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Theorising Personal Medical Devices

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Introduction

The overarching aim of this chapter is to make sense of Personal Medical Devices (PMDs) from a social science perspective. To do this, I consider both the nature of technology and the active role it plays in the construction of self and society. I begin by introducing standard sociological definitions of technology in order to bring conceptual clarity to the subject area. Five are offered: technology as objects, activities, forms of knowledge, modes of organisation and their combination within complex systems. Having said what technology *is*, I go on to note the issues that preoccupy theorists of technology today. I examine the politics of technology, technology's place within power relations, and its role in both personal and collective well-being. This forms part of a broader consideration of what technologies, PMDs included, *do*.

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This is amplified in the following section, which is devoted to the notion of non-human agency. Drawing on actor-network theory, I note four senses in which technologies can be regarded as actors: I argue that technologies make society possible, function as mediators of our world, perform moral and political functions and gather actors from other times and places. The fourth section engages with current debates around technologies and humanity: do technologies enhance or diminish humanity? The fifth section continues this theme: it looks at the ways in which technologies reconfigure identities, roles and social relations. The sixth section discusses the unintended consequences of personal medical devices. These novel vulnerabilities include powerful new forms of surveillance, the literal possibility of ‘life hacking’, and reliance upon critical (and very often frail) infrastructures. While these technologies open up a new ‘biological’ frontier operating between metabolism and mechanism, PMDs map onto old technological impulses to extend human forces and senses, and to help us operate competently in the world. Consequently, I urge us to think of these technologies as prostheses.

Defining Technology: Going Beyond the Thing Itself

This chapter draws on current technological scholarship as a way to both theorise PMDs and discuss the sociological issues and debates that arise from their use. I begin by defining technology. The simplest way to define technology is as objects, which now need to be considered as virtual as well as actual. We should also remember that these objects may be fixed or in flux; software, for example, which helps code ever-greater areas of social life, is virtual, and it tends to upgrade continually. We also need to think about technology as activities (MacKenzie and Wajcman 1985, p. 3). Technologies are normally produced and utilised to create certain effects. In order for these to be realised, we need to know how to use them. This takes us into the realm of technique, which entails right knowing and right doing. Even the simplest tool is useless in the hands of an unskilled user. Three different levels of technology—object, activities

and techniques—have been identified, but it is important to remember that they all combine in use. So, for example, you are reading this book. Reading is the activity, and the book is the object, but it relies on technique-related knowledge too, in this case a working knowledge of the English language. A fourth way of seeing technology is as modes of social organisation (Winner 1977, p. 12). This is a necessary addition, for we live in a world in which complex socio-technical systems inform everything that we do.

The notion of the socio-technical system may be invoked to capture our reality and thus to theorise technology properly. We might think of ‘a’ motor vehicle, but in order for it to operate unproblematically, we require a well-functioning socio-technical system to support it. This system involves such things as roads, signage, street lighting, policing, fuelling and servicing. This in turn relies upon such things as the energy and insurance industries, car manufacturers and numerous regulatory agencies of the state.

The same point holds for PMDs. When we look at ‘a’ device, we end up with a socio-technical system. All the definitions of technology that have been identified come into play. A single device is never just the thing itself; rather, it is composed of multiple components (hardware and software), practices, knowledges, authorities and organisations. This alignment of a large array of actors is necessary to manufacture the device and manage it, the patient, their records, the medical issue the PMD seeks to resolve and so forth. A network is required to select, fit and configure the PMD, to ensure proper monitoring and use, and to provide follow-up, repair or replacement. The first substantive point is therefore somewhat obvious: the theorising of PMDs can never simply focus on the thing itself as an isolated technology. To do so would be to ‘punctualise’ the technology, as John Law (1992, p. 385) puts it, which is to say it would essentially abstract the PMD from the networks that produce, support and regulate it. Punctualisation mistakes technology for a single thing, when in reality it is composed of numerous parts (and systems). Following actor-network theory and social thinking’s general turn to technology, it is now commonplace to see the big picture, to think about how technologies and other agents are something more than the sum of their parts and to note their connections. This involves

locating them within (often very complex) interactive systems and seeing how they are enacted by the networks that sustain them.

In the case of PMDs, complexity exists in their internal components, their bodily connections and their linkages to external systems of maintenance and monitoring. (And we have yet to note the infrastructures that provision energy and communication: power generation systems and the Internet. I note some issues relating to this in the fifth section.) The thing itself may be highly complex, but it is also located upon or within the most complex organic being that exists, and there remains the possibility, at some stage at least, that it will involve a raft of experts within the most complex organisation we have ever created: the hospital (Drucker 2006, p. 54).

Theorising Technology: Five Key Themes

Engagement with the major themes in technological theorising helps us to conceptualise PMDs and to think about the complexities that present themselves when we study them. Here, I suggest that we pay serious attention to the politics of technology (as it relates to form and function); in other words, when thinking about PMDs, we need to think about how, for whom and on what terms they work. Similarly, we need to be mindful of the symbolic and practical elements of these PMDs in order to appreciate what they mean at an individual and collective level.

To begin with, all artefacts have politics. I use ‘politics’ to refer to the operations of power: the ability to control, regulate, settle outcomes and order others. Artefacts are political in two specific senses. The first is in what might be called an *intrinsic* politics: how technologies like PMDs come to appear and perform in the ways that they do. This takes us to the literature on the social construction of technology (SCOT) and critiques of the notion of ‘pure’ technology (Bijker 2010). Against such notions, these sociologists stress the *contingency* of technology. John Law and Wiebe Bijker (1992, p. 3) remind us that ‘they [i.e. technologies] could be otherwise’: the reason being that they are the outcome of compromise. There are competing interests in play, between

designers, engineers, manufacturers, marketers, accountants and so on. Take a hypothetical PMD: a designer will be interested in aesthetics, an engineer in how things will work and how materials will perform, while an accountant is interested in how much it all costs. These competing interests can conflict. Some positions win out over others. Here, it should be noted that different stakeholders have different vested interests, and they may well envisage very different types of end user. And when it comes to medical devices, there is considerable debate as to what constitutes a user (see Shah and Robinson 2008).

Then, there are what might be called the *extrinsic* politics of artefacts. Technologies are always designed to do certain things: to help or hinder, to liberate or control and to enable or constrain. Technologies channel action: they permit some behaviours but prevent others. As such, they have a morality to them (Latour 2002a). Sociologically, this brings up numerous questions relating to power, such as what is being decided, and by whom (Pfaffenberger 1992)? Which groups and individuals are advantaged, which disadvantaged, and with what consequences?

The second theme flows on from the first. If technologies shape behaviour, if they have a role in constraining, affording and generally shaping our conduct, then they have an expressly political function. Heed must be paid to the materiality of power, the ways in which power works through objects and organisations (I discuss this in more detail in Matthewman 2011, pp. 70–91). Langdon Winner (1980, p. 128) is insightful here. He concludes that technologies are ways of structuring the world and that divisive or unifying issues are settled both in the formal realm of politics proper and informally through technology, ‘in tangible arrangements of steel and concrete, wires and transistors, nuts and bolts’. Winner wants us to think of technologies as new forms of social power, and like those older orderings, as the equivalent of legislative acts.

But in technology, as in formal politics, settlement is only ever a temporary accomplishment. Do today’s technologies ever stabilise? Mobile phones originally projected voices. Then, they started to send text. Now, they take photographs, play music, relay moving images, store data and surf the web (Khoo 2005). It should also be acknowledged that stability, when it does emerge, requires ongoing effort. For this reason, Bruno

Latour (2005, p. 143) says that ‘work-net’ might be a preferable term to ‘network’ because it foregrounds the labour involved in successfully tying people, institutions and technologies together.

The third theme is subjectivity and technology. If a complex area is reduced to a single question, it can be posed thus: to what extent do technologies make us? How are humans shaped, informed or—thinking about pharmaceuticals and PMDs—even *performed* by technologies of various types? The notion of performance came to prominence through posthuman scholarship, which heralded a move away from representational modes of analysis that merely described reality. In contrast, posthumanist accounts look to explore the ways in which reality is achieved, how it is made in practice and how the world is constructed (Barad 2003, p. 802). This helped bring new attention to the place of technology within explanatory schema. Social theory had tended to regard technology as passive. It was largely given a symbolic role. The posthumanist turn helped stress the material properties of technologies and their ability to exert agency. What sort of person are you, say, minus mobile devices, access to social networking sites or various medicines? (I will return to these issues in the following section on technology and mediation.)

Technological use beyond narrowly instrumental purposes should also be signalled. Technologies can be freighted with symbolism, as earlier theorising has noted. Any watch will mark time, but a luxury watch simultaneously marks status. Technologies charm and are used for a variety of reasons, not all of which are narrowly functional (e.g. emotional appeal or aesthetic quality). Many devices, some PMDs included, are marketed on the twin promises of fashion and fun.

Notions of personhood have always been technologically inflected. The emergence of Web 2.0 produced websites stressing ‘writable’ user-generated content, social networking, simplicity of use and ease of interaction with other technologies and systems. Here, Facebook is a good example. In contrast to the ‘readable’ information portals of Web 1.0 like personal web pages, Web 2.0 sites emphasise active use over passive consumption and cooperation over control. These platforms have in turn enabled Health 2.0. This refers to products, services and information relating to health—care workers, patients and researchers, and

includes such things as online patient communities and telemedicine. They provide new outlets to express feelings, find community, seek medical advice and exchange information. The proliferation of Web 2.0, mobile technologies and PMDs has also served to further blur the subject/object, self/social, private/public, individual/environment distinctions upon which classical social analysis was founded. Indeed, thanks to such technologies, theorists have announced new ways of being, heralding such things as the emergence of a networked self (Rotman 2008), tethered self (Turkle 2006) and quantified self (Lupton 2013).

This leads into our fourth theme: technology and society. If technology has an important role to play in the formation of individual subjectivity, and in the creation of social selves; if technology channels individual and collective action; if it acts, and if it is implicated in power relations, then it plays important roles *within* society. After all, we relate with, to and through technologies. It is within us (in thought, in some PMDs, through vaccinations), and on us (as contact lenses, clothing, glasses and hearing aids); it exists through us (in language, gesture and technique) and around us (as pills, ambulances and hospitals). Just as technologies play a crucial role in the construction of individual subjects, they also play their part in the construction of society. Early sociology proffered the notion of *social* construction. It suggested that society was ‘built’ on moral orders and shared social bonds. Contemporary sociology suggests that we take notions of construction more literally. It stresses material properties instead of social projections. It looks at the ways in which society is built, secured and transformed *with* technologies.

The fifth theme is non-human agency. Thinking about the materiality of power, and debates relating to technology’s role in the maintenance of social order, forces us to think about what it is that technologies actually *do*. To what extent can they be said to *act*? To answer this, we must trace their effects. This will allow us to assess the ways in which they challenge or contribute to the order of things and to human being. Winner (1977), for instance, suggests that we think about technologies as forms of life. In the following section, I further develop the theme of technological agency by discussing technology’s role as mediator. In other words, technologies are shown to materially alter our existence in the world.

Non-human Agency: The Mediating Role of Technology

From the previous section, it can be seen that technologies clearly do things: they channel action, perform political functions and play a part in individual and group identities. Scholars have recognised this. Technologies are no longer ‘the missing masses’ of social theory, relegated to merely symbolic value (Latour 1992). Matter now matters (Connor 2008). The non-humans have been let in. In this section, I ask: what exactly do they do? How do they exert agency? To clarify, Edwin Sayes (2014) distils decades of the teachings of actor-network theory down to four distinct ways in which technologies actively contribute to social life.

First, technology should be seen as the condition for the possibility of society. This was our closing point in the previous section. Technologies help make society possible; they give it its sturdiness, making social life both stable and predictable. Bruno Latour (2002b, p. 10) writes: ‘It is only because there exist *long lasting physical ... structures such as buildings, houses, paintings, large stones* etc. that it is possible to entertain at all the notion of a society overarching individual and local interactions. Without the existence of a material artefactual world of things’, he says, ‘it would almost be impossible for us, anatomically modern humans, to think at all about society’. As we will shortly see, this statement does not only apply to modern humans. As a species, we have always evolved with, and been enhanced by, our technologies. There has never been a time when human beings have been without technological assistance. Nor does Latour’s point apply to artefacts and architectures alone; it also holds for our other defining elements of technology: institutions and organisations.

It is possible to observe group organisation that is socially and politically complex minus tools or technology of any type. Under such conditions, relations are friable, and consequently in need of constant maintenance and repair. But such observations are not made of humans. Does this mean that traditional sociology is useless? No, answer actor-network theorists, it is perfectly adequate for baboons (Callon and Latour 1981). The first thing that technologies do, then, is stabilise society.

Second, technologies do not just transport or channel action—they do something more. They materially alter associations and interactions. They have effects of their own. Technologies mediate between the physical world and culture, between matter and meaning. Thus, says philosopher Peter-Paul Verbeek (2005, p. 114), '[w]hat humans are and what their world is receive their form by artifactual mediation. Mediation does not simply take place *between* a subject and an object, but rather *coshapes* subjectivity and objectivity'. So, we should not think of technologies as neutral intermediaries interposed between humans and the physical world. Instead, we should see them as fully blown mediators affecting what it is to be in the world. Verbeek uses the example of a simple prosthesis: wearing glasses. When he wears his glasses, he is different. Glasses give him additional competencies and experiences. Without his glasses, some activities like writing are more difficult, while others like driving and piano playing are simply not possible.

Latour (1999) argues that technologies primarily permit mediation, in several senses. Technologies create interference. They create new programmes of action, new possibilities: you are a different person with a foot drop implant, gastric simulator, insulin pump or pacemaker. Technologies provide for new distributed practices, new compositions and new associations. They afford the exchange of performances and competencies. So, for example, a technology might do what a human once did. A doorperson can be replaced by an automatic door opener. Similarly, a technology might substitute for a human organ. A pacemaker does what a well-functioning heart would—specifically, what the electrical signals in the sinus or sinoatrial nodes would.

Third, non-humans are members of moral and political associations. We might think of this as morality materialised. We often get told to do things: drive slower, lose weight, stop smoking. These are inter-subjective commands; we may obey or not. To firm them up, they are often backed by political authority—the authority of the state, the force of the law. Thus, we get seat belt legislation, speeding tickets, smoking bans and other things such as driver education and smoking cessation programmes. Technologies enter too. Inter-subjective commands are woven in with inter-objective demands, and they become all the more compelling for it. Social norms and legal sanctions are strengthened by

things. Computerised voices tell us off for not putting our seat belts on, beeps sound continuously, and the ignition refuses to work. The car is inoperable. Sensors encode morality. If I refuse to wear my seat belt, my car refuses to start. Dissent is not an option. Technologies perform regulatory roles. And not just in the realm of extrinsic politics—life ‘out there’—but, thanks to PMDs, also in terms of intrinsic political roles, regulating life ‘in here’, too. They stabilise society, and they stabilise the self. Take, for instance, a news story of a woman who had endured years of incapacitating acid reflux. This made every meal a misery, disturbed her sleep and all but destroyed her social life. As part of a global trial, she was implanted with a device whose electric pulses stimulate the muscle valve at the base of the oesophagus, preventing or minimising reflux. Following the operation, food is now approached with pleasure rather than dread, and sleep is unproblematic. The newspaper headline ran: ‘Implant Gives Reflux Sufferer Her Life Back’ (Morton 2014).

Fourth, non-humans should be seen as gatherings. The limits of non-human agency should also be noted. Technologies do not have purpose and will and a sense of justice precisely as humans do, but they do still play a significant role in human associations. Non-humans gather actors from other times and places in a structured network. One of the implications here is that actors can act—which is to say, exert influence—when not present. Technologies extend us, which is one of the reasons for theorising them as prosthetics. Another point to reiterate is that any single thing only acts because of the other non-humans and humans that are associated with it. This was our point regarding socio-technical systems.

Latour (2002a, p. 249) uses the simple example of a hammer as a way of thinking about how technologies fold time and space. On the issue of time, the minerals in its composition are as old as the world itself, the wood in the handle will be of a significantly lesser age, and the time since it left the factory is less still. Latour’s hammer holds together a German forest (the raw material for the shaft), a German mine (the raw material for the head), a German factory (the site of the hammer’s production) and a French work van (the place of its sale). I would add something which Latour overlooks: the factory also folds in relation to production. Technologies delegate. They cross boundaries between

symbols and things, and importantly they do the work that humans would otherwise have to do (and in the case of some PMDs like pace-makers, work that we can no longer do).

Technology, Life Itself and Life as Such

I have argued that individuals and individual technologies can be seen as network effects, enacted (or performed) by their socio-technical relations. This is a call for theorists to see the big picture, a point made in the preceding three sections. This section continues the theme by looking at the technology/politics/morality nexus today. In other words, I historicise the discussion by pausing to consider the contemporary human condition.

There has been a long-standing humanist tradition in which the actions (or consequences) of technology are greatly feared, the typical argument being that emerging technologies, whatever they may be, diminish our humanity. The fundamental question of what it is to be human underpins much of this. One of the most enduring motifs within technological theorising, and one of the longest voiced concerns, is that modern technologies are essentially dehumanising. This can be found in the work of Karl Marx on the rise of the objective machines of industrial modernity. Suddenly, the worker was reduced to a cog in the industrial apparatus, rather than being its controller. Equally, it can be found in some current theorising on the ‘inner net’ of the sensor society which we address in the section after next (Andrejevich and Burdon 2014; Turkle 2011).

PMDs are equally open to fears that we have somehow ceded agency, that we are no longer in control. Here, other concerns can be added that they threaten to extend life beyond natural life, whatever ‘natural’ life may be, or that they will extend humans beyond humans. Technological advances often lead to anxieties that we are going into a realm in which we do not properly belong, with consequent moral and ethical costs. Here, we can also note the costs accruing from the current political and demographic landscape, for in an age of austerity and with an ageing population, we are also talking about significant financial

costs too. Interestingly, they are often advocated by those seeking to make savings (West 2013).

It may be helpful to note at this point that there is nothing new about arguments that technological advance is transgressing our humanity. Indeed, we have always used technology prosthetically, to go beyond ourselves, to surpass our physical limits. It is worth stressing that *this is one of the very points of technology*. As a species, we continue to extend our forces and, as Marshall McLuhan (2005, pp. 48–49) noted, since the electronic age, our senses as well.

Nigel Thrift (2005, p. 155) argues that throughout our history, there have been three great extensions of humans: the first was through writing, the second through machines (hardware) and the third through software. A number of PMDs are very much part of this third great extension (although they rely on the other two). And it is worth remembering that while they provide the prospect of new or prolonged ways of being in the world, they are very much part of an old debate.

As a counter to those arguments asserting technological degradation, a case can be made for technology as that which makes us human. Philosopher Bernard Stiegler (1998) argues that ours is a life form like no other, unique in that we are not simply life itself, but life always supported by, and dependent upon, technics. Stiegler uses ‘technics’ to denote the artificial, the inorganic, the technological, and through what they enable, the horizon of what is possible. We can think about this by going back to technology’s very origins.

The oldest known technological object is a stone tool, found in the Olduvai Gorge in the East African Rift Valley, Tanzania (estimated age 1.8–2 million years old). The archaeological record shows that we have been using tools ever since. In fact, some suggest that we have been using tools for significantly longer, perhaps as long as 3.4 million years, which would mean that tool use precedes our own genus (Wong 2010). From the point of simplest tool use onwards, our evolution ceased to be merely genetic. It incorporated a ‘new system of inheritance based not on the transmission of genes but of technical artefacts’ (Stiegler 2011). Conceiving, creating and utilising technological objects have played a pivotal role in the development of our humanity: our history is entangled with technology. Some other animals use rudimentary objects,

but no species other than the human species has constructed a complex socio-technical system. And in terms of object use, only humans manufacture them before they need them, exhibit an endless desire to improve them, anticipate their effects before they apply them and retain them for future use. Technology, then, is the difference that makes the difference: 'From the point where our ancestors started making tools ... people have been unable to survive without the things they make; in this sense, it is making things that makes us human' (MacGregor 2010, p. 13).

There is, of course, a world of difference between the Stone Age society and contemporary existence, and as such Stiegler's philosophical abstractions on technology and humanity should be anchored in history and politics. Here, the suggestion is to locate discussions of PMDs and technology more broadly within the regimes that Nikolas Rose (2001) referred to as 'life itself' and to what Didier Fassin (2009) called 'life as such'.

Political authorities in Western societies have been deeply interested in the health and well-being of the population as a whole for the best part of a century and a half, as marked by the rise of the human and life sciences and clinical medicine, and the range of administrative practices from accident prevention all the way to town planning. In the academic literature, this has been most famously captured by Michel Foucault's (2010) scholarship on governmentality, which at once speaks to the art of government, the production of ideal populations, and the modes by which they are rendered governable. This is often described by another Foucauldian term: biopolitics (for an extended meditation on this see Lemke 2011).

This tracking of morbidity and mortality and targeted interventions to reduce their aggregate levels gave rise to a 'vital' politics (Rose 2001, p. 7). (I discuss vital technologies in the next section.) The older eugenic models based on notions of the defective have been displaced today by actuarial models based on risk. The growing salience of biotech and Big Pharma also means that interventions take place at the molecular level. Contemporary notions of selfhood also figure here: sociologists argue that the modern self is a project to be endlessly worked upon (Lawler 2014; Rose 2001, p. 18). To this, we must add the power of advertising

in today's so-called consumer society, and the general ethos of neoliberalism whose politics have dominated for decades in most Western societies. Both exhort individuals to seek solutions to their problems through market mechanisms: we should buy the answers to our problems. Thus, we take pills to replace hormones, but we also take them to improve our fitness, lift our mood and enhance our sex drive.

From this, Rose concludes that what is significant about 'life itself' in our own times is the collapsing distinction between two things: (i) treatment and enhancement, and (ii) the natural and the prosthetic (which is where PMDs figure). He adds that management and enhancement of life is not simply the responsibility of the individual, but of their doctors *as well as* scientists, entrepreneurs and companies 'who make the reworking of life the object of their knowledge, inventions and products. Natural life can no longer serve as the ground or norm against which a politics of life may be judged' (Rose 2001, p. 17).

I reserve some scepticism towards the notion of 'natural life': what is it and when was it? But Rose's point that biomedical advances are giving us a range of choices that we never had before seems incontestable. With this in mind, it seems fruitful to refer to Didier Fassin's (2009) alternative anthropology of life, which he calls 'life as such'. This seems particularly apt given our knowledge of the social determinants of health and given the hitherto unprecedented health disparities within Western nations, as well as between West and rest. Fassin (2009, p. 48) draws our attention 'to life as the course of events which occurs from birth to death, which can be shortened by political or structural violence, which can be prolonged by health or social policies, which gives place to cultural interpretations and moral decisions, which may be told or written—life which is lived through a body (not only through cells) and as a society (not only as a species)'.

It strikes me as being important to think through PMDs as embodied experience, and in relation to the connections between self and society, as well as in terms of human dignity: who deserves these technologies, who decides who can have them, and what level of care is received? As Fassin (2009, p. 57) writes, 'What politics does to life—and lives—is not just a question of discourses and technologies,

of strategies and tactics. It is also a question of the concrete way in which individuals and groups are treated, under which principles and in the name of which morals, implying which inequalities and misrecognitions’.

New Technologies, New Distributions, New Challenges

In this section, I look at how PMDs act, giving particular emphasis to the ways that new PMDs can change scales, social forces, relations and conditions. I begin with the work of Marshall McLuhan. McLuhan (2005, p. 57) was well aware of the notion of technological agency and the consequences of technological adoption. He claimed that each new technological innovation creates its own environment. In follow-up work with son Eric, McLuhan identified a tetrad of scientific laws that they claimed applied to any media, indeed any technology. McLuhan and McLuhan (1988, p. 7) argue that we interrogate our technologies by asking of them: what do they intensify? What do they displace? What do they recapture? And what eventuates when they are pushed to extremes?

Their thinking can be applied to PMDs. Here, I reflect on debates regarding cochlear implants. In a strict biomedical sense, deafness may be seen as a disability, whereas for many insiders within the deaf community it is simply another way of being. Deafness is its own culture with its own mode of communication (particularly sign language). Seen thus, we are dealing with difference, not disability. And from this perspective, cochlear implants, when pushed to extremes (i.e. widespread mandatory use), would result in the destruction of deaf culture as it is currently practised. This would be nothing short of an act of cultural genocide. Recalling Fassin’s points in the previous section, vital politics could here be read as a form of structural violence. Just because a technology allows us to do something, it does not follow that we should do it. There are important ethical questions to be addressed. *Can* does not imply *ought*.

We might also think about the McLuhans' points about changed relations and displacement. Amongst other things, the Internet allows for new modes of provision and procurement for medical technologies. This may downgrade, bypass or depersonalise the role of traditional medical authorities. The distribution channels for hearing aids are a case in point. Previously, they had gone through audiologists and other hearing specialists. Increasingly, insurers, pharmacies and large retailers like Wal-mart have moved into this domain. And now they are available through the Internet direct from manufacturers like America Hears and online retailers like Amazon. The technologies now self-program, although remote assistance is available.

Relatedly, the rise of peer-to-peer health care can be noted. According to the findings of the Pew Research Centre's Internet and American Life Project, over a third of all American adults have gone online to figure out a medical problem. From that group, 46% then went on to seek the advice of a medical professional, while 38% concluded that such actions were unnecessary. The Pew Research suggests that we are witnessing the rise of 'online diagnostors', who follow a certain pattern: they are more likely to be female than male, young than old, college-educated than not, and white rather than from an ethnic minority (Fox and Duggan 2013).

What this trend actually means is harder to say. The study cannot tell us if this trend is positive, negative or neutral, or for whom. They also remind readers that people have always reflected on the need for medical consultation, and it is only after a period of deliberation that most people go on to do so. (They can tell us that 70% of US adults sought information, care or support from a doctor or other health-care professional when a serious health issue presented.) Perhaps, then, the Internet merely adds another element to this process. It may even be considered a PMD in its own right. Perhaps, the Internet does just that, says Christine Moyer (2012) in a post on *American Medical News*, but physicians often argue that reading medical information online results in misdiagnosis and raised levels of anxiety. Plus, there is one diagnosis that patients are sure to miss: 'cyberchondria'.

There is one final point to be made about the potential of PMDs to redistribute relations. There are occasions when PMDs work too well, e.g.

when they are seen to prolong life-beyond-life. In such cases, complex ethical issues are brought up. Phillipa Malpas and Lisa Cooper (2012) discuss a New Zealand case in which a 75-year-old pacing-dependent woman was brought to the accident and emergency department of a public hospital. She had a brain injury and was in a coma, and it was thought that she would remain so until death by organ failure. The family requested that her pacemaker be deactivated. After some deliberations, the senior cardiac physiologist then reprogrammed the pacemaker to non-functioning mode. (will we see a growing role for technicians in this area?). The patient died shortly thereafter. The decision was made by assessing the clinical reality of her situation, her likely prognosis, the wishes of her husband and immediate family, and also their opinions of what they thought the patient would have wanted had they been able to articulate their own wishes. There was also a consultation with the hospital's legal team.

There have been suggestions in the literature that this constitutes a form of euthanasia. Expert bodies deny this. But it does seem that pacemakers may constitute a special case in the world of PMDs. L.A. Jansen (2006) makes precisely this argument, for three reasons: (1) spatial location—they are part of us, literally under our skin; (2) temporal duration—how long they have been part of us; and (3) they are life-sustaining. As Malpas and Cooper (2012) write, 'they are viewed as being part of the person's self'. On their view, stopping a pacemaker can be likened to hastening death by interfering with a patient's heart.

Technologies and Unintended Consequences: Lifhacking in the Sensor Society

This final section of my discussion thinks further through the social implications of these new technologies, their forms of monitoring and the technological systems that sustain them. It offers comment on subjectivity, social research, system abuse through surveillance and hacking, and (recalling our earlier points about thinking beyond the thing itself to consider supporting socio-technical systems) infrastructural provision.

Health apps and wearable technologies sell in their millions and make billions. Market research firm Markets and Markets (2015) produced a study predicting the mHealth market—which consists of connected devices, apps and monitoring services—to be worth almost \$60 billion by 2020. (By comparison, it was worth just over \$14 billion in 2015.) They highlight a number of related factors to account for this spectacular growth. In particular, they signal the growing number of smart devices, the enhanced use of connected medical devices and mHealth apps in health-care management (chronic diseases in particular), the increasing costs of health care (which incentivises cheaper treatment possibilities), the growing penetration of 3G and 4G networks and greater emphasis on patient-centred health-care provision.

Currently, the general health-care and fitness apps sector dominates the market. These PMDs offer new ways of knowing thyself, particularly the lifestyle ones which are sold (and bought) on the promise of empowerment (see Fitbit 2016). But what one has no way of knowing is the security of one's personal data, what 'normality' one is being measured against, the populations from which this benchmark data is derived, or the social assumptions that are built into the software's algorithms. Thinking back to our earlier point about the morality of technology, when we look at what gets built into health-monitoring technologies, we frequently find that the assumed user is a fit, white, middle-class male in the Global North (Lupton 2016). This, of course, assumes access, and access assumes both the necessary infrastructure to support it (e.g. Internet provision) and the ability to afford it as well as the apps and devices it enables. PMDs are therefore likely to open up yet another frontier of the digital divide, and be yet another means by which inequalities manifest.

Self-monitoring for health purposes is by no means new (Crawford et al. 2015), but M. Andrejevic and M. Burdon (2014) suggest that two connected trends most certainly are, and together they are transforming the worlds of information processing and surveillance. One is the proliferation of sensor technologies, those interactive networked devices that record and relay information, and the other is the rise of Big Data. An IBM (2013) report claims that 90% of the planet's stored data was created in the last 10 years.

When Sherry Turkle (2006) talked about ‘the tethered self’, it was largely in terms of our attachment to mobile devices. They are always on and always on us (and increasingly inside us). To which an important component must be added: they are always monitoring us too. This also creates new ways of being known. If technologies are implicated in the construction of society, we might reasonably ask what sort of world these technologies are helping to establish. For Andrejevic and Burdon (2014), ubiquitous media technologies and growing modes of data capture are contributing to the emergence of a new ‘sensor society’.

Whereas the surveillance of old was discrete, targeted and purposeful (we may even say exceptional), the new sensor society continuously accumulates information: *It’s the rule*. Data-mining displaces searching, patterns replace people. But this new logic of computation is somewhat opaque. The purposes for which information will be used, how it will be analysed and what will be discovered are all unclear, at least to individual users.

That there are powerful discoveries to be made is clear. Alex Pentland of the Massachusetts Institute of Technology tracked 60 families living in campus quarters using sensors and software in their smartphones. Records were made of movements, meetings, moods, physical health, social and spending habits. One of the claims made by this study is that ‘[b]y analyzing changes in movement and communication patterns, researchers could ... detect flu symptoms before the students themselves realized they were getting sick’. Pentland stated: ‘[p]hones can know... People can get this god’s-eye view of human behaviour’ (cited in Hotz 2011).

This gives pause for thought about Big Data. It creates exciting new possibilities, but it also brings new risks. Pentland et al.’s study raises the unnerving possibility that others can come to know us better than we know ourselves. For this reason, many commentators suggest that the rise of these new monitoring technologies is creating the ‘inner net’ as technologies enter us and render more aspects of our being transparent. It has been a fundamental axiom of social science research that subjects are expert in their own lives. Implicit within Andrejevic and Burdon’s (2014) piece is the suggestion that researchers will be less interested in soliciting subject beliefs. In preference, we will track behaviours.

Positivism 2.0 will follow a new logic of computation and find truth in the numbers. Andrejevic and Burdon signal alarm at the new and powerful forms of surveillance, the God's-eye view that the sensor society can give rise to. Who is watching? Why? What powerful new forms of information are they in possession of? They also worry about privacy issues: patterns, signals and digital traces can all be tracked back to individuals.

Marc Goodman (2012) offers further points on the downside of the Big Data digital revolution in his article 'Dark Data', reminding us that no technology has ever been produced that has not been hacked. Here, the Sony Playstation hack serves as a worrying precedent: 'more than 100 million people had their accounts compromised and their passwords stolen. Never before in human history has it been possible for one person to rob 100 million people—but our interconnectedness and mass data storage now make this possible' (Goodman 2012, p. 76). We are very used to ideas of identity theft and online fraud. But with the increased, and increasingly intimate, knowledge that accrues about us in the sensor society, it seems that we are exposing ourselves (or being exposed by others) in profoundly new ways. We can change a password easily enough, but not our gender, and certainly not our height or blood group. And we might think about all those traces of us that get stored in various (and never totally secure) databases. The traffic between data centres is growing at a faster rate than the traffic from and to end-users (Mills 2013, p. 20).

Ominously, Goodman suggests that we are really only seeing the beginnings of cybercrime. The explosion of medical monitoring technologies—smart bracelets, smart phone apps that measure such parameters as blood sugar levels or brain activity—is particularly concerning. What happens when these technologies get hacked? What also of the swathe of medical implants that transmit digital data: cochlear implants, diabetic pumps, pacemakers and defibrillators? Over 60,000 Americans have pacemakers connected to the Internet. (And globally there are something like 600,000 pacemakers implanted annually.) How would these device users feel about others illegally accessing that data? How

would they feel about the risk of their pacemaker being turned off? The phrase ‘life hacking’ is now commonly heard. It refers to tips and techniques, short cut and tricks through which life is made more productive or efficient. But life can be hacked in more visceral ways. Indeed, PMDs such as insulin pumps, pacemakers and defibrillators have already been hacked (Robertson 2012; Holpuch 2013).

The discussion thus far has conveyed a sense of the frailties inherent in these complex interconnected socio-technical systems. The same issues present in the infrastructures that support them. Energy grids are complex, tightly coupled systems. They are not merely infrastructure; they merit being described as critical infrastructure. Critical infrastructures are large-scale human-built systems that supply continual services central to society’s functioning. Disruptions to critical infrastructures have rippling effects, as they are dynamic and interdependent arrangements. Electricity powers, connects to and synchronises with other systems. Graham (2010, p. 5) argues that it is more apt to think of separate infrastructures as a complex single whole. Blackouts affect pumps, refrigeration, traffic lights, trains and cell phone towers. This has serious consequences for water, waste, food, transportation and communication systems. Modern social life is impossible to imagine without it. Consider how essential electrical power is for the proper functioning of many PMDs. Indeed, PMDs could open up a new front of ‘vital’ technologies. Scholarship on vital technologies grows from the idea that in contemporary society citizenship is simultaneously political and technical, that to be a fully functioning member of society we need access to what Lakoff and Collier (2010) call ‘material systems of circulation’ like water, electrical power and communication systems.

The continuing sophistication and prevalence of electrical appliances only serves to increase our dependence. Here, digitisation is a key factor. In the digital world, interruptions and disturbances less than 1 cycle (1/60th second) can have catastrophic effects. Servers and computers crash; life support machines become their opposite; intensive care operations are compromised, as indeed are all manner of automated machines and microprocessor-based devices (Galvin Electricity Initiative 2011).¹

Conclusion: We have Always been Prosthetic

David Harvey (2014, p. 97) writes that we are at a new point in the history of technological evolution: our technologies are now becoming 'biological' and are acquiring the types of properties that we associate with living organisms. In the case of PMDs, many may also be performing a role normally carried out biologically, and helping organisms to live thereby. These technologies are smart technologies that interact with their environment, self-monitor and sometimes self-repair. Technology, then, is now occupying a strange new domain between what W. Bryan Arthur (2009, p. 200) calls 'metabolism and mechanism'.

But we have always had to rely on things beyond our organic selves in order to survive. We have never been a closed system. This was Stiegler's point: human life has also always been technological. Opening up ourselves to our own reality will hopefully open up the space to properly theorise PMDs. Careful considerations need to be given to them, and we need to ask of PMDs what we would of all other technologies: who gets to access them, who produces them and under what conditions, what issues arise regarding ownership and control, how are they used and abused, and, noting the toxicity of e-waste, how are they to be disposed of? What intended and unintended consequences present themselves?

Medical devices permit competency in the world. We employ them for their efficacy. So it goes with all other technologies. If we think about prostheses in the literal senses of the word, as additions, applications and attachments, would we not say that all technologies are prostheses? They extend our bodies, forces and senses. They mediate our being in the world. Nikolas Rose (2001, p. 16) in a discussion of the transformational properties of drugs noted how they change people and their abilities through linking bodies with chemical actors: 'The body of the diabetic has been prosthetic since the invention of insulin treatment: calculated chemical artificiality here has sought to replace the missing or damaged normativity of the bodies own vital processes'. But if we turn to Stiegler or McLuhan, we could say that *we have always been prosthetic*.

The most famous prosthetic in Graeco-Roman antiquity was Pelops' replacement shoulder, fashioned from ivory. This was mythical, but there are others which arguably were not. In *The Natural History*, Pliny discusses Marcus Sergius, who lost his right hand in battle and had a replacement fashioned from iron. This did not seem to diminish his performance; Pliny felt him unsurpassed in valour.

Two things appeal about this idea of technologies as prosthetics: (1) it can be traced back to the origins of Western civilisation itself, and (2) it places theorising about personal medical devices at the very heart of things. This seems like a good place to end.

Note

1. Elsewhere, I have undertaken work with a colleague predicting increasing numbers of blackouts due to growing uncertainties in supply and growing certainties in demand. Supply will become increasingly precarious because of peak oil, political instability, industry liberalisation and privatisation, the precariousness of energy delivery systems, infrastructural neglect, global warming and the shift to renewable energy resources. Demand will become stronger because of population growth, rising levels of affluence and the consumer 'addictions' which accompany it (Byrd and Matthewman 2014). Curiously, very little health research seems to have been done on the impacts of blackouts. The first literature review on it was produced by Public Health England (Klinger et al. 2014).

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