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## Making Sense of Sensors

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### Abstract

*The paper explores the different projects resulting from a practical workshop on making and hacking biosensors. The projects and the workshop enable a series of reflections about biosensors and their commercial promises and what they might offer to other constituents in digital arts theory and practice. These reflections include issues about expertise and how to “make with sensors,” how inner states of being can be communicated in social situations, non-human relations and the possibility of radical communication beyond the human, and questions about materiality and performance and the role of the manifesto in relation to devices. These points are developed to argue that despite the radical promise of biosensors to offer new forms of communication, the objects they produce often fail. However, the process of design and making opens up questions about the technological horizon and possibilities for connection in a device-orientated culture.*

### Making sense of sensors

In relation to this journal issue on making and hacking, this paper opens up a discussion about hacking into and making biosensors. It does this through an account of a practice workshop and a reflection on materialisation in relation to both technological objects and manifestos. In a recent project between the Digital Arts and New Media Programme (DANM) at the University of California Santa Cruz (UCSC) and the School of Media Film and Music (MFM) at the University of Sussex, we took up the question of making biosensors. The project was spurred by the question of how locked down commercial biosensors are and what hacking and making opportunities they might avail. We proposed looking at biosensors in relation to the question of how they might be used to vector communication between humans, non-humans and environment through a practice workshop that aimed to use maker kits for sensing

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projects. The ensuing event brought together a mix of people at UCSC, from both institutions, and beyond. This included PhD students and academics from different disciplines, together with a workspace, a workshop brief and a range of Arduino-connectable sensors. The different projects developed in the workshop are one way of giving an alternative account compared to that of commercial wearables like Fitbit, to the question of what biosensors might be and do. The maker space facilitated a process-based activity, the collective production of prototypes, allowing for the articulation of a number of issues in relation to biosensors.

Biosensors have become popular through self-tracking forms such as fitness trackers and their applications, for example Fitbit and Jawbone (Munson et al. 2014; Crawford/Lingel/Karppi 2015; Whitson 2015; Fotopoulou/O'Riordan 2016; Lupton 2016; Neff and Nafus 2016). They have also emerged as medical instruments (heart monitoring, diabetes management) (Lupton 2016; Mort et al. 2016). In art practice they have been cast as surveillance technologies (Morrison 2015) and used to gather sensory input from humans, plants, water and air to generate other forms of expression (lights, music). Biosensors offer to register or make visible phenomena that are not sensible through other means, such as pollution (Goatley 2016) or microbes (The Cotard Syndicate 2015). In other words biosensors have been understood as opening up the possibility of new forms of communication, whether sensory or non-human, for example registering the signals of the body in new ways or taking readings of invisible signals like bacteria, radiation or chemical balance. However, their use in this respect – to open up new forms of communication – has been limited.

The workshop approached biosensors with these questions in mind. It tried to consider what it would mean to try and be faithful to the promise of new forms of communication such that a communicative back and forth could be established across different sensory worlds and human and non-human agencies. The paper offers a series of reflections on the workshop to think further about how biosensors have been taken up and what it means to make an intervention. The paper gives an overview of the workshop and the projects it entailed. It discusses these projects in turn and makes connections between these and other digital art projects involving biosensors. The paper concludes with a discussion of manifestos. The main argument is that the promise of biosensors to open up the possibility of new forms of communication is always a failed project, but the critical praxis of trying to take this promise seriously opens up interesting questions about materials, practice, process and the technological horizon.

## Workshop overview

The workshop was hosted by the DANM at the UCSC and funded by both the University of Sussex and the UK's EPSRC as part of the Sussex-UCSC digital media partnership initiative. The DANM programme has been a centre for generating critically engaged digital art practice in the United States, and MFM has also been innovative in this area in the United Kingdom. The participants included DANM staff and students and MFM staff and students and other interested participants on or visiting the UCSC campus. The workshop aimed to think about how we might take these new ways of knowing and turn them to the environment and other species as well as ourselves. People are increasingly asked to understand themselves through data as a new way of knowing the world, and this offers the possibility that we might know the world differently.

The practical workshop focused on forms of contemporary mediation: the measuring of the self – together with the sensing of environmental and non-human animal factors, to bring them into conversational modes such that some kind of relationship between bodies might be engaged. The aim of this kind of engagement was:

- For people to learn about sensing technologies in a hands-on maker format
- For individual tracking to be extended into a relationship with environmental and inter-species interaction
- To expand the role of higher education in opening up the politics of knowledge production across art and science
- To create a collaborative space of reflection

Questions concerning biosensors are simultaneously humanistic, artistic, philosophical, technical and design orientated. How could existing wearables be opened up or new ones be created and made accessible in a mode of critical engineering? What would it take to bring human centric data into conversation with environmental and non-human animal data in meaningful ways? Is it possible to make such sensing multi-directional? How could such an experiment be set up as a form of encounter for participants and further audiences?

## In practice

Emile Devereaux, from MFM and David Harris, from UCSC, respectively, facilitated the workshop with these ideas in mind. They selected the hardware, developed a brief and provided support and structure. Participants at the event organised into project teams and tried to develop prototypes, following an initial ideas session. The mix of people at the workshop included people with a wide range of expertise, some of whom had worked with this mix of hardware and software

before and many who had not. The teams developed a range of ideas, and the final projects were presented the following day. These included:

- a. An open-hearted communication monitor: this was a blinking badge expressing heart rate – measured by pulse.
- b. A series of experiments in detecting fear and anxiety about social encounters – this compared reactions to fear of imaginings of fearful encounters and provided recordings of response rates as part of the documentation.
- c. AEEP: Actor Emissions and Environmental Probabilistics. This aimed to measure perspiration as a way of tracking how agents (humans, in this case) are vectors for emitting chemicals into the environment and how this has a relationship to consumer practices, or conditions of environment.
- d. A project to detect the relative reaction of trees and people to chillies; this created a sensor for heart rate after eating chillies – the tree part remained unresolved.
- e. A manifesto – one group eschewed the sensor prototype and put together a critical design manifesto which riffed off the critical engineering manifesto (Oliver/Savičić/Vasiliev 2011).



Figure 1: Unpacking the kit at the workshop.

In the workshop an issue that came up repeatedly was that of access to technologies, making things work (or not work), and there were varying capacities to learn enough about them to use them. Some people took up expert roles and worked on problems that the whole group ran into, other people spent a lot of time working on trying to make one aspect functional and others quickly sorted through the available kit (see Figure 1) to find something they could work with and based their project on that. In all cases the ideas outstripped what was practical. This raised questions of agency and expertise, not least the question of whether we are used by

our technologies or can we intervene in them? There are a number of responses to this question from coding literacy and education programmes, sponsored by both the state and industry; critical art collectives; hacking communities; activism; and critical engineering.

Technological innovation rather famously works as much to deskill and demote specific groups of people and practices as much as it progresses (McNeil 1987; Bassett 2015). Access and capacity have been discussed extensively in relation to digital culture, largely framed in terms of the digital divide and in terms of gender, expertise, coding or computer literacy (Haddon 1990; Eubanks 2011; Berry 2014). Using Arduino and e-health kits is somewhere in between a commercial device and making it up yourself as this equipment provides short cuts to making things up entirely, but it also affords multiple constraints in that you can work only with what the kits provide.

In many examples there seems to be inverse relationships between the commercial success of devices and hackability, and ease of use and hackability. A problem in the space of digital device design and making is that of balancing the power or potentiality of devices with accessibility. The solutions offered in many maker contexts is to not design this into the devices but to rely on the knowledge of experts to seed collective knowledge pools such as wikis and discussion boards from which people can benefit.

Some of these problems can be read through the workshop. For example, the e-health kits used in the practical session output, that is generate, data in close to human-readable text format. While this might seem useful, it actually limits the value of the intervention by presenting information in a form that was usable in only one way. Participants would have to be sufficiently privileged in the culture of the digital to reinterpret the information back. Of course, this digital-person choreography was designed in by humans in the first place and carries assumptions about the kinds of uses and users.

Arduino and other maker intermediaries require some basic knowledge of coding, and the better the resources for coding the more things open up. The combination of sensors and e-health kits did provide an extensive range of possible sensing, but there were still multiple issues within the workshop around making these work, identifying the right generations of code libraries (including different generations for different sensors) and rendering the data in a way that made sense.

## Monitoring states of being

Ideas that emerged from the workshop followed directions not dissimilar to other art work in this area. Two projects (a and b mentioned earlier) looked at questions of communicating inner states of being indexed through both pulse and heart rate. One team (a) came up with a blinking badge that expressed light in relation to heart rate (via pulse), where the pulse was taken from the earlobe, and

a wire joined the earlobe and a badge to transmit the signal. The badge itself was made out of mirrored Perspex with an engraving of a flower. The idea behind the badge was to use sensors to engage with the idea of open-hearted communication. This was taken from one of the teams’ recent experience at a permaculture-inspired activism camp where the language of open-hearted communication had been used. The point of this project was to engage with the question of what this communication might mean and how it could be understood and engaged with. The prototype was imagined as something that everyone in a decision-making group could wear to be responsive to and thoughtful of nervousness and anxiety in communicative encounters. The idea of the mirrored badge was that you would see yourself in relation to others and could think about your own expressed light blinking and thus not only be motivated to surveil others. Another project (b) looked at how to track and represent levels of fear and anxiety that people experience in social situations. It, thus, also shared an interest in looking at how inner states of being might be registered and made explicit in communicative situations. This project didn’t result in a device like the blinking heart but demonstrated recordings of reactions via video and pulse data.

These workshop ideas had some resonance with the Necomimi headset (see Figure 2), which is a fairly well-known example that blurs art practice and consumer device. The headset was a result of a partnership between NeuroSky and Neurowear, resulting in the Necomimi head band, which features cat ears that adjust position according to electrical brain impulses. This headband claims to express brain states through the position of animal ears attached to a headset, possibly biosensors finest moment to date. Although not explicitly an art project, the headband received an honorary mention in the interactive art section at Ars Electronica 2013.

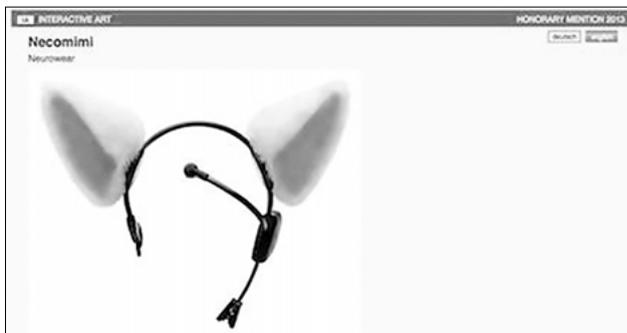


Figure 2: Necomimi headset with ears which move in response to electrical brain impulses.

## Culturing non-human relations

Two of the projects in the workshop (c and d mentioned earlier) looked at human-environment interactions and explored ways of registering these. One of these aimed to explore how the chemical composition of sweat might be detected for indicators that would demonstrate how humans act as vectors for the distribution of consumer substances in environments. An example would be the emission of chemicals from cosmetics or foods through sweat into the sea and air or onto the surface of plants. This project again didn't result in a device but used a fictional narrative to draw on the idea in the final presentation. The team spent much of the workshop learning about the possible substances that might be measured through the available kits.

The second project in this genre was the human-chilli-tree project, which aimed to look at how to measure human responses to chillies and tried to adapt this to think about how to measure any response that redwood trees might have to chilli oil or other indicators related to the way that humans taste chilli. This team again spent a lot of time figuring out different possibilities. In the end they recorded human-chilli sensations and left the trees out of it.

These non-human orientations can be aligned with some of the examples in wider art work with sensors. For example the project by Stephani Bardin (*The Cotard Syndicate*), *M(y)crobes*, has resonance with a kind of post-digital aesthetic in its sculptural focus on the biosensor as installation, where the seeds and the Petri dish are the interface rather than a representation of them. The prototype in this case is designed to allow microbial life to be made visible through a Petri dish as pendant. The pendant contains seeds in agar jelly and enables a visual registering of microbial growth through the sprouting plants. The *M(y)crobes* project could be thought of as a more faithful attempt to open up the capacity of biosensors to bring new knowledge to the sensible world by making microbic life visible to people. This intersects with contemporary interest in the microbic, including the sequencing of the human microbiome. This project was launched in 2008 and explores the possibility of genomic sequencing of the estimated 10,000 microbial species that inhabit (cohabit) what is, in this context, referred to as the human ecosystem. The kinds of organisms that are thought to make up the human microbiome are bacteria, yeasts, eukaryotes and viruses. This microbial turn in the sciences has resonance with the turn to "green materialism" (Bennett 2010) in other disciplines such as philosophy and with the material turn. The connection across these fields is the desire to acknowledge and account for a much more radical assemblage of actors and agency in relation to both explanations of the world and interventions in it, in this case, making visible the relational actions of microbes and humans and environment. Other versions of this direction could include works by Julie Freeman who describes her practice as broadly "translating nature" through works including "Lepidopteral" (2012), which uses kinetic sculpture to express environmental signals. Other examples of environmentally

disposed biosensory art could include the Open Lab project “Oceanic Scales” developed by Gene Felice II and Jennifer Parker at UCSC with their collaborators, which explores a combination of interests in biosensors and biomimicry to look at pollution, human agency and marine life in the Monterey Bay.

## Making manifest

Another response generated in the workshop was one which resisted the call to produce a prototype using biosensors. For example, one team member was the most active in the workshop in figuring out coding solutions and navigating the issue of code libraries. However, this team presented a manifesto as their contribution and read from a collective statement that riffed off the critical engineering manifesto (Oliver/Savičić/Vasiliev 2011), making theory rather than other types of technological demonstrations.

The production of a manifesto in relation to a maker brief helps to pull out what constitutes material form and technological intervention. A manifesto has a material form in that it is written down, and it is declarative of presence and intention, it is read out which performs presence and materiality and beyond the moment of its reading it might cease to exist. It involves technologies of writing, speaking and performing. Taken as a declarative form it involves materiality: voice, breath, sound, hearing, echo, bodies that speak and hear, sound that is generated and travels. Those elements that could be said to be immaterial are the meaning of the sounds, the meaning making of the audience, the memory, trace and echo of the declaration passed into and through the bodies of audience and declaimers. The etymology of the word is such that it draws together the meanings of a public declaration and things evident, obvious and made plain. However, the meaning is both the most immaterial and the most important element of the manifesto. What it makes plain is done so in an ephemeral moment of transition, conveyed through noise, but that sound is not the *it* of the manifesto, so much as what is said. How then to think about this tension between multiple states when all that is material fades into air, all that is ephemeral is material and all that is material is technical.

Writing in 1999, Caroline Bassett cautioned against finding utopia or the revolution in the realm of technology. “This paper began life as a Manifesto against Manifestos. It ends as a call for the restitution of the idea of Utopia in cyberfeminism” (Bassett 1999: 16). Her manifesto against manifestos is more specifically a critique of Sadie Plant’s (1997) *Zeroes and Ones* as a manifesto. The paper reads Plant’s piece and other declarative modes of cyberfeminism that said the revolution had already happened and critiques these declarations for a kind of narrow tyranny. She argues that an engaged politics needs to reconstitute an idea of Utopia beyond the horizon, rather than celebrate technology. Her critique locates some modes of feminism in a similar terrain to that of the promissory futures of high-tech imaginaries because of their connection in celebrating technology

as liberation. This has resonance for thinking about biosensors, because in this moment again engaged politics and technologies come together. The technological promise of biosensors is that through new forms of sensing beyond human capacity – or through changing dominant modes of human perception – we can see the world in new ways, and the declarative tone of some media theory is that the conditions of the present have an (already) radical capacity to make people see the world in new ways. However, the vision of fitness trackers as facilitating a population of self-monitoring, joined-up, always-on, productive, empowered and inspired people is also a narrow and tyrannical framing of life. It isn't surprising that biosensing at its most commercial might also be at its most mundane. Thus, it makes sense to try and explore its avant garde.

From motorised cat ears that read brain signals (Necomimi), to air quality monitors that show us how polluted our environments are (e.g. Polli's "Particle Falls"), the experimental end of biosensing indicates a sense of utopian thinking beyond the horizon. Like much of digital art, biosensing work is as much about conceptualisation and process, and what it gestures towards, as it is about the objects made. The radical promise of materialist theory is that the world beyond language will become communicable, and this will displace human centrality and bring about conditions through which we see the world beyond the narrow prism of capitalism or economic rationality (Bennett 2009; Morton, 2013; Galloway/Eugene/Wark 2014). The use of biosensors to try and communicate signals beyond human perception, from our own sleep to the life of microbes, gestures towards that radical promise but also marks out its impossibility. All experiments with biosensors recuperate the possibility of the non-human communicable into human language and tell us that there is much beyond that realm, but it remains unknowable, elusive and unamenable to the register of human systems of counting and measuring.

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