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Know thy Flesh: What Multi-disciplinary Contemporary Art Teaches Us about Building Body Knowledge

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Building body knowledge is a multi-disciplinary, interpersonal endeavor that implicates medical imaging capabilities, scientific institutions, and datafication of personhood in popular culture. Drawing on existing scholarship in critical digital health studies, we contribute an articulation of how self-tracking leads to a paradox of control: the motivation to extend body knowledge is complicated by the experience of available consumer tools. Self-tracking as a mechanism of biopower underpins this paradox of control and contextualizes the subversive or resistant aims of the proposed resolutions. Prior work has suggested paths of subversion and resistance through available consumer technologies, as well as a critique of how these technologies are designed. Our work focuses on relating biotechnologically mediated art to the use of self-tracking tools more generally. This article is intended for both artists working with biological data or matter, and consumers of self-tracking technology who are interested in adapting these tools as creative means for building body knowledge. We turn to contemporary artworks constructed using biological material or bodily observation to find resolutions to the paradox of control, which include (1) renegotiating the relationship to institutions, (2) mobilizing available tools for unconventional narratives, and (3) embracing biological material.

1. Introduction

How do you know your own body? One increasingly common route of exploration uses consumer self-tracking technology. For example, wrist-worn devices promise the visibility of the unseen experience of sleep. Although self-tracking is motivated by building body knowledge, and although available devices reveal an otherwise-unobservable bodily reality, these methods also introduce new tensions (Lupton 2016). In Section 2, we describe how consumer self-tracking has been informed by advances in biomedical understanding and imaging, measurement, and extraction technologies, as well as the popular-culture relationship to them. Challenging these normative aspects of self-tracking from the intersection of human biology, science, biotechnology, and contemporary art (including bioart, sciart and or biotech-art), we demonstrate how this tension can be resolved while using the tools that are already available. As Sanders (2017) notes, "calls to opt out of self-tracking obscure the fact that all individuals remain subject to regulatory forces" and suggests that "it may be more fruitful to theorize resistance (1) from the perspective of the user and (2) in terms of subversion rather than renunciation."

In this article, we focus on visual observation, whether medically or artistically, as the primary vehicle for building body knowledge. We draw on multidisciplinary artworks constructed using the body as a site for self-knowledge, observation, and exploration using medical imaging techniques and biotechnology. Our key arguments are:

Section 3 - A paradox of control arises in self-tracking.

Motivations for self-tracking include not only observation,
but gaining control:

- reducing or eliminating uncertainty
- truthfully observing a bodily experience
- directing behavior change

However, methods for self-tracking entail losing control, such as when:

- new sources of uncertainty are encountered
- "objective" data brings disconnection from the subjective experience
- behaviors are influenced in unintended ways

Section 4 - Possible resolutions to the paradox of control are suggested by artworks that:

- Renegotiate the relationship to institutions
- Mobilize available tools for unconventional narratives
- Embrace biological material

We illustrate this resolution through several multidisciplinary artworks that utilise and embrace biological material and data in unusual ways outside of conventional institutional and medical use, emphasizing instead rich subjective bodily experiences. Technoscientific advances, biological materials, and biological data can be used in subversive ways, resisting their own algorithmic authority and normalising medical gaze. We consider: Orlan's artwork *La Liberté en écorchée*, Mona Hatoum's *Corps Étranger*, Laura Splan's *Embodied Objects*, Susan Aldworth's *Out of the blue* and *Brainscape 24*, Marc Quinn's *Genomic portrait of Sir John Sulston*, WhiteFeather Hunter's *Mooncalf*, and Rebecca D Harris's *Symbiosis*.

We contribute an articulation of the paradox of control in self-tracking, which draws on existing scholarship in critical digital health studies (inc. Lupton 2016; Sanders 2017) and human-computer interaction. Prior work has suggested paths of subversion and resistance through available consumer technologies (Sanders 2017; Nafus and Sherman 2011). Our work focuses on applying subversive technobiological mediated art (e.g., Šlesingerová 2018) to the use of self-tracking tools generally.

2. Background

Through medical imaging technologies, deep empirical observation, and data mining, the human body becomes a site of knowledge-building; however, visibility can come at a cost. We include in this account consumer self-tracking technologies, which also include technologies of digitizing observation and storing memory of these observations over a long term to render them computationally workable. First (2.1), we discuss how visibility of the body can be in tension with trusting one's own experience. Next (2.2), we review how developments of these technologies displaced artists and anatomists as natural philosophers and thereby replaced narrative depiction of the dissected human body with more standardized and disembodied representations. Lastly (2.3), we outline the power dynamics of building personal and institutional body knowledge. Self-tracking as a mechanism of biopower underpins the paradox of control

(Section 3) and contextualizes the subversive or resistant aims of the proposed resolutions (Section 4).

2.1. The Body Made Visible

Unconventional narratives in multi-disciplinary art practices convey new enriching and immersive dimensions in building body knowledge. Research in human biology and public health "illuminates" artistic work in its "quest to understand ourselves and the nature of life" (Wilson 2010, 64). Scientific epistemologies do not typically center human narrative, but artists do: "Scientists may be able to explain how the brain works in terms of mapping the cortex or understanding synaptic connection making or the function of neurotransmitters, but they cannot convey how experience feels the way it does to us as individuals" (Ede 2000, 3-5). Contemporary artists engage with the subject of the human body "at the service of self-perception and self-knowledge" (Di Marco 2015, 37); and "although contemporary artists are not looking for a divine order, they are nevertheless in search of a deeper understanding of what (they) call the 'interior space' of the body, which is at the same time physical and spiritual" (Di Marco 2015, 37). The body is furthermore made visible through long-term and large-scale storage, comparison, and mining of data (Lupton 2016; Neff & Nafus 2016; Meyer et al. 2020; Borbély et al 2017).

Consider two artworks by Susan Aldworth that embrace biological data (cerebral angiograms of hospital patients) and demonstrate unconventional narratives (embroidered texts). These works center the subjective, lived experience; and combine qualitative and quantitative data. In *Out of the blue* (2020), 100 items of clothing were embroidered with personal testimonies contributed by people living with epilepsy and their carers, hung from the gallery ceiling by wires, and programmed to move patterns associated with epilepsy (Aldworth, 2020). Through Aldworth's use of patient data and testimonies, she creates a vessel for personal and collective healing while renegotiation of institutional relationships of bodily knowledge. For Aldworth, working as an artist-in-residence in a medical or academic setting is central to her practice (Aldworth, 2020). In *Brainscape 24* (2006), Aldsworth used cerebral angiogram data of thirty hospital patients to make etchings of the arteries of the brain. Imaging techniques in medicine offer alternative and enriching views of the inner body; however, they "do not provide unadulterated access to core levels of reality, but rather produce screen images based on sets of decisions embedded in the technologies that underpin them" (Wilson 2010, p.64). Here, cerebral angiograms, which are "an X-ray of a high-contrast dye flowing through the arteries of the head or brain",

are mobilized against the normalization of institutional medical understanding, conveying a plurality and subjectivity of experience.

Lupton observes that the cultural prevalence of medical images, in addition to widespread use of self-tracking devices, has shifted the sense of objectivity outside the body, to the devices used to observe it: "where once people relied upon the sensations they felt in their bodies and reported to their physicians, medical technologies devoted to producing images of the body have altered the experience and treatment of bodies. The optic has come to take precedence over the haptic in revealing the 'truth' of the body" (2016). Such technologies produce a virtual patient, a "screen body". The visual image of the data they generate are often privileged as more "objective", and "as part of the project of seeking security and stability, such technologies attempt to penetrate the dark interior of the body and to render it visible, knowable and thereby (it is assumed) manageable" (ibid.). The term "transparent body" is a "complex product of our culture" and a "cultural construct mediated by medical instruments, media technologies, artistic conventions, and social norms", and describes a body characterized by "perfectibility and malleability" (Van Dijck 2005, 3-4).

What we refer to as the paradox of control is therefore an instance of a broader tension introduced by standardized tools for rendering the body visible, not only by their technical capacity, but their cultural and institutional context of production and use. Next, we consider the development of such tools and their relationship to power from the Renaissance until today.

2.2. Building Institutional Body Knowledge

Both artists and anatomists sought basic knowledge of the human body, and this professional and intercultural exchange has enabled the mapping of the human body (Rifkin 2006, 6). In Vesalius' *De Humani Corporis Fabrica* (1543), shown in Figure 1, artist Jan Stephan Van Calcar portrayed the dissected body (*écorché*) in animated poses across natural landscapes, and involved it in various narratives (Rifkin 2006, 7). Through artists' representations, the body started becoming "more transparent" (Di Marco 2012, 35), making the Renaissance era "a major turning point for the representation of the body," with Leonardo Da Vinci as one of the "prophets and pioneers of a revolution in the representation of the human body". Da Vinci's "deep seeing" (deep empirical observation) skills were developed as a tool for understanding natural phenomena (Wilson 2010, 13). His "deep seeing" and application of "the theory of proportions as an empirical science" (Wilson 2010, 13) allowed him to become a master visualizer

of the human body. He was the only known artist-anatomist that managed to "capture" and "isolate" parts of the body with his drawing techniques before the invention of Magnetic Resonance Imaging (MRI) and X-rays. (Kemp 2005, 49).

Fig. 1. Vesalius' *De Humani Corporis Fabrica* (1543). Images in the public domain.

Prior to the invention of microscopes, X-rays, radiographs, MRI, and PET SCANs, medical professionals had to depend primarily on their own senses (sight, touch, hearing) to visualize the inner body and determine a diagnosis. Such "direct sensory perceptions are still important diagnostic means for physicians, even though they depend increasingly on the optical-mechanical eye" (Van Dijck 2005, 5). Scientists, like artists, need to "see" or visualize ideas to understand the human body and other phenomena (Ede 2000, 11). The invention of instruments for extending human sight replaced the skills of artists, their empirical observations, and their senses, which inspired skepticism (ibid., 72).

From the 19th century onwards, these innovations ultimately revolutionized the visual sciences and the arts (Ede 2000, 72), and, by extension, way we see ourselves. More widespread use of microscopy and the invention of x-rays in 1895 introduced a new world of visual access to the inner body (Kemp and Wallace 2000, 18), displacing artists and anatomists as natural philosophers; deep seeing as the primary tool; and the depiction of the dissected human body in a humanizing narrative. The emergence of these imaging technologies coincided with the introduction of a "new medical gaze", and apart from medical visualization tools, "media technologies have also substantially contributed to the body's transparency" by revealing and disseminating a variety of documentaries on different medical conditions, viruses, etc. (Van Dijck 2005, 4).

Technoscientific advances have made the dissected human body accessible to a wider audience, beyond a limited elite. These images have become an inseparable part of our everyday visual culture and cultural mainstream. Increasingly, visibility extends also to micro-organisms and microbial communities: for example, consider *Symbiosis* (2015) by Rebecca D. Harris (Harris 2020), shown in Figure 2. Today, self-tracking makes a continuous measurement of the body possible. For example, over the course of three decades, a researcher used a "self-contained battery-powered wrist-worn electronic accelerometer" to collect actimetry data (Borbély et a. 2017). This is one of many examples of self-tracking undertaken not by consumers of a general technology, but by "bona fide researchers, with a background in experimental science ... [some] using grant money and lab resources to perform long-term vertical studies," as Gimbert and Lapointe (2015) write regarding microbiome self-tracking in particular. At the outset of data collection, the device was self-assembled by a research team; today, wearable activity and sleep tracking technologies (still often using accelerometer data) are widely available and used, as we will discuss in Section 3.2.

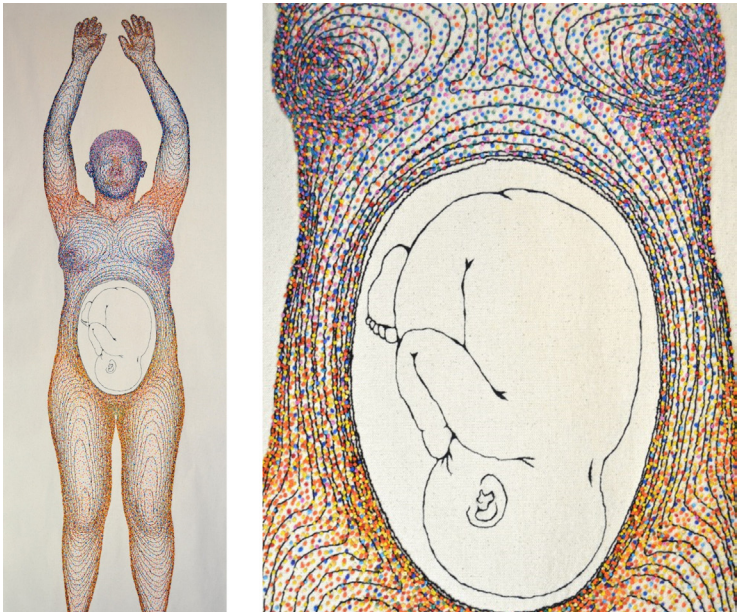

Fig. 2. "Symbiosis" (2015) by Rebecca D. Harris, working with microbial community data from University College London microbiologists working as scientific advisers on the commission for the Eden Project, supported by the Wellcome Trust. The detail (b) contrasts how "in the womb we are microbe free, 100% human ... it is through birth we acquire the first stage of crucial development of human health, microbes" (Harris, 2015). Images courtesy of the artist.

2.3. Self-Knowledge and Power in the Anatomised Body

The "know thyself" ethos ("γνῶθι σαὐτόν" in ancient Greek, originating from understanding or exploring, "γιγνώσκω", and the word for self, "εαυτός") originates from the Apollo Temple in Delphi (Kemp and Wallace 2000). Re-introduced during the Renaissance, this ancient tag not only justifies the dissections carried out in the early Renaissance period, but also informs the work of every medical image produced until the 19th century along with the work of today's contemporary artists (Kemp and Wallace 2000, 13-14). In the 21st century, the "know thyself" ethos also informs both the development and widespread use of self-tracking technologies, with quantification of the self via digital devices as a fundamental aspect of contemporary selfhood (Lupton 2016,9-13). The biomedicalization of society and the human body and the synthetic engineering of life have also significantly influenced contemporary art (Šlesingerová 2017, 3).

Technoscientific advances, including medical imaging and self-tracking, transform the human body into a site of data mining and knowledge building with the aim of control. Building body knowledge can become a form of biopower that "manifests itself in the form of daily practices and routines through which individuals engage in self-surveillance and self-discipline, and thereby control themselves" (Foucault 1976, in Pylypa1998, 21). Lupton (2016, 45-51) notes that "neoliberal political rationalities rely on apparatuses of 'soft' rather than 'hard' power" under which practices of self-optimization "appear to emerge from personal desires and voluntary objectives related to the achievement of health, happiness, and success rather from imperatives issued by the state of other sources of authority" (ibid.). Sanders additionally recognizes gendered dynamics, wherein these devices "foster increasingly rigorous self-policing mentalities in women" (Sanders, 2017, p.18). Emerging evidence suggests that "the tendency to experience one's body principally as an object [that is] evaluated for its appearance," which also has a gendered component, can be associated with lower "interoceptive awareness, assessed by heartbeat perception" (Ainley and Tsakiris, 2013).

To connect our discussion of the anatomized body to self-tracking through the lens of normative observation, consider Gunther von Hagens' *Body Worlds* expositions, which explicitly present posed plastinated cadavers and human organs as vehicles for projecting a self-improvement narrative, in addition to its stated general anatomical education goals. When one of the authors visited Berlin's exhibit, many plaques highlighted pathologies in organs (e.g., effect of smoking on the lungs) and, at the exit, directly asked visitors to votes which

healthy habit (more exercise, healthier eating) they would commit to after leaving. Survey findings ("The Philosophy behind BODY WORLDS", 2021) states that "68% left the exhibition with valuable incentives for a healthier lifestyle", and that "a follow-up survey... [showed that many] changed behavioral patterns according to their resolutions to lead a healthier life." Another survey found that although "49.8% visitors ... felt disturbed," "42.6% resolved to pursue a healthier lifestyle" (Leiberich et al. 2006). The presentation of plastinated cadavers employs visual presentation of disease and pathology within human specimens that are made observable in a way that the viewer's own body is not. The cadavers presented are posed with an "artistic dimension" (Burns, 2016, p. 14) though the creator "has claimed that his craft is not an essentially artistic enterprise" (ibid., 19). Though the stated aims are educational, the impact is only through visitor exit polls (ibid.).

Today, general anatomical knowledge can be accessed in many ways, and mobilized for one's own self-knowledge. Self-tracking provides additional direct access to one's own inner bodily space, mediated by external tools. Responding to the claim that self-tracking is "a profoundly different way of knowing what data is, why it is important, who gets to interpret it, and to what ends" (Nafus and Sherman 2014), Lupton (2016) suggests this is insufficient for "resistance against algorithmic authority:" "while a small minority of technically proficient self-trackers are able to devise their own digital technologies for self-tracking ... the vast majority must rely on the commercialized products that are available and therefore lose control" over the resulting data.

The act of dissection and observation of the human body, and the resulting knowledge, was historically itself an act of biopower (Foucault 1976) in which only spectators of certain social and economic standing could participate. To artists and anatomists of the time, the scrutinization of human anatomy was considered an artistic, cultural, and social achievement (Foucault, 1997, in Di Marco 2015, 34). In *The Birth of the Clinic* (1975), Foucault (as cited in Pylypa 1998, 23) describes how the medical profession gained prestige by employing "scientific" knowledge, which gave it considerable power in defining reality. Today, this ''scientific knowledge'' is being reproduced and disseminated in the media, cadavers can be dissected virtually, and medical and anatomical images have become widely accessible aspects of everyday visual and aesthetic culture (Ede 2000, 71).

Contemporary artists apply these techniques outside of their everyday institutional and medical diagnostic use. Working with available techniques can help regain control, building "knowledge that can be used to defy the normalizing gaze" (Di Marco 2015, 35). Artist Laura Ferguson works with representations of the body, such as her own X-Ray and CT scan imagery of the unusual structure of her skeleton, to "regain a sense of ownership of the body that is usually lost when one's experience of disease or disability is taken in charge by doctors" (ibid.). Artist Laura Splan uses Electromyography (EMG) and other forms of biometric data (EEG, EKG) that are extracted from the body itself to create a series of "Embodied objects" which interrogate technological representations of the body through sculptures, weavings and works on paper (Splan, 2021a). One of the artworks, *Manifest* (2015), shown in Figure 3, consists of 3D-printed sculptures that use EMG sensors to visualize the fluctuating levels of electricity in stimulated facial muscles during expressions. Through the extraction of intangible biometric data, Splan can re-materialize intangible bodily processes. These practices may require technical skills that are not widely taught; hardware that is not widely accessible; and potentially limited institutional connection, so, as an alternative practice, this may also be limiting.

Fig. 3. *Manifest* (2015) by Laura Splan: "data-driven 3D-printed sculptures using electromyography (EMG) readings of facial expressions ...The project examines the potential for objects to embody human experience and to materialize the intangible " (Splan, 2021b). Installation view (a); *Blink Twice, Swallow, Squint* (b-d) and *Frown, Furrow, Smile* (e-g). Images courtesy of the artist.

3. The Paradox of Control

Self-tracking, as a set of tools and methods, makes the body visible through widely available technologies. The newfound visibility contextualizes the paradox of control. In this section, we first introduce this paradox along three different aspects of control: reducing uncertainty, truthful observation, and taking action. Second, we use sleep tracking as a case study of how each aspect of this paradox plays out in one specific domain of a previously inaccessible human experience.

3.1. Reducing Uncertainty, Truthful Observation, and Taking Action

A paradox of control arises in self-tracking. The word paradox was chosen to highlight the difference between expectation (more control) and reality (less control). This concept builds on research by Lupton (2016), Sanders (2017), and others. This section reviews the tensions that arise in three different aspects of control. First, the motivation to reduce or eliminate uncertainty through self-tracking is met by new sources of uncertainty associated with self-tracking. Second, the motivation to truthfully observe a bodily experience can be associated with disconnection from the felt experience. Third, the motivation to direct behavior change may result in behaviors being influenced in unintended ways.

Observation of the body is entangled with expectation of manageability: "[sociologically] self-tracking might be understood [as a] response to the problem of dealing with the uncertainties ... of late modernity" (Lupton 2016). In a study of wearable activity trackers (WATs), Duus et al. (2018) note that the devices "not only contributed to skills related to capturing, storing, and visualizing performance data, but were also expected to provide certainty and reassurance." However, self-tracking itself also introduces uncertainties. Knowles et al.(2018) distinguish input uncertainty ("whether the data coming into a system is sufficiently accurate to produce meaningful outputs—where 'meaningful' is defined in relation to the user's needs"); output uncertainty (regarding "the meaningfulness of the inferences or recommendations produced by a system"); and functional uncertainty ("how, why and by whom their data is being used", including concerns about privacy and security). Our examination of sleep tracking (3.2) refers to studies that compare the many available devices, attempting to characterize the accuracy and bias. However, comparative studies must speculate over specific mechanisms and be limited to black-box experimentation with proprietary closed-source consumer tools.

The truth of the object itself stands in conflict with the truth of the experience. The "screen body" that is rendered visible through biomedical visuals appear more "objective" than the experiences in the "real, fleshly" body (Lupton, 2016). Duus et al. (2018) note the "the perception that health-related decisions that were informed by data were better decisions than those simply informed by their own opinions, feelings, and experiences," adding that biometric data collection led to "a sense of bodily disconnect for some [which was] was expressed as a form of alienation between the participant and her own body", including "experiences of stress, disappointment, and self-blame".

In Orlan's 2013 artwork, *La Liberté en écorchée* (2013) her body becomes a virtual flayed muscle figure, resembling the flayed figure in Vesalius's *Fabrica* (1453) and in Gunther Von Hagens's plastinated flayed men. Her transhumanist muscle figure poses as the animated figures in historical anatomical illustration books. The visual language evokes the uncompromising gaze of truth; and though it is not the literal flayed body of the artist, it has a truthful connection to the object being represented. Meanwhile, in reaction to "Body Worlds," which contains actual flesh, visitor comments reveal themes of questioning truthfulness, asking whether posed bodies (for example, "yoga lady") are "real practitioners'' of a stated activity (Moore and Brown, 2007).

Self-tracking may be motivated by seeking behavior change, but the relationship becomes interactional. The devices and our bodies "respond to and alter" one another (Lupton 72). At the level of specific instances of daily decision making, "the human is enabled to affect and create change; in other situations, it is the WAT that influences and impacts decisions and behaviors'' and that "some participants had developed an intensive dependency relationship with the data, feeling obsessed with checking it" (Duus et al. 2018). Lupton (2016) also mentions how "self-tracking can begin to make people feel as if they are losing control when it descends into an obsession", and in the next section we consider potential anxieties specific to sleep-tracking. Transhumanist and cyborg imagery might suggest that observational devices can be "prosthetic devices, intimate components, friendly selves'' (after Haraway, p.61). However, as in the following example of sleep-tracking, the relationship between the device and its wearer is not only intimate; it also a site of cultural norms and institutional relationships.

3.2. Observing an Unobservable Bodily Experience: Sleep

Sleep tracking is a now-commonplace encounter with the invisible and uncontrollable body through wearable sensors. Although some new multi-sensor devices are said to be more accurate and are commercially used for detecting sleep phase, most of the established research validating wearable sleep trackers concerns actigraphy-based approaches. Polysomnography (PSG) is the laboratory gold standard for sleep assessment and is expensive and cumbersome. Actigraphy works by collecting accelerometer data via "a portable wrist-worn sleep monitoring device" and using a classification algorithm, rendering it into legible data about when the wearer is sleeping or not. These are "used in clinical sleep medicine for assessing certain sleep disorders, such as circadian rhythm sleep-wake disorders, and for characterizing day-to-day patterns or sleep disturbances in insomnia" (Kolla et al. 2016). Actigraphy has a relatively high sensitivity and accuracy, but low specificity, compared to the gold standard approach, polysomnography (PSG) (Marino et al. 2013), although "validity in special populations such as the elderly, in subjects with poor sleep quality, or in those with major health problems is not well established" (Kolla et al. 2016).

This approach introduces its own uncertainties. For example, specific biases in which measures are over- or under-estimated may interact with the biases that consumers may meanwhile hold: "[Two specific devices] have shown a tendency to overestimate [sleep onset latency, SOL: the amount of time it takes to fall asleep]. Patients with insomnia already tend to overestimate SOL, and data from these devices could perpetuate their cognitive errors" (ibid.). Some medical professionals have coined the term "orthosomnia" to describe as preoccupation with sleep tracker data that may "reinforce sleep-related anxiety or perfectionism for some patients" (Baron et al, 2017). This anxiety has been observed in subsequent qualitative human-computer interaction study of 75 individuals in a multi-week study design considering multiple available wearables, most of which provide as "an objective measure" a score out of 100 to describe sleep quality (Aupetit et al. 2019).

Subjectively, uncertain accuracy of a device can be one barrier to long-term continuous sleep tracking (Liang and Ploderer, 2016): in the words of one interview respondent, "it never takes me zero minutes to fall asleep. I know that at the time that [my wrist-worn wearable] said I was asleep, I was actually reading." Because it is difficult to export and integrate data from any one tool (Liu et al. 2015; Lupton 2016, 33; Meyer et al. 2020), individual consumers are not able to validate the accuracy of these methods. It is also unclear to users

of these devices "whether their readings are normal, exceptional, or worrying" (Knowles et al. 2018). The difficulty of interpretation (e.g., in the words of a study participant, "I don't know whether that's normal, because I don't know what's normal for other people") is a barrier to long-term continuous sleep tracking and unclear connection to potential contributing factors (Liang and Ploderer, 2016), and supports the critique of sleep trackers as fueling "orthosomnia."

In addition to scoring sleep on a scale of 100 (Aupetit et al. 2019), devices and associated applications support explicit goal setting. However, "established approaches like goal setting do not work well with sleep, because goals like falling asleep quicker or not waking up at night are typically not things a person can control" (Liang and Ploderer, 2016). Regarding insufficiently motivating sleep goals, one study participant noted: "Of course I want to get 8 hours sleep every day. But how to control that? If I try to get 8 hours sleep, I have to go to bed early, and that's just not feasible," due to existing "work and family commitments" (ibid.). There is an assumption that the design of this tool should bring about greater control; meanwhile, these design attempts may instead highlight uncontrollable aspects of daily life. The anxiety reported in the case studies by Baron et al. (2017) does lead to seeking intervention, but not sustained behavior change, outside of monitoring.

The sensors and charts render some data available, but the relationship between that data (processed accelerometer and other data) and the object of observation (sleep quality, duration, and so on) have a relationship that itself resists observation. In the case of sleep tracking, low level data (accelerometer) is not useful/legible, while high level data (score) requires a series of inferences and transformations, each of which may introduce new biases. Furthermore, the process of interpretation is itself unobservable. Observing sleep, which hinges on a variety of factors and cannot be quickly or effortlessly influenced, can highlight the false expectation that visibility leads to manageability.

After thirty years of continuous activity tracking, including movement during the day and rest at night, the reported visualization (Borbély et al. 2017, 191) not only renders the intimate details visible (like timezone adjustments) but also changes in technical efficacy of the device itself, demonstrating the interconnectedness of observation and its object. This report includes technical and analytic notes on the changes in sleep duration during retirement, in addition to personal narrative regarding weekday alarms prior to retiring: "The subject of the present study has not perceived the reduced sleep time on weekdays as a real problem … He regards the pre- and post-retirement phases essentially as different modes of living" (ibid., 194).

4. Resolution

In the previous section, we demonstrate that observation is not passive: not at the level of daily action, and not at the levels of personal narratives and institutional relationships. The fact that observation itself has agency complicates the motivation to control. Across the artworks reviewed, we see recognize recurring methods to resolve this tension, illustrated by these guiding questions:

» Renegotiate relationships to institutions: how can we be collaborators and co-creators of the data collection method rather than isolated users of technical tools?

» Mobilize tools for unconventional narratives: how can I draw on (quantitative or objective) data and localized biomedical understanding of body parts/processes in service of investigating (qualitative or subjective) experience of the body as a whole?

» Embrace biological material: how can I engage not only with useful abstractions but also with direct, subjective bodily reality and experience?

Sanders (2017, 21-22) suggests "potentially subversive body projects by counterposing them to conventional self-improvement projects." First, instead of an emphasis to use quantification to "discover an authentic self has always already existed," Sanders suggests users "treat digital self-tracking devices not as means of self-discovery but as tools for inventing oneself as something new and not yet imagined". Second, rather than "[defining goals] in terms of the exterior form of the body," Sanders suggests "purposefully goal-unoriented" body projects. Lastly, with respect to exercise behavior-change related tools, Sanders suggests replacing "game design elements" with a "focus on the quality of one's interior." (Sanders 2017, 21-22). Returning to cyborg imagery, we hope it "can suggest a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves" (Haraway, 67), which here means using biological material and tools for bodily observation in an open-ended way (as in 4.2).

These ideas are consistent with our themes. The critique of authenticity here aligns with what we discuss in Sections 2.1, and 3.2. However, because we have focused on artworks, our proposed resolution highlights narrative and creative aspects, which we believe is generally informative. In the following two sections, we consider the construction of immersive experiences (4.1), and the growth of biological

material (4.2) as case studies where all three of the above resolutions are present.

4.1. Immersion

Aldworth, whose work was introduced in (2.1), works as an artist-in-residence in a medical or academic as a central part of creating an immersive installation based on bodily data. Other works (for example, those in Figure 4) also entail engaging, evocative objects. We use the notion of "immersion" broadly, as an invitation to actively engage with these objects of bodily knowledge. We now consider another example, Mona Hatoum's ''Corps étranger'' (Foreign Body) installation related to the digestive tract. The representation and observation of the inner fabric of the human body in endoscopic visualization techniques is depicted as hostile, alienating, and standardized.

This work highlights not only the boundary between self/other, but also personhood/institution. In Hatoum's installation, procedures including endoscopy and colonoscopy penetrate the interior landscape of her own body, turning the invisible internal workings of her bodies to visible circular tiny visceral landscapes enclosed in a circular structure. The internal landscape is exposed without the human body having to be ''sacrificed'' (after O'Reilly 2009, 130). The ''foreign body'' of the camera, like an alien probe, enters the stoma (mouth) and colposcopic cavities recording the visuals and the geography of the visceral bodily landscape. According to Hatoum, ''the camera is in a sense this alien device introduced from the outside'' and the "foreign body also refers literally (and metaphorically) to the body of a FOREIGNER" (cited in Hatoum 2002, 125).

Truthfulness arises from centering the personal experience. Hatoum emphasizes that "it had to be my body" in the artwork, centering her own experience of being "probed, invaded, violated, deconstructed" (ibid.) by medical procedures and their representational visualization techniques. The video recording of the deconstructed ''woman'' is projected onto the floor and enclosed within a circular structure. The projected moving image in an otherwise dark space is complemented by audio recordings from the echogram of her heartbeat and breathing, creating a strong audio-visual force that reconfigures the spectator as the camera, the ''foreign object''. The camera travels past the eyes and the skin, then ''enters an orifice, dividing into the, moist, pink, depths ... on a spectacular enigmatic journey" (O'Reilly 2009, 132). Hatoum works against the penetrating and normalizing gaze of these technologies by embracing biological material through immersive audiovisual aspects, collapsing the audience/artist distinction. Her body is looked at so closely, it becomes alien and foreign itself, as well

as genderless: "You have the body of a woman projected onto the floor. You can walk all over it. It is debased, deconstructed, objectified. It's the fearsome body of the woman as constructed by the society" (cited in Hatoum, 2002, 125-126).

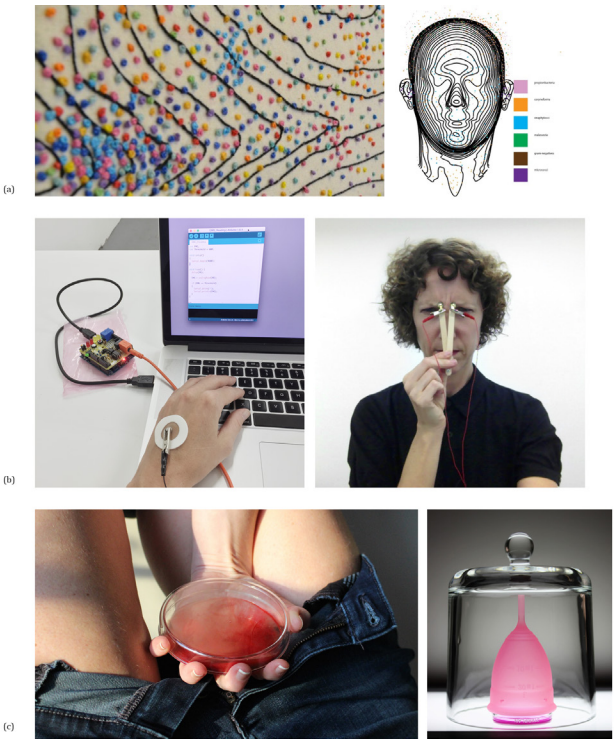

Fig. 4. Engaging Objects: (a) in Harris's *Symbiosis* data is made tangible, soft, and narrative; (b) in Splan's *Manifest* (2015) the body is measured on its own terms; and (c) in Hunter's *Mooncalf* (2019-present), Hunter's own body materials are centered. Images courtesy of the artists.

4.2. Growth

Biotechnology and imaging techniques expand the modes of portraiture and bodily biographies, "revealing our internal selves as 'functioning and intact systems' without having to sacrifice life itself" (O'Reilly 2009, 130). Beyond such non-destructive seeing, biotechnology also enables the growth and generation of further biological matter, such as in the following examples.

In Marc Quinn's *The Genomic Portrait of Sir John Sulston* (2001), no anatomical parts are visible, the self "reduced" and "compressed" to DNA (Anker and Nelkin 2004, 10). Sir John Sulston played a major role in the international effort for mapping and sequencing the human genome (ibid., 9). His DNA forms the basis

of the portrait: generic material harvested from sperm, replicated in bacterial colonies, and mounted on a mirror-like frame. Thus, "this portrait reflects the gazing viewer's image while encasing a centered overall field of creamy blots" (ibid., 10). Quinn describes this portrait as "the most realistic portrait in the Portrait Gallery" (cited in ibid., 11). Sir John Sulston himself comments of his genomic portrait: "It is not me, it is my starting point," and "there is enough genetic information there to identify me" (Anker and Nelkin 2004, 10).

Another example is WhiteFeather Hunter's use of endometrial stem cells from her menstrual blood in *Mooncalf* (2019-present), a prototype of which is shown in Figure 5. In *Mooncalf*, her own biological material forms a new nutrient media for tissue culture, which "could constitute a more ethical and alternative way to the fetal calf serum used in cellular agriculture" (Debatty, 2020). Hunter's collection and development of tissue cultures from her own menstrual blood during her PhD research stirred institutional reactions related to "the common cultural perception of menstrual blood as somehow tainted, 'unclear' or dirty" (ibid.). However, as Hunter points out "the actual production of menstrual blood is still a material outside the control of the patriarchal capitalist economy" (ibid.). Rebecca D. Harris also directly addresses the common value judgments toward microorganisms through her work, writing: "When we normally think of microbes we think of those bad for our health" and how the "bright and tactile" embroidery of *Symbiosis* (2015) shows that "our bodies are not blemished by the microbes" but rather embellished (Harris 2020).

Fig. 5. "Mooncalf prototype: Constructed prototype of the imagined final product. Digital photograph. Object constructed of bacterial cellulose and polymer clay" (Hunter, 2021). Image courtesy of the artist.

Working with microorganisms for Hunter entails "a state of perpetual curiosity" though she is "always aware of the systems of control that are in play when generating the work. Ultimately, we are all co-creating our realities with innumerable microorganisms, electronic and other systems every day" (Debatty, 2020). Gimbert and Lapointe (2015) consider the use of self-tracking and self-experimentation in microbiome research; they not only recognize limitations but overview a variety of methods for addressing scientific validity concerns, as well as precedent of using self-experimentation in a scientific setting. Working with microorganisms can be a subversive, imaginative experimentation without a set self-improvement goal (after Sanders, 2017) that embraces flesh as a creative medium. Even in cases of isolated observation or analysis of a particular part of the body, a direct and/or expressive engagement with biological materials supports embodiment rather than disembodiment or alienation. These examples, in addition to Aldworth's *Brainscape 24* (2.1) re-negotiate institutional relationship, requiring institutional support and exploring notions of truthfulness in representation, as well as expectations of agency between observer, subject, and tools used.

5. Conclusion and Future Work

When artists use self-observation technologies and body data mining methods to renegotiate relationships to institutions, construct unconventional narratives, and work with direct biological material, they can subvert the normative medical gaze and self-disciplining dynamic of the self-improvement ethos. Self-tracking as an alternative data practice (Neff and Sherman, 2014) can also have a subversive character (Sanders 2017). Through practice-based research, we have taught classes open to the public, and encountered often-ambivalent interests in self-tracking and self-observation. We found that taking direct inspiration from such artworks can be an effective tool for the public to resolve a tense and paradoxical relationship to self-tracking. In this article, we have outlined the basis for our approach. In future work, we aim to explore its application further, addressing some of the limitations of the current work.

This article does not address all self-tracking. We focus on individualistic control-oriented motivations and uses. We do not directly consider neutral curiosity as a motivation, although it is one (Neff and Nafus, 2016; Lupton, 2016, p.33). Our lens of "know thyself" is tied to the self-improvement ethos as it is (re)produced by the institutions involved. Additionally, we do not address the design of self-tracking tools, which is a major subject in human-computer interaction research. Existing literature in this area identifies similar tensions and

proposes recommendations for design (e.g., Purpura et al., 2011). Although it is desirable that self-tracking tools ultimately support, rather than hinder, bodily awareness, both through design and through the ways in which these tools mediate their users' relationship to institutions, these tools overwhelmingly still currently embody the "soft" authority of normative self-surveillance (Lupton, 2016). Therefore, our future work focuses on "subversion rather than renunciation" (Sanders, 2017) through expressive practice.

Although a deeper look into collaborative dynamics is out of scope for this article, themes of collaboration recur across the works discussed: collaboration with scientific advisors (e.g., Harris's *Symbiosis* or Aldworth's *Brainscape 24*) or direct use of technoscientific methods (e.g., Hunter's *Mooncalf* or Splan's *Manifest*), as well as bringing collective narrative into focus (e.g., Aldworth's *Out of the blue*). On the other hand, citizen science projects, which focus on collective motivations, and engage with scientific institutions in some forms, are not addressed. All three of our proposed resolutions accommodate and benefit from substantial collaborative elements, and interrogating the possibility for expressive, data-informed collective knowledge-building about the body is the subject of our ongoing research and practice.

Lastly, this article focuses on various types of visual observation, whether medically or artistically, as the primary vehicle for building body knowledge, but in ongoing work, we have expanded the notion of body knowledge to include proprioception (the sense of a body's position in space) and interoception (the sense of a body's internal experience). The methods for building knowledge can also include movement practices: different methods of seeing can inspire experiences of embodiment or dis-embodiment. Furthermore, "body knowledge" may not be literal, verbal, or medical. In future work, we will also study movement practices explicitly aimed in building body knowledge.

Technoscientific advances for observing the body, which include sophisticated self-tracking technologies, have shaped the tools available for artistic practice and building personal self-knowledge. These extensions of our human senses can help us realize patterns in our bodily biological processes, though at the cost of potential for disembodiment. We demonstrate how inter- or multi- disciplinary contemporary art inspires resolutions for this paradox of control.

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