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The Computation of Bodily, Embodied, and Virtual Reality*

Abstract

This essay investigates the impact of the digital age on corporality as a constitutive condition of experience. Rather than just considering the multitude of phenomena at the surface of digitalization, the essay uncovers the conceptual development that underlies them. I apply Edmund Husserl's concept of the "mathematization of nature" to digitalization, and, more specifically, digitization of data from experience. This leads to an explanation of some of the reasons for the apparent and the factual loss of corporality. Building on ideas of Günther Anders and Martin Heidegger, I then show how the use of humans as a source of data deepens the incorporation of the human body into the digital world. Yet, other recent developments of the digital age, such as "virtual reality" and other forms of "extended reality," rediscover not only the human body but also corporality. I again make use of Husserl's insights into digitization, this time inverting them to explain the computation of "extended reality."

Keywords: Corporality, Information, Digitalization, Digital Technology, Experience, Extended Reality

Introduction

Talk of "ages" has become so commonplace nowadays that the "digital age" may sound like just another buzzword. At best it seems to be a generic term for more concrete expressions such as the "computer age," "age of intelligent machines," "age of robots," and "age of the mobile phone." All of these latter expressions seem clearer because they refer to physical objects, and thereby gratify the common tendency to think of reality in terms of physical objects. Expressions such as "intelligent machine" furthermore evoke fantasies of weird subject-objects that cause excitement, arouse fear, and lead to confusion. All this resonates strongly in our agitated times and hence sells well.

Digital machines, however, are not only a cause of wide-ranging changes, but also the result of a more profound albeit less palpable conceptual development. Revealing this underlying development is crucial for understanding the complex impact of the digital age on corporality and experience, and will thus be attemp-

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ted in this essay. To this end, insights from classical phenomenology on the relation between the digital representation of the world, corporality, and the world of ordinary experience will be applied to some more recent developments of the digital age.

The etymological origin of "digital" in the Latin *digitus*, referring to someone's ten fingers or toes, suggests that the numerals of the decimal system are at the heart of the concept. But today's meaning of "digital" is rightly not restricted to the decimal numerals, and at present computers operate at their core not in the decimal, but rather in the binary system. It is not some specific set of symbols that is constitutive of digital computation, but rather the establishment of an ordered set of discrete states, which can then be transformed to other discrete states by applying rigid logical rules. Digital computation is primarily formal, and the objects (hardware) used for computation are built in such a way as to enable operations that correspond to formal transformation processes.

Groundbreaking contributions to the formal foundations of digital computing had already been made by François Viète in the 16th century, who was also a successful codebreaker. In the 17th century, Descartes and Leibniz further contributed to the formal foundations of computation, including work on a universal science modeled on mathematics, the *mathesis universalis.* Alan Turing showed in about 1936[1] that the computation of all digital computers can in principle be accounted for with a rather simple theoretical model of a computer, which is today known as the "Turing machine." A digital computer could be an electronic computer, but also a mechanical computer such as those envisioned and (partly) built by Pascal (1642), Leibniz (1672), and Babbage (1822). It could even by a human being equipped with pen and paper. Indeed, the latter was the main meaning of "computer" until electronic computers became widespread in the second half of the 20th century. What matters for computing are ultimately not the computing machines, but rather the kind of processing they do.

[1] Turing's article "On Computable Numbers, with an Application to the *Entscheidungsproblem*" was submitted and "read" in 1936. The journal that printed the article states on its website that it was published in 1937 (Alan Mathison Turing: "On Computable Numbers, with an Application to the *Entscheidungsproblem.*" In: *Proceedings of the London Mathematical Society* s. 2–42(1), 1937, 230–265), and a correction in 1938 (Idem: "On Computable Numbers, with an Application to the *Entscheidungsproblem.* A Correction." In: *Proceedings of the London Mathematical Society* s2–43(1), 1938, 544–546). Others, however, hold that all parts of the paper were published in 1936 and the correction in 1937 (Robert I. Soare: "Computability and Recursion." In: *Bulletin of Symbolic Logic* 2(3), 1996, 284–321, here 320 f.; Alan Mathison Turing: *The Essential Turing: Seminal Writings in Computing, Logic, Philosophy, Artificial Intelligence, and Artificial Life, plus the Secrets of Enigma.* Edited by B. Jack Copeland. Oxford 2004, 5–6, fn. 1).

One must not overlook, of course, that this is usually not just numerical calculation but information processing. "Information" is hence the core concept of the digital age, although this word has several fundamentally different uses. On the technical level of computation, the information of the discrete state is just the value of that state (such as 0 or 1), independently of what it may represent. It has a place in digital memory and stands in a causal relationship to other parts of the computer. Sets of values of states by themselves do not represent anything either. Information as representation only comes into play when technical information is interpreted to stand for something else, which of course is crucial for making computation useful. The technical sense of information will here be called information^{T}, and the representational sense information^{R}, leaving aside other important yet frequently conflated uses of "information."[2] Today's uses of the word "data" exhibit analogous ambiguities: it usually means the representation of something but sometimes it means mere ordered sets of information^{T} (such as "00110001"), which may stand for different kinds of information^{R}. In this essay, "data" refers to a subset of information^{R}, namely measurements and computations thereof that are saved in a digital format, i. e., by means of information^{T}. When data cannot be recovered, i. e., when its referent cannot be determined, data becomes a mere set of physical states that may provide information^{T} but no information^{R}.

It is easy to overlook the fact that going from information^{R} to information^{T} and vice versa involves a fundamental transformation. Getting information^{R} from information^{T} presupposes that information^{T} can be "interpreted," "recognized," or "understood" as information^{R}. To throw light on what this involves in relation to intuitive experience and corporality, in the next section I will consider Edmund Husserl's concept of the "mathematization of nature." The world comes to be represented by digital data, and there seems to be no need for corporality. This explains the *impression* that corporality is lost in the digital age, despite corporality remaining a constitutive condition of experience. The mere impression of the loss of corporality by itself has grave consequences for how humans relate to themselves and the world, some of which will be explored throughout this essay.

Besides explaining reasons for the apparent loss of bodily activity and corporality, the essay explains reasons for a certain *factual* loss. More surprisingly, however, it also shows that there are novel intertwinements of technology with the

[2] For instance, there is information in an ordinary sense: anything that one can come to know about something. Other examples concern the different definitions of information in physical science. See Christoph Durt: "From Calculus to Language Game: The Challenge of Cognitive Technology." In: *Techné: Research in Philosophy and Technology* 22(3), 2018, 425–446.

human, as a body *and* as a corporal being. I will distinguish two ways in which technology intertwines with the human body: by means of technology becoming part of the human body, and by means of the body becoming part of a computationally ordered system of information. In section 2, I develop further some ideas of Günther Anders and Martin Heidegger to show how the use of humans as a source of data deepens the human body's incorporation in the digital world. Yet, other recent developments of the digital age, such as "virtual reality" and other forms of "extended reality," are rediscovering not only the human body but also corporality. In section 3, I explore the intertwinement of digital technology and corporality.

1. The Apparent Loss of Experience and Corporality in the Digital Age

Data (as defined above) is information^{R}, because it represents some aspect of empirical reality. If it did not represent anything, it would be mere information^{T}. "Represent" can mean many things, but if the representation is of empirical reality, for Husserl it must be founded in intuitive (*anschauliche*) experience. Information^{T} can only be "interpreted," "recognized," or "understood" as information^{R} when its connection to experience is not severed. According to Husserl, who was brought from mathematics to philosophy by a concern for the psychological foundations of mathematics,[3] this is not only the case for data, but even for logical concepts. His relatively early *Logical Investigations* are renowned for their excellent critique of psychologism, but even here he writes that "[l]ogical concepts, as valid thought-unities, must have their origin in intuition [*Anschauung*]."[4] Toward the end of his life, Husserl dramatically broadened the idea that overlooking that origin has led to what has been called a "foundational crisis of mathematics."[5] In *The Crisis of the European Sciences and Transcendental Philosophy*,[6] he again claims that overlooking the origin of the scientific concept of

[3] Edmund Husserl: *Über den Begriff der Zahl: psychologische Analysen.* Halle 1887; Edmund Husserl: *Philosophie der Arithmetik mit ergänzenden Texten, 1890–1901.* Husserliana XII, edited by Lothar Eley and Herman Leo Van Breda. Den Haag 1970; Edmund Husserl: *Studien zur Arithmetik und Geometrie: Texte aus dem Nachlass 1886–1901.* Husserliana XXII, edited by Ingeborg Strohmeyer. Den Haag 1983.

[4] Edmund Husserl: *The Shorter Logical Investigations.* Edited by Dermot Moran, translated from the German by J. N. Findlay. London 2001, 88.

[5] Hermann Weyl: "Über die neue Grundlagenkrise der Mathematik." In: *Mathematische Zeitschrift* 10, 1921, 39–79.

[6] Edmund Husserl: *The Crisis of European Sciences and Transcendental Phenomenology: An Introduction to Phenomenological Philosophy.* Translated from the German by David Carr. Evanston 1970.

the world in intuitive experience results in a foundational crisis, in this case the crisis of all Western science.

Husserl's concept of the "mathematization of nature," which he extensively develops in *Crisis*, spells out how the seemingly purely objective world of modern science is founded in the world of intuitive experience. This world – empirical nature – Husserl here calls the "lifeworld" (*Lebenswelt*). The concept of the mathematization of nature stands for a complex process that took off around Galileo's time, and which involves several later developments in mathematics, science, and philosophy.[7] Together, these lead to nature being conceived in terms of a formal and non-intuitive mathematics. But in fact, rather than representing reality in itself, the mathematical representation represents the lifeworld.[8]

According to Husserl, a key process of the mathematization of nature consists of the application of measurement techniques to the lifeworld, which derive numerical values from concrete experience and generalizations thereof.[9] As idealities conceived in a formal mathematical framework, numerical values cannot, by themselves, be intuitively experienced. Only their material expressions can, such as symbols written on a piece of paper or shown on a display. Here, a symbol represents a numerical value, but the numerical value would be mere information^{T} if it did not represent something in the lifeworld, such as the length of an object. Because it represents something in the lifeworld, the value constitutes data in the above defined sense. Husserl did not speak of a "digital" world, but since the "mathematical world"[10] of modern science is made of data, it is a digital world. The mathematization of nature is a digitization and digitalization of nature.[11] Husserl's insights on the relation between intuitive experience and the mathematical world thus also apply to the relation between intuitive experience and the digital world.

Husserl's account of mathematization explains why it is easy to overlook the fact that the mathematical or digital world is fundamentally different from the lifeworld. The reason is that there are technologies that relate one to the other. On the one hand, measuring technologies (techniques and instruments) are designed to deliver digital values that fit the lifeworld as accurately as possible, i. e., data. In Husserl's expression, the lifeworld is dressed in a made-to-measure

[7] For an analysis of the steps involved in this mathematization and their philosophical implications, see Christoph Durt: "The Paradox of the Primary-Secondary Quality Distinction and Husserl's Genealogy of the Mathematization of Nature." Dissertation. eScholarship University of California 2012, online available at http://www.durt.de/publications/dissertation/.

[8] Husserl: *Crisis*, 51.

[9] Ibid., 44.

[10] Ibid., 293.

[11] I mean by "digitization" the transformation of experiential qualities into data. "Digitalization" furthermore includes the consequences of the uses of digitization.

"garb of ideas."[12] On the other hand, data can straightforwardly be applied back to the lifeworld. For instance, calculating a distance from data that is presented on a map can easily tell us how many meters we have to walk to reach our destination. Because of the accurate fit, and because data can be used to predict experience in the lifeworld, it is not immediately apparent that this garb in fact "substructs"[13] intuitive experience with a world of idealities that by themselves have no intuitive content. Lifeworldly experience becomes "sedimented"[14] beneath several conceptual layers. It seems as if empirical nature itself were a mathematical or digital manifold[15] void of intuitive experience.

This concept of nature has critical consequences for understanding corporality and its constitutive role for experience. Because experience itself is excluded from the digital concept of nature, the consciously experiencing being has no place in nature. The body that experiences, and which is itself experienced, i. e., the corporal being (*Leib*) or, more generally, corporality (*Leiblichkeit*), is reduced to the physical body (*Körper*) that receives "information" via its senses. In the – apparent – end, this leads to a conception where the corporal being can be replaced by a computer, because the corporal being is itself conceived as a computer. Those who consider computers to provide a good model for the human mind have taken up the (not only Cartesian) idea of a disembodied mind and frame the mind in terms of "software" that can run on different sets of "hardware." One consequence of this is that it seems possible to transform the human mind to digital memory. This possibility is alleged, for instance, by the heralds of technically mediated immortality, who pronounce that the human brain could be scanned and digitally uploaded. Allegedly, this amounts to uploading the most important parts of the mind, which now inhabit a "virtual body."[16] When consciousness is reduced to information^{T} processing and the human body to a machine, the idea of the corporality of experience looks like a superfluous myth.

The hardware concept of corporality can have grave consequences for humans' relation to themselves and the world, some of which will be investigated in the next section. The conceptual disregard for corporality, however, does not entail that corporality in fact becomes ineffective. From a phenomenological point of view, it is clear that the corporal subject is a constitutive condition of

[12] Husserl: *Crisis*, 51.
[13] See, e. g., ibid., 38.
[14] See, e. g., ibid., 361.
[15] Ibid., 23.
[16] Ray Kurzweil: *The Singularity Is Near: When Humans Transcend Biology.* New York 2005, 203.

experience and understanding. We live in the lifeworld as corporal beings,[17] and one's own living body always participates in sense perception.[18] As human beings, we are also physical bodies, but the corporal being is necessarily more than a mere body. The corporal being actively participates in all perception, and is at the same time immediately aware of its activity; it forms the "kinesthetic" unity by which one perceives.[19] Since Husserl held intuitive experience to be corporal experience, he would agree that, like logical concepts, information can only be understood by a "living, embodied, and subjective mind."[20]

Kurzweil's "virtual body" is made of information saved into a digital memory. It is not a living being, and it does not by itself have experience. At most, it could be used to produce the simulation of a body, such as an avatar, which, if projected into a perceptible form, may change the experience of the corporal being that identifies with it. The apparent possibility of disembodiment remains a fantasy that works well in science fiction, but not in serious science. The real change of corporality as a constitutive condition for experience in the digital age is not found in grand disembodiment fantasies, but in more serious developments.

One way in which the digital age contributes to a loss of the body and corporality is so obvious that it is easily overlooked. Like other technology, digital technology aims at making life easier by dealing with tasks that would otherwise require more laborious effort, and thereby renders superfluous corporal skills and activities that would otherwise have been required for those tasks. Newly required corporal skills such as typing, clicking, and tapping require some corporal activity and skill, but in sum tend to involve less corporal activity and skill than the activities and skills they replace. The use of digital technology itself is becoming more effortless and in the future, new brain-computer interfaces may enable us to give orders just by thinking. In fact, the need to give explicit orders is itself diminished by predictive technology and autonomous systems. It seems as if the body and corporality would become superfluous.

Notwithstanding the fast acceleration of this perennial tendency of technology, digital technology is also developing in a way that assigns new importance to the body and corporality. In the next section I investigate how digital technology intertwines with the physical body, which becomes part of a system of infor-

[17] Husserl: *Crisis*, 50.
[18] Ibid., 106.
[19] Ibid., 106–7.
[20] Thomas Fuchs: "Künstliche und menschliche Intelligenz: Eine Klarstellung." In: Idem, *Verteidigung des Menschen. Grundfragen einer verkörperten Anthropologie.* Frankfurt am Main, forthcoming.

mation. In section 3, I then contemplate how human corporality is beginning to attain new importance in the digital age.

2. The Intertwinement of Digital Technology and the Human Body

Traditionally, input had to be put in terms close to the mechanics of the machine; levers had to be pulled, buttons pushed, punch cards inserted, machine language programmed, command lines typed. Then "user-friendly" computing increasingly hid away the workings of the technological devices, yet it still mostly operates on explicit orders. Technology is coming ever closer to the user, and metaphorically or literally wraps the user, as a data glove does. The human is no longer a user, but is now a wearer of technology, and may even become a cyborg: a hybrid of technology and human being. Here, the embodied being literally incorporates technology into its physical body. Such incorporation, however, is only the more palpable aspect of the intertwinement of digital technology with the human body. It contributes to the inverse and possibly more consequential intertwinement of digital technology and the human body: the incorporation of the human into a system of information.

Already today, the amount of explicit input and output is dwarfed by the amount of unconscious activity that is recorded and processed by increasingly autonomous systems. To activate these, it is often enough to check (or not to uncheck) a box – with or without knowing the impact of this – and vast amounts of data are thus collected and processed, data the user may never have been aware of. Just a couple of clicks on "like" buttons can reveal a lot about somebody with a statistically high degree of confidence. Considering the variety and vast amount of data that can be combined in a profile of the same individual makes clear that data can indeed be very valuable – e. g., for political and economic purposes.

Politically, mass surveillance provides unprecedented means for controlling whole populations. This does not necessarily entail that chips or other devices are implanted in the human body. Even passports become redundant when facial and other biometric recognition techniques become reliable enough to securely identify individuals. Movements and actions become controllable, and already the possibility that each digital activity is observed suffices to significantly change behavior and thinking. For illustrations of such phenomena, we do not

need to recur to dystopian science fiction; tight digital control has become the reality for whole populations.[21]

Economically, consumers suddenly find that they are not only consumers, but also providers of a valuable resource, namely data. Some have gone as far as to speak of "surveillance capitalism,"[22] which aims to exploit all the data that can be gathered about potential customers. Traditionally, when humans have been treated as providers of a resource, this is usually with respect to labor. The use of humans as providers of physical resources, such as human hair for wigs, organs for donations, or flesh in cannibalism, is relatively rare. Heidegger's student (and in some philosophical and personal respects his rival) Günther Anders sees a tendency toward transforming humans into physical resources on a large scale, the beginnings of which he locates in Auschwitz.[23] In comparison, using humans as a source of data seems almost innocent. But this innocent appearance hides a vast potential for the use and misuse of data, much of which can be utilized to infer intimate details about individuals, including their desires, wishes, preferences, beliefs, thinking, and behavior.

Being treated as providers of a resource further radicalizes a tendency that is already present in the reduction of the human to a consumer, namely that humans are assigned the roles of "parts of a machine (*Maschinenteile*)."[24] The concept of a machine is problematic, however. It again gratifies the tendency to think of reality in terms of physical objects. Like tools, machines are typically associated with objects that were designed and built for a purpose outside of themselves. Machines can relatively easily be controlled and turned off if their owners decide so. All this is not true for socio-economic systems that assign computational roles to its constituents. Anders himself uses the concept of "machine" in a very wide sense to include everything that is part of a "machine process (*maschineller Vorgang*)."[25] It is probably less misleading to speak of a system of information, and I here prefer this concept.

[21] Chris Buckley, Paul Mozur: "How China Uses High-Tech Surveillance to Subdue Minorities." In: *The New York Times*, May 22, 2019, sec. World, https://www.nytimes.com/2019/05/22/world/asia/china-surveillance-xinjiang.html; Darren Byler: "Ghost World." In: *Logic Magazine*, May 1, 2019, https://logicmag.io/china/ghost-world/; Idem: "China's Hi-Tech War on Its Muslim Minority." In: *The Guardian*, April 11, 2019, sec. News, https://www.theguardian.com/news/2019/apr/11/china-hi-tech-war-on-muslim-minority-xinjiang-uighurs-surveillance-face-recognition.

[22] Shoshana Zuboff: *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power.* New York 2018.

[23] Günther Anders: *Die Antiquiertheit des Menschen. Band II: Über die Zerstörung des Lebens im Zeitalter der dritten industriellen Revolution.* München 1995, 22.

[24] Ibid., 112.

[25] Ibid.

Becoming parts of a system of information inverses the above-mentioned development of technological devices becoming parts of the human body, but it is not the opposite. Both developments mutually reinforce each other, as well as the mechanistic conception of nature, from which they result in the first place. When humans are regarded as parts of a system of information, all that really matters is their function within a large mechanism. Not only lifeless nature, but also animals and humans themselves are regarded as mere bodies, and thus as calculable by the same means. Today, digital information processing provides the means to apply this view to managing humans on an unprecedented scale. Beyond Heidegger, we can recognize that in the digital age it is not only nature that "reports itself in some way or other that is identifiable through calculation and […] remains orderable as a system of information,"[26] but also humans themselves.

Although Heidegger did not foresee the rise of information technology, he recognized that information is central to the success of the increasingly global collaboration between technology, science, and economy. That same success, however, also entails severe problems not only for the philosophical concept of the world, but also for humans' self-understanding, including their corporality, sensitivity, and reason. Husserl's concept of crisis, which was mentioned in the beginning of the last section, has its place here. Whether the crisis of the sciences is their loss of meaningfulness for life, and/or whether that loss results from the crisis of the scientificity of science, is an issue of debate between Husserl scholars.[27] In either case, the crisis is ultimately caused by science's seeming detachment from the world of intuitive experience, which leads to a lack of understanding of both the intuitive foundations of science and the meaningfulness of science for ordinary life. When, furthermore, humans are regarded as mere subsystems of information in a larger system of information, there is complete confusion. According to Husserl, this has wide-ranging consequences for society and politics. Anders and Heidegger warn that this conception of human nature can easily lead to the subjugation of humans to a man-made but inhuman system of information.

The developments just described are escalated by the progress of digitalization. Humans "report themselves" through the data they provide: data which, with increasing precision, allow its collectors to model, calculate, predict, and

[26] Martin Heidegger: *The Question Concerning Technology, and Other Essays.* New York 1977, 23.

[27] See, e.g., Emiliano Trizio: "What Is the Crisis of Western Sciences?" In: *Husserl Studies* 32(3), 2016, 191–211; George Heffernan: "The Concept of Krisis in Husserl's The Crisis of the European Sciences and Transcendental Phenomenology." In: *Husserl Studies* 33(3), 2017, 229–257, here: 219.

control future human actions. The vast amount of data provided by measurements of the human body means that the human body, which was rather neglected in the early years of digital computers, has become important again. The concept of "body" that is operative here, however, merely corresponds to what can be digitally measured and processed. Since we cannot directly measure feelings or thoughts, but only their bodily manifestations, the intertwinement of technology in this first sense is not corporal. Hence, it is not the embodied being in the full corporal sense that is recovered, but only the body. The impression that, even when the body becomes a focus of digital technology, this is only the physical body may further support the idea that the digital age renders corporality superfluous. But that would be to overlook the fact that digital technology, besides intertwinement with the body, is also beginning to intertwine with the corporal being.

3. The Intertwinement of Digital Technology and Corporality

The second way in which digital technology can be incorporated concerns the human being in the full corporal sense: the perceiving, feeling, and thinking body. The point is not that some machines themselves develop consciousness, but rather that they are built to change human consciousness through changes of corporal experience. Corporal experience here is the center around which digital technology is built. To change corporal experience, technology may but does not necessarily have to become part of the human body in a literal sense. The output of any computer operated by humans ultimately has to be put in a form that humans can perceive. Since digital computers work with bits, a simple output is that of a byte in the form of a symbol that can be perceived by humans, such as on a display. Interfaces such as displays and speakers transform the physical states that correspond to data into physical modifications of the lifeworld that can be perceived by humans. In short, (digital) data is projected back into the analogue world of human experience.

Since the output of digital technology is not restricted to symbols, and, over time, interfaces are coming closer to the limits of perception, they are getting better at catering to experience. Furthering analogue virtualization technologies such as cinematography, they enable the user to immerse themselves in a "virtual reality" (VR). Of course, corporality is crucial for virtualization technologies, since without it there would be no perception of the virtual world. Paradoxically, however, technology that caters to corporal experience can also foster a sense of disembodiment. In addition to accidental distractions from immediate experience of the lifeworld, which are a typical byproduct of the use of any tech-

nology, virtualization technologies purposefully distract their users. Already relatively primitive virtualization technologies, such as cinema and TV, entice the user to immerse themselves in a different "reality." Traditionally, this involves a certain degree of corporal passivity: the user sits in a comfy chair and is helped to imagine a different "world," the visual and acoustic properties of which are pre-given together with the action and its temporal order, as well as the spatial perspective. The user is rendered a relatively passive consumer of more or less fictional "worlds," rather than an active participant in the happenings of the real world.

Upcoming virtualization technologies such as those used in the production of VR aim at an increasingly perfect immersion of the user, which may seem to further remove the user from their corporal existence. Although they add the crucial element of activity, the activities possible in VR tend to be stripped of many corporal elements. Movements in VR are often amplified, so that relatively little actual bodily movement is required, and the levels of corporal movement are much more confined. Here again, one's usual sense of corporality can diminish. Furthermore, VR applications are often best at stimulating the visual and acoustic senses, while one's haptic and olfactory senses and sense of balance are still "back" in the ordinary lifeworld. This can contribute to VR sickness, with symptoms such as headaches, nausea, and disorientation.[28] Such corporal experiences may further contribute to making corporality look like a hindrance. Notwithstanding this appearance, the need to integrate the different senses properly in a realistic VR system, and to include bodily activity, reaffirm that the corporal being is constitutive of experience.[29]

The concept of VR can easily give the impression that "virtual *reality*" is a complete reality that can stand on its own. But this impression is wrong; any special "reality" is only subordinate to reality in the singular. VR tends to be restricted to limited periods of time, and even if all our experiences could be computed (such as in the movie "The Matrix"), our bodies would still exist "in reality." VR is better understood as an extension of experiential reality on one end of a continuum that has intermediate forms, such as when in "augmented reality" artificial entities are projected into the regular experience of reality. The

[28] Eugenia M. Kolasinski: "Simulator Sickness in Virtual Environments (ARI 1027)." U.S. Army Research Institute for the Behavioral and Social Sciences, 1995, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA295861.

[29] The possibility to directly stimulate the brain to cause experiences similar to sense perception does not speak against the importance of corporality. To the contrary: the aim of the stimulation is still corporal experience, and the experiences caused by the stimulation will seem unreal if they do not properly integrate with other experiences of the corporal being.

concept of "extended reality" or "XR" will here be used as a shorthand for all forms of computational modifications of the experience of the world.

To understand the relation between the computing behind XR and the world of corporal experience, we can again apply Husserl's account of the mathematization of nature. As discussed in section 1, Husserl holds that modern science dresses experiential nature with a "garb of ideas" made of data. In the case of XR, we can speak of "garb" in two senses: In the first, the garb of data in Husserl's sense. The human body, too, is measured and represented or "dressed" in the same way as nature, and is hence considered a mere physical body. As discussed in section 2, this sense corresponds to the measurement technologies used in the mathematization and hence contributes to the reduction of humans to data. In the second sense, however, the transformation between data and experiential reality enabled by the garb now also takes the opposite direction. The processes involved in transforming lifeworldly experience into non-intuitive mathematical representations of the world are conversed in virtualization technology. Rather than merely wrapping bodies to retrieve data, the "garb" of interfaces also wraps the corporal user to produce experience. An output is computed that consists of data with respect to the states of physical interfaces and which may be experienced by corporal beings as a modification of the lifeworld. Since the direction of transformation here goes from data to experience, the computation of XR is the converse of the mathematization of nature.

Since virtualization technology is built to alter corporal experience, the user is now not merely considered a body, but also a corporal being. The original lifeworld is enriched and to a certain degree replaced with artificially-created experience. Of course, the means of the digital calculation of XR operate at the level of information^{T}. The categorical difference between information and intuitive experience remains (see section 1). With respect to information^{R}, however, there is now a doubling. The digital computation of XR works at the level of information^{T}, but it produces two kinds of information^{R}. On the one hand, the information^{T} computed is used to deliver a physical output: it is used as information^{R} with respect to the physical world, such as the pixels on a display. On the other hand, the computed information^{T} is meant to represent something in XR: it is information^{R} with respect to the experience of XR. Digital technology now calculates both "mathematized" nature and the embodied corporal experience of artificial modifications of reality.

Since technologies such as XR place the corporal being at the center of their efforts to alter corporal experience, they endow corporality with a new importance. The fact that they are still driven by computations on information^{T} and information^{R} in the first two senses just discussed, however, may reinforce the impression that ultimately reality is reducible to information and that corporali-

ty could exist in a "virtual body" (see section 1). But this impression remains erroneous. The computed information by itself does not constitute a reality. The output of the computations needs to be properly integrated into the world of (corporal) experience to become part of XR. XR is created cooperatively by the computer and the corporal being. Not only does corporality remain a constitutive condition of experience, but it is also the center around which novel digital technologies are built.

Outlook

The novel role of the corporal being in novel digital technologies leads to multiple interesting phenomena. For instance, XR can be finely adjusted to cater to the interests of the individual subject. Yet much in XR is potentially observable by others in all its details, and can be efficiently processed by digital means. As pointed out above (section 2), already at the bodily level there is a huge amount of data that can easily be used to infer someone's desires, wishes, preferences, beliefs, thinking, and behavior. Such inferences can become much more accurate when digital technology intimately intertwines with corporal experience as described in section 3. Inferring from data to the corporal being's experience may seem foolproof when that experience was produced from data in the first place. In spite of the categorical difference between the two, transformations between data and corporal experience increasingly appear seamless.

The danger here is not that the human is reduced to its bodily existence and assigned the role of part of a machine in Anders's sense. While this danger does not necessarily decrease, the rediscovery of corporality also recovers a fuller sense of the human being. It does not recover the full corporal being, however, but merely those aspects of corporality that can be digitized and processed by computational means. The new danger is that the human is reduced to properties and states that can be managed by computational means in the new, wider, sense. That may feel more humane than being reduced to a provider of physical resources, or of data. But the profundity of the alterations of upcoming technologies also increases the difficulty of realizing that there is more to humans and the reality they live in than computable properties and states. As a result, the human being may be assigned the role of part of an even more pervasive system of information.

This essay has shown that taking on the difficult challenge of disentangling the very developments that led to the reduction of the human can also reveal how corporal experience and computation can work together. This is necessary for fathoming how digital technology, instead of reducing humans, can support the progress of humankind in a full sense. When we look at digital technology,

we need not be like the "Angelus Novus," who in Walter Benjamin's interpretation can only retrospectively assess the multiple consequences of progress piling up in history.[30] As I said at the beginning, technological devices are not only causes of wide-ranging changes, but also the result of a more profound conceptual development. This essay has attempted a first step toward understanding this development underlying the digital age with respect to corporality and experience. Many aspects of this and related issues are still in need of investigation. Indeed, I hope that this essay will inspire such investigations.

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[30] Walter Benjamin: "Theses on the History of Philosophy." In: Idem, *Illuminations.* Edited by Hannah Arendt, translated from the German by Harry Zohn. New York 2007, 258 f.