Will the Body become a Platform?: Body Networks, Datafied Bodies, and AI Futures

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Introduction

In September 2017, news emerged that a computer virus had been created to target all Bluetooth networks. Dubbed "BlueBorne," the attack vector would allow "attackers to take full control of devices . . . and spread malware laterally to adjacent devices" (Armis 2017). BlueBorne spread across Bluetooth devices—smartphones, watches, tablets, speakers, fitness trackers, and even smart cars—searching for weak spots in these personal networks. At one point, it was reported that it could affect 8.2 billion units, the entire range of Bluetooth-enabled devices (Armis 2017). Google, Apple, and Microsoft dealt with the risk, and some immediately issued security patches to stop it in its tracks. But the BlueBorne event was noteworthy beyond the technical fix. Most people were completely unaware of the threat and potential disaster, and even more so, how it could harm them personally. Designed to be nearly invisible, the virus was developed to be infectious as it moved through the air, device to device over Wi-Fi with agility.

BlueBorne might have been even more dangerous if current proposals for new technologies called Body Area Networks (BANs) had been in operation. BANs, or *body networks*, are wireless network technologies designed for embodied devices. In this chapter, I discuss what happens when our bodies become platforms during the next computing revolution. Once networks are on and inside the body, collecting data from within, what would happen if body networks were attacked? Who would control these devices (and, by extension, ourselves)? What would happen to the people who rely on them? The BlueBorne event hints at a future of embodied computing, when immediate threats to our bodies will be hidden, and when data about human thoughts, emotions, vital signs, and movements can be uploaded and monitored.

Connected to the internet, bodily information would be available to algorithms and actors who might be anonymous to us. One can imagine the positive possibilities with constant bodily monitoring ("automonitoring") for disease, for anxiety, for security. Yet, the negative possibilities are equally concerning (Catherwood, Finlay, and McLaughlin 2015; Jiang, Tan, and Liu 2018). The BlueBorne story notes obvious risks, but it also evokes the potential for profound societal change. As Shoshana Zuboff (2019) writes in *The Age of Surveillance Capitalism*, "automated machine processes not only know our behavior but also shape our behavior at scale" (7). I am suggesting we are on the brink of another significant turn that will shape our digital futures.

In earlier work, I contributed the term "continuum of embodiment" as a critical framework to explore the ideological justifications for technology hardware platforms that are increasingly embodied (Pedersen 2013). Framing the phenomenon as a continuum enabled me to write about how public, academic, journalistic, fictional, and commercialized discourses valorize prerelease personal technology on a continuum linking mobile to wearable to implantable innovations as a seemingly necessary, imminent, and determined future (Pedersen 2008, 2013). I made the argument that this is a ruse that contributes to a constant mediatization of lifestyle. Through popular public discourses or even through spectacles of wealth, marketers celebrate how mobile technology evolves to become wearable, a process which would then lay the groundwork (and expectations) for implantable technology as one exigent next step, with little or no consideration for how people will be dehumanized by it. Likewise, many scholars are now researching the biased, harmful social implications of artificial intelligence and algorithmic decision making, emphasizing "that computational methods are not inherently neutral and objective" (AI Now 2018, 24). Embodied computing has advanced tremendously due to both euphoria over future tech imaginaries, on the one hand, and seemingly neutral science and technology descriptions that go unchallenged, on the other (Pedersen and Dupont 2017). It also develops against a backdrop of wide-scale biotechnical advancement, economic upheaval, social disruption, and mass automation through AI, under the hyped conditions that some refer to as the Fourth Industrial Revolution (*The Economist* 2016).

In a sense, this book is about how the body is imposed upon to become a platform across a series of technologies that are increasingly interdependant. This chapter's focal point is the concept of *body networks*; it brings critical attention to the mounting expectations that personal computing is going to achieve much more direct, bodily integration with automated processes. I look at body networks as a prerelease, preadoption computing paradigm to ask questions about how they will impact us in reontologized future environments. Early standards are being agreed upon and conventionalized (again in neutral, objective terms), and social science and humanities critiques are not included in the dialogue, to our detriment.

Critical Data Contexts

If topographical (*on* the body), visceral (*in* the body), and ambient (*around* the body) computing are to combine to function as an embodied ecosystem, body networks are the innovation that will bring about the change. Technologists are beginning to create systems to absorb bodily processes into more developed architectures that could eventually evolve to host mature platforms. The political economies of platforms have been exposed as sites for the purpose of driving profit for intermediaries at the expense of users and workers (Gillespie 2010; Gillespie 2018). The concept of platformatization is also relevant because it foregrounds the idea of programmability and the "material-technical perspective" that informs the business model behind platforms (Helmond 2015). I am concerned with how these networks will also make people's data vulnerable in myriad ways by treating the body as a platform and making bodily data further monetized. Following Fiore-Gartland and Neff (2016), I examine infrastructure-focused policy attempts to platformize the body "to examine the role that power plays in the discursive process of framing new technologies," including biosensing (101).

How will the platformized body create new sources of datafication? Mosco (2017) aptly calls the quantified self, the "commodified self" when talking about embedded body sensors on the rise in post-internet society (16). The related notion of "datafication" draws much attention from critical data studies circles (van Dijck 2014; Iliadis and Russo 2016; Lupton 2016; see Lupton's chapter in this collection). Hildebrandt (2014) defines "datafication" as "the process of translating the flux of life into discrete, machine-readable data points" (38). The "flux of life" imagery is apt for body networks that are designed for continuous or *flowing* data capture. If biosensors will be able to mine data from inside, they will further perpetuate how "the body functions dialectically as both a producer and recipient of data" (Smith 2016, 110). In this vein, Smith calls upon scholars to concentrate more work on what he terms the "embodiment–

datafication–affective nexus" (Smith 2016, 114). Likewise, Nafus (2016) calls for attention to where "social choices about biosensors are being made" (xii). The adoption of cloud applications for bodies, formalized as the idea of an Internet of People (IoP) or *human intranet*, is one such area of concern. As Moin et al. write, "A Human Intranet should seamlessly integrate an ever-increasing number of sensors, actuation, computation, storage, communication, and energy nodes located on, in, or around the human body, and acting in symbiosis with the functions provided by the body itself" (2017). In this model, the body takes on the labor of sensing, computing, energizing, storing (data), transmitting, and hosting a network, with a seemingly infinite capacity for expansion. It connotes the "ever-increasing" instrumentalization of humans through bodily functions.

Human–Machine Relationships

In 1967, Marshall McLuhan made a provocative comment in a famous interview when he said, "technologies are highly identifiable objects made by our own bodies." His scholarship helped launch the rich heritage of writing that treats bodies as media. In 1997, Frank Biocca tellingly asked, "Are media progressively embodying the user?" (3). Lombard and Ditton (1997) wrote about how embodied technologies like virtual reality produce the feeling of nonmediated presence. They named that bodily feeling of simply *being there*, of feeling wholly present in virtual experiences (Lombard and Ditton 1997).

Embodiment, human–machine relationships and affective computing are broad areas that many have explored for a long time, contributing to a rich theoretical dialogue on interrelated topics (Picard 1997; Picard 2000; Hayles 1999; Hayles 2012; Hayles 2017; Clark and Chalmers 1998; Dourish 2001; Massumi 2002; Danesi 2008, Blackman 2012; Karppi 2018). Germane to this chapter are the concepts of *adoption* and *adaptation*. In a projected future, body networks will connect and report on such things as human thoughts, memories, and feelings, along with organ functionality, biochemistry, and brainwaves. Bodies will participate in cooperative relationships with other human and nonhuman actors and digital infrastructures. In simplified terms, these networks could make bodies adapt, respond, and communicate in combinations that are only now being discussed in the emerging field of human-machine communication (Guzman 2018). Body networks will hyperaccelerate embodied computing adoption, which in turn, instigates adaptation. Hayles (2012) posits that "contemporary technogenesis, like evolution in general, is not about progress . . . [it] is about adaptation, the fit between organisms and their environments, recognizing that both sides of the engagement (human and technologies) are undergoing coordinated transformations" (81). In later work, Hayles (2017) contributes a redefinition of human cognition and digital interaction into three layers, "consciousness and unconsciousness," "nonconscious cognition," and "material processes" (69–76). The notion of "cognitive assemblages" recognizes how complex systems between "human and nonhuman cognizers" enlist both material and decision-making forces (269). Likewise, writing about implantable brain chips, Fitz and Reiner claim, "we have entered a transitional era in which we are comingling our cognitive space with technology" (2016, S9). Describing a variation of ambient computing, they speculate over a future cultural trajectory whereby device "comingling" will define identity.

Body Networks Defined

Wireless Body Area Networks (WBANs) or Body Area Networks (BANs) are networks of wireless sensors that can be sewn into clothing, placed directly on the skin, or implanted into the body. Human Body Communication (HBC) or intrabody communication uses the body itself as the channel, rather than air for transfer. Currently in the prototyping stages, body area networks will enable powerful convergences among technologies by providing a single unified solution for connectivity. They are meant to be safer (e.g., less radiation, lower power emission), faster (e.g., higher data rate with higher bandwidth), and much more data secure (Astrin, Li, and Kohno 2009). Wearable and implantable body networks would connect with each other for controlled data flows, able to translate life signs into data points. The demand for them is a response to calls from many sectors for more sophisticated and safer kinds of connectivity for personal data capture, essentially something better than Bluetooth.

An example of a body area network configuration for medical monitoring appears in Figure 2.1. The first layer depicts a human data provider with biosensors, topographical and visceral devices (e.g., EEG sensors). It also depicts a body network or BAN connecting all of the devices together. In theory, it could string together countless wearable and implantable sensors, some at the nanoscale. The second layer depicts handheld mobile devices for user manipulation or for transfer through a central processing unit to the third layer. In layer two, users might get a glimpse of their data, visualized for them through interfaces as it streams to the next layer. Layer three involves data analytics and "black box" data interpretation on external servers that filter, analyze, and make decisions based on data collected from the human subject. In the fourth layer, collected data are dispersed to multiple potential external actors that have remote access, including third-party platforms, in this case, health care providers. Information resides on a "medical information database" in this example, but it could go to government, corporate, academic, military, or numerous other types of data users.

Figure 2.1

One example of an architecture of an eHealthcare system using a BAN. (Ghamari et. al. 2016) Creative Commons Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/).

There are countless visual depictions of body networks like this one on the internet; images usually focus on a solo body providing data, decontextualized from any social situation. The datasphere imagined for them is usually tied to health, sports, or entertainment, where people will enjoy some kind improved experience due to heightened connectivity. Further, these design schemata represent neutral relationships among technologies, people, governments, and corporations, as if the body is part of the platform. They do not reveal or portray power relationships, for instance, or the kinds of social bias increasingly "baked" into AI (Layer 3) during *filtering, analyzing, and deciding* by machines. They do not account for the way platforms are "sociotechnical assemblages" often used for profit by stakeholders (Gillespie 2018, 19). Body network architectures incorporate human subjects and vitalized bodies as mechanisms in larger dataspheres.

History

In an ongoing body area networks case study, I collected more than 1,300 articles from the Association for Computing Machinery (ACM) digital library that reference "Body Area Networks" (dated 2001 to 2019). The earliest mention, from 2001, explains: "These networks are also called Body Area Networks or Personal Area Networks. Unlike the mobile technologies mentioned above, they are not based on a fixed network infrastructure (e.g., base stations). The possibility of building up such networks in a spontaneous and fast way gave them the name ad hoc networks" (Eberspaecher, Bettstetter, and Vjogel 2001). Many of the current papers are from the annual International Conference on Body Area Networks ("BodyNets"), which self-describes its aim "to provide a world-leading and unique opportunity for bringing together researchers and practitioners from diverse disciplines to plan, analyze, design, build, deploy and experiment with/on Body Area Networks (BANs)." Academic papers usually emphasize urgent or legitimate needs—saving lives, curing illness, and securing information. However, ideas creep into design cycles that go unchallenged, without a contextualized vision for future outcomes in myriad social spheres. They take future technology convergence as a given to justify a current stage of development. One paper opens with this sentiment, "In recent years, the Internet of Things (IoT), cloud computing, and wireless body area networks (WBANs) have converged and become popular due to their potential to improve quality of life" (Ramu 2018). One might argue that they have *not* converged yet, but futuristic speculative events appear justified as a neutral given.

The wireless Bluetooth standard was invented in 1994 by Jaap Haartsen of Ericsson. Bluetooth advanced device connectivity dramatically; nearly all personal wireless devices today use Bluetooth (Ericsson 2012). However, Bluetooth has been deemed insufficient for the needs of body networks. The road to agreeing to any new international engineering standard is long. The governing organization is the Institute of Electrical and Electronics Engineers (IEEE). Its Internet networking standards committee, the "802," deliberates and eventually votes on the standards that govern protocols for networking of all kinds. The key focus for the 802.15.6 BAN standard is "for a short-range, low power, and highly reliable wireless communication for use in close proximity to, or inside, a human body" (Astrin, Li, and Kohno 2009). The BAN standard forms part of the Personal Area Network standards PAN IEEE 802.15, which defined the original Bluetooth. But the intent now is to create networks for controlled, safe data flows to and from the body. Another concern is device interoperability, with the goal to ensure that a wide range of devices can connect to each other. Because biometrics are now used for authentication, for example, in place of passwords, personal data conveyed over a body area network will need to incorporate much more robust encryption. 5G or *fifth generation* network technology promises much higher and more efficient capacities to send data; body networks will become intergrated in this global movement for 5G networks to advance ehealth, smart cars, and connected homes.

Arthur "Art" Astrin, one of the pioneering architects of Wi-Fi, led the IEEE 802.15.6 task group that finally approved the standard, which was published in 2013 after a five-year consultation process (Redelf and Weber 2016). In many ways, this event serves as a benchmark historical moment; many corporate representatives were concerned with data vulnerability, but also clearly wanted to further intensify data mining using sensing devices. Interestingly, Astrin gained his expertise by working for Apple, IBM, Siemens, ROLM, Memorex, and Citicorp. He was a key figure in the global mobile turn; some even say Astrin “birthed Wi-Fi” (Redelf and Weber 2016).

In the year before his death, Astrin was interviewed by the *Computer History Museum* and he described the slow-moving process to pass the standard, discussing his personal goals for body networks (Redelf and Weber 2016). He served as the IEEE chair at the start and explained that he was influenced by Ray Kurzweil’s 2006 *The Singularity Is Near*, which Astrin says predicted “little robots going around in the body” (Redelf and Weber 2016). Kurzweil’s predictions fuel innovation in many sectors; they act as transhuman beacons that people race toward (Satell 2016). Astrin’s role as standardizer brought an important ethos to the idea. Naming specific diseases that might be alleviated by these networks, Astrin’s goal was to better the health and longevity of human subjects. However, he mentions the fact that large multinationals were also at the table with him, altering choices at the early stages for this standard. Tellingly, he points out that cyberthreats are a key concern—for example, that denial of service attacks could cause fatalities.

The Lure of Body Area Networks

The discourse analysis and narratives surrounding Astrin’s work led me to frame three conceptual themes for why body area networks are proposed as a desirable mediated future. These include approaching body area networks as technologies for seamless computing, the dominance of data profiles, and the ruse of human–cloud infrastructures.

Seamlessness

Seamless interaction has developed into a value-based governing logic. It reveals itself through calls to make computing “friendly” or unified with other tasks, but it also appears through transgressions, when computing is fractured. Nick Bilton of *Vanity Fair* writes about social media’s fractured activities:

> One of the problems is that these platforms act, in many ways, like drugs. Facebook, and every other social-media outlet, knows that all too well. Your phone vibrates a dozen times an hour with alerts about likes and comments and retweets and faves. The combined effect is one of just trying to suck you back in, so their numbers look better for their next quarterly earnings report. . . . And then, there's the biggest reason why people are abandoning the platforms: the promise of connection has turned out to be a reality of division, (Bilton 2017)

Bilton discusses the trend of abandoning social media. He points to the physical disruption social media provoke, goading people to participate despite the fractured or impoverished experiences they cause. Through his distaste, he also simultaneously reveals value-based expectations for personal computing, that it should involve efficient, continuous interactions. Seamlessness is also used to promote much more invasive technologies. Mikael Wiberg discusses the idea of using the body as interface: "No longer are peripherals a necessity for interacting with computers when gestures, our bodies, our eyes, our skin, our position, or even our fingertips can do the job for us" (Wiberg 2013). The drive for seamless, constant connection makes the assumption that the body will be the interface.

Skin-based computing is one hyped future-proposed, sensing technology that works along these lines (Rogers, Someya, and Huang 2010; Dae-Hyeong et al. 2011; Ma 2011; Boyle 2011). *Digital skin* is also known as "epidermal electronics" (Dae-Hyeong et al. 2011), "electronic skin" (Ma 2011), "smart skin," or "digital tattoos" (Boyle 2011). It resembles the temporary stick-on tattoos that children adhere to their bodies. But they are ultrathin, flexible devices intended to sense brain, heart, and skeletal activity and that promise to revolutionize medical biofeedback. Described by one team as having "superior flexibility and a mobility," another team notes their "sensing skin" breakthrough as "[having] key characteristics of artificial skin designed to sense touch or temperature" (Marks 2013). Yet, using human skin as the site for a computer interface is still very much in development. Preceding the adoption of skin interfaces are wearables that are normalizing the idea.

One current wearable, Hexoskin, is described as "a smart device that connects to a compatible high-tech intelligent garment with integrated sensors that captures body metrics including heart rate, breathing rate, and acceleration" (AZoSensors 2019). The Hexoskin intelligent shirt uses "skin" metaphorically. These are wearable interfaces and hardware that aspire to be more like skin by design. They entail covering the torso or a significant portion of the body. They seek to mine the body through topographical contact. However, the idea sometimes fractures the promise of seamlessness. Many applications still require users to log on to web dashboards and work with their data (see Figure 2.2). The imagery of using "dashboards" for monitoring the body always strikes me as discordant; the user suddenly meets her own body the way a pilot meets a plane, a panel of instruments and controls in front of her to manipulate, making the body seem a disconnected vehicle.

With the coming era of body area networks, the proposition is to progress seamlessness one more step, whereby the body *is* the channel (Astrin, Li, and Kohno 2009). The idea is to make bodily monitoring (like that of skin tech) and data transfer more active and direct.

Figure 2.2

Screenshot of the Hexoskin online dashboard demonstrating sleep metrics, ©Isabel Pedersen

Earlier in the chapter, I touched on emotion monitoring. Once a body network for Brain–Computer Interaction (BCI) can be established, interactivity will evolve in dramatic ways. Cognitive experiences will not only be used for digital telepathy (i.e., moving computer interfaces with the brain), they could be stored by third parties, or they could be used in predictive models to draw conclusions about thoughts and feelings (Nick, Berman, and Barnehama 2015). Smith (2016) expresses the risk of the body as "a walking sensor platform":

> In a similar vein, but with different motivations in mind, Irma van der Ploeg points to how our implication in such processes of networked surveillance is initiating a new bodily ontology and politics, where bodies exist in a "symbiont" relationship with the digital data they produce. She notes how the notion of autonomy, of being able to freely decide an identity and trajectory, is increasingly contingent on the data profile one accrues and/or is assigned. (109)

Smith is not necessarily referring to cognitive sensors, but the premise applies. The concern is with data profiling and the kinds of surveillance that instigate a "'symbiont' relationship with the digital data they produce" (109). In keeping with this view, I think that body networks have been proposed as constituting symbiosis, but they also run the risk of parasitism through bodily data profiling. Seamless interaction with cognitive processes, if networked, would risk parasitic relationships where humans (i.e., thoughts, ideas, memories, lies, etc.) are the source for data, rather than positioning humans as the benefactor of seamless services.

Writing about the technocultural adoption of Internet of Things, Nicholas Fitz and Peter Reiner also weigh in on the risk of achieving seamless interaction by assigning "intelligent objects" cognitive predictive tasks:

> As the Internet of Things gains momentum, we will find ourselves interacting with "intelligent" objects that predict our preferences and make decisions on our behalf. Ideally, delegation of these tasks to our devices would allow us to expend more energy pursuing challenging activities such as improving willpower and analytical thinking. . . . But that is not how the human–technology connection is playing out. Instead, the same devices that extend some cognitive abilities degrade others (Fitz and Reimer 2016, S9).

Using predictive analytics to delegate tasks to achieve a seamless lifestyle might end up degrading human capacities. We need to ask if automated and networked biosurveillance initiatives are instigating a new bodily politic that we did not expect.

Discussed earlier, remote patient monitoring for disease control is a concept under discussion as technologies are imagined, designed, and developed (Vegesna et al. 2017; Hernandez 2014; DeAngelis 2015). The belief is that emerging technologies, network culture, and human and nonhuman processes of datafication will revolutionize healthcare and everyday life by directly sensing the body's core through passive monitoring (Hernandez 2014). To meet such a speculative scenario, brain, heart, skin, skeletal, and other topographical and visceral sensors would need to track biometric data continuously through biomedical telemetry. The bio-surveilled body would be datafied in numerous ways. Furthermore, connectivity would be of paramount concern because data would be sent to remote servers to be interpreted. Safer, more robust personal data infrastructures and body networks would be required to connect and transfer all the data. In this ambient and utopian scenario, algorithmic decisions would interpret "life signs" directly from inside the body. If one extrapolates from obvious and already proposed medical goals, then military, entertainment, and lifestyle will be inculcated with the same momentum for interconnectivity.

Bodywise, Data Profiles, and Surveillance

In this section, I point to another justification that is related to seamlessness, an ideology I call *bodywise*. Bodywise focuses on passive, continuous, tracking and quantifying of bodily functions, combined with the value system that assumes automated feedback is superior to human-interpreted information or human feelings. Bodywise is related to *dataism*, the belief in "objective quantification and potential tracking of all kinds of human behavior and sociality through online media technologies" (Van Djick 2014). However, bodywise takes the assumption a step further, whereby human intervention is seen as inept. Body networks are often justified as a more sophisticated means to collect biofeedback:

> As data sources of the BAN system, body sensors are used for collecting the vital signals of a user or patient. Based on these body signals, an accurate diagnosis can be obtained to give the patient correct and timely treatments. Traditionally, measurements via body sensors involve human intervention by medical staff. With the continuous advances in circuit design, signal processing, and Micro Electro-Mechanical Systems (MEMS), body sensory data can be collected in a non-invasive fashion. (Chen et al. 2011, 176)

In the proposed body network, human intervention is diminished as traditional in favor of a modern automated system. The rhetoric argues that directly collecting bodily data will be a better diagnosis paradigm. While monitoring patients with devices on the body has long been accepted as more illuminating, correct, and timely, this description mistrusts human doctors ("medical staff"). The patient is subordinate and objectified, while automated processes, coordinated by the BAN, have agency. Bodywise justifications maintain that body monitoring can and should be done by a network that yokes together a system of sensors, data to be transferred for analysis, and software for algorithmic decision making, rather than human medical professionals.

The more embodied technology becomes internalized, the more bodywise rhetoric will underpin justifications. For instance, ingestible technology is a new frontier under much development in the sphere of visceral computing, but one that is also meeting the public in popular science forums. The idea of swallowing a computer device (see Iliadis's chapter in this collection), allowing it to either act on or surveil the body from within, then to leave the body, is a tantalizing notion. The "chip in a pill," "digital drugs," or ingestible tech paradigm is unique because its effects are fleeting and invisible (Nikita 2014, 2). Ingestibles are often designed as antennas that require the omnidirectional ability to transmit signals as they float through the body (Kiourti and Nikita 2014, 210). They are intended to visualize, monitor, and diagnose internal processes such as blood pressure, PH balance, core body temperature (Nikita 2014), and ultimately report to an external receiver. One example is MicroCam, a tiny surveillance camera that uses "the body as a communication medium" (Nikita 2014, 18). In subtle bodywise terms, the intent is to constitute the body as data ready for transfer to external agents and corporate platforms.

Bodywise rhetoric also operates through the quantified self movement, which is proposed as a way to know the self by tracking one's own bodily processes, largely with personal wearable devices. However, others frame self-tracking in alternative terms: "A counter-argument to the empowering view of (self-)surveillance, however, is that emerging forms of self-tracking in. for example. mHealth or other measurement apps. in combination with participation as a design principle could be seen as a facade or illusion of self-control, where actually users are being tracked and traced in the background" (Galič, Timan, and Koops 2017, 30). Infiltrating our lives through myriad devices, data processes create a paradoxical relationship with the self. Like a one-way mirror, information exchange goes on without our ability to fully grasp, follow, or understand it, much less determine it. In cybercapitalism, algorithms make decisions for us, and computers filter what we read and what we buy (or consider buying), map our whereabouts, remember faces of people we know, and often inform our next move. For us, this leads to estrangement rather than cohesion because data processes are operating covertly. Paradoxically, quantified health/self applications report some information back to us with seemingly overt precision and clarity. In a sense, we are coming to terms with a new self—a datafied body—that negotiates itself differently with selective information.

I align the notion of bodywise with previous ideas concerning self-tracking. Paula Gardner and Barbara Jenkins note the reductionist nature of displayed biometric data when working with mobile devices (Gardner and Jenkins 2016). In a point made by Nora Young concerning the self-tracking movement, ambient awareness becomes an overt system of signs: "In our new digital lives, though, ambient awareness is achieved precisely by making explicit statements about how we are feeling and what we are doing. The digital realm required replacing that which is embodied and physical with that which is literal, specific, and disembodied" (Young 2012, 62). Things we used to simply feel or do are assigned meaning requiring us to *know* them, essentially disembodying them. Data produce a conflicting semiotic of self-awareness; signs are both covert and overt.

Smith (2016) proposes a useful vocabulary on data profiling involving surveillance, speaking of the "embodiment–surveillance nexus" and "the way in which the body functions dialectically as both a producer and recipient of data" in a form of "disembodied exhaust" and "embodied exhaustion" (110). By referring to data in this way, Smith pinpoints how our twinned roles as consumer and producer yoke the surveilled body into service. When advancing the notion of the embodiment–surveillance nexus, he also discusses sensor devices "in terms of their developing mass surveillance dragnets and a profusion of data flows" (115). Because body area networks are proposed so that sensory data can be collected automatically from internally implanted sensors, they will be a core conduit for further bodily surveillance. But unlike Smith, I do not see a "bordered" body anymore. When a person ingests the surveillance device into her organs, the border disappears.

The implications will range into how people constitute selves and identity. Gillespie (2014) writes of data algorithms in a manner relevant to embodiment: "A sociological analysis must not conceive of algorithms as abstract, technical achievements, but must unpack the warm human and institutional choices that lie behind these cold mechanisms" (169). Gillespie goes on to write of the dual relationship we have with data providers: "digital providers are not just providing information to users, they are also providing users to their algorithms. And algorithms are made and remade in every instance of their use because every click, every query, changes the tool incrementally" (173). Both quotes are key. With cognitive computing, every thought or feeling will also "change the tool incrementally." With cognitive analyses made possible with brain-computer interaction and algorithms being written to interpret emotional interactions, embodied data will amount to a storing of self that is far more intrusive than anything seen before. Data profiling of our digital selves will expand to include deciphering of emotions by digitizing affect (Montero and Suhonen 2014; Jaques, Chen, and Picard 2015; Pedersen and DuPont 2017). Emotional profiling could be reductive and lead to decisions made for us by autonomous machines through artificial intelligence (AI) protocols. In the next section, I examine the concept of the *personal cloud* more closely.

Cloud Computing and Embodiment

Body area networks emerge amid a culture that generally accepts cloud computing as a given. Historically, the concept of a personal cloud can be traced to several sources. One emerged from an Apple spin-off company called General Magic in the early 1990s. *Wired* writer Stephen Levy quotes developers Bill Atkinson and Andy Hertzfeld on the cloud concept in 1994, when Personal Digital Assistants (PDA) were first spawned:

> We have a dream of improving the lives of many millions of people by means of small, intimate life support systems that people carry with them everywhere. These systems will help people to organize their lives, to communicate with other people, and to access information of all kinds. They will be simple to use, and come in a wide range of models to fit every budget, need, and taste. They will change the way people live and communicate. (Levy 1994)

The dream of carrying "small, intimate life support systems" was an early primary goal. The desire to inhabit one's own computing cloud, inspired the development of early personal digital assistants. The idea of "access[ing] information of all kinds" is pivotal as it worked against the idea that devices should be geared to single task spheres such as work, fitness, or entertainment. A conceptual life support system was to drive all needs. Over the twenty years that followed, cloud computing became popular.

In 2013, I went to a large Computer Human Interaction (SIG CHI) conference in Paris[1]. The trend at that time was the confident belief that cloud computing could be combined with wearable computer devices to create a set of networking cloud applications that would surround an individual and mine her data—a personal or human cloud. And the trend was celebrated as a perfect business opportunity, one that Big Data would bring when human activities, opinions, bodily sensations, and thoughts could be digitized, data mined, and aggregated in profound ways to create a focused, personal, profit-generating data cloud. Conversation could breeze over the technicalities, which reduced and obfuscated questions about the algorithms that would need to be deployed to create this augmentation.

For example, in 2013, Rackspace released *The Human Cloud.* One paragraph framed the larger goal:

> With adoption becoming mainstream, wearable technology will form an integral part of the 'Internet of Things'—a growing network of devices—from wearable tech and smartphones to road traffic sensors—that connect to the internet to share data in real time. "The rich data created by wearable tech will drive the rise of the 'human cloud' of personal data," said Chris Brauer, co-director of CAST at Goldsmiths, University of London. "…with health insurance firms encouraging members to use wearable fitness devices to earn rewards for maintaining a healthier lifestyle. It is likely that the public sector will look to capitalise on the wearable technology trend with a view to boosting telehealth and smart city programs." (Rackspace 2013, 8)

This speculative model for a personal human cloud locates an imaginary subject as an ideal center, amid a network geared to surround her. Wearables, Internet of Things, and telehealth would eventually feed smart cities. Human wearers would be empowered to become healthy, but also goaded to work to create this cloud infrastructure, with a view to helping companies capitalize on it. Inculcated by institutions that would co-host it—"health insurance firms," "healthcare institutions," "third parties"—the human cloud would bind people to a transformed,

1 https://chi2013.acm.org/

utopian, commodity-driven, urban lifestyle.

A Wi-Fi network does not exist to funnel this kind of data from humans to third parties. Consequently, this passage serves marketing goals to help leverage innovation that marketers want (e.g., “a growing network of devices—from wearable tech and smartphones to road traffic sensors” (Rackspace 2013). Interestingly, even in 2013, researchers had begun to deal with the rise (and ruse) of cloud computing and its trajectories.

At the same Paris 2013 SIGCHI conference, Bruno Latour delivered the closing keynote lecture to an audience of three thousand. The room was filled with HCI designers, developers, and engineering professors—individuals employed in creating embodied computing, such as wearables, smartphone apps, and personalized cloud computing platforms. Despite his academic fame in social science disciplines, Latour is not recognized in computer science to any great degree. One of Latour’s many books, *Science in Action: How to Follow Scientists and Engineers through Society* (1987) has more than 23,000 social science citations. Yet, the ACM digital library of the world’s largest educational and scientific computing society, only cites him nineteen times in total. At this conference, his was the voice of an outsider bringing social theory to computer scientists to explain a “conundrum” (Latour 2013). Latour went on to discuss the “oligopticon,” a reverse panopticon as a form of governance assembled by the microstructures of computer surveillance and individual bodies acting as relational networks. An oligopticon involves governance consisting “of a set of partial vantage points from fixed positions with limited view sheds” (Galič, Timan, and Koops 2017). Latour’s speech, aimed at a technical audience (many working in cloud computing), sought to reveal a fallacy in the notion of personal cloud. A computing cloud is simply an ideology that operates to promote more data collection for profit-generating entities, “collecting devices” (Latour), socioeconomic practices, and networked surveillance infrastructure. When discussed as business speculation, the cloud concentrates on the number of units that will be sold or the money that will be made, without much consideration for social, political, and economic implications for everyday citizens. However, interpreted as speculation, personalized cloud applications stand to transform multiple spheres of life.

Increasingly, people are writing about digital citizenship in light of what Obar terms “the fallacy of data privacy self-management, or the misconception that digital citizens can be self-governing in a digital universe defined by Big Data” (2015, 2). He explains, “Even if we had the faculties and the system for data privacy self-management, the digital citizen has little time for data governance" (13). If we consider body networks along these lines, concepts such as privacy, safety and data self-management change in fundamental ways, and we need to think about that at this stage, while we are standardizing technology. A body network that funnels personal data (cognitive and physiological) directly to data clouds needs considerable discussion. However, I point out that the desire to have "small, intimate life support systems that people carry with them everywhere" (Levy 1994) persists as such a captivating offer that it will likely overshadow people's hesitancy.

Conclusion

This chapter asked will the body become a platform? I have explored body networks as a coming phenomenon promoted by technologists that needs critical attention at this stage. I have argued that they will be the glue to connect bodies and brains with the cloud through myriad embodied computing devices in the future. As society expects computing to be increasingly seamless, the idea of a networked body working autonomously through data assemblages seems less futuristic than before. A tandem concept is a value system that places more authenticity on machines reading and analyzing the body. Bodywise rhetoric serves as the rational underpinning for body area networks. Finally, the neo-liberal broad acceptance of cloud computing makes body networks seem inevitable, the continuum of embodiment will meet the lofty goals proposed decades ago.

One thing this chapter has not discussed to any great extent is the impact of big tech companies and the sway they hold over technology adoption and adaptation. A quick catalogue of key people makes the point. Brain implants have been glorified by Elon Musk (see Orth's chapter in this collection) through the announcement of his new company, Neuralink, "for the uploading and downloading of thoughts to a computer" (Johnson 2017). In a video introduction to his early phase research, Musk explains the implants he calls "neural threads" and emphasizes their tiny size (Musk 2019). The video discusses the wireless connectivity that will be required to run the implanted tech to send data to a wearable called "the link" to be controlled through an "iPhone App" (Musk 2019), a setup that is essentially a body network. The video justifies the implant through a doctor-thyself rhetoric by encouraging people to be self sufficient in configuring their own implants, rejecting “exotic programmers” in doctors’ offices (Musk 2019). His other endeavor, the nonprofit OpenAI, originally claimed to be “building safe Artificial General Intelligence (AGI), and ensuring it leads to a good outcome for humans” (OpenAI 2017). OpenAI has transformed into a for-profit company run by Sam Altman with significant investment from Microsoft (Metz 2019). The frenzy around AI is rapidly changing expectations of what computers can and will do. Digital life can be stored, counted, curated, shared, reexperienced, and reimagined as data on AI-fueled platforms. Even earlier, Sergey Brin was the front man for the announcement of Google Glass in 2012, which launched the wearable turn. Apple’s Tim Cook regularly hosts spectacles at his developers’ conferences and makes announcements that Apple Watch will make life better (CNBC 2017). The spectacle of Silicon Valley wealth obfuscates, challenges, and makes an already hailed public assume a positive outcome long before the reality of a development is even possible to chart.

Another topic that plays a role is cultural impetus. The popularity and commercial successes of wireless communication have also evolved expectations about how people understand human communication and the sharing of personal experiences. Vincent Mosco places the onus of this kind of innovation on the commercialized cloud, writing that “mastery of the Cloud is one of the primary reasons why Amazon, Google, Microsoft, Apple, and Facebook are the most valuable companies in the world” (2017, 20). Wireless devices have become much less clunky. Big headphones are no longer plugged into giant cell phones to augment listening. Apple’s iPod/iPhone ecosystem changed all that awkwardness over the past decade. Apple sets cultural expectations for how wearable tech ought to look and act through its leading minimalist design philosophy (Wissinger 2017, 2; see Wissinger’s chapter in this collection). Yet, ten years earlier than the first iPod release, Steve Mann defined wearables in several criteria including that a wearable should be “unrestrictive to the user: ambulatory, mobile, roving, “you can do other things while using it,” e.g., you can type while jogging, etc.” (Mann 1998). We are only now beginning to understand unrestrictive as a value for wearable interactivity.

Popular press is glorifying automation, algorithmic decision making, and deep learning by machines, despite critical questions over the opacity and ambiguity that surround these processes (Wachter, Mittelstadt, and Floridi 2017). Dourish (2016) points out that the concept of an algorithm has come to stand for much broader social issues than the scope of the original definition, noting the conflation of “algorithm” with “digital automation.” Any discussion of network connectivity and future augmentation for humans is implicated in this rhetorical friction. Embodied computing is deeply contextualized in a moment absorbed in machine-centricity (e.g., machine automation, machine learning, AI decision making) that appears impervious to challenge. Another related, popular-culture factor is the collaboration between the military-industrial complex and American culture industries that glorify technology in films and videogames (Mirrlees 2016). Transhuman military ideologies promote fictional embodied computing devices across a wide range of film franchises, making them seem exciting and destined for real-world emergence.

Current hype touts a future that will transform the internet into an immersive landscape, a glossy new reality, where iPads will be chucked aside for full-body pointing, swiping, and scrolling of virtual components that will fill our physical spaces. Yet, the undercurrent is a place where we will passively offer data to invisible networks we host, where malicious actors threaten attacks, where our facial expressions, heartbeats, thoughts, feelings, memories, sensations, movements and ambitions will be exchanged across data spheres far beyond our total control.

Bibliography

AI Now Institute. 2018. *AI Now Report 2018*, December: 1-63.

Armis. 2017. Blueborne. Armis.com. https://www.armis.com/blueborne/#/general.

Astrin, Arthur, Huan-Bang Li, and Ryuji Kohno. 2009. Standardization for body area networks. *IEICE Transactions on Communications* Vol. E92-B (2): 366–372.

AZoSensors. 2019. Hexoskin. July 17. https://www.azosensors.com/suppliers.aspx?SupplierID=3795.

Bilton, Nick. 2017. The end of the social era can't come soon enough. *Vanity Fair*, Nov. 23. https://www.vanityfair.com/news/2017/11/the-end-of-the-social-era-twitter-facebook-snapchat

Biocca, Frank. 1997. The Cyborg's Dilemma: Progressive Embodiment in Virtual Environments. *The Journal of Computer-Mediated Communication* 3(2): 1-11.

Blackman, L. 2012. *Immaterial Bodies: Affect, Embodiment, Mediation*. London: Sage.

Boyle, R. 2011. "Epidermal electronics" paste peelable circuitry on your skin, just like a temporary tattoo. *Popular Science*,August 12. https://www.popsci.com/science/article/2011-08/epidermal-electronics-paste-peelable-circuitry-your-skin-just-temporary-tattoo/.

Catherwood, P.A., D. D. Finlay, and J. A. D. McLaughlin. 2015. Subcutaneous body area networks: A SWOT analysis. *Proceedings of IEEE International Symposium on Technology in Society (ISTAS)*. Dublin, 1-8

Chen, Min, Sergio Gonzalez, Athanasios Vasilakos, Huasong Cao, and Victor C. Leung. 2011. Body area networks: A survey. *Mobile Networks and Applications* 16 (2): 171–193.

Clark, A., and D. Chalmers. 1998. The extended mind. *Analysis* 58 (1): 7–19.

CNBC. 2017. Tim Cook: Apple Watch is now the number one watch in the world (video). CNBC, September 12. www.cnbc.com/video/2018/09/12/tim-cook-apple-watch-no-1-in-the-world.html.

Dae-Hyeong, Kim, Nanshu Lu, Rui Ma, Yun-Soung Kim, Rak-Hwan Kim, Shuodao Wang, Jian Wu, Sang Min Won, Hu Tao, Ahmad Islam, Ki Jun Yu, Tae-il Kim, Raeed Chowdhury, Ming Ying, Lizhi Xu, Ming Li, Hyun-Joong Chung, Hohyun Keum, Martin McCormick, Ping Liu, Yong-Wei Zhang, Fiorenzo G. Omenetto, Yonggang Huang, Todd Coleman, and John A. Rogers,. 2011. Epidermal electronics. *Science* 333 (6044), 838–843.

Danesi, Marcel. 2008. The medium is the sign: was McLuhan a semiotician? *MediaTropes* vol. 1: 113–126.

DeAngelis, Stephen F. 2015. Patient monitoring, big data, and the future of healthcare. *Wired*, Aug. 6. www.wired.com/insights/2014/08/patient-monitoring-big-data-future-healthcare/.

Dourish, P. 2001. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, MA: MIT Press.

———. 2016. Algorithms and their others: Algorithmic culture in context. *Big Data & Society* 3 (2) (July–December): 1–11.

Eberspaecher, Joerg, Christian Bettstetter, and Hans-Jhorg Vhogel. 2001. *GSM: Switching, Services and Protocols* (2nd ed.). New York: John Wiley & Sons, Inc.

Ercisson. 2012. Bluetooth inventor nominated for top European honor. June 12. https://www.ericsson.com/en/news/2012/6/bluetooth-inventor-nominated-for-top-european-honor.

Fiore-Gartland, Brittany and Gina Neff. 2016. Disruption and the political economy of biosensor data. In *Quantified: Biosensing Technologies in Everyday Life*, ed. Dawn Nafus. Cambridge, MA: The MIT Press, 101–122.

Fitz, N. S., and P. B. Reiner. 2016. Perspective: Time to expand the mind. *Nature* 531 (7592): S9.

Galič, Maša, Tjerk Timan, and Bert-Jaap Koops. 2017. Bentham, Deleuze and beyond: An overview of surveillance theories from the panopticon to participation. *Philosophy & Technology* 30 (1): 9–37.

Gardner, Paula, and Barbara Jenkins. 2016. Bodily Intra-actions with Biometric Devices. *Body & Society*, 22. (1)(March): 3–30.

Ghamari, Mohammad, Balazs Janko, S. R. Sherratt, William Harwin, Robert Piechockic, and Cinna Soltanpur. 2016. A survey on wireless body area networks for eHealthcare systems in residential environments. *Sensors* 16 (6): 831.

Gillespie, Tarleton. 2010. The politics of 'platforms.' *New Media and Society*. 12 (3): 347–364.

———. 2014. The relevance of algorithms. In *Media Technologies*, ed. Tarleton Gillespie, Pablo Boczkowski, and Kirsten Foot. Cambridge, MA: MIT Press, 167–194.

———. 2018. *Custodians of the Internet: Platforms, Content Moderation, and the Hidden Decisions that Shape Social Media*. New Haven, CT: Yale Press.

Guzman, Andrea. 2018. Introduction: "What is human-machine communication, anyway?" In *Human-Machine Communication: Rethinking Communication, Technology, and Ourselves,* ed, A. Guzman. New York: Peter Lang.

Hayles, N. Katherine. 1999. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press.

———. 2012. *How We Think: Digital Media and Contemporary Technogenesis*. Chicago: University of Chicago.

———. 2017. *Unthought: The Power of the Cognitive Nonconscious*. Chicago: University of Chicago Press.

Helmond, Anne. 2015. The Platformization of the Web: Making Web Data Platform Ready. *Social Media + Society* 1 (2): 1–11. https://journals.sagepub.com/doi/full/10.1177/2056305115603080

Hernandez, Daniella. 2014. Big data healthcare: The pros and cons of remote patient monitoring. *MedCityNews*, March 10. https://medcitynews.com/2014/03/big-data-healthcare-pros-cons-remote-patient-monitoring/.

Hildebrant, Mireille. 2014. Location data, purpose binding, and contextual integrity. In

Protection of Information and the Right to Privacy—A New Equilibrium?, ed. Luciano Floridi. New York: Springer.

Iliadis, Andrew, and Federica Russo. 2016. Critical data studies: and introduction. *Big Data & Society* 3 (2): 1–7.

Jaques, Natasha, Weixuan Chen, and Rosalind W. Picard. 2015. SmileTracker: Automatically and unobtrusively recording smiles and their context. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* New York: .ACM: 1953-1958.

Jiang, Wenbin, Jin Tan, and William Liu. 2018. An internal node reprogrammable security scheme based on IEEE 802.15.6 in wireless body area networks. In *Proceedings of the 2nd International Conference on Telecommunications and Communication Engineering* New YorK: ACM: 285–289.

Johnson, Madeleine. 2017. What is Neuralink, Elon Musk's brand new company? Nasdaq.com, March 28. http://www.nasdaq.com/article/what-is-neuralink-elon-musks-brand-new-company-cm766902.

Karppi, Tero. 2018. *Disconnect: Facebook's Affective Bonds*. Minneapolis: U of Minnesota Press.

Kiourti, Asimina, and Konstantina S. Nikita. 2014. Antennas and Rf communication. In *Handbook of Biomedical Telemetry*, ed. Konstantina Nikita, 209–251. Piscataway: IEEE Press.

Latour, Bruno. 2013. *CHI 2013 Closing plenary: From aggregation to navigation* https://www.youtube.com/watch?v=VDr2qBVIQjI

Levy, Steven. 1994. Bill and Andy's Excellent Adventure II. *Wired*, April. https://www.ozy.com/flashback/the-magical-apple-spinoff-that-almost-invented-the-iphone-in-1993/40708

Lombard, Matthew and Theresa Ditton. 1997. At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication* 3(2). https://onlinelibrary.wiley.com/doi/full/10.1111/j.1083-6101.1997.tb00072.x.

Lupton, Deborah. 2016. The diverse domains of quantified selves: self-tracking modes and dataveillance. *Economy and Society* 45 (1):101–122.

Ma, Zhenqiang. 2011. An electronic second skin. *Science* 333 (6044): 830–831.

Mann, Steve. 1998. Wearable computing as means for personal empowerment. May. Keynote address presented at the *International Conference on Wearable Computing*, May 12–13, Fairfax VA. http://wearcam.org/icwckeynote.html.

Marks, Paul. 2013. Feather-light sensors are as comfy as a second skin. *New Scientist*, July 24. https://www.newscientist.com/article/dn23932-feather-light-sensors-are-as-comfy-as-a-second-skin/.

Massumi, Brian. 2002. *Parables for the Virtual: Movement, Affect, Sensation*. Durham, NC: Duke University Press.

McLuhan, Marshall. 1967. The Hot and Cold Interview with Gerald Emanuel Stearn. In *McLuhan: Hot and Cool: A Critical Symposium*, Ed. Gerald Stearn. New York: Dial.

Metz, Cade. 2019. With $1 Billion From Microsoft, an A.I. Lab Wants to Mimic the Brain. *The New York Times*. July 22. Section B: 1.

Mirrlees, Tanner. 2016. *Hearts and Mines: The US Empire's Culture Industry.* Vancouver: UBC Press.

Moin, Ali, Pierluigi Nuzzo, Alberto L. Sangiovanni-Vincentelli, and Jan M. Rabaey. 2017. Optimized design of a human intranet network. In *Proceedings of the 54th Annual Design Automation Conference 2017 (DAC '17).* New York: ACM: 1-6.

Montero, Calkin Suero, and Jarkko Suhonen. 2014. Emotion analysis meets learning analytics: online learner profiling beyond numerical data. In *Proceedings of the 14th Koli Calling International Conference on Computing Education Research*, 165–169. New York: ACM.

Mosco, Vincent. 2017. *Becoming Digital: Toward a Post-Internet Society*. Bingley, UK: Emerald.

Musk, Elon. 2019. Watch Elon Musk's Neuralink presentation. *CNET YouTube.* July 17 https://www.youtube.com/watch?v=lA77zsJ31nA.

Nafus, D. 2016. Introduction. In *Quantified: Biosensing Technologies in Everyday Life*, ed. Dawn Nafus. Cambridge, MA: The MIT Press, ix–xxxi.Nick, Teresa A., Laura M. Berman, and Arye Z. Barnehama. 2015. Personalized neuroscience: user modeling of cognitive function and brain activity in the cloud. In *Proceedings of the 10th EAI International Conference on Body Area Networks* (*BodyNets '15*) Sydney, 78-84.

Nikita, Konstantina (Ed.). 2014. *Handbook of Biomedical Telemetry.* New Jersey: IEEE Press.

Obar, Jonathan. 2015. Big data and the phantom public: Walter Lippmann and the fallacy of data privacy self-management. *Big Data & Society* July–December 2015: 1–16.

OpenAI. 2017. *Join Open AI*. openai.com.

Pedersen, Isabel. 2008. MyLifeBits, augmented memory, and a rhetoric of need. *Continuum: Journal of Media and Cultural Studies* 22 (3): 375–384.

———. 2013. *Ready to Wear: A Rhetoric of Wearable Computers and Reality-Shifting Media* Anderson, SC: Parlor Press.

Pedersen, Isabel and Quinn DuPont. 2017. Tracking the telepathic sublime as a phenomenon in a digital humanities archive *Digital Humanities Quarterly* 11 (4).

Picard, R. 2000. Synthetic emotion. *IEEE Computer Graphics and Applications* 20 (1): 52–53.

Picard, R. W. 1997. *Affective computing*..Cambridge, MA: MIT press.

Rackspace. 2013. The human cloud: Wearable technology from novelty to productivity report. https://www.rackspace.com/.

Ramu, Gandikota. 2018. A secure cloud framework to share EHRs using modified CP-ABE and the attribute bloom filter. *Education and Information Technologies* 23 (5): 2213–2233.

Redelf, Rich and Marc Weber. 2016. Oral history of Arthur "Art" Astrin (video interview). *Computer History Museum*, April 12. https://www.youtube.com/watch?v=Tj5NNxVwNwQ.

Rogers, John A., Takao Someya, Yonggang Huang. 2010. Materials and mechanics for stretchable electronics. *Science* 327 (5973): 1603–1607.

Satell, Greg. 2016. 3 reasons to believe the singularity is near. *Forbes.com*, June 3. https://www.forbes.com/sites/gregsatell/2016/06/03/3-reasons-to-believe-the-singularity-is-near/#81758e17b392.

Smith, Gavin. 2016. Surveillance, data and embodiment: On the work of being watched. *Body & Society* 22 (2): 108–139.

The Economist. 2016. G force; American economic history. *The Economist*, January 7, 69.

van Dijck, José. 2014. Datafication, dataism and dataveillance: Big Data between scientific paradigm and ideology. *Surveillance & Society* 12 (2): 197–208.

Vegesna, Ashok, Melody Tran, Michele Angelaccio, and Steve Arcona. 2017. Remote patient monitoring via non-invasive digital technologies: a systematic review. *Telemedicine Journal and e-Health* 23 (1): 3–17.

Wachter, Sandra, Brent Mittelstadt, and Luciano Floridi. 2017. Why a right to explanation of automated decision-making does not exist in the general data protection regulation. *International Data Privacy Law* 7 (2): 76–99.

Wiberg, M. 2013. An interFACE or to INTERface? On joineries of interactables. *interactions*. https://interactions.acm.org/blog/view/an-interface-or-to-interface-on-joineries-of-interactables.

Wissinger, Elizabeth. 2017. Wearable tech, bodies, and gender, *Sociology Compass* 11 (11): 1–14.

Young, Nora. 2012. *The Virtual Self: How Our Digital Lives Are Altering the World Around Us*. Toronto: McClelland and Stewart.

Zuboff, Shoshana. 2019. *The Age of Surveillance Capitalism*. New York: PublicAffairs.