* complement each other – all prostheses, therefore, exist as agents coupling the human-environment-relationship.

Vision and Conflict of a Prosthetic Equilibrium

With the emergence of the *techno-organic sensorium*, a shared extended phenotype was constructed that expands the dimension of human sensitivity. Nowadays it operates on the temporospatial scale of the planet, configuring a reality of the world that is no longer limited to the sensory system of the individual's body and mind. Instead, a collective multi sensorial experience is established – transmitted over the planet, open to everyone who connects to it. Information, distributed by the *pathways* of the *techno-organic sensorium* in near real-time, guides its recipients' decisions and behavior within the environment. Observation and perception of events that could pose a potential danger to humans were the primordial drivers for the development of sensory enhancements. Millenia later, however, these prosthetic extensions reveal environmental changes activating an epistemic shift in which humans have to acknowledge that the main danger threatening their survival does not only come from the forces of *nature* but themselves. The massive amounts of extracted resources and energy consumed to acquire those enlightenments, however, renders the apparent necessity of such paradoxical undertakings absurd. A total view of the planet – even though this perspective implies a superior position of control – seems needed to organize and react to the perceivable dysfunctions of the planetary ecosystem (Gabrys 2016). Yet, the *techno-organic sensorium* enables humans to learn about the *naturally* existing *eco-homeostasis*[6] and the symbiotic relations of all living and non-living things. Along with these realizations, forms of reflexivity and responsibility emerge that actuate ecological thinking. By doing this, the *techno-organic sensorium* becomes not only a human extension but obtains a *concrescing* agency that develops social relationships among humans and sensed entities. These mediating processes inherent a chance of becoming environmental through technology and might allow a step into what philosopher Glenn Albrecht names *Symbiocene* – an era constituting a community of interconnected relationships with mutual benefits for all living beings (Albrecht 2015). *Environmental prostheses*, which emerged from the knowledge that life on Earth can only survive through the preservation of an ecological equilibrium, might navigate first transits into the new age. Some express as interventions in local regions, while other prostheses act on country-size scale as they become implemented into national constitutions in the form of *Earth Rights* [**Fig. 15**]. Organizations like the *Intergovernmental Panel on Climate Change* are prosthetic responses that operate internationally, such as the *techno-organic sensorium* that once activated the knowledge about the phenomenon after which the *IPCC* is named. Even though these substantial *environmental prostheses* have the power for a worldwide impact, they are enmeshed within political, religious, and economic systems – prosthetic societal frameworks. Being tied to these existing structures and their ideologies might supplement the execution of the necessary goals or inhibit it – perhaps making it impossible.

The imagined state of an ideal equilibrium is also one of constant conflict between *intra-acting* agents whose relations adapt to shifting power-dynamics. A growing influence of human activities on Earth and beyond demands a change in the intentions of their prosthetic extensions as mainly *serving* the human. To reach a more balanced state of ecosystemic relationships, some human agents more than others have to attune the impact of their prosthetic extensions, give up or share their intervening powers, or distribute their actions to open *pathways* that equally include the needs of non-human entities. The environment as a dynamic space of conflict requires prosthetic extensions that consider and establish a harmonic co-existence with mutual benefits among the living entities of the Earth – if existing parties dismiss that and do not change their actions accordingly, the invention of new prostheses is needed that counter or replace lack of human-centered-thinking extensions. As much as humans prove ingenuity in designing prostheses, so much are their future actions for preserving the earth's ecosystem guided by and entangled within the pre-established constraints of their prosthetic world.

Fig. 15 | Prankster, Whanganui river. *Earth Rights* is a jurisprudential theory that recognizes ecosystems and species as distinct personalities and gives them rights, similar to the concept of fundamental human rights. In 2012 a treaty agreement between the government and the indigenous group Maori iwi established the Whanganui River, and its tributaries as a legal entity with its own standing

Notes

1 *Theory of evolution by natural selection*: conception independently developed by Charles Darwin and Alfred Russel Wallace who propose the idea of evolution of living things based on variation and natural selection.

2 The "Blind Man's Stick" is a thought experiment in which Gregory Bateson opens the question of where to localize the mind of a blind person whose tactile perception is sensorially connected to its environment through the stick.

3 Coining the term "techno-organic sensorium": it comprises the whole of all technological sense-extensions (e.g. sensors and monitoring stations) including their connection to communication network infrastructures (e.g. Internet) that complement the humans' organic, endogenous sensory system.

4 *Shared realities* are constituted on the basis of information and experiences distributed through the techno-organic sensorium and collectively received by the humans connected to it.

5 Coining the term "environmental prosthesis": metaprosthesis that operates as a supporting augmentation/intervention for the environmental- and non-human-body.

6 "Eco-homeostasis" is a state of balance in which an intra-acting dynamic ecosystem mutually regulates itself.

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