Seeing 21st Century Data



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re individuals at risk of "data bleedout" in 21st century environments saturated with wearable devices? Is there a good way of visualizing the range of wearables and related technology so that we can see the impact on both the human

and their data? Wearable have been around for a long time – eyeglasses date to the 13th century and artisans created wearable clocks in the 16th century. The wearable technologies of the 21st century are multiple and plentiful in many commercial markets. CCS Insight has updated its outlook on the future of wearable tech, indicating that 411 million smart wearable devices, worth a staggering \$34 billion, will be sold in 2020 (1). This estimate depends upon a strong growth in the sector; global wearable retail sales in 2017 reached 126 623 units (2). Much of this growth is expected to come from young adult sectors; according to the Global Web Index, 71 percent of those ages 16 to 24 want "wearable tech," defined as a smart watch, smart wristband, or smart eyewear. Nearly two-thirds of global Internet users have worn a piece of technology already or are eager to do so in the future (3).

While the growth in wearables is expected to be commercially significant, it is also possible that smart, Internet-connected devices that are inserted, ingested, or implanted in human bodies will actually outstrip that market. The two sectors and their explosive growth suggest that we need to think hard about the privacy and ethics concerns for smart devices in, on, and around human bodies. As Katina Michael has suggested, it is time that we begin to grapple with the social and personal implications for "the Internet of us" (4). In this article, we outline a process for exploring the emotional and practical dimensions of deep human integration with surveillance technologies such as wearable fitness trackers and implantable Bluetooth devices. This process entails utilizing a 15th century visualization known as "Wound Man" and creating an updated version to understand ways that technologies mediate human bodies in a 21st century "body area network" (4). This old visualization draws attention to the ways in which digital technologies situate the body not as a self-contained, sovereign subject but as a leaking, commodified dataproducing body.

"Self-Knowledge Through Numbers"

The growth in the wearables market owes a great deal to the popularity of the Quantified Self (QS) movement. Started by Gary Wolf and Kevin Kelly in 2007 and codified with a 2009 piece in *Wired*, the QS movement encourages people to better understand their lives and experiences through data (5). QS-adherents, or "quants," measure aspects of their daily activity sleep, calories, steps, blood pressure, weight — with the objective of noticing trends over time and optimizing based on their personal observations. As Gina Neff

Digital technologies re-orient the body from a self-contained, sovereign subject to a leaking, commodified, data-producing body.

observes, there is a strong culture of personal data metrics with QS, but the ethos of self tracking has to be balanced with the recognition that what was once personal is now deeply commercial. Commercial QS and the commercial wearables that support such self-monitoring is big business and so is aggregating such data in order to render it meaningful.

Many QS consumers are paying significant sums to be able to track themselves with devices that are under the control of one or more corporate entities who almost always build the device software in such as a way as to limit direct access to the "raw" data by those who wear the device. This can happen in so called "autonomous" wearables - those able to run third party applications - and in "basic" wearables that track biometric data and return it to the user with a phone or other app. In both scenarios the data are hashed and perhaps also encrypted using proprietary software making them impossible for the user to read or use (10).¹ Users can download their information once it has been processed by the proprietary software, but not before. As a result, we have created situations where 24/7 surveillance is something that people opt into in order to get access to information about their own bodies and activities.

Given how effective the black-boxing of commercial technology can be, we wanted to create a compelling and effective way to help people visualize the amount of data they were producing in the process of quantification and self-tracking. This builds on work that

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¹The work of Gabi Schaffzin has been instructive in the ways that we might attempt to get at the proprietary data and how limited the possibilities are with current devices. See his work at (10).

Wernimont and colleagues have done elsewhere using haptics and sonification to make invisible data sensible to device users (11), (12). Rather than look to current data visualization technologies, we looked to the past, in particular to the cutting-edge technology of the 15th century and the way that early modern Europeans visualized the body and its boundaries.

A 15th-Century Innovation

While the religious and medical professionals of medieval Europe often wanted to see blood flow (for example, when bloodletting a patient), there was "one group concerned with stopping this red tide in its tracks as quickly as possible" — surgeons (13, p. 176). These surgeons used graphic hand-drawn or engraved pictures known as *Wundenmann*, the "Wound Man," to learn about the kinds of wounds that their patients might present (Figure 1).



FIGURE 1. By Hans von Gersdorff. From Feldtbuch der Wundartzney, newlich getruckt und gebessert (1530). Image courtesy of the Wellcome Collection https://wellcomecollection .org/works/yaw4kj5k.

The earliest known versions of these images appear in late 14th century German texts (13, p. 176). Such images functioned as "a human table of contents" for a surgeon who could then look up the technique needed to address a particular wound and they rhetorically served as a kind of hopeful figure who while wounded was still very much alive (13, p. 178). We wanted to bring the sense of dangerous bleeding forward in order to encourage people to think about the risks of such massive data sharing. We also wanted to embrace the juxtaposition of a barrage of technology (Wound Man was a veritable catalog of not just wounds but the swords, knives, and other tools used to make them) with the sense of hope manifest in the still-living wounded person.

Wound Man was part of a larger medical tradition in medieval and early modern Europe that vacillated between struggling to keep the human body intact and delighting in pulling it apart. Anatomical sciences flourished in the period, creating a new scientific culture of the body in parts, carefully detailed and spectacularly rendered in work by medical artists like Leonardo DaVinci and Andreas Vesalius (14). Wound Man, by contrast, remained stubbornly whole, if punctured, ruptured, and bashed. The various weapons on and around his body have caused him harm, many of them penetrating the previously secure boundary of his flesh, but have not yet led to his death. He also manifests the many assumptions of patriarchal culture about men as martial and as the predominant model for the human body. As with anatomical drawings that were nearly universally male except for instances where an interest in pregnancy demanded the use of a female pregnant body, the only known female version of wound man is a pregnant woman known as "disease woman" who appears in twelve known extant copies and who models diseases and disorders of the body (including pregnancy) rather than wounds (15, p. 153). For centuries, the body of interest was represented as male.

A 21st Century Wound Person

Wound Man provided us with a literal picture of the wounds that surgeons felt were important enough (and fixable enough) to diagram. The wounds on his body were something surgeons could hope to repair and he was accompanied by a table of contents directing the viewer to the instructions for mending that specific wound. Inspired by these early visualizations of bodies, technologies, and certain kinds of injury we created our own diagram designed to show the many sites of intrusion into a 21st century body by wearables — essentially creating a visualization of the sites where data might "bleed" out from a person.

As 21st century researchers, drawings of male bodies are important but incomplete and we sought to produce an image that would disrupt not only the patriarchal "one-body" model of early anatomy but also highlight that while technology is often explicitly sexed (that is, designed with one sex in mind) it does not have to be, nor does it have to be gendered (assumed useful only within a paradigm of male/ female sex). Hence our "Wound Person" has both male and female reproductive organs and devices designed with women and men in mind (as well as devices that might well have been designed without a gender binary in mind).

Selecting Devices Designed to Track

If the body does it, there is a device to measure, track, or quantify it. The "umbrella" of wearable technology includes smartwatches, Bluetooth headphones, and GPS trackers. Many of these are not explicitly designed for self-tracking or quantification, but may still perform these tasks — our smartphones do many things, including counting our steps or engaging with our health data via applications like Apple HeathKit or Samsung Health, for example. For our study, we created our visualization with devices that were

- designed to perform self-tracking, quantified self, or body measurement tasks,
- wearable or that in some way penetrated the body boundary,
- connected to the Internet,
- accompanied by an app,
- commercially available or slated for commercial or institutional use.

A first pass of initial devices that met the above criteria yielded 97 devices, and we chose not to duplicate devices where we had several identical functions (for example, wrist-born fitness trackers). These 97 devices included fertility tracking, blood alcohol monitoring, hydration tracking, and pelvic floor strength trainers (and monitors).

Despite our initial boundaries, as the project evolved, we encountered items that were getting extended media coverage and we wanted to include them as well. For example, we included both the Abilify pill and the smart toilet because they were getting coverage in popular press outlets (16)–(19).

In Table 1, the devices that Wound Person is wearing have been grouped into broad categories with brand names provided in parenthesis where possible.

Devices on a Modern, Adult Body

As discussed, the original Wound Man was explicitly gendered as male, not only in his physical form. In contrast, Wound Person is not explicitly gendered at all, and their physical representation contains a breast, penis, vagina, and a uterus. The devices placed on their body are not limited to those that can be used independent of sex or gender characteristics. Instead, Wound Person is using ovulation trackers, fertility trackers, and erection enhancement devices. As a result of this gender and sexual fluidity, Wound Person demonstrates that vulnerability to data collection is a problem for every body.

Medieval Wound Man was also geographically situated. His wounds and wounding implements represent technology that was available in Western Europe.

TABLE 1. Wearable Devices for Wound Person. Daily Activity and Experience Trackers **Bioenhancement Devices Retina Prosthesis** Stress Tracker (Leaf, Spire) Emotion Tracker (WellBe, Airo) Pace maker Activity Band (FitBit) Posture (Lumo Lift) Insulin Pump Multi-purpose smart devices Brain implant **Google Glass** Cochlear implants Apple Watch Abilify Pill Diet Biomarker/bioactivity trackers **Ovulation tracker (Tempdrop)** Smart weight scale Oral thermometer (Kinsa) Smart fork (Hapi) Waste tracker Ingestion monitor Sexual Health Biome tracker Tension/Erection Ring (Lovely) Embedded tooth food tracker Smart menstrual Cup (Loon Cup) Blood alcohol level Teledildonics **Ovulation tracker (Tempdrop)** Kegel egg (Minna, Perifit) Smart condom Breast pump (Willow) Bra Tracker (OmSignal) Arm blood pressure monitor (Qardio) Smart clothing Leggings (Hexoskin) Vitals patch (OmSignal) Smart H2O bottle (Spring) Running sock (Sensoria) UV sensor (UVSense) Smart pants Smart underwear (Skiin) Institutional trackers Smart shirts (Xenoma, AiQ) Employee tracker Smart ring (Oura)

Smart shoe

Prison ankle monitor

SCRAM



FIGURE 2. "Wound Person." Graphite and pencil on paper. Art by Jacqueline Wernimont, photo by Leah Newsom.

Similarly, our 21st century Wound Person's devices are all widely available in the United States. Devices made by companies like Xiaomi and Huami, two of China's largest suppliers of wearable technology, were not readily available to us as researchers in the U.S. Additionally, we point out that Wound Person is situated in an affluent social context — the abundance of devices on Wound Person reflects a consumer market that supports the development and sale of these devices.

While both Wound Man and Wound Person are clearly adults, many of the devices we encountered also track and quantify children. For example, the Starling is a wearable device that clips on to a baby's clothing and tracks the number of words that the baby is exposed to (20). Other infant wearables like the Mimo and the Owlet track a baby's respiration, sleep cycles, and activity levels. In a future iteration of this project, Wound Person will be accompanied by a child or a baby who is also being extensively tracked.

Data

The image of Wound Person (Figure 3) is presented surrounded by its own table of contents. On the right, there is an abbreviated list of "what it knows about you" in the format "It knows _____.", "It records _____.", or "It is able to _____." The "what it knows list" presented with Wound Person is substantial, including six-ty-seven unique "It knows..." statements that refer to the information gathered explicitly or covertly by the devices. This list of known information is itself drawn from our larger matrix of data gathered by each device (see Figures 4 and 5 below).



FIGURE 3. Wound Person is designed to be shown as a triptych with the device list to the left, figure in center, and "what it knows about you" statements to the right. Details of the device list can be found in the "Selecting Devices Designed to Track" section and "what it knows" list in the "Data" section. Art by Jacqueline Wernimont, photo by Leah Newsom.

All of the devices Wound Person is using are equipped with sensors like microphones and gyroscopes. These sensors detect biological events from the body and the environment. The data collected by sensors is not stored on the devices, but is sent to servers, where software consumes the data and then converts, shapes, transforms, edits, stores, displays, and aggregates it. In Wound Man, once the wound is inflicted, the intrusion is complete and surgeons can begin their work of "stopping the red tide" (13, p. 176). But for Wound Person, the continual collection of biometric and environmental data means that every moment a device is used, it is adding to the corporation's data store. The only way to stop the flow of data from a device is to discontinue its use.

Unlike the fixed amount of blood in a human body (approximately 1.5 gallons for a 180 pound person), there is an unlimited amount of data that can be drawn from a body. As a result, determining what a device and its platform knows about a user is a complicated task. Over a few moments, a device with a gyroscope and a heart rate sensor may be able to determine resting heart rate and number of steps; but over a few months, the associated app can determine your average activity and sleep/wake patterns. In the same way, location tracking for a day may be an invasion of privacy, but location tracking over several weeks will reveal likely locations of home, work, gym, daycare.

If the body does it, there is a device to measure, track, or quantify it.

Additionally, the devices' marketing obfuscates many of the data points they collect. Instead of a list identifying the specific data points used (heart rate, respiration, activity, location), corporations emphasize the user benefits of data collection: "Learn about the quality of your sleep and how it may impact your overall wellbeing" (21). As we made the list of "things it knows," we focused not on biometric details or on marketing-level user benefits, but on straightforward pieces of information that would be accessible to anyone viewing Wound Person, regardless of technical or electronics knowledge. We made a matrix of known things and devices (Figure 4) and used both marketing materials and hardware specifications to match each device to a statement. In this iteration of Wound Person, there are 139 things that are "known" by devices.

Our list includes items common to many healthbased quantification devices as well as more specialized items:

- It records your body composition
- It records how many steps you take each day

Statements	Ava	Oura	SleepScore	QardioArm	Furbo	Petzi	Petcube	Hush	OMSignal	Skiin	Sensoria	Kinsa	QardioScale	NokiaScale	HealthLabs	Hexoskin	Komodo	Athos	Spire	BBLeaf	i.Con	LumoLift	SecuraFone	LoonCup	AppleWatch	SamsungGear
It connects via bluetooth to transmit information.		x						x			x		x				x					x		x	x	x
It records the number of steps you take.									x	x	x								x	x		x	x		x	x
It records how many calories you born.									x	x	x				x	x			x	x		x	x		x	x
It records your heart rate.	x			x					x	x				x		x	x						x		x	x
It records your location throughout the day.												x											x		x	x
It records when you fall asleep.	x	x	x							x						x	x			x					x	x
It records each time you move while you're sleep.	x	x	x							x						x	x			x					x	x
It knows your age.									x	x	x								x	x					x	x
It knows your gender.									x	x	x								x	x					x	x
It connects to Wi-Fi to transmit information.					x	x	x						x		x										x	
It is able to listen to the inside of your house.					x	x	x																		x	
It knows when you are not home.					x	x	x																		x	
It records your respiration rate.			x						x										x				x		x	
It knows if you are pregnant.																									x	
It knows if you are breastfeeding.																									x	
It connects to your Amazon account.							x																		x	

FIGURE 4. This is an enlarged section of the larger matrix included below in Figure 5. As can be seen here, devices are listed across the top and the "It Knows" statements are along the left. While the final mounted triptych did not produce the larger matrix, we want to be able to identify which device captured and shared particular knowledge about the wearer. Matrix created by Nikki Stevens.

	The second se	aceMaker sulinPump utSensor	gestionMoni rainImplant	lassEnterpri isoner nartShoe	CRAM sothFood billty	wiet proutling mo	tarling onbaby Baby	acifi ipiFork illow	rush vie	eilBe	ax neable	ocketFinder uddyTag anderWatch	obit ngelSense	out	Infit	enna en	ecuratione	eepScore	rbo	etzi	tBark tPace	oyce	histle	uzzie nkAKC	etChatz BitAce	abCat Irana
Category / C activity	It records the number of steps you take.	4 5 0	5 8 9	2 2 2 2	N P R	0 2 1	is w s	d I A	¥ B	* 4	631	d B X	14	2 4	4	2 4 I	ă Ō	50		4	Pe	N N	* *	źĴ	Pe	6 6
activity	It records how many calories you burn.			x																						
kids	It records text-based conversations between children	in.										x														
kids	It records when the child fails asleep.																								x	
kids	It records the child's proximity to your phone.												x x													
kids kids	It records the number of steps the child takes. It allows live-listening to the child's surroundings.																								x	
kids	It records the child's typical routine.												* *			x										
location	It records your location throughout the day.			* * *						х 1															×	
milk	It records when you are outside It records how long it takes your body to release im			*				×																		
mik	It records how much milk is expressed at each s itt	12						x																		
mik	It records the length of each pumping session.							X																		
pets	It records when the animal wakes up																				x	×	×	x		
pets	It records when the animal falls asleep.																				x	x	×	x		
pets	It records each time the animal moves. It knows the height, weight, age and sex of the similar	nal																			x	×	×	x		×
pets	It knows how to contact other animal caregivers .	·																			xx	x	x	x		x
pets	It records the animal's body position																				×	ж				
pets	It records the animal's biomarkers (heart rate, te my It records the animal's location	erature, etc))																		×	x	x x	x x		x
pets	It records safezones for the animal									1												x	x x	x x		
pets	It records the temperature of the animal's enviro no	ent																				x	x	x		
pets	It shares the animal's data with others on the so cla	network																				×	×			×
SCX	It records each time you have sex.																									
SEX	It records if you have any sexually transmitted in ife	tions.																								
SEX	It records each position in which you have sex. It records the duration and other data points about	each of your	r sexual end	counters																						
SOX	It records data about male sexual performance.																									
SCK	It records the girth of your penis.																									
sex	It records each time you masterbate. It records when you fail asleep.													×		×	×	×								
sleep	It records each time you move while you're sleep in	2												×		x	×	x								
stress	It records your stress levels.									хх						XX	x									
vaginas	It records the time you wake up It records your pelvic floor force.													xx	×											
vaginas	It records the strength of your pelvic floor								к к						x											
vaginas	It records the duration of each pelvic foor trainining	ession							к х						x											
vagnas	It records the motion of your pervicition It records each of your scheduled meetings.									x					× >											
	It knows how to contact others on your behalf.			x x												,										
a/v	It takes pictures of the inside of your house																		x x	x				x	x	
arv	It is able to listen to the inside of your house It knows when you are not home.			x															xx	x				x	x	x
2	It records motion in your house.																		x x	x					×	x
	It knows how to contact your phone			×															* *	×					×	
alv	It records when numans are moving in your house. It streams video of the inside of your house.																		xx	x					x	
pets	It records when dogs are moving inside your house																		x x	x					x	
alv	It records video of you.																			x					x	
alv	It records audio of you.			×																x					x	
a/v	It records audio of your house.			×																x					x	
a/v	It stores pictures of the inside of your house.																		×	x						
a/v	It streams two-way audio.			х х																			×			
E.	It knows your race.																									
	It knows your age. x	хх																								
baby	It records audio of the baby.																									
child	It records audio of the child.																									
a/v	It records audio of the caregivers.																									
	It knows how to authenticate to your other servicies			x																						
2 bio	It records "real-time concentrations of NO2, VO(2,	M2.5 and P	M10°																							
bio	It records each time you drink alcohol			×																						
pets	It records the anima's "elimination activity"																									
activity	It records each time you do yoga.																									
activity	It records the position of your body.																									
sex	It knows how to contact your current? sexual partn	<i>u</i> .																								
vaginas	It knows when you are on your period.																									
vaginas	It records the amount of menstrual blood your brod	produces																								
vaginas	It records the color of your menstrual blood.																									
vaginas	It records the temperature of your menstrual blo od																									
bio	It records when you take your medication for me int	liiness			x																					
bio	It knows when you are about to have a seizure		x																							
and a start	It monore activities in your out																									
DID	in teces of account of the year	*																								

FIGURE 5. A matrix of devices and user-friendly phrases about the device's data collection. We identified 139 unique "what it knows" statements across all devices.



- It records each time you masturbate
- It knows when you are on your period
- It is able to listen to the inside of your house

As you can see from the scale of the figure below, the range of information gathered by worn or ingested devices is significant. To see the complete matrix, please visit the project page at http://jwernimont.com/ woundperson/.

The Afterlives of Wound Person and Their Data

Despite his many injuries, Wound Man remains stubbornly alive — standing boldly for the viewer. In so doing, "his battered body was ultimately an imaginative and arresting herald of the different types of powerful knowledge that could be channeled and dispensed through the medieval surgeon" (13, p. 179). Wound Man not only visualized the impact of medieval martial technology, he also visualized the wounds that a contemporary surgeon could heal. He was at once a symbol of the disturbing breaches that war or battle could inflict on

The only way to stem the data bleeding from the use of a digital device — is to discontinue using the device.

the human body *and* of the immense power of professional knowledge capable of stitching the body together again until is seemed whole one more. What would the equivalent healing look like for our Wound Person? Who is the surgeon figure in our 21st century context and does their knowledge also promise the reintegration of a body punctured, bleeding, and torn?

For Wound Person, implicit knowledge is channeled through the servers of corporations and dispensed in infographics and data visualizations. In our current digital commercial culture, the data that Wound Person generates belongs to the corporations. It may be returned in modified format through an app, but it's been highly processed. Perhaps more troubling is that the knowledge and insights that data provides will remain with the corporations long after Wound Person stops using a device (assuming that opting out is an option, for pacemakers and brain implants, there is no user off-boarding process). Even if Wound Person were to delete their account, many platforms would simply disconnect the user login record from the other userspecific data records. This would prevent Wound Person from logging in, but enable the corporation to use Wound Person's data to inform aggregate knowledge operations. Where the powerful knowledge of Wound Man was "channeled and dispensed" through the medieval surgeon, the information ecology is different for

In our current digital commercial culture, the data generated by Wound Person belongs to the corporations.

Wound Person. Their data bleeds out to the corporate servers, portions of it are returned or "dispensed" back via applications, but it's not at all clear that Wound Person is as they were before. Instead, data traces remain perpetually separated — channeled to corporations and held captive for other uses. The knowledge circuit of the 21st century Wound Person differs from that of their medieval predecessor and given the power of that knowledge, both in terms of actionable information and individual security, we would do well to more fully articulate that circuit for all to see.

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