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Heart Sense: experiments in design as a catalyst for feminist reflections on embodiment

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This paper presents the design of a series of experimental data visualizations aimed at reflection and conversation about embodied interactions and physiological data. Taking heart rate as the point of entry, these visualization challenge binaries such as matter/meaning, subjectivity/objectivity, and self/other. More specifically, we present three visualizations. The first one illustrates physiological interaction with emotionally engaging material. The second one explores the experience of time by centring the rate of heartbeats. The third one foregrounds the impact of the environment on physiology and its role in creating a kind of embodied social connection. Together, these three visualizations open up space for new problem formulations and design explorations in and around the themes of data, embodiment, and visualization that are distinctly feminist in their orientation.

feminist science and technology studies; physiological data; data visualization; interaction design

1   Introduction

How can the very creation, rendering, and experiencing of biological data be distinctly feminist? For example, how can it start from women's lives in all our plurality and complexity,[1] break down binaries such as objectivity/subjectivity[2] and science/feminism,[3] and contribute to a more nuanced understanding of our bodies—a kind of knowing that is in and of the world?

Heart rate data may seem like a counterintuitive choice as an entry point into these questions. The monitored heart rate can be very mechanistic and even disciplinary: the persistent mechanical beeping during surgery (Kneebone, 2017), the fetal heartbeat of anti-choice politics (Edgar, 2017), monitors that can spur excessive intervention in childbirth (Cartwright, 1998), and even fitness monitors that incite increased intensity in exercise (Pirkko and Pringle, 2006: 59). Heart rate can be a site of plural layers of "control by quantification" (Browne, 2015: 9). Yet the heart remains ambiguous and undisciplined. In times of emotional intensity, a racing heart rate can feel very much

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[1] A complex but worthwhile undertaking—see, for example, Harding (1993).
[2] This has been canonically explored in foundational texts of feminist STS, including by Keller (1985) and Rose (1983).
[3] As inspired by Subramaniam and Willey (2017).

out of control. At the same time, we can feel our own heartbeat and that of others with whom we are intimate. In this manner, heart rate offers an accessible route into engaging with our bodies. This mundaneness and accessibility, in turn, makes it less likely that data about the heart could mechanize subjectivity the way that data about, say, the brain might. The heart's pace is at once most intimate and personal, while simultaneously deeply connected to others and the outside world. Creatively engaged, heart rate can offer an intriguing point of departure for feminist engagement with the entangled nature of data, matter, and meaning both in theory and practice.

In this paper, we present ongoing work that draws together scholars from science and technology studies, physiology, and design to seek speculative ways in which heart rate and other physiological data might facilitate new explorations of embodiment. We do not take biological data as a given and theorize from there. Rather, we engage with both the generation and analysis of data in ways that foreground the inextricability of matter and meaning. And, unlike what is common in discourses around data in recent years, what we seek is not the kind of data collection that might produce patterns for scientific discovery. Neither do we seek to provide a precise and comprehensive representation. Rather, we seek to direct the physiological data that we gather to more open-ended uses by striving to make the visualizations spur reflection, build awareness, and open up a space for conversation—for those who participate in our installations, and for ourselves and designers and theorists. This paper thus serves an illustration of how feminist theory could be a point of departure for *problem making and questioning* in design (Forlano et. al, 2016), as well as for feminist theory.

By creating, visualizing, and encouraging reflection on circumscribed datasets, we strive to approach physiological data for its capacity to inspire an alternative epistemological and experiential engagement from either standard scientific visualization or the quantified self. Ours is an object-oriented feminist approach: "in light of a specific and particular materiality to hand, what if we see the world like this?" (Pollock, 2015)[4]

2   Feminist Data Visualizations

This project is aligned with recent calls for feminist data visualization (D'Ignazio and Klein, 2016), even as its starting point is different—engaging not only with representation, but also with *creation and experience of data*.

Our approach toward biological data takes its starting point from the humanistic perspective that troubles the concept of *data* as a *given,* restoring it to its original sense as *taken*—or what Johanna Drucker (2011) characterizes as *capta*: taken and constructed (Drucker, 2011).[5] As Drucker notes, this is a key distinction between natural sciences and humanistic inquiry: "Humanistic inquiry acknowledges the situated, partial, and constitutive character of knowledge production, the recognition that knowledge is constructed, taken, not simply given as a natural representation of preexisting fact" (Drucker 2011). We take this idea further though by collapsing the binary of *given* and *taken*. Our visualizations are created in circumstances that are blatantly artificial and arguably perhaps even arbitrary: installations that provoke physiological response that gauge states that are neither normal (as, for example, 24-hour readings would create) nor optimal (as, for example, while running or engaging in a target activity of rehabilitation). For us, biological data is simultaneously given and taken, a flow of sorts. This idea of flow is relevant both for an understanding of the creation of data mediated by instruments of science, and the experience and interpretation of data mediated by visualizations.

Moreover, we seek to foster open-ended interpretations, and in so doing highlight the indeterminacy of data itself. As Lisa Gitelman and Virginia Jackson (2013, 6) have pointed out, "Data are familiarly 'collected,' 'entered,' 'compiled,' 'stored,' processed,' 'mined,' and 'interpreted.' Less obvious are the ways in which the final term in this sequence – interpretation – haunts its

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[4] For further discussion, see Behar (2016).
[5] For more on the constructed and local nature of data see also, Loukissas (2017)

predecessors." We take seriously their point that "data need to be imagined as data to exist and function as such, and the imagination of data entails an interpretive base," (Gitelman and Jackson 2013, 6). In doing so, our visualizations of biological data are designed to *expand* the interpretive base.

The visualizations that our team is creating broadly seek to bring to fore the intra-actions of bodies and environments (Barad, 2017). This builds on Anne Pollock's object-oriented feminist writing on heart feminism, which makes a conceptual argument for considering the heart's receptivity beyond democratic exchange or domination (Pollock, 2015). We build on this evocative argument and employ visual media to ask more capacious questions. More specifically, we use the tools of scientific measurement and digital visualization to explore theory's capacity to open up new avenues for creative exploration. We have found, in turn, that this material engagement opens up new theoretical spaces for feminist theory. In this paper, we present three visualizations. In the first, visualizations foreground embodied responses to emotionally engaging materials such as short videos, challenging the taken for granted duality of affect and viscera (Wilson, 2004). Another explores the experience of time as marked by the beating of the heart, breaking down binaries between objectivity and subjectivity. A third engages how the heartbeat resonates with music, foregrounding the way that the outside world may serve as a starting point for a kind of embodied social connection and resisting the arbitrary boundary of self and other. From a design perspective, these visualizations also serve as a point of reflection on the rhetorical dimensions (Buchanan, 1985; Jun, 2011) of the creation, visualization, and experience of data.

Here, it is also important to note that other artists and designers have engaged biological data in ways that are resonant. While these visualizations are not necessarily explicitly labeled feminist, they have characteristics that are aligned with its ethos. For example, artist Kelly Dobson (2007) has created machines that mimic an individual's heartbeat and other physiological phenomena (such as breathing), foregrounding autonomic connections between ourselves and machines. *Biomorphic Typography* by Diane Gromala (2002) introduces a conception of writing driven by biofeedback, thus enabling users to become aware of their autonomic physiological functions during typing. Other artists have also drawn attention to heartbeat in large public installations. For example, *Pulse Park* is an installation by Rafael Lozano-Hemmer that uses pulse readings of 200 individuals to light up Madison Square Park. According to Lozano-Hemmer, drawing on heartrate is not meant to be medical but rather, "It's meant to bring everyone together, to allow people to express some sort of agency in a public space" (Siegel, 2009). In doing so, Pulse Park directs its audience's attention to the communal dimension of heartbeats, challenging its dominantly individualistic framing. *Heart of the City* by Anaisa Franco is an interactive public art sculpture that is designed for people to sit on it and interact with it with their pulse. The sculpture pulses light according to the heartbeat of the people sitting on it (Franco, 2015). What these visual presentations have in common is that they take biological data as their materials yet present it in ways that challenge its mainstream interpretations.

Creating and expressing data differently is particularly important if we consider how dominant imagery limit imagination and engagement and thus our understanding of phenomena. An example is illustrative here. In an ethnographic study of the London Underground Map—arguably one of the most important communication design achievements of the 20th century—Janet Vertesi asked Londoners to draw a map of London. She noted that they draw maps that look more like the distorted map designed for navigating the tube system as opposed to other features and characteristics of the landscape (Vertesi 2008). In this way, the map limits and confines the imagination about the city: the most important that I need to know is how to traverse it.
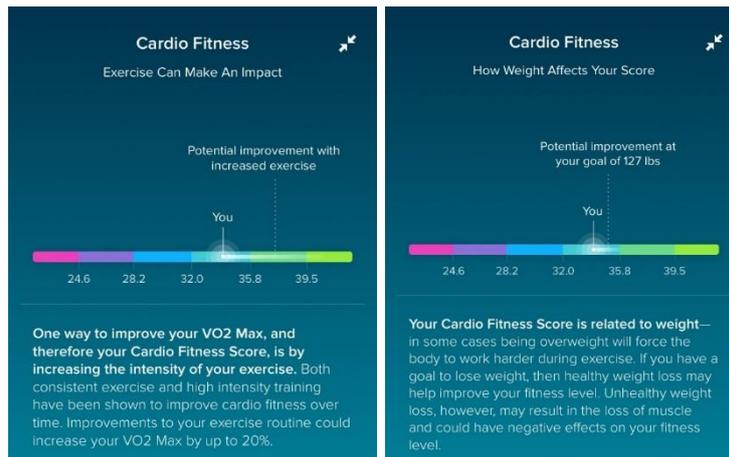
Figure 1. Fitbit Cardio Fitness Screenshots. An Example of how the graphs focus on "improvements" that can be made through exercise and weight loss

In a similar manner, images produced by medical imaging devices and self-tracking tools limit imagination and understanding of our bodies: we are encouraged to see the body in disaggregated bits, and the most important thing that we need to know is how to improve its metrics (See Figure 1). Those who engage with this data are meant to take these images as given. These kinds of renderings are what we are used to, and they dominate our imagination of what heartbeat is and does—and how to attend to it. Whereas in much wearable technology design, "the greater visibility of the bodily information implies an associated responsibility to act, and more specifically to act within intensified regimes of self-improvement and bodily control" (Viseu and Suchman, 163), we seek to create opportunities not to act toward more efficiency and control, as if to save time or to win against time. The experiments described in this paper seek to provide alternative ways of seeing and understanding the heartbeat and biological data more broadly.

2.1 Embodied Emotional Engagement

The first project that is fully realized takes heart rate, galvanic skin response, and breathing as input to produce flower-like visualizations that illustrate physiological responses to a short emotionally engaging video (Figure 2).
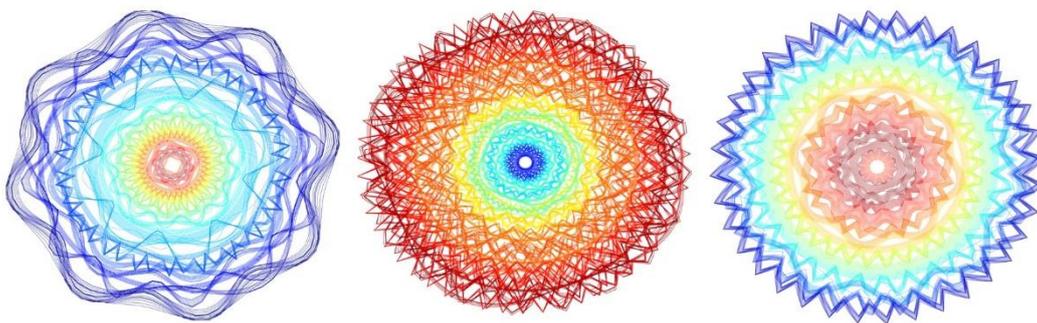
Figure 2. The graph generated for each participant is unique to their experience

Each circular line represents the individual's heart rate, depth of breath, and galvanic skin response at a distinct point in time, with the circles growing outward as time progresses. The quality of the line, that is how smooth or spiky each circular line is, represents how fast the heart is beating. In other words, when the heart beats faster, the graph renders a wave line of higher frequency. The amplitude of the wave line represents how deep the breath is. Shallow breaths produce a shallow wave line while deep breaths are rendered as steeper ones. We also measure the electrical

conductance of the skin, which increases with one's emotional intensity, such as experiencing excitement or fear. The colour intensity changes from blue to red to indicate this variable associated with intensity of emotions (Figure 3). Our choices of color are rather conservative (blue: calm; red: excited). This was the most practical way to render the data, since it was the default spectrum in MATLAB, and we decided that following this established convention makes it easier for our audiences to interpret the data. Moreover, since the drawings are rendered in time, the emphasis is more on the transitions and changes in color as opposed to their absolute values. Participants watch the line of the visualization as it is being drawn over the course of about ten seconds in a way that evokes drawing with a Spirograph toy, and encourages a mindset of wonder and creative exploration rather than assessment and control. We render the x-axis of time in a circular rather than linear way, producing a flower-like drawing that grows with the passage of time. Each drawing is unique to the experience and the individual (Figure 2).
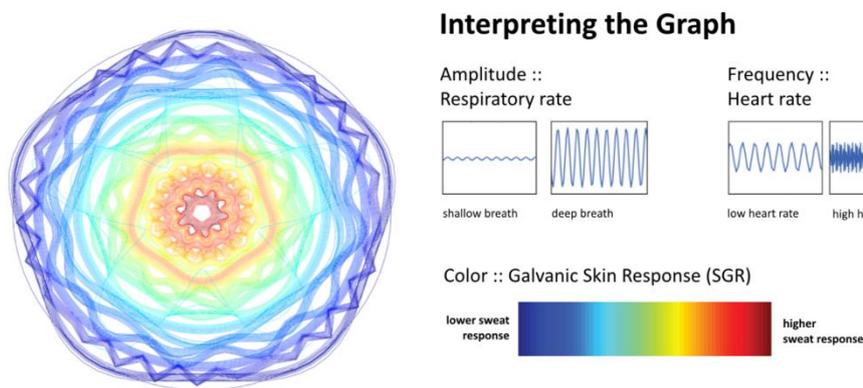
Figure 3. Interpreting the Graph

The way that the installation is set up is this: the viewer sits at a desk in front of a computer that equipped with the sensors. We use a *Xethru* breathing sensor measures the depth of breath by capturing the chest movement. Both heartrate and galvanic skin response are recorded using sensors that the participant wears on their fingers. One of multiple short movies is selected randomly. After they are done viewing the movie, the sensors are removed and the participant is invited to watch the visualization being rendered on a large screen. The final image is also printed on a card that the participant can keep as a souvenir of the experience (Figure 4).
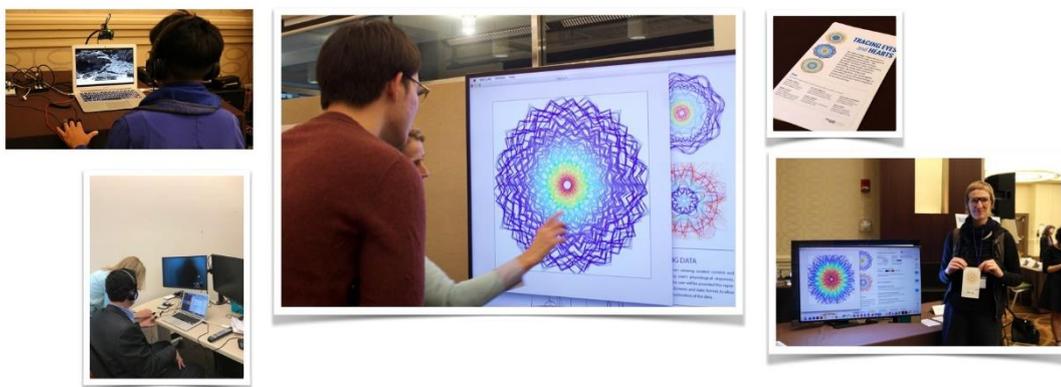
Figure 4. Installation Setup

We showcased this installation at the "Making and Doing" session of the Society for the Social Studies of Science meeting in Boston in August 2017, and the responses that it generated were

extraordinary. People were intrigued by their visualizations—and we say "their" quite consciously People claimed their visualizations in interesting ways. For example, when one of us commented to one participant as her visualization came to completion "wow, that's beautiful," the participant said "thank you." The response was entirely in earnest. Another manifestation of this sentiment was the participants' eagerness to print and "keep" their visualizations. In a few occasions they compared these prints telling stories about what they were experiencing and what the visualization suggested about how they felt.

Whereas data visualization as a field tends to take data about the body for granted, self-tracking discourses tend to take data about the body as a tool of control. This installation, however, manifests one of the ways in which methods and tools drawn from medical imaging and self-tracking devices can be rendered in ways that seek to challenge dominant modes of visualization as a means of optimization—what anthropologist Natasha Dow Schüll (2016, 329) has called "the datafication of biopower," in which the "datafied subject" is constantly nudged to make healthier choices. We were struck by how participants were intrigued by their visualizations as opposed to being confronted with a lack or shortcoming as often happens with self-tracking devices (e.g., "I didn't meet the daily 10,000 step goal last week"). In this manner, the presentation was successful capturing biological data in ways that are whole evocative rather than authoritative.

The other two visualizations are as yet less realized as fully implemented installations but exist as conceptual companions to the above.

2.2 Time

The second experimental configuration engages the experience of time from the heart's perspective. Clock time is set by inorganic means, specifically, the elapsed time of a specified number of cycles of radiation of a Caesium 133 atom. In real life, our time is generally set by our smartphones, which in turn draw their time data from satellites with atomic clocks. But what if we were to use more organic senses of time? What if the heart rather than the Caesium atom could provide a metronome? Could this be a new way of knowing time that takes its starting point from the lives of women and other living things?

Variations in heartrate are of course often due to changes in physical activity, but they can also be due to changes in emotional state. When we are experiencing emotional intensity, our heart rate elevates, and we experience time slowing down. Seconds can feel like minutes, as if we are experiencing life in cinematic slow motion. When we are emotionally disengaged, our heart rate slows down to a baseline, and—unless boredom itself provokes its own state of emotional elevation, aggravation—we become less aware of the passage of time.

In this visualization, we seek to create an opportunity to reflect on the passage of time, as reoriented through attention to the pace of the heart. The animation on the left traces time and heart rate relative to one another while the one on the right keeps track of the numeric value of heart rate. The intensity of the red colour indicates faster heart rate and thus an expanded experience of time. More specifically, on the left we see two lines sweeping the circle. One of the lines represents time just like the "seconds" hand of the clock. The other line, which we refer to as heart time, also sweeps the circles except this one represents heart rate. When time and heart rate get closer together, as would happen in a fleeting neutral state between engagement and disengagement, the colour changes to purple and we also see the two sweeping lines aligned. When heart rate increases, we see the heart rate line falling behind the time one to indicate the appearance of time slowing down. Conversely, when heart rate slows down, we notice heart time speeding up thus indicating that one is experiencing time as if it is going more quickly. In both of these circles, heart time is represented in red, and clock time is represented in blue. In the circle on the left, the relative pace of heart time and clock time moves clockwise, such that sometimes one races ahead of the other. In the circle on the right, when the heartrate exceeds clock time, the number is depicted in red, and when heartrate goes below clock time, the number is depicted in blue.

Figure 5. The image pair on the left shows the state of the visualization when heart time is faster than Caesium time, indicating an experience of time feeling expanded. The image pair on the right shows heart rate line moving below that of the Caesium time, indicating diminished subjective experience of time.

All of the visualizations that we have created engage with temporality, since rates are at the core, but this is the visualization that engages most directly with time itself. Feminist scholarship has recently foregrounded temporality as folded histories (M'Charek, 2014), and temporality as promissory futures (Walker, 2014), but what, after all, is time? Whereas "molecular clocks" of population genetics can fix time and place (Oikkonen, 2017), might a "heart clock" offer something more open-ended? Even as the very assessment of heartrate relies on an x-axis of Caesium-based time, foregrounding the pace of the heart offers gestures toward an ever-emergent organic alternative basis of measure. For both participants in the installation and for ourselves as theorists, we seek to evoke a mode of relationality with the heart's sense of time that is aligned with feminist scientist Evelyn Fox Keller (1983) characterizes—following biologist Barbara McClintock—as "a feeling for the organism." McClintock studied plants, and it is easy to see that plants have a different kind of time and place than humans do. But humans ourselves have plural ways of sensing time. Awareness of diverse human experiences of time can be obscured as our smartphones constantly privilege Caesium time. Bringing heart time to our attention through visualization provides an opportunity to empathetically engage with *ourselves* as organisms, our own pace never quite reducible to Caesium time.

2.3   Embodied Social Engagement

The third visualization engages embodied aspect of social connection through the mediation of the physical environment. Although we are not generally aware of it, our heart rate syncs with our environment. It won't necessarily match the rhythm of loud machines, music, or other stimuli, but its rhythm will come into relation.

Imagine a round table with four chairs and four headphones. A projector positioned on top of a table renders the visualization, which, in the initial state, represents the beat of the music in purple (Figure 6). Participants sit at the table, put on the headphones, and hold a small object that allows their heart rate to be recorded. Each individual heart rate is then rendered in a different colour. Brighter colours such as orange or red signify heart rates that are faster than the beat of the music. Darker colours such as green or blue mark slower heart rates. As each individual's heart rate gets closer to the beat of the music, the colours gradually change to different shades of purple. In this manner, the visualization captures the ways that the heart adapts in tune with the rhythms of space as well as a kind of non-communicative social connection that is otherwise invisible.

A. wave line showing music beat

B. Addition of two wave lines showing two participants heartbeats.

C. Four wave lines representing four participant heartbeats.

D. Wave lines changing color and moving closer to the music beat.
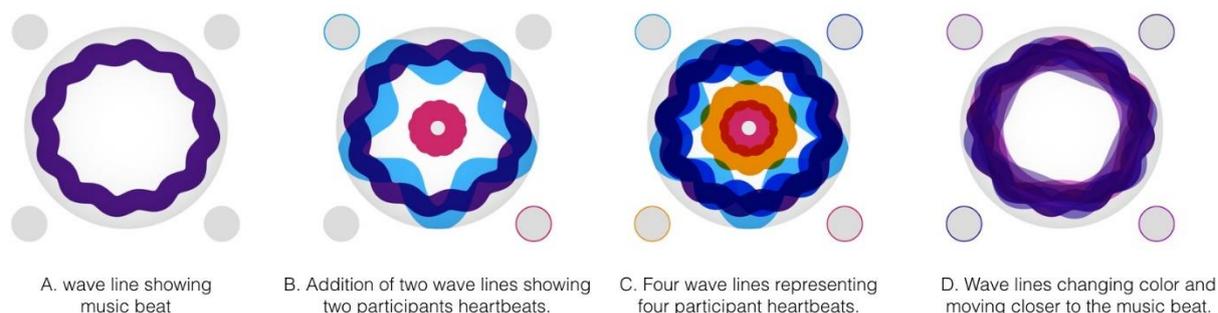
Figure 6. Music Installation

This installation seeks an opportunity to reflect on how "my" heart rate is not merely mine, and that social connection is also physiological connection. In doing so, it foregrounds the arbitrary binaries of inside and outside, self and other, illustrating social and material entanglements. This installation provides a novel route into the classic question raised by Donna Haraway in her Cyborg Manifesto: "Why should our bodies end at the skin, or include at best other beings encapsulated by skin?" (Haraway, 1991: 178). The installation illustrates that our bodies are always already in relation, at the same time that it provokes curiosity about *how* this might be so.

3   Conclusion

To close with a reprise of our opening question: How can the very creation, rendering, and experiencing of biological data be distinctly feminist? Taking heart rate as a point of entry and the above approaches to engaging with biological data gesture toward some ways that we might respond. We seek, for example, to elicit experiences of the body that are not readily available or visible otherwise. These visualizations create and illustrate data produced by instruments of science (cf. Barad, 2017), but prioritize the evocative over the precise in the rendering. These installations gestures toward what feminist STS scholar Angie Willey (2016, 555) has articulated as "biopossibilities," which "seeks to capture conceptually the way our creaturely capacities depend on the constraints of both intelligibility and matter."[6] In this way, our visualizations intervene on prominent non-feminist discourse of data about the body such as the research and discourses around self-tracking.

Our approaches to visualizing physiological data are broadly aligned with the idea of a cyborg feminism (Haraway, 1991), in which neither bodily integrity, nor control over the body, are the goal. While draw on these feminist ethos, however, it is important to caution against a set interpretation of feminist values that unquestionably produce feminist visualizations. We do not see the task of design as *identifying* a set of values to then be *applied* to design problems (JafariNaimi, 2015). Rather, we have *employed* values in feminist theory such as awareness, reflection, and conversation to open up the processes of selection, creation, and visualization of biological data as well as its experiences as generative places for asking new questions, new modes of knowledge making, alternative intra-active engagements. In these engagements, we do not see the biological and the social, or the ontological and the epistemological, as separate—but rather as deeply entangled.

Even as we provide an opportunity for feminist engagement with numerical facts about the body, we do not want to cede too much epistemic authority to those numbers and are careful about making totalizing claims of our own. Thus, a broad goal of this project is to serve as an illustration of how feminist theory allows us a more inclusive definition of science as a postcolonial, queer,

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[6] Although part of Willey's argument is that feminists should look to non-data-driven ways of knowing the body, such as the erotic, we believe that our imprecise and expressive engagement with biological data is sympathetic with her approach.

feminist enterprise—as called for by Banu Subramaniam and Angie Willey (2017). We view our contribution as one provisional response to this call and an invitation to future conversation and inquiry in this space by designers and theorists alike.

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