Chapter 4

Digital research methods and sensor technologies

Rethinking the temporality of digital life[1]

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Abstract

This chapter examines the role of digital sensor technologies in social science research practices. I discuss the ways in which these sensors subvert the slow deliberative time of the 'human' subject and track rhythms beneath the timescale of human consciousness. This kind of research data all too easily joins the accelerated flows of capitalist capture, and we need to find ways to resist that capture. I suggest we rethink the nature of sensor technologies, not as affordances or prosthetic extensions but more in terms of atmospheric media. This opens onto new philosophical frames for technology and helps to theorise biodata as belonging to the environment first and foremost. This chapter explores new forms of presencing that are less individualistic and more ecological, as we study the micro-scale aspects of interaction and practice.

The problem of sense data and method

Research practice has an uncomfortable relationship with method. St. Pierre (2016) critiques the blind trust in qualitative research methods that 'collect' empirical data from interview, observation and other conventional practice. Research methods can be staid and conservative, constraining what we are able to see and say, and confirming what we already know. In this way, research method itself can work against innovation, and curtail rather than serve the study of other practices. Manning states that, 'In working as an apparatus of capture, method gives reason its place in the sun: it diagnoses, it situates, it organizes, and ultimately it surveys and judges' (2016, p. 32). She demands 'an explicit disavowal of method as generator of knowledge' (p. 12). These are strong words, condemning the controlling gesture or intervention pursued in the name of method. In related criticism, Maclure (2013) also raises legitimate concerns, pointing to how the coding of data often entails an act of erasure, when textured qualitative details vanish under the heavy-handed brute force of coding. Echoing this concern, Weaver and Snaza (2017) use the term *methodocentrism* to argue that method has been fetishised and ossified into a set of procedures that exist separately from research events.

It is evident, however, that issues with method stretch well beyond the social sciences. The methodological crisis is much wider and linked in large part to the proliferation of digital technologies and advanced computing power. In 2008, for instance, the chief editor of the popular culture magazine *Wired* infamously declared that big data makes the scientific method obsolete (Anderson 2008). This provocative comment concerns the monumental shift across the sciences as they become increasingly computational and data-driven. Stevens states that the common Baconian image of the scientific method as hypothesis-driven is 'giving way to hypothesis-free experiments' (2013, p. 66). The digital data deluge and information explosion is so extensive, there is common belief that scientists are merely *following* the data, as it generates patterns (Stevens 2013).

In this chapter, I focus on the impact of digital methods in social science research and explore some of the implications of using sensor technologies to study human practices of various kinds. Digital sensor technologies are increasingly part of human activity, embedded in buildings (movement, sound, temperature) and worn on bodies (heart rate, electrodermal activity (EDA), eye-tracking). Many of these operate at scales well below the bandwidth of human consciousness. Biodata typically pathologises individuals and serves the capitalist corporate interests of the control society (Deleuze 1992). Many contemporary biotechnical interventions are harnessed to highly conventional and reductionist models of learning and behaviour. Biotechnologies and 'biopedagogies' are being used with children and adults to track and modify attention, engagement, decision-making, emotional states, motion, performance and creativity (Williamson 2016). The sensor technologies that are central to this kind of research carry serious ethical implications as they permit new levels of intervention into the bodies, mental states and conduct of individuals and groups (Fitzgerald & Callard 2015; Lupton 2014; Nafus 2016; Platoni 2015). However, my intention in this chapter is to move beyond critique and to call for a creative re-engagement with digital sensing technologies, so that computational sensing might better help us understand practice.

I focus in particular on the way sensor technologies change our understanding of practice and raise important questions about the ways we are *present* to each other. I argue that such a re-engagement requires us to recast digital sensing data as belonging first to the environment.

To do this, I work with the ideas of Mark Hansen (2015) and John Protevi (2013) to reclaim sensor data as atmospheric and ecological, in an attempt to open up more ethical approaches to shared response-ability for our collective practices. This involves shifting away from individualistic theories in which biodata is said to belong to the human subject—whether it be through phenomenology or brain-based theories of activity—towards new methods of studying more-than-human ecologies. Conventional ethnographic methods and associated concepts of *embodiment*, *lived experience*

and *situatedness* are not up to the task, but neither are purely biological approaches that envision an all-controlling central nervous system (Wilson 2015). I argue that sensor technologies point to how bodies ruminate differently with the world, underscoring the many different ways *presencing* is distributed across an environment. This new form of presencing draws attention to the diluvian temporality of the digital flood of data as not a directional, irreversible arrow of subjective time, but a multiplicity of heterogeneous flows—stretching, folding, iterative—allowing for lightning fast convergences, short-circuit returns and gradual diffusion. This calls for new perspectives on human practices that bind human and non-human together in reconfigured modes of existence, transforming human experience from an agent-centred perceptual modality to an *unequally* distributed *worldly sensibility* (Hansen 2015).

Digital access to the present moment

Empirical methods in the social sciences, championed since the 1940s, entailed going out and actively collecting data, through interview, observation or survey, and involved reaching out to research participants and obtaining some form of consent to participate (Savage & Burrows 2007). Today, these methods are seen by many as obsolete, in the midst of our current deluge of digital 'social' data. An important methodological shift is occurring in empirical methods, as practices once dominant in the social sciences—the sample survey, the in-depth interview and ethnographic observation—are no longer well suited to current computational culture and the proliferation of both social transactional data and micro-bio data (Rose 2013). Such data is automatically uploaded when we use our phones, computers, banks, coffee shops, toilets, etc. and then packaged, processed and disseminated across widespread circuits of connectivity. If past empiricisms in the social sciences have involved an active retrieval of information and data, this new kind of *passive* data, often offered up without conscious consent, marks a radically different kind of empiricism (Papoulias & Callard 2010). Digital data of this kind does not require a special effort to collect, but is 'the digital by-product of the routine operations of a large capitalist institution' (Savage & Burrows 2007, p. 887).[2]

The data deluge is thus 'reassembling social science methods', and forcing the social sciences to rethink its role in the study of the social, 'as digital devices are increasingly the very stuff of social life' (Ruppert, Law & Savage 2013, p. 24).

Indeed, digital devices have become both the material of social lives and the apparatus that many social researchers are using to understand those social lives. In other words, digital devices are part of the social life of research methods, as much as they are part of social life itself. What such devices do—much like other devices in the history of empiricism—is

actualise relations and connections that are otherwise beyond perception. They are materialisations of a traceable social rendered visible; such devices are actively involved in the production of a new imaginary and ontology of the social (Latour 1998).

The *temporal basis* of this new predicament needs to be addressed. Environmental sensing technologies operate at bandwidths below the human perceptual scale and can feed-back in seemingly instantaneous adaptive ways, influencing human practices without our awareness or conscious consent. The accelerated speeds of our digital sensory milieu subvert the slow deliberative time of human consciousness. The older methods, of interview and ethnography, for instance, tend to assume a phenomenological *present* that can be accessed through the research encounter. These methods operate on the scale of human observation and discursive interaction, assuming that the usual human sensory capacities offer the best insights into human behaviour. The answer may well be to seek a slow science (Stengers 2018). But we also need to explore new forms of *presencing* that are less individualistic and more ecological as we study the micro-scale aspects of interaction and practice. We must think with atmospheric media (McCormack 2018). We need to consider how digital sensing technology inhere in and offer access to new kinds of practices that entail radically different spatio-temporal ways of being together. New research methods and methodologies are needed to help us explore these new spatio-temporal relations.

Hansen (2015) argues that our current digital situation—whereby social data circulates without our conscious engagement—is unique insofar as there is a near synchronising of data gathering and analytics. The feedback loops in 'smart buildings', for instance, allow for temperature, lighting and other environmental factors to be altered in the moment of data collection. Face recognition software that is used to monitor game engagement can modify the game when there is apparent lack of attention on behalf of the player (Nevermindgame.com). Studies of traffic and other human movement throughout cities are similarly sensed and fed-back for immediate processing (analysis) so that the system can be responsive (Banaee, Ahmed & Loutfi 2013; Dyson 2007). These are all industry examples, but similar developments are occurring throughout the social sciences, as disciplinary boundaries are changing. Moreover, as social scientists aim to understand 'social' life, they are compelled to consider the vast array of sensor technologies that now saturate our environments (Nold 2009). These kinds of 'augmented' environments appear to respond to human action instantaneously, generating responses at more-than-human reaction speeds. The increasingly fine-grained temporal acuity of micro-sensory devices shows how many of our conventional observational methods trail behind other more nuanced and rapid flows of sensation now captured by sensor technologies. Micro-sensed data seems to dethrone the deliberative reflective time of the human subject.

This synchronising of stimulus and response is exactly where our nightmares of capitalist exploitation are most pronounced, for this is when ubiquitous assessment becomes total control. The situation could easily become a nightmare where we chase only the simultaneity of sensory solicitation and response, a goal that inevitably serves the 'brutal functionalism' of marketing firms and culture industries (Hansen 2015, p. 58). If we want to reclaim digital insights for more creative efforts, so that computational sensing affords more than corporate interests, then we need to think more creatively about this strange new world of immersive measure (de Freitas 2016a; Hansen 2006; Thacker 2009).

The technosphere

I adopt an expanded definition of *sensor technology* to reference all technologies that indicate sensory data about the body or the environment. This approach turns on a radical rethinking of what constitutes sensation (who owns it, how it works, why it exists and how the digital mutates it). Thousands of different types of digital sensors are currently embedded in buildings and public spaces, worn on persons or carried in mobile phones. These include environmental sensors that register movement, global positioning, temperature, air quality, light, weather patterns and climate, as well as biological sensors that register heart rate, facial expression, identity, affective arousal, eye movement and breath.

Biosensor technologies seem to plug into the human body and access what is sometimes called 'precognitive data'. This data is then typically used in behaviour interventions that are grounded in normative assumptions based on control or correction of bodily phenomena that irritate dominant notions of proper conduct (e.g., 'fidgeting', repetitive gestures, noises, agitation or the turbulence of crowds). Deployments of biotechnologies to track such behaviour are easily and often rightly critiqued on ethical grounds (Gillborn 2016; Satel & Lilienfeld 2013), but it is also important to move beyond the agonistics of critique to creative experimentation and the development of new theory.

Rather than simply dismiss the possibility of a research practice that uses such technologies because they are all too easily appropriated by corporate interest, new theoretical approaches are needed that offer compelling alternative frameworks for making 'sense' of sense data. Hansen (2015) argues that such devices plug into an impersonal 'worldly sensibility', an approach that demands a rethinking of the way that technology operates in the world. He claims that these new digital intrusions 'enjoy a sensory domain all their own' (Hansen 2015, p. 234) and are able to access 'primordial sensibility' (p. 222). This sensibility, however, does not belong to the individual human organism but to the atmospheric conditions. Thus, any corporeal data that is captured does not belong to the body where we found it but is part of the

relational environment. This expands the ethnographic project into more-than-human ecologies. It would then seem that the technical devices 'serve' the more-than-human environment rather than being the prosthetic extensions of the human. We can then study technical being as inherent to the world, rather than solely as human invention.[3]

Hansen's focus is specifically on the affordances of digital technics, and the term 'sensibility' is crucial here. On the one hand, digital sensing technologies produce data that is *about* sensibility, while on the other hand, this data *is* sensibility. Hansen (2015) suggests that this convergence of meaning ('about') and being ('is'), captured uniquely in our current technology, is a distinctive mark of our particular technology. In other words, the digital nature of our current data deluge makes for a singular synchronicity of being and meaning. This kind of saturated digital environment changes the temporality of the present moment. The present seems intensified with a proliferation of feed-back loops, and to spread out across a space that goes well beyond our individual organic bodies. These digital devices seem to be expanding the distribution of more-than-human sensation, rather than mimicking or magnifying human perceptual organs. New mobile media and ubiquitous computing register the 'environmentality' of the world (Hansen 2015, p. 8). One might say that 21st-century technology is resulting in a 'media-driven transformation of human experience itself' and thus a move from an 'agent-centered perceptual modality to an environmental sensibility' (Hansen 2015, p. 8).

This approach to sensor technologies considers sensibility outside the temporality of human consciousness, pointing to how new research methods using these devices might be linked to temporalities that are more-than-human. Hansen treats these biosensors as 'media' and defines media as that which 'operate as instruments that mediate sensibility for experiential achievement' (2015, p. 231). But this achievement is dangerously indifferent to human embodiment. Hansen's method moves 'from perception-centred accounts of experience to a broader understanding of sensibility as the concrete texture of experience across the board' (Hansen 2015, p. 48). Indeed, the very notion of 'lived experience'—as that fundamental focus of most social science research—becomes unrecognisable in a world of microtemporal biometric and environmental data that circulates and is absorbed at rates well below and above the bandwidth of human consciousness.

The crucial thing here is that technology is no longer a surrogate for a human faculty or capacity, but instead operates directly on the sensibility of the *total* environment which precedes and partially animates our own corporeal phenomenal experience. Hansen (2015), however, claims that his position is not anti-human. In fact, he critiques contemporary theorists working on the post-human (including the speculative realist Graham Harman and the new materialist Jane Bennett) for arguing a position that is anti-human. Instead, he sees his work as an attempt to 'grasp the place of

the human within today's media networks' (Hansen 2015, p. 2). He seems to be looking for a 'properly elemental conception of the human':

> [We must] adopt a radically environmental perspective encompassing human activity as one element among others: such a perspective views human agency just as it does any other type of agency, namely, as internally differentiated, dispersed across various scales and operational divisions, and implicated in and immanent to a total, multi-scalar cosmological situation (p. 2).

This suggests the need to conceptualise subjectively as inextricably environmental and in/corporeal.

Microsensors: data-mining the electric body

The Empatica E4 wristband is designed to record continuous *real-time* data during waking or sleeping hours. It contains a three-axis accelerometer that tracks motion, an infrared thermopile to track temperature, a photoplethysmography sensor (PPG) that measures blood volume pulse (BVP), from which heart rate, heart rate variability (HRV) and other cardiovascular features may be derived. It also contains an EDA sensor used to measure sympathetic nervous system *arousal* and to make claims related to stress, engagement and excitement.

In what follows, I draw on and problematise examples of research practice that rely on these devices, revealing how researchers *interpret* sensor data as belonging to individual human organisms and ultimately the central nervous system. EDA is used to study anxiety and engagement, usually according to cognitive psychology assumptions about learning and behaviour. I aim to offer a compelling alternative interpretation. I show how recent work in biology is rethinking the electric body and the nature of the sympathetic nervous system. This raises implications for theorising and practising education research. Central to my argument is the fact that these biosensors are not operating prosthetically, because they engage with the body in a more distributed and unconscious way, and thus have no correlate to the usual embodied organs, but instead seem to transcend the very notion of organism, while still, paradoxically, mobilising embodied forces. Following Hansen, I argue that 21st-century digital media bypass the slow time resolution of human perception, making material contact with the sensory continuum in ways that enact very different human–technology relations:

> The idea, then, is that human experience is undergoing change caused by our entanglement with contemporary media environments, and that the directionality of this transformation inverts the long-standing privilege held by humans as the well-nigh unique addressee of media.
>
> (Hansen 2015, p. 6)

The Affective Computing Lab at MIT (http://affect.media.mit.edu/) uses Empatica bracelets in a multitude of projects to study 'skin conductance' associated with stressful activity, tracking the variability in how people express stress physiologically (Hedman 2018, np). Projects are entirely focused on how such data belongs to an individual human body, and how such data is the expression of affect possessed by that individual human body. In addition, projects affiliated with the lab that are focused on learning assume that such data underscores the cognitive achievements of that individual body. For instance, a study of children as they play with LEGO blocks claims to show that 'children are excited to take on new responsibilities but are then quickly discouraged when they aren't given the resources to succeed' (MIT Media Lab nd, np). They also claim that the children did not always recognise their own achievements, based on the EDA data. In other words, the research suggests that skin conductance is a better or more accurate way of determining when children have accomplished something, rather than facial expression or verbal or other visible activity, and that there is a disconnect between these kinds of data, revealing that children *do not know when to value what they have done*.

The aim of the Lego project is uncritically industry oriented, as the researchers claim that 'by using skin conductance sensors, we can help companies better understand the unique perspective of children and build experiences fit for them' (MIT Media Lab nd, np). This research is thus explicitly invested in using the EDA data to serve corporate interests, as they redesign and 'personalise' learning experiences that maximise the individual child's affective engagement, as well as their accurate evaluation of their embodied actions. These aims together reveal how so much of the EDA research inspired by and emerging from the MIT Affective Computing Group is based on a desire to correlate and also control the degree of intensity in any learning experience and to cultivate self-regulation of affect in children.[4] We see here how this work continues to pathologise the individual learner. My aim is to open up alternative research practices, through the work of Hansen (2015) on new media. Can we reclaim sensor data in more politically inclusive ways?

At MPath, a company that pursues 'Empathic design through rigorous science' (www.buildempathy.com nd, np), EDA data is used to show when people are un/excited, dis/engaged or stressed. In learning experiments, the data is typically used to show when affect interferes with or supports a goal of some kind. MPath interprets fluctuation in skin conductance as evidence of stress, when, for instance, the EDA graph shows a series of hills and troughs during the experiment. They interpret large singular spikes in EDA data as excitement or severe anxiety, and a trailing off of EDA levels as a sign of disengagement. In Figure 4.1, EDA data from a child is shown, while he uses some building blocks with his mother. The EDA data is said to correlate with two possible scenarios: the first tracking positive excitement,

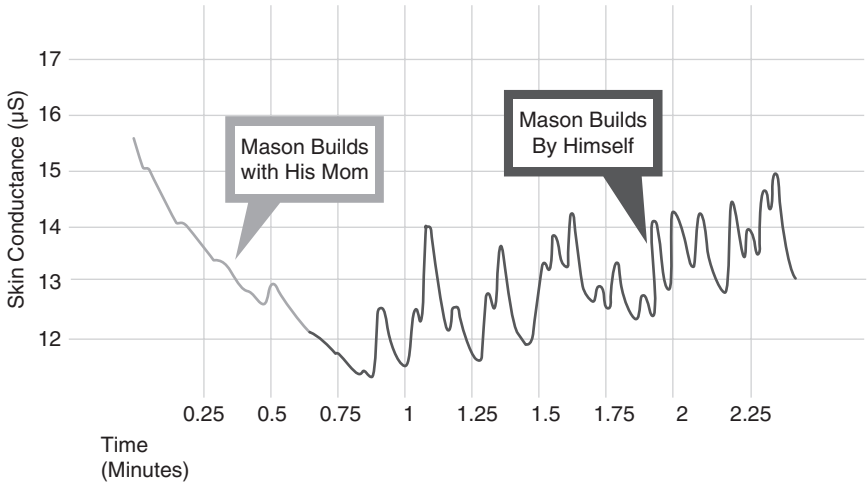

Figure 4.1 Mason watches and then engages in activity.
Source: http://www.buildempathy.com/emototype/.

the second negative anxiety. I wish to emphasise the deeply indeterminate nature of this data and the significance of this for how we understand the time of becoming. *The two standard interpretations underscore the inherent ambivalence of this data*: (1) the falling graph marks the *boredom* of a child as he watches his mother build a block toy, followed by the positive excitement and fluctuation of the EDA when the child works independently. An alternative interpretation of the same data might be (2) the falling graph marks the *calmness* of the child while he watches his mother build a block toy, followed by the negative stress and fluctuation of the EDA when he anxiously builds independently. The data does not definitively indicate one or the other, although the researchers state that the boy Mason 'slouches' and begins chatting about the blocks, losing interest in what his mother is doing during the first minute.

The main textbook on EDA research was written in 1992 by Boucsein, with a second edition released in 2012. EDA is part of a larger set of data—electrodermal biosignals—which are now the most commonly used data in psychophysiology. Despite the widespread use of such data, electrodermal phenomena are not fully understood. EDA refers to all possible electrical dermal data, and thus is at the heart of any kind of research that aims to study the charged nature of our nervous systems. Electrodermal experiments with humans and animals have a long and checkered history, including horrific public displays of the power of electricity to shock animals into submission (or death), and discredited liar detection devices and other experimental instruments said to correlate electric current with social

disposition or competency. Bertucci and Pancaldi (2001) recount episodes in the history of medical electricity, tracking scientific interest in the *electric body* over many centuries. Luigi Galvani's theory of animal electricity, published in 1792, *De viribus electricitatis in motu musculari*, triggered a new line of investigation into electrophysiology that carries on today (Piccolini & Bresadola 2013). Even before its publication, in the mid-18th century, when natural philosophy and medical electricity were forging new kinds of empiricism, electric shocks were administered, using Leydon jars, to *penetrate* the patient's body with whatever medical substance was mixed with the water in the jar. I mention this now debunked work as a reminder of our often unhealthy fascination for the electric body.

My argument, however, is not that the EDA data is evidence of an emotion or affect possessed by the human organism, but that skin conductance can be studied as evidence of the radical exteriority of experience and as evidence of the transitive, relational event-nature of learning. Sensor data is profoundly indeterminate and thereby refuses to belong to any one organism, overturning conventional notions of learning from an agent-centred perceptual modality to an *unequally* distributed 'environmental sensibility' (Hansen 2015, p. 8). This perspective underscores the need to rethink embodiment, and the need to introduce 'a more porous and less self-referential conception of embodiment, a conception that understands the body to be a society of microsensibilities themselves directly and atomically susceptible to technical capture' (Hansen 2015, p. 193). In other words, the data does not belong to the individual organism but is part of a technosphere or 'general ecology' that includes both organic and non-organic life (Hörl 2018, p. 172).

I am interested in the way that EDA data points to alliances that are formed between *internal* organic processes and more distributed processes, associated with networked sociality. Following Elizabeth Wilson (2015), I submit that affects, nerves, cells, skins, buildings and sociality intra-act in just the way that speculative Biology 3.0 might suggest (Stevens 2013). Rather than dismiss EDA data as irrelevant or insignificant, or serving only to individualise and pathologise the learner, I want to trouble the all-too-easy antibiologisms of social theory and explore the entanglements of biochemistry, ecology and learning. My focus on skin conductance is a way of attending to the neurological periphery—the far flung electrical activity of the body—rather than what is assumed to be the centre and administrator of that system, the brain. I see this as a way of reclaiming biosocial data for more politically inclusive aims. I am less interested in the central nervous system (the brain, the spinal cord), than in the 'distributed network of nerves that innervates the periphery' (Wilson 2015, p. 5). The electrical charge that innervates the skin is at the periphery of the human body, but it is as central to the activity of rumination, deliberation and comprehension as the brain. The challenge is how to engage with this EDA

data without, on the one hand, simply acquiescing to the claim that biodata provides a factual foundation for learning theories and, on the other hand, repeating the doxa of social constructivism and simply dismissing such data (Colebrook, 2014).

Wilson shows how the peripheral nervous system actually dominates the central nervous system in the transmission and distribution of crucial biochemical compounds, such as adrenaline and serotonin. She argues that we must no longer treat 'the biological periphery as psychologically inert', nor treat biology itself as inflexible and an obstacle to politics (Wilson 2015, p. 16). Investing in the speculative potential of matter, she uses recent work in physiology to argue that 'biological substance' is as much a 'phantasmatic substance' as it is mechanistic (p. 41). She argues that the so-called biological bedrock of the body is robust with both physical and phantastic capacities, a claim that I unpack somewhat differently below, using Protevi's (2013) interpretation of the virtual. The implications for learning theory are risky, as Wilson calls for the existence of 'organic thought' and the 'biological unconscious', concepts which have an awkward psychoanalytic history (2015, Chapter 2). But these are also concepts that help us problematise the conventional coding of such data in terms of cognitive achievement, or as evidence of an all controlling central nervous system, directing our attention instead to the dispersed nature of affect and thought.

The skin sensors are one way to study this dispersed or distributed phantastic capacity. Indeed the skin occupies the quivering periphery of the *bounded individual* that we take to be the mark of the organ/ism. The EDA skin data is thus perfect for showing how the bounded individual is always being broken down, disassembled, remade, intensified and charged. Rather than treat synapse and society as disjunctive and antagonistic, one can use the EDA data as a way of tracking the blended world of the peripheral nervous system. At the juncture of the skin, are mixtures of synapse, cilia, sweat, mind and society, all percolating. Such a reading of the data might be 'biological but nonlocalized; chemical but nondeterministic; interior yet worldly' (Wilson 2015, p. 106). The data might offer access to the present moment, but only insofar as that present moment is rife with heterogeneous temporalities dispersed across a meshwork of sociality. Here the biological becomes truly ecological, and with that theoretical shift, we find that time and temporality are shredded into a thousand pieces.

The futurity of matter

EDA data is purely differential, insofar as it marks a gradient or rate of change, rather than a definitive quantity that correlates with a particular level of affect (this is why there are at least two interpretations, as discussed above). Measures of electrodermal data track changes in electrical skin

conductance. These changes are linked to the skin's production of sweat, which is itself linked to the sympathetic nervous system, often said to reflect changes in arousal. Researchers distinguish between *phasic* data with lots of peaks that seem to mark arousal, and *tonic* data that record gradual changes in engagement (Kim et al. 2013). The fact that there is always this differential element to the electric body helps us theorise a body that is charged, but never static or still—bodies are related rates of change, each rate itself changing. In other words, becoming is an infinitely differentiated process, a change of a change of a change … involving 2nd, 3rd, and nth derivatives. The peripheral nervous system, extending the body into its frayed periphery, carries charge in nonstop differentiated flows. *It's as if individuation of a body is a massive related rates problem.* Attending to the electro-magnetic field (as that which sustains a body), we can begin to study the provisionality of human bodies, and the microtemporality of boundedness. As Bennett suggests, individuation of bodies 'proceeds at a speed or a level below the threshold of human discernment' (2010, p. 58). EDA points to the different speeds of becoming, and the articulation of bodies as *relations or ratios of speed and rest*.

Biosensors like the Empatica bracelets detect activity below the perceptual threshold of the human. In this vein, the data testifies to processes of becoming that operate at micro-scales. These EDA devices help us track the provisional ground of embodiment but also the distributed and differential nature of individuation. In other words, rather than demonise the technology as an extraction device that fails to capture lived experience, we need to find better ways to think about these new kinds of digital plug-ins, and different ways of understanding the significance of the EDA data.

The concept of *the virtual* is pivotal in clarifying an approach to sensor data that is not reductive scientism, nor mystical occultism, but is rather based on an alternative way of understanding the material force of the body. Following Protevi's (2013) lead,[5] I argue here that Deleuzian notions of *the virtual* and of *intensive individuation* can be used to analyse micro-sensory data. Deleuze (1994) elaborates a distinction between the actual and the virtual, as part of his attempt to build a pluralist ontology, where the virtual refers to the ontogenerative and pre-individuated vitality of the real. By thinking through the role of the virtual in digital sensing data, we can begin to think differently about the *capacity* of a body, and this I believe is crucial in developing a bioethics for biosocial research. Deleuze offers a new way of thinking about bodily capacity, less as a fully individuated possibility awaiting realisation—achieving its teleological goal of actualisation—and more as a live wire or differentiated field of charge. A body's capacity is precisely this terrifying potentiality, this contraction and expansion of forces, this ongoing unexpected worlding. Perception is not the organised synthesis of this sensory surround but involves another differentiation of already differentiated flows. Protevi (2013) characterises this sensory confound by arguing

that perception is not the synthesis or the representation of the complex virtual web but belongs to the environment first:

> Thus an individuated perception does not resemble the distributed and differential brain-body-world system, when that is conceived at the level of a virtual web of linked rates of change of neural, somatic, and environmental processes.
>
> (p. 138. My italics)

For Protevi, recognising a body's capacity involves reclaiming the electrodermal *data* as environmental or ecological rather than only representational of a particular body's properties. But we are still faced with the usual assumption that this micro-sensory activity determines or causes the more macro bodily activity. This notion of *determination* is at the heart of the dilemma concerning our use of biosocial data, haunting all attempts to bring the biological and the social sciences together. Protevi (2013) seems optimistic, arguing that Deleuze's work resonates with many ideas from the 4EA movement—where 4EA designates embodied, embedded, enacted, extended, affective—in embodied cognition, drawing primarily from phenomenology and ecological dynamic systems. But many of these theories still hold to a notion of the biologically prior that determines all biosocial expression. Deleuze's emphasis on a virtual differential potential that is actualised in the machinic phylum undermines this kind of determination and proposes a different process of determination. For Deleuze (1994), determination is a robust process of *different/ciation*, a term he derives from three key ideas in mathematics—the undetermined, reciprocal determination and the potential (see de Freitas 2016c, for a discussion of these terms, derived from mathematics). These three key aspects of Deleuzian determination are crucial for how Deleuze moves away from Kant's 'conditions' of perception, towards an explanation of how new sensations come into the world.[6]

Speeds of becoming

We can begin to grasp the significance of this theoretical shift by turning now to more general considerations of speed and temporality in biometric research. Consider the microtemporal gap that is said to separate neuronal events from consciousness—a missing fraction of a second between brain activation and awareness. Neuroscientists like Antonio Damasio (2003) suggest that this delay undermines the agency of consciousness—it seems as though conscious discernment is simply that which performs or ratifies what has already been *decided* by the brain. For Damasio, this shows how consciousness is an epiphenomenon, or emergent mental state, a belated effect of its material conditions.

This 'fundamental delay' of consciousness in relation to the brain and the body is often cited when researchers work on biodata like that from E4 bracelets. The accelerated speeds of these new biometric devices seem to subvert the slow deliberative time of human consciousness. Following such a reading, we might imagine speeding up humans so that they might simply get faster at becoming. Again, that approach would clearly serve the accelerated interests of advanced capitalism. But perhaps contemporary digital media of this kind 'afford no direct correlation to human perceptual experience whatsoever' (Hansen 2015, p. 247). In other words, perhaps we need to better grasp the *ontological distinctions* that differentiated temporalities produce. Data-gathering from computational microsensors 'modulate[s] worldly sensibility directly' without the human subject necessarily recruiting any value from this activity (ibid). The humans are on the sidelines—they may indeed be affected, but indirectly because this new kind of digital technicity is, according to Hansen, simply better at plugging into a worldly vibrational sensibility. Humans—with their unwieldy organs—simply are not as good at plugging into that vibrational sensibility.

So rather than chase the simultaneity of sensory solicitation and response, a goal that inevitably serves the 'brutal functionalism' of marketing firms, and rather than celebrate the tiny delay as the site of some phenomenological affirmation of our right to slow science, Hansen suggests we study micro-sensory data for how it plugs into the futurity of matter. Rather than look backwards at the assumed-to-be-complete event of human sensation, and our late arrival, look *into* a futural matter that harbours unscripted potential (the virtual).[7] Rather than confine the causal efficacy of sensation to past conditions, take up and analyse the data for how it plugs directly into a robust and ongoing sensibility, a worlding process. The issue is how to avoid or resist the controlling hand of predictive analytics, while still affirming this futural matter. Given how sensor data is already being used to fuel predictive analytics, it seems urgent that we develop this theoretical and practical approach to rethinking the nature of this futurity.

How does the future live in the present moment? Husserl used the concept of *protention* to describe how the living present already includes the tickling agitation of the future. But Hansen (2015) suggests that protention was largely based on the assumption that there was a ground of finite possibilities, assembled into memory banks that were then tapped, perhaps much like many machine learning algorithms today must tap vast amounts of training data before they turn to the act of prediction. For Husserl, the human subject accessed this potentiality in the present moment through ratiocination or heightened consciousness. The future was then a sort of projection or a set of expectations based on mental or conscious reflection on this accumulated past. Instead, Hansen (2015), following Alfred Whitehead's philosophy of nature, argues that the future is felt in the present because the future is literally produced (rather than predicted) through the

real potentiality of matter. That potentiality is felt (by humans) as *intensity* in the present moment. Intensity becomes the key concept for Hansen, as a complex force (from the future) that animates the present moment. Just as for Deleuze the virtual rumbles perception (and calls forth the actual), for Hansen, intensity is the 'vibratory character of actuality' and is the feeling by which we sense the future animating the present moment. The intensity of the present moment 'simply is the index of the power of this potentiality' (Hansen 2015, p. 210).

If there is a vibrant futurity queering time, then we need to rethink forms of *presencing* that are not conventionally phenomenological. The 'present moment' is more or less animated or intensified by an undecidable future, and the sensing of that potentiality might be accessed by other kinds of non-human being. This chapter follows Hansen in suggesting that digital media play a unique role in this situation, as 'the scope of the present depends on the degree of precision of technical access' (2015, p. 195). In other words, the degree of that intensity and the specificity of its affect (joy or fear) depends on our access to a worldly technicity that sustains the undecidability of the future. Research on learning could then attend more carefully to how biosensors are imbricated in worlding processes. I suggest that such a perspective brings forth a new politics more adequate to the ubiquitous computing environments in which we now dwell. Reckoning with this digital data deluge requires a new approach to ecologies of learning. Everything hinges on how well we can live with this 'resolutely technical' matter while resisting the ossifying instrumentality that captures and controls it (Hansen 2015, p. 198).

Concluding thoughts

I argue in this chapter that new research practices need to plug into a more-than-human worldly becoming, as we learn how to 'do' time differently in the current digital data deluge. Focusing on sensor technologies, I argue that these devices subvert the slow deliberative time of the 'human' subject and track rhythms beneath the scale of human consciousness. By studying and speculating about how to work with these devices, we can better understand how the temporal fabric of research method is elastic and responsive, sensitive to the environment in which, and through which, it operates. Rethinking the space-time configurations of embodiment could reveal new kinds of duration and queer temporalities.

This chapter is a call to researchers to pursue counter-deployments of sensory data stolen from skin, neuron, eye and electrical pulse and to build new kinds of research methods that seek the production of intensity while also ensuring an ethical future for labouring human bodies. The concept of intensity plays a pivotal role here, because intensity, rather than perception, better expresses the more-than-human forces operating alongside

the human in today's digital deluge: 'intensity is precisely what is at stake experientially in twenty-first-century media's direct mediation of worldly sensibility' (Hansen 2015, p. 103). Developments in micro-sensory digital technology support post-phenomenological studies of learning environments and demand new analytic frames that better integrate the qualitative with the quantitative (de Freitas 2016a, 2016b).

According to Latour (2010), new mixed methods that better address both the quantitative and qualitative nature of relationality are needed. If in the past, ethnography was said to attend to the particulars of situated individuals through thick description, allowing for an intimacy and proximity that defined qualitative methods, today the digital saturation of most lives brings the quantitative into that proximate fold. If in the past, the quantitative was that model or code that failed to capture the kind of data collected when up close and intimate with a participant, today, the internet has completely altered the nature of proximity and intimacy. Calculations are thus never cut off from the social world, performed in some cold objective way upon the material base (Meloni, Williams & Martin 2016). Ongoing continuous evaluations (*different/ciation*) occur without our wilful participation. This approach to data entails a philosophy of immanence which troubles qual-quant distinctions. In a provocation to all of us, Latour suggests that social scientists have not pursued enough quantification, the infinitesimal kind of quantification that operates well below the narrow bandwidth of human perception. We must, urge Latour and Lépinay, track the proliferation of 'tensors' that carry 'a vast reserve of quantification' (2009, p. 17). Only after multiplying the types of quantum does the quantitative fabric of life come alive. The calculating universe is simply operating at scales that most often escape us, while we wander around within this 'swarming of assessments' (Latour & Lépinay 2009, p. 30).

In turning to the subjective and social nature of the quantitative, I am not positing a *real* that lurks behind the quantitative, or an authentic subject that fails to be captured by measure. Instead I have argued that sensor data is implicated in (rather than explicating of) a direct (but unequal) sharing of worldly sensibility. Reclaiming the quantitative dimension of life is perhaps our best way into the radical rethinking of subjectivity called forth by the digital deluge. Even the most seemingly inert, objectified and datafied event or body is part of a new circuit of sensory links within a qual-quant milieu that is so finely grained (or stretched), we can no longer rely on our conventional metrics (de Freitas, Dixon-Ramon & Lather 2016). This approach aims to rethink the human as an inseparable ingredient of a larger environmental sensory milieu.

My hope is to trigger new methods of inquiry in which sensor technologies might be used differently and inventively (see, for instance, Gabrys 2016). This means studying corporeal data, not only as that which belongs to the body but also as part of the relational environment. As social science research

maps a new biopolitical terrain, I see a need to shift the focus from theories of agent-centred perceptual capacities to theories of worldly sensibility and *environ/mentality*. Through biosocial research, and related policy, people's bodies are being reconfigured and reassembled (Goodman 2013; Gravlee 2009). Sensor data is precisely the kind of data that all too easily joins the accelerated flows of capitalism. For this reason, we need to find new ways of studying the material ecology of learning environments, refusing to package sensation in terms of biomarkers of dis/ability and in/attention. New kinds of questions need to be posed by researchers, questions that can help us build more complex models of the charged environment, to avoid being trapped in overly simplistic models of stimulus–response and to enhance our appreciation for the worldly sensibility that is at stake. This expands our older inquiry practices into studies of more-than-human ecologies. This also involves rethinking the nature of digital biotechnologies, not as affordances or prosthetic extensions, but more in terms of atmospheric media (McCormack 2018). Perhaps we need a kind of social meteorology or geostory to better understand these complex environments (Galloway & Thacker 2007). In other words, technology is not only a human invention but also part of a worldly process of ongoing transformation, part of a more-than-human general technicity (Gane 2005). Looking ahead, into a multifarious future, it seems crucial that we consider how the virtual and the actual are continuously folded and refolded through a worldly technicity that is not only of our own making.

Notes

1 This chapter combines material previously published in two articles: de Freitas (2018) in *Discourse: Studies in the Cultural Politics of Education* and de Freitas (2017) in *Research in Education*.
2 Notably, 2017–2018 findings concerning Cambridge Analytica, and more generally the partnering of academic researchers with companies like Facebook to harvest personal data, underscore the need to grapple with our current digital condition.
3 There are links here to the important work of Gilbert Simondon on the mode of being of the technical object (Simondon, 2017).
4 The lead MIT researcher at the lab, Rosalind Picard, founder of the company Affectiva, is interested in how EDA might help Autists, and people suffering from seizures, anticipate and thereby avoid traumatic incidents. For other examples of research in this area, see Choi, Ahmed and Gutierrez-Osuna (2012); Hernandez et al. (2014); and Sano and Picard (2013).
5 Protevi cites works by Anthony Chemero, Alva Noe and Michael Wheeler. He then adds and complicates this work in embodied cognition by introducing ideas from Gilles Deleuze (in particular the concept of the virtual).
6 Although there is not adequate room here to develop this idea, there are important ways in which the concept of the virtual offers a twist to conventional theories of emergence. There is also increasingly more work on quantum cognition and quantum sociology, offering alternative ways of conceiving of emergence as articulated in dynamic systems theory (see, for instance, Alexander Wendt 2015).

7 Hansen (2015) critiques Deleuze and the concept of the virtual and emphasizes intensity instead. Indeed, Hansen is keen to differentiate himself from many other theorists. Despite these claims, my reading of Deleuze—his work on both virtuality and intensity—shows some points of overlap between these theorists.

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