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Introduction

Note: this is a draft copy of the Introduction to

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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 he 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 acknowlege 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

realites 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 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 CO_2) 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 defintion. 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 accumlations. 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 like 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 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 inhabited 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 communicating 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 suggest 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 makes this possible both mathematically and socially. Mathematically speaking, when two time series co-vary, they co-vary across time, as in the correlation that says "when my steps increase, so does my heart rate," Jumping from a single person to a population requires a decision about how time is to be handled. The correlation that says "people who take many steps also have high heart rates," contains no notion of time, and can be made by averaging all the data

in each time series before correllating across a population. However, the second correlation does not follow from the first. We might imagine that people who take many steps have lower heart rates overall because exercise tends to lower resting heart rates while temporarily raising heart rate during exercise. If we re-introduce time through more sophisticated statistical techniques, however, a researcher can detect this more fine grained pattern.

The ability to look for patterns in time, rather than just across a population, comes from the technological conditions which make it possible to sample things at much higher rates than a survey or health record data can. In a sense, sensors lay tracks in time (Day and Lury, chapter 3). The exact cadence of these tracks, or traces, depends on the sampling rate the sensor is set to, which can be anywhere from a second-by-second data collection, to once a day, to "when someone feels like it" in the case of manually initiated data collection. Where there are differences in sample rates, the calculation techniques can become complex, as the people processing the data must make a claim that variable X spiked at the "same time" as variable Y for practical purposes, even if their time stamps are not exactly the same. Similarly, where data have been collected from two different devices, if those devices do not use the same technique to record which time zone the person is in, chaos can ensue. A covariance in time is much harder to generate if one device/service adjusts how it records time when a person travels, and the other does not. Without good metadata, one can only guess which "5pm" those steps took place in.

Not only does time make data relate to other data, it also makes data relate to people, and to the broader cultural imaginations they possess. For example, where there is a spike in steps or heart rate, a sensor user might simply recall what else was happening when that spike occurred. In this way, the experiential qualities of time can be a more powerful analytical tool than mathematical correlation (Ruckenstein 2014). Similarly, data examined in the moment of, say, a

bike ride, is experienced very differently than data designed to be contemplated post hoc. *Aasarød* (2012) describes the bodily sensations people have when they use continuous glucose monitors. Some use the devices to calibrate their own experiences of their body, to "learn" what a high or low level of glucose feels like by looking at it at the moment of physical sensation. Others effectively outsource that sensing to the device, which effectively tells them what to feel. Nevertheless, for both kinds of people it is *the moment of looking* that makes the tie between body and number possible.

In other contexts, longer time cycles are at stake. In Böhlen's work (chapter 10), water quality needed to be tracked over the course of a year, not just in the moment, to check that it was safe. The seasons had an effect on the water's physical attributes and therefore on the social practices around collecting and purifying it. Similarly, bodies themselves have temporal cycles, and need time to respond to new treatment regimes devised on the basis of biosensor data (see Kragh-Furbo et al., chapter 1). Institutions also have their temporal cycles. Changing biosensing practices can require carefully timed orchestration of both technology and policy (Gregory and Bowker, chapter 12). The pace at which institutional decisions are made can sometimes be disastrously out of sync with the rate of data collection (Böhlen, chapter 10). Could rapid sampling rates constitute a new round of space-time compression (Harvey 1989), quickening the pace of life? Perhaps, though data in the *longue durée* also matters (see Wolf, chapter 4), and there is no such thing as "real time" *per se*. How quick is "real"? Down to the hour? Minute? Nanosecond? What we can say for now is that biosensors mediate temporal calibrations among people, materials, and institutional processes.

Biosensing practices also share a difficult relationship to indexical forms of meaning making. Sensors are designed to indicate. They are designed to point to a phenomenon as if data

were like smoke to a fire—that is, an index in a straightforwardly Peircian way. In practice, indications are hardly straightforward or clear. A single sensor can indicate many things. For example, activity monitors often use accelerometers to detect both steps taken and sleep quality, while elevated body temperature can indicate anything from ovulation to stress to influenza to Ebola. A raised heart rate might indicate stress, but is it stress the body experiences through exercise, known to reduce "stress" in a different sense? And what exactly does one look for in this heart rate—sustained elevation or spikes? A continuous sampling of heart rate as opposed to a pulse taken once a year in a doctor's office could indicate something entirely novel, and put someone down a very different path just by increasing the sampling rate. The human lifeworld that exists around a thing we might call "stress" is only partially evoked by what might be mechanically sensed. Conversely, what is mechanically sensed might not speak to "stress" at all but something entirely different (Leahu and Sengers 2014). In these ways, sensors point to a possible wider phenomenon, a whole, but do not make the exact contents of that whole evident (Nafus 2014). The problem is not that lay people are confused or lack expertise to make sense of sensor data; it is that the technology is itself confusing. For example, brain-imaging technology (PET scans) poses to neuroscientists exactly this kind of confusion around parts and wholes (Dumit 2004). Simple changes of color contrast in the PET image can produce wildly different interpretations of the underlying data.

The cultures that would connect lifeworlds and machineworlds are so nascent and diverse that those who endeavor to puzzle these issues through have much work ahead of them (Kragh-Furbo et al., chapter 1; Böhlen, chapter 10; Gregory and Bowker, chapter 12; Nafus 2014). To use Kragh-Furbo et al.'s phrase, data are overloaded with potential, and without further work, they remain mere potential. Taylor (chapter 11) calls our attention to the additional work

necessary to make data culturally and socially meaningful, beyond the scientific work that would, say, establish the relationship between genotype and the physical expression of those genes. On the one hand, he points out that there are cultural, aesthetic, and social questions that go unasked of datasets, and argues that data collection and calculation are done in highly conservative—dare I say it, boring—ways. On the other hand, Estrin and De Paula Hanika (chapter 9) point to the rapid expansion in medical comprehension of sensor data for clinical intervention, hardly tedious. What these two contributions share is a notion that data can, in fact, be designed. A greater sense of intentionality in what data *should* be collected and calculated is likely to yield more productive sensing practices than treating datasets as stockpiles of found objects that inadvertently exude meaning.

How This Book Is Organized

This book is organized to reflect where the conversations about biosensing actually are, not what kinds of conversation will prove satisfying in any one of those quarters. The various contributions to this book necessarily contain large differences among intellectual traditions, and differences in practical versus theoretical orientations. The authors are not all participating in exactly the same conversation, and neither is the public. My hope is that this collection can thicken some of these connections.

Leaving academia has only strengthened my belief that some academic concepts are too valuable to be left as matters of insider discussion. At the same time, it is foolish to pretend research is not research. In a research publication, there is no avoiding terms of art when they are useful, and simplifying a complex world is not the same thing as actually understanding it.[10] I have tried to find a way to expand engagement with public concerns, while still directly

conveying the research, by asking three people doing important work outside the academy (Estrin, Wolf and Mehta) to join the conversation happening in this small arena of ours.[11] Two of these chapters engage the scholarship directly, and offer their own thoughts in return. Estrin's offers an explanation of why she builds technologies in particular way—important explanations that could go missing if buried under a wider social scientific argument. This was a genuine experiment, in as much as I wanted to know which ideas from the scholarly chapters these contributors would find interesting, and what other ideas they would want to raise for a largely social scientific audience.

In some senses, this editorial choice follows the longstanding tradition in anthropology of directly including voices of the people we study (Clifford and Marcus 1986). As anthropology no longer confines itself to studying the marginalized, we can no longer presume that it the anthropologist's voice that is the voice of privilege. This is not a book written from the margins of social life, though I look forward to someone writing one with respect to biosensing. Here, including people who build technologies and communities does a different kind of work. It experiments with what kinds of conversations in the "center" could become possible if more voices from the "margins" of the social sciences and humanities were taken seriously. Being taken seriously is not the same thing as being agreed with, of course, or even sharing the same epistemological frame. However, these contributions give us grounds to ask practical questions about what it might look like for social scientists to intervene more directly in the trajectories that biosensors take.

Part I, "Biosensing and Representation," examines how data, personhood, and abstraction relate to one another. Mette Kragh-Furbo, Adrian Mackenzie, Maggie Mort, and Celia Roberts begin chapter 1 with perhaps the most urgent political question: *Do biosensors biomedicalize?*

Using the case of direct-to-consumer genomics, they answer affirmatively, while also observing other social practices that cannot be accounted for by the biomedicalization thesis alone. They see new sites of "negotiation, contestation, and diversity that may not be fully biomedicalizable." Part of what makes room for diversity is the complexity of the datasets themselves. Layers upon layers of abstraction make the connection between DNA data and body not just partial but circuitous, far more indirect that the indexicality I described earlier. This creates room for, say, care and affection between people trying to make sense of the data, or attention to individual biography and experience. It also creates room for false hope. To work on this sort of data presupposes it could contain an answer to one's problems, when in fact there may not be an answer.

In chapter 2, Jamie Sherman takes an entirely different approach to the question of what data's abstractions do for people, and to people. The data that her research participants use are not as complex as in the first chapter, but this brings into sharper relief its connection to aesthetic practice, as opposed to technoscientific logics. Using the work of Walter Benjamin, she argues that we can think about data as a cultural medium of recording analogous to film and photography that came before it. Self-tracking data keep a quasi-abstracted account of one's activities, allowing the tracker to conduct tricks of proximity and distance. Much like the photographic practices of Benjamin's day, these maneuvers afford different vantage points from which to see and experience the self. This self-in-data is never the "whole self" but is comprised of details made separable by the technologies of the day.

In chapter 3, Sophie Day and Celia Lury argue that data cultures push on ideologies of the self more radically than in Sherman's account. They argue that contemporary cultures of observation expose the fictions we in the West tell ourselves about personhood—in other words,

that there is such thing as an individual with clear boundaries, such that we can then also sensibly draw fixed rings around what is public and what is private. Instead, they argue that what we are really doing in acts of tracking is recursively producing those notions of private and public, individual and others, more or less on the fly. Their notion of the "dividual," drawn from the Melanesian ethnography of Marilyn Strathern, entails a personhood that is partible, constitutive of the relations it forges. It does not carry around an essential "core" that moves unchanged from one social relation to the next, as we like to tell ourselves. The dividual bears an uncanny relation to the personhood Sherman describes, which comes into being through attention to separable details. It is also not dissimilar from the "pixelated person" described by Greenfield in chapter 7. Could it be that pixelation becomes the technoscientific idiom with which the West tiptoes up to a notion of "dividuality," without, perhaps, fully embracing its ramifications in the way the Melanesians do?

Journalist and Quantified Self community founder Gary Wolf responds in chapter 4 to the material part 1with an observation about self-tracking enthusiasts: "These maneuvers of self-separation, carried out with varying degree of expertise, are unhesitatingly presented as techniques of enlightenment. Hasn't anybody noticed the trouble the self is in?" Perhaps not, even though anthropologists are quick to point it out. Wolf offers yet another way of thinking about self-tracking, by reminding us that most community members are also technology producers. In that industry, talk is relentlessly about the future. By comparison, putting digital breadcrumbs in the past by recording it numerically provides a rare opportunity for grounding in the here and now.

Part II, "Institutional Arrangements," focuses on the institutions of law, commerce, and medicine as they both shape and are shaped by biosensors. In Chapter 5, legal scholars Helen

Nissenbaum and Heather Patterson also reject the notion of privacy as somehow fixed, but they do so for very different reasons than Day and Lury. They argue that privacy violations are experienced when there is a disruption in the expected flow of information. It is not that specific data types are inherently "sensitive," nor does the specific institutional context alone make data "private." For example, a blood pressure measurement collected in a clinical setting falls under U.S. medical privacy law (HIPAA), but that same data collected in a home by a consumer-grade device may not. If employees are going to be coerced into giving their employer or health insurance company blood pressure data, it matters little where or how the data were generated, or the nature of the data *per se*, because overriding this is a normative expectation that employers do not concern themselves with employees' bodies. These authors provide specific, practical guidance for how to trace where data flow, and how to surface the gap between expectations and reality in order to help designers and policymakers identify sources of privacy violation.

In chapter 6, Brittany Fiore-Gartland and Gina Neff help us understand how business school conceptualizations of markets are being mobilized to secure a place for biosensor companies within the U.S. healthcare system. They point out that companies take aim at "disrupting" traditional medicine through biosensing by claiming to "cut out a middleman, while integrating seamlessly all the parts of the middleman's very system that will soon be made obsolete." They argue that companies skirt regulation by delivering "raw data" on an informational basis, yet deliver those data alongside encouragements to talk with a medical professional about it. This effectively outsources much of the interpretive work back to the medical system, without the firm having to pay for that work. The authors see the "democratization" talk used to legitimate such "disruption" as a kind of bait and switch. It mobilizes the sometimes-strong desires of patients for health systems to "give me my damn

data," but ensures more control over the medical system for the "disrupting" firm than for individuals.

Dana Greenfield writes as both an anthropologist and medical professional. In chapter 7, she addresses the relationship between medicine and self-tracking. While Fiore-Gartland and Neff direct our attention toward a power struggle within a political economy, Greenfield directs our attention to the multiplicity of coexisting medical and paraclinical practices. She focuses on the "n of 1," a trope used within the Quantified Self community to talk about the relation between self-tracking and medical research. When we look at how "n of 1" is invoked, we find a polyvocal concept. Sometimes "n of 1" is about the open-ended tinkering with the protocols of care, which fits well with Mol's (2008) logic of care. It can also be a way to think about massive datasets that scale up to population levels and back down again to an individual, who would receive personalized treatments calculated through the difference between her and the population-level aggregation. It can yet again be a way to interject narrative form back into medical practice. Put together, though, the "n of 1" suggests that self-tracking can be usefully thought of as a paraclinical practice: "By taking up the tools of medicine, but not its claims to expertise, this is medicine turned inside out."

Rajiv Mehta is a Silicon Valley entrepreneur who reflects on the material in part II as someone who has had to make practical decisions about privacy by design and his relationship to the healthcare system. In chapter 8, he helpfully observes that there are serious tradeoffs between preserving privacy by designing better user controls, and enacting legislation that targets harmful use of data (an example of similar policy in the UK can be found in chapter 3). Mehta also calls into question whether "disruption" is actually at work in this market. The apps he designed and sold are calendaring programs adapted for caregivers, and did not remotely come close to

"skirting medical jurisdiction." Still, he had to contend with a powerful assumption that "health-related" meant the same thing as medicine, and at every turn was questioned about the extent to which his calendars had been medically vetted. This is not the way disruption works as traditionally understood. The aggressive treatment he received, simply for not giving biomedicine totalizing authority, suggests that more is going on here.

There are some things that only become clear by doing, rather than by commenting on the results of what was done. The final part III, "Seeing Like a Builder," offers an engineer's-eye view from the trenches of building technical systems. Here I have reversed the pattern of social scientific commentary followed by a response, and instead begin with an interview[12] with Deborah Estrin, a founder of Open mHealth. I asked Estrin to help us understand what it takes to move data between institutions. The hard part, she observes, is ensuring that data remains intelligible as it moves from one party to the next. There is a tension here between Patterson and Nissenbaum's concern about privacy violations enabled by the free flow of data, and Estrin's concern about the careful technical decisions that need to be made to build systems that make "flows" possible at all. The tension is not over whether there are too few or too many controls on where data are exchanged. All of the authors agree on the importance of controls. Instead, the work of Open mHealth suggests a broader conceptual point. Universal free flow of data does not exist in the way that social science's extensive reliance on the term would have it. The trope of data "flowing" reflects our ability to imagine the connective qualities of data. It is easy to imagine how a piece of location data combined with heart rate data combined with yet more data can paint a detailed picture (and the truly frightening things that can happen when this picture is painted without our consent). However, the material realities do not come together as easily. Remember my earlier example of two services that do not handle time zones in the same way.

The data cannot just "flow" between those services, even if the connecting pipes are there. There is friction (Edwards et al. 2011) between the datasets themselves, and nontrivial resources are required to remove that friction if someone is going to successfully paint a picture with it. With NSA-sized budgets, such friction is easily overcome, but not so for smaller firms and research projects. Just as there are services that happily expose data to the highest bidder, these frictions create points of nonexchange that hinder entirely appropriate medical research, clinical practice, and personal self-tracking.

In chapter 10, Marc Böhlen gives us a ringside seat to the tradeoffs and uncertainties of building biosensor systems. Böhlen reshapes the capacities of technical systems in an ongoing way, in response to the relationships he builds to both individuals and institutions. He reflects on a moment of calibrating water-testing equipment in Indonesia, in which the calibration of his technical system was really a kind of social and political calibration that made the Indonesian state more at ease with his presence. Through his actions, Böhlen makes evident the sheer complexity of maintaining multiple layers of socio-technical calibrations. Like Open mHealth, his data "flows" were a hard-won outcome of social and technical work. His shuttling between two social institutions, one state-based and focused on health, and the other a less formal but very powerful network of neighborhood organizations, also serves as an important reminder that the institutions that shape medicine and health do not necessarily fight for control over the domain in the way that Mehta experienced in the United States.

In chapter 11, Alex Taylor raises the question of what alternative forms of data might look like, by attempting to make different "cuts" of data. He takes to task the claims of big data proponents who argue that the promise of big data is to learn something new, of human value. If this is so, why do these same proponents launch so few challenges to the preexisting social

categories that shape what is measured and where the data is stored? Taylor argues that there is room to do better if we take the stated promise at its word. He embarks on a small data collection project to point toward what goes unnarrated in commercial and civic systems, such as heart-rate monitors or bicycle-sharing programs. He shows the importance of datasets that do not fit the flat just-so stories of TED talks and marketing pitches. Taylor sums up the spirit of this collection when he says: "The computational substrates that . . . are constitutive of big data should be given over to enlivening the relations, not flattening them. The trick here, as I see it, is to build in computational capacities that keep the vastness open, that don't slip too soon into neat classes-- regimes even—of data that we know too well."

In the final chapter, Judith Gregory and Geoffrey C. Bowker further elaborate on what it might mean to keep the vastness open. By examining both microbiomes and genomes, their concept of the "data citizen" expands into the ecological. When they look at data they take the relationships, not the categories they supposedly refer to, to be ontologically prior. This opens up new spaces for design, and a much wider, and more inclusive, sense of who ought to be doing the designing. Such spaces include the design of policy, as well as objects. Indeed we could infer from their attention to aesthetic considerations that a more expanded space for design might also include rhetorical form alongside functional concerns.

Notes

1. Readers curious about this sometimes vexed, sometimes productive form of public engagement might explore www.epicpeople.org and Denny and Sunderland (2014).

2. See Guthman (2011) for a critical take on the social dynamics that have led to constructing America's growing waistline as a medical problem.

3. Research from chapters 1, 3, 6, and 10 was supported through this program. Researchers were in no way restricted in whether, how, or when they could publish their results.

4. At the time of writing, nearly every Quantified Self group in a large city has a resident ethnographer. Early works include Watson (2013), Lupton (2014a), Dow Schüll (forthcoming), Boesel (2013), Williams (2013), and Nafus and Sherman (2014).

5. Boesel (2013) usefully distinguishes "lowercase qs" (the generic description for self-tracking practices) from "uppercase QS" (for Quantified Self, the group of enthusiasts who meet on a regular basis, and describe themselves as a lead user community).

6. Lupton's self-tracking "types" (2014b) makes helpful progress here, in that it makes explicit the relations between selves and others, but still puts selves at the center. My desire is not to suggest these types are not useful—hardly—but to explore what happens if we can decenter selves entirely so as to revisit them anew.

7. Americangut.org.

8. Shteyngart's (2011) fictional satire of a biosensor-rich world captures the at-once toxic and comical social arrangements that are a natural extension of a gamified, biomedicalized world.

9. A notable exception to this rule is genome data, which technically speaking will contain a time stamp (the time at which the sample was taken or processed), but further sampling is largely meaningless as individual genomes do not change.

10. It is a cruel irony that those who are most confused about the public value of the social sciences and humanities are among the quickest to demand simplistic explanations of what researchers do. This is a trap. Time, resources, and generous listening are required to get public and yes, economic, value out of research. If policymakers have trouble seeing the connection between social science and the matters of public import, they would do better to examine the absence of resources available to make this translation, and not the nature of the research itself.

11. Estrin is a computer scientist at Cornell University, but she speaks here as a founder of a nonprofit organization.

12. The interview format is something of a conceit. It indeed took place, though Estrin and her colleague Anna de Paula Hanika edited the text printed here.

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