QUANTIFIED

BIOSENSING TECHNOLOGIES IN EVERYDAY LIFE

EDITED BY DAWN NAFUS

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Introduction

Dawn Nafus

A Critical Encounter

My first encounter with biosensing was in 2009, when a colleague ran some ideas past me for research projects he thought promising. While I maintain my own scholarly commitments as an anthropologist, and publish in the normal academic way, I do not work at a university but inside the research and development labs of Intel, a large computer hardware company.[1] Most of these ideas were technical research topics worthy of computer science dissertations, such as how indoor location sensing could be made more precise. Another one of the proposed projects involved something my colleague called "biosensors," which he explained are a special class of computer components called "sensors" designed to detect various bodily phenomena, such as perspiration rates, or the levels of glucose or oxygen in blood. Biosensors take signals from these things and turn them into electronic data. He had seen the technical trajectory for biosensors—they were getting smaller and cheaper, just as computers had gone from mainframes to PCs. Because miniaturization had enabled computing to go from an expert-only affair to everyday use by nonengineers, he projected that biosensors would similarly no longer be limited to large medical labs with large budgets. An ordinary person could buy one. Would they want to, though, or was this a mere flight of industry fancy? If mass adoption of personal biosensors were to happen, the commercial implications could be enormous—not just for Intel, but also for many firms across a variety of industries.

I thought about it. The implications sent shivers down my spine. Being somewhat familiar with the basic lessons of medical anthropology, and even more familiar with the ways that expert forms of knowledge have become tools of social control by subjecting anything and everything to quantification, whether appropriate or not, this seemed like a

spectacularly bad idea. To my mind the implication was a clear probability that these technologies would exacerbate this deeply problematic form of social control. It is a job requirement to speak up when I have reason to believe either that there is no market for the technologies under consideration, or that the social risks and institutional costs of entering that market make it a poor idea. This seemed to clearly fall into the latter category, and I was prepared to tell him so.

I remember that a now-embarrassing smugness came over me in this moment. I resembled the breed of critic Latour (2004) so roundly lampoons, who revels in showing the naïve believers in a technology that "whatever [the believers] think, their behavior is entirely determined by the action of powerful causalities coming from objective reality they don't see [social structure, power, etc.], but that you, yes you, the never sleeping critic, alone can see" (239). In truth, I wanted nothing more than to give my colleague an earful about panopticality and Foucault, but my experience had been that delivering earfuls rarely ends well. Instead I appealed to empiricism. I explained how the predecessors to these technologies—bathroom scales—in fact have not succeeded in "encouraging" people to lose weight, but more often simply add to the intense guilt, shame, and anxiety people already have about their bodies. The Foucauldians would note that that is the point to such things—that social control happens not just by legal fiat or physical violence, but also by the capacity to convince people to see themselves only through the lens of what the more powerful would see (here, the narrow band of "normal" weight, now statistically abnormal in the United States but defined as "normal" by the medical profession). This well-established technique of social control works by compelling people to take on the task of controlling their bodies according to the categories that others produce, as if it were one's own idea all along.

It would be fair to say that the issue was not merely an intellectual one. The very question of whether there was social or market value in biosensing technologies summoned in me the toxic combination of shame and anger I too feel when I am subjected to such "encouragements" about my body. I recalled the patronizing tone a nurse once took with me about how a "woman of your age should really be taking folic acid," without the faintest knowledge of the contents of my uterus or the painful social costs I pay for my reproductive choices. I began to imagine the horror of being sent a text message about how fat I would no doubt get if my various biosensor readings didn't change, all because a thinnish white man in Silicon Valley took it upon himself to solve the obesity crisis,[2] and offered a mobile phone-based solution that effectively turned a complex

social phenomenon with deep-rooted structural causes into my personal responsibility to solve. I might live with such a technology for a few days, at which point I would enthusiastically throw it out the window, most likely straight after a proper dessert. With port.

Having mulled over these things, I told my colleague that these new biosensors are much more likely to do harm than good. I asked whether he really wanted to go into a market where actual utility is likely to be so low, and risks so high. Frankly, I didn't see reason to sponsor university research on the topic, if the answer was so obvious and clear.

"Okay, I see your point about the guilt and anxiety," he responded. "But I am a diabetic. If I don't know my glucose level, I could die. How is that not useful?"

I had to concede the point.

What we ultimately agreed was that there was a set of empirical and theoretical questions here that required closer examination. Our answer was going to be found in the complexities and contingencies of social life, not in any claims about the utility (or lack thereof) of a particular product to a particular individual, which is what market research traffics in. It was not a problem that market research could handle, but one that raised intensely challenging social questions that only scholarship could meaningfully pursue. Figuring out whether a consumer market for biosensors was even thinkable had everything to do with whether the data they produced cohered with a cultural and social imaginary, such that users stood a chance of making sense of them. It had to do with whether socially productive design strategies were conceivable, or whether the social systems made the conditions of possibility for these technologies a dead end.

This book, then, has its origins in a controversy that shows no sign of abating. The temporary agreement with my colleague eventually became the Biosensors in Everyday Life program, a three-year program involving four universities, which provided space for us to continue our discussion with more evidence. All of the projects from that program are represented in this volume, alongside others.[3] Time has answered my colleague's question about whether a consumer market is feasible—ninety million wearable sensors were shipped globally in 2014 (ABI 2014), most of which are designed to sense the body. The underlying reason for the debate between us has not simply resolved itself. Nor will it. Biosensors mediate uncertain, sometimes fraught relations between medical practice and self-care, between scientific knowledge and lay knowledge, between community and commercial impulses, and between aesthetic production and instrumentality. They represent a significant new chapter in the ongoing story

of what it is that numbers do for us, and do to us. Who gets to enumerate their bodily experiences—and who is begrudgingly made to do so? Enumeration can mobilize the cultural logic of numbers as abstractions, as claims to superior truth, but it also can mobilize the equally long history of enumeration as an embodied, situated practice. Are these numbers a mere tool of capitalist accumulation, or participatory knowledge making that cannot be understood in those terms? Is privacy truly dead, a fantasy that never was, or a right that must be asserted anew?

These are all high-stakes questions. As these devices continue to proliferate, they could yet become the very worst modernity has to offer—social control masquerading as science, and the soulless abstraction of bodies into bits, to name two ugly prospects—or they could participate in a flourishing of alternatives. There are still collective choices to make about what social logics will be mobilized, and we cannot afford to think about these technologies as finished products awaiting after-the-fact comment. Technologies are never a done deal, and this book aims to reopen the negotiations, so to speak. With less desirable paradigms in such strong positions of power, shaping these technologies into something better than the current offerings requires a tremendous amount of work, however necessary.

This is also work that requires a more expansive notion of critique. The ability to see outside of one's current position is perhaps the only way to imagine how things might be otherwise, yet the cartoonish critic-denouncer role I initially played has little to offer those who would begin crafting, imagining, and, yes, physically building alternatives. Here I draw inspiration from Latour's version of the critic, who "is not the one who lifts the rug from under the feet of the naïve believers, but the one who offers the participants arenas in which to gather" (2004, 246). This book is designed to be that sort of arena, socially situated in its own way but committed to enabling the broadest possible participation in the discussion of what biosensing could come to mean. It includes views from the social sciences and cultural studies, and from those who are primarily concerned with "convening" materials together into physical or digital objects.

This volume is intended to serve as a resource to inform conversations like the one I found myself in, wherever social choices about biosensors are being made. I say "choice" as a way to acknowledge the very real power many of us have to reshape our material world, including those of us without formal positions or large budgets. "Choice" is a term that has its problems, but it reminds us that the direction of our material world is not inevitable, and that readers of this book are part of its shaping. I do

not say "choice" to elide the important experiences of those who have no meaningful choice when biosensing is foisted upon them, such as when an employer requires its employees to wear physical activity monitors. As chapter 5 points out, it is important that we always acknowledge when there is no neoliberal "choosing" one's way out of such a situation. Choices are also not limited to deliberative democratic processes, or the kinds of societies that choose policies through participatory discussion and debate. The choices I have in mind involve difficult struggles and frequent failures where social realities fall far short of open deliberation. The social and technical arrangements we live with will be decided in public outcries, in legislative changes, and in the hands-on, painstaking work of building hardware and calculating data. They will be decided through changes in policies by companies, governments, and research institutions, and in the ad-hoc practices of those who work for them. And, of course, they will emerge through the quotidian exchange between technology user and technology developer, and the cascade of adjustments to material infrastructures necessary to support the continued use of these technologies. Each is an important moment in the unfolding of this new technology, and in each, choices will be made, deliberatively or not, based on beliefs about what is within the sphere of conceivability.

A social scientific understanding of the kinds of social relations that are conceivable can, I believe, make a positive contribution to the public discussion by making more choices available. So can perspectives from people who build things, who can articulate, and expand, the material realities of what biosensors can and cannot do. This volume contains both perspectives. It unpacks what is at stake socially, culturally, politically, and economically when biosensors become a matter of lived everyday practice. It critically examines biosensing practices both as a new extension of social control, and as a site where alternative modalities of power are being forged. It exposes the intertwining of materiality, everyday practices, economic relations, communities, and new medical and legal formations that shape these new socio-technical practices.

What Are These Things and Where Did They Come From?

For the purposes of this book, we focus on biosensing technologies, defined as technologies that indicate something about the body or the physical environment. If you ask an electrical engineer what a biosensor is, the definition she will give you will likely be more specific. A biosensor proper combines a biological element (like sweat, saliva, or CO2) with

a physiochemical detector, often optical or electrochemical. The detector interacts with the substance being analyzed, and converts some aspect of it into an electrical signal. These sensors in turn form one part of much larger sensor systems, which include all the other components necessary to go from electrical signal to display on a screen or other type of communication. One reason biosensors are proliferating is that new techniques have been developed to use light for identifying ever more minute substances (see chapter 10 for an explanation of how these techniques work). If light can be used to detect the signatures of tiny substances, then the kinds of substances that can be discerned and turned into data grow exponentially. This expansion is what makes biosensors interesting from a social perspective.

From the perspective of an engineer, if you don't have liquid or gas touching a detector, you haven't got a biosensor. Sensors that detect movement do not count in this narrower definition. While this distinction matters deeply if you are trying to build a biosensor, it is not necessarily socially significant. A person using sensors to understand her patterns of stress may or may not care whether that stress is detected through cortisol levels in saliva using "wet" biosenors or the comparatively "dry" electroencephalogram (EEG). In this volume, we use the term "biosensing" to refer to any *practice* that uses information technology to understand something about bodies or the environments in which they live, whether the technology is at the cutting edge or not. This might involve a biosensor of the type already described. It might involve one of the many sensors currently ubiquitous in computers and mobile phones, used to indicate something about the body or the environment (e.g., accelerometers which detect movement in space, microphones and cameras, timers, GPS), but which are not, strictly speaking, biosensors. Finally, it might involve manually recording events (the foods one ate, the mood one was in, etc.) in a mobile phone application, in a spreadsheet, or on paper to varying levels of precision. Indeed, many biosensing services invite their users to manually record additional phenomena related to what the sensors sense. This perhaps says something interesting about the limitations of sensors. Sensors now capture more than ever, and more than their designers anticipated (often called "data exhaust"), but the human capacity to imagine what is meaningful to record necessarily exceeds sensors' capabilities.

This adaptation of an engineer's term has advantages. Focusing on biosensing foregrounds the sensors, and therefore the very physical link back to what is being sensed. This connection is important, and can easily be lost in a more data-centric view, especially one that focuses on the

bigness of data accumulations. By examining biosensing practices, we can follow biosensors (proper) as a set of objects that change over time, yet have much in common with their predecessors, such as accelerometers. Wherever they might ultimately go, we can attend to the uncertainties they encounter in their travels.

There is a nascent but rapidly growing social scientific interest in the Quantified Self community,[4] in which biosensing enthusiasts meet in person to discuss what they have learned from their technologies. There is also growing social scientific interest in the "quantified self" phenomenon as constructed outside this community,[5] through idioms of datafication (van Dijck 2014), big data (Neff 2013), digital labor (Till 2014), self-surveillance (Lupton 2014a), and data doubles (Ruckenstein 2014). However, there is not yet social scientific work that focuses on biosensors as a class of technical objects; that is, other work largely prefigures which social phenomena the technologies engage with. Not all biosensing is about the quantified self, or about big data. As both Sherman and Taylor (chapters 2 and 9 in this volume) show, not all biosensor data are aggregated at great scale, nor does "bigness" capture everything that is, or could be, meaningful about this data. Nor is all biosensing about measuring selves. Indeed, in Böhlen's work on water-quality sensing in Indonesia (chapter 10), the self would be a wildly inappropriate starting point. Notions of the quantified self are hardly irrelevant to this volume; indeed, the person who coined the term, Gary Wolf, is the author of chapter 4. Although sensors always quantify, "the quantified self" is deliberately not the overall framing device of the book. The phrase is too apt; it taps too strongly into longstanding Western tropes of calculative rationality and preoccupations with the individual as the privileged locus of action. Instead, the focus on biosensing requires us to slow down our judgment about who is tracking what.[6] It opens up a view onto the diversity of practices possible by making it harder to pretend that we already know, by looking at the technology itself, what sort of phenomenon we are examining—a trap I clearly fell into in my first encounter with the topic.

The purposes to which these sensors are put are varied, and you will encounter many in the chapters to come. Devices designed for fitness monitoring (that count steps and measure distance run, heart rate, etc.) are easily seen on any street in North American or European cities. Medical and quasi-medical devices are less visible, but no less pervasive. Examples include glucose monitors, fertility monitors that track basal temperatures, implanted sensors to monitor the workings of the organs or contents of the blood, and devices that assess posture, or the sleeping

position of an infant. There is an extensive literature on using sensors to remotely monitor the elderly (Mort et al. 2013; Mort, Roberts, and Callén 2013; Pols 2011). Because that literature is fairly well known, it has not been directly addressed in this volume, but it is notable that in many senses the predecessors to these technologies can be found in assisted living facilities. It is also notable that the elderly have proved as able to subvert the intentions of sensor system designers as their younger counterparts in the Quantified Self community who fancy themselves hackers and tinkers.

Finally, biosensors are being used to understand, and keep track of, the "-omes," not just genomes but also exposomes (the pollutants to which bodies are exposed) and microbiomes (the microbes in our bodies believed to affect physical and mental states). Consumer-grade environmental monitoring technologies are less robust and more expensive than those that grew out of medicine, but they too are getting smaller and cheaper. In genome and microbiome sensing, the sensing is conducted in a lab, and participants mail in samples. Accessing such data has become relatively simple, and thus these sensors raise the same social questions as a sensor worn on the wrist. In the "-omes," the sensing capabilities largely outpace the scientific understanding of the effects on the body of the substance being sensed. Indeed, in the case of the American Gut Project,[7] participants know that the data they receive back about their bodies in exchange for contributing to that research project may or may not be interpretable.

These sensors did not simply arrive on the market free of social entanglements. The fact that we often talk about technologies as asocial objects that need to be *set* in some context is itself evidence of the kind of context they are in (Strathern 2001)—one that considers them to be "free" of social origins. While a full genealogy of these technologies is impossible to trace here, I will pull on a few significant threads. Computation and medical knowledge have been intertwined since the 1960s (November 2012). The relation is most starkly visible in genomics research, where biologists use machine learning techniques to expand their statistical repertoire. However, it was the shift in computer science toward "ubiquitous computing" in the early 1990s (Weiser 1991) that set the stage for biomedicine's entry into popular use of computers. Ubiquitous computing is a vision in which the best computer is the one that becomes all but invisible to its user, moving off the desktop and into a computationally rich environment. While this vision cannot entirely be credited or blamed for all of what today's mobile phones, tablets, wearable computers, and

smart buildings do, it has made the dispersion of computation beyond the PC conceivable. This dispersion created physical spaces on the body (pockets, wristbands) that were inhabitable by information technology, into which biosensors fit relatively easily.

Biosensors also cannot be understood outside the social history of biomedicalization, which Greenfield (chapter 7) and Kragh-Furbo et al. (chapter 1) address more deeply. I will only note here that biomedical ways of understanding the body have become inescapable in postindustrial societies. They have been inserted into ever more corners of social life. In that sense, it is thoroughly unsurprising that technologists have seen fit to turn their energies to building instruments of individual bodily control through the idiom of medical science. However, computer science and the information technology (IT) industry do not take all social changes surrounding them to be their cause (to wit: feminism), and so in that sense, the biomedicalization of information technologies was far from inevitable. One important mechanism by which biomedical frameworks became embedded in technical systems is through the subfield of "persuasive computing" (Fogg 2002). In this subfield, designers of technical systems abandoned a long-standing self-image of social neutrality, and set themselves the task of "nudging" their users toward the "right" behaviors, often by using the psychology of game design ("gamification," see Whitson 2013). While this acknowledgment of social entanglement is undeniably admirable, it has also written the permission slip for technology developers to think of themselves as the enforcers of medical prescription. There are few papers in this subfield that do not take "behavior change" as their object of study and design. One does not describe the actions of others as a "behavior" unless one deems their worth questionable. One also does not couple the word "change" with "behavior" so readily unless one believes it is individuals, and not institutions or political economies, that need changing.

I realize that I am now using ungenerous language, speaking more as the critic-partisan than the convener of arenas. Culture makes hypocrites of us all, and it is true that I find it difficult to summon affection for this sort of software, or to work with developers who are disinclined to acknowledge the political causes and consequences about which I care a great deal. In fact, there is more diversity and controversy within computer science than I am letting on. For example, Purpura et al. (2011) is a computer science paper in which the authors built a fictional weight loss encouragement system, "Fit4Life," by taking principles of persuasive computing to their logical extreme. It is a deliberate comment, in design

form, on how easily unrestrained persuasive computing could spiral out of control. For example, Purpura and colleagues load up their system with multiple sensors used to "tunnel" users, guiding them through a staged set of interactions that communicate what to do next based on the sensors' data. They designed in alerts encouraging other users to shame someone who no longer wears the technology. Notably, the authors found that their audience could not distinguish earnest design from provocation.[8]

With that in mind, there is one last partisan point to be made. Whether the IT industry's acceptance of biomedical frameworks and cultural ideals about fit bodies happened through the trope of persuasive computing, or via more complicated routes, it has nevertheless resulted in an immunity to the basic facts of marketplace failure. Sixty percent of health-related apps fall into disuse after six months of ownership (Economist Intelligence Unit and Price Waterhouse Cooper 2012). The trade press considers such early abandonment to be a constraint on market growth (Rank 2014) because this figure suggests a lack of engagement and costly customer churn, not the effects of planned obsolescence. The problems of modern living these apps and devices were designed to solve (obesity and its various cousins) are problems that require much longer than six months to correct. This suggests that people are not using these products as intended, yet if anything, the industry has doubled down on gamification and images of strong, disciplined, lycra-ed bodies to articulate the value their products offer. When the private sector has not responded to market signals, we have perhaps the surest sign that a cultural logic more powerful than capitalism is at work.

Time and Partial Indication

Biosensing systems have two fundamental things in common: the centrality of time, and a problematic relationship to indexicality. Tom Boellstorff (2013) reminds us that the words "data" and "dated" are etymologically related for a reason. Data always have a date—they are that which is stamped by time, recorded as having taken place. Data generated by these technologies may or may not be associated with a location, but it most certainly will be associated with a time, often called a "time stamp." This makes biosensor data largely time-series data.[9] This is no mere technical detail. As Sherman (chapter 2) observes, time is what makes it possible to treat data abstractly, and to create new abstractions from it. Data can only become meaningful when it is brought into relation to other data (Gitelman 2013; boyd and Crawford 2011), and time is the hinge that