Sensor technology and the time-series self

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In 1990, just as digital information and communication technologies were coming into widespread use, the French philosopher Gilles Deleuze suggested that the architectural enclosures, institutional arrangements, and postural rules of disciplinary societies were

giving way to the networked technologies of "control societies," involving continuous coding, assessment, and modulation.[1] The latter scenario bears an uncanny resemblance to the tracking-intensive world of today, in which the bodies, movements, and choices of citizens and consumers are ever more seamlessly monitored and mined by governments and corporations. Heated public debate has arisen over how such tracking might undermine personal identity, liberty, and privacy.

Yet even as this debate over surveillant monitoring unfolds, the public has embraced practices and products of *self*-tracking, applying sensor-laden patches, wristbands, and pendants to their own bodies. The contemporary world is characterized by "an intimacy of surveillance encompassing patterns of data generation we impose on ourselves," writes anthropologist Joshua Berson.[2] As prescient as Deleuze's vision of the future was, Berson notes that he did not anticipate the degree to which the tracking and coding of bodies and acts would be drawn into the ethical project of self-formation and self-care.

What Foucault called *technologies of the self*—means through which individuals perform "operations on their own bodies and souls, thoughts, conduct, and way of being, so as to transform themselves in order to attain a certain state of happiness, purity, wisdom, perfection, or immortality"[3]—take an actual technological shape in the assemblages of wire, chips, and batteries that constitute contemporary self-tracking devices.

While people have long used simple, analog devices to record, reflect upon, and regulate their bodily processes, use of time, moods, and even moral states (here we can list mirrors, diaries, scales, wristwatches, thermometers, or the lowly "mood ring"), the past five years have seen a dramatic efflorescence in the use of digital technology for self- tracking. As mobile technology spreads, as electronic sensors become more accurate, portable, and affordable, and as analytical software becomes more powerful and nuanced, consumers are offered an ever-expanding

array of gadgets equipped to gather real-time information from their bodies and lives, convert this information into electrical signals, and run it through algorithms programmed to reveal insights and inform interventions into future behavior.

The recent rise of self-tracking is epitomized by the practices of the Quantified Self (QS) community, an international collective of individuals—as of summer 2015, there were over 45,000 members in 40 countries—who ascribe to the quest for "self-knowledge through numbers." In online forums and in meetings around the world, quantified selfers share their attempts to experiment with diet and meditation, monitor drug side effects, correlate hormone levels with mood fluctuations and relationship dynamics, or even evaluate semantic content in daily email correspondence for clues to stress and unhappiness. In large volumes of numerical self-data, rendered in spreadsheets, pie charts, graphs, and other visual media, they seek to detect patterns and uncover habit pathways (see Fig. 1).

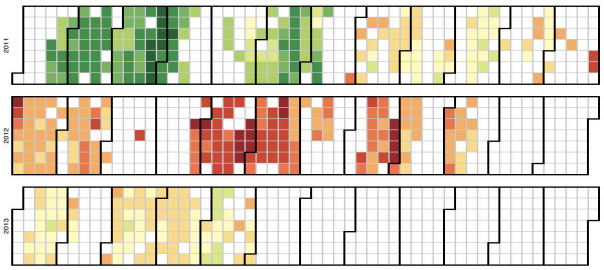

Figure 1. "2.5 Years of My Weight" by Mette Dyhrberg, posted to the visualization gallery of quantifiedself.com. "I gained a lot of insights from this heat map," writes Dyhrberg.

Started in 2009 by Gary Wolf and Kevin Kelly, two former editors at WIRED magazine, QS made its public debut when "The Data-Driven Life," authored by Wolf, appeared on the cover of April's *New York Times Sunday Magazine* in 2010.[4] In the piece, Wolf proposes that data can serve not only as a means of inspecting others' lives (as an actuary, policy maker, or welfare officer might) but as a tool for introspection—a new kind of digital mirror in which to see and learn new things about ourselves. "Humans have blind spots in our field of vision and gaps in our stream of attention," writes Wolf; "We are forced to steer by guesswork. We go with our gut. That is, some of us do. Others use data." In heart rate spikes or mood dips charted over time, he argues, we can grasp how we are affected by seemingly trivial habits or circumstances. "If you want to replace the vagaries of intuition with something more reliable, you first need to gather data. Once you know the facts, you can live by them." Automated sensors and statistical correlation become tools for the good life.

"The idea that our mental life is affected by hidden causes is a mainstay of psychology," notes Wolf. And yet, "the contrast to the traditional therapeutic notion of personal development is striking." He explains:

"When we quantify ourselves, there isn't the imperative to see through our daily existence into a truth buried at a deeper level. Instead, the self of our most trivial thoughts and actions, the self that, without technical help, we might barely notice or recall, is understood as the self we ought to get to know."

Longtime self-tracker Eric Boyd, a mechanical engineer who runs Toronto's Quantified Self meetup, believes that the tools and practices of self-quantification are less about numbers than self-discovery. "The reason you begin tracking your data is that you have some uncertainty about yourself that you believe the data can illuminate," he said in 2013. "It's about introspection, reflection, seeing patterns, and arriving at realizations about who you are and how you might change." And yet this intimate journey commences not with a turn inward but with a turn outward to the streaming data of a device: an extraction of information, a quantification, a visualization. Self-tracking, following Boyd, renders "an *exoself*, or a digital mirror; it lets you look at things you otherwise couldn't see using just your own eyes, and see yourself more honestly."[5]

At his company Sensebridge, Boyd designs a variety of devices intended to produce these digital mirrors of the self. The Heart Spark pendant, for instance, flashes in time with one's heartbeat, externalizing the body's affective rhythms (see Fig. 2); Sound Spark flashes along with the cadence of one's voice; a "compass anklet" vibrates to augment one's sense of direction. As experience feeds into data streams, so data streams feed back

into experience, becoming a vital aspect of sentience and self-knowledge.

Figure 2. The Heart Spark pendant by Sensebridge flashes in time with wearers' heartbeats, broadcasting their emotions.

Like Wolf, Boyd distinguishes data-driven modes of self-discovery from those of talk- based therapy: "Quantified self is not a linguistic exploration like psychoanalysis—it's more of a digital exploration, and the stuff you're exploring is made up of many little bits and moments." One arrives at insights not through language unfolding in time, he elaborates, but through tracking these bits and moments *over* time. "You may not gain any knowledge in a week or even a month, but maybe with a year of data you might see something significant about yourself; you need a view that's longer than whatever moment you're in." In the interview prompting this verbal rumination on the "exoself," Boyd shifted the plane of existential significance and the possibility of self-knowing from the fleeting temporality of single events to the longitudinal temporality of accretion:

"*In our physical world we're actually quite small creatures – our powers only extend a few meters. But in the temporal dimension we're actually extremely effective. The trouble for us is that it's difficult for us to see the amount of power we have in time because our sense of time is so limited. We go through life one minute a time—but we're actually going to live a billion moments or something like that.*"

Digital tracking and time-series analysis allow us to take stock of these billion moments; "they gives a longer view of our power in time" by showing how our habits—"the things we're doing over and over"—add up to affect our lives in positive and negative ways. "Without good time calibration," notes Wolf, "it is much harder to see the consequences of your actions." Thus tracking tools become ethical tools, technologies of the self; in self-tracking Boyd finds a pathway from self-knowledge to self-transformation. Tracking has allowed him to regard himself as a "time-series self," which he finds both liberating and empowering.

Over the last five years, the practice, ethos, and technology of self-tracking has migrated out of the "geeky," rarefied domain of QS and hacker conventions to capture the attention of venture capitalists, technology startups, established electronics companies, and mass- market consumers. The aisles of Best Buy and Wal-Mart are abundantly stocked with gadgets designed to record personal metrics, the Internet rife with downloadable smartphone apps that can monitor behavior and suggest, as Boyd commented, "how you might change."

"You can build a profile or picture of what it is you're doing and this lets you see and understand the choices you're making on a daily basis," said a representative of Verizon's Health Care Management group in praise of self-tracking technology, "which is really who you *are:* the choices that you make all day long, whether to take the stairs or the elevator, what you will eat or not eat."[6] It was important, he continued, that one remain in constant touch with one's data profile—one's *exoself*, to use Boyd's term—in order "to see *now* how your choices are impacting you—see how the gauges are moving *as* you make choices..." In this scenario, sensing happens not only in or through the body, but also in and through sensor technology; one's own "data

exhaust" (contemporary parlance for the traces given off by citizens of the networked world), tracked and filtered through analytic algorithms, becomes a trustworthy guide through the uncertainty of human experience and perception.

While the most common trackers on the mass market are wearable devices that monitor such data as steps taken, heart rate, and sleep phases, the past few years have seen the introduction of posture-regulating clip-ons that buzz when slouching is detected, "smart" eating utensils that help people chew and swallow more mindfully, and water bottles rigged to remind users when it's time to hydrate. Some of the most recent tracking products extend to the intimate, self-generated act of breathing—arguably the most elemental and vital unit of existence in and through time. The measure of breath, coupled to heartbeat, is the metric that constitutes seconds, accumulating into minutes, aggregating into hours—much as data itself aggregates into the time-series self. A small device called the Spire, for instance, helps people to regulate their breath—and, by extension, their stress levels—by alerting them when their respiration becomes shallow or erratic. The product website suggests that users review graphs of their breathing during activities such as meditating, reading, and working on a computer as a way to enhance their self-awareness (see Fig. 3). The idea is that by wearing the Spire, receiving its prompts, and reflecting on its data, users will be able to cultivate better breathing habits.

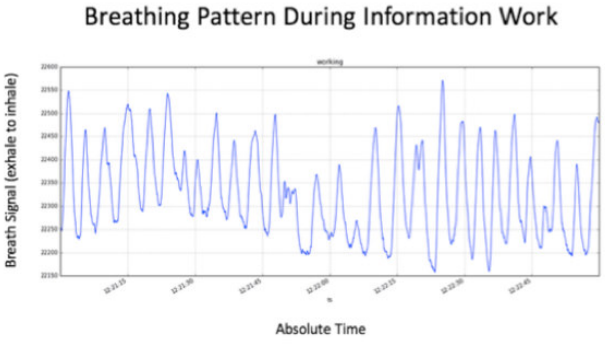

Figure 3. "Breathing during information work," when compared to breathing during meditation or reading, is revealed to be more erratic with more short "breath holds" (published on the Spire.com website).

Another device concerned with entraining new patterns of breath and focus is the Muse, a seven-sensor, mobile EEG headset designed to give users a window into—and, over time, a handle on—the intimate signals of their brain data via real-time audio feedback and dynamic onscreen visualizations. The ad speaks with the voice of a personal coach: "See and hear your brain activity; Test how well you can manage stress; Learn how to calm your busy mind." Giving a cyborgian twist to centuries of analog meditation devices of the visual (mandalas) and acoustic (chants) sort, the Muse tunes into internal brainwaves to offer an external read-out; it is a real-time informatic instrument designed to help individuals achieve mindfulness as they move through their days. "I'm really interested in figuring out what is actually possible in terms of mental augmentation with this new digital mirror that we have," comments Boyd of this and other emerging "brainware" devices. "In sense you could call it a cyborg, because it lets you look at things you couldn't look at using just your own eyes."

Fantasies of the body measured by thermometers and controlled by feedback devices exist from the European Enlightenment to mid-20th century cyborg imaginaries in which human self-regulatory controls would be enhanced and extended via feedback loops with machinic controls, creating powerful "artifact-organism systems." Such fantasies are present in the technologies and practices of dedicated self-trackers like Boyd and Wolf—and yet these self-trackers insist on the core humanism of their enterprise: rather than compromising or degrading human subjectivity, technology like the Sensebridge suite of electronics or longitudinal graphs of automatically tracked data enable new awareness of one's being in the world and in time, and lend new tools to the project of self-care and the good life. The novel ethical mandate of the digitally self-tracking subject is not simply to "know thyself" but to let digital sensors and big-data analytics share in the knowing. Tracking, on this account, reveals new truths about who we are and who we might become.

Sections of this piece are based on material found in two prior publications: "Obamacare Meets Wearable Technology" (MIT Technology Review,

May 6, 2014); and "Data for life: Wearable technology and the design of self-care" (BioSocieties, published online January 2016).

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[3] *Ibid.*

[4] Gary Wolf, "The Data-Driven Life," New York Times Sunday Magazine, April 28, 2010, http://www.nytimes.com/2010/05/02/magazine/02self-measurement-t.html.

[5] *Author interview with Eric Boyd, Toronto, July 2013.*

[6] *Panelist at the Consumer Electronics Show 2014.*