

The Body is Not a Neutral Design Space

How Designers Can Use Feminist and
Phenomenological Theory When Defining the “Self”
in Self-tracking

Sarah Homewood, IT University of Copenhagen
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Supervisor
Anna Vallgård, IT University of Copenhagen

Co-Supervisors
Marisa Cohn
Madeline Balaam

Committee
Jonas Fritsch, IT University of Copenhagen
Kristina Höök, KTH Royal Institute of Technology
Daniela Rosner, University of Washington

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Summary

Self-tracking technologies that attend to physiological processes artificially turn bodies inside out. Feminist theorists and phenomenologists show that the body is not an a-historical, pre-cultural or neutral object to be discovered through biological science. These theories reject Cartesian dualism, where the self is split into the cognitive mind and the mechanical body. They warn that this attitude leads to the erasure and oppression of bodies that do not fit the white, male, able-bodied norm that is held preferable in Western society. It is therefore relevant to consider the particular ways in which we understand and define the body within the design self-tracking technologies. This dissertation shows how current self-tracking technologies can be seen to treat the body as an object of science; to be measured and diagnosed through quantitative and normative practises. This approach to the body risks re-enforcing reductive and essentializing perspectives through treating the body solely as an object.

In an attempt to imagine alternatives to Cartesian dualist designs of self-tracking technologies, feminist theorist Elizabeth Grosz's theory of 'embodied subjectivity' is adopted and augmented with phenomenological theories on how the inside of the body is experienced. Grosz's theory holds that the body as object and the body as subject are entangled in a mobius-strip-like relationship. This approach seems relevant where the group of users or the design case at hand is a particular facet of the body or anatomy; a particular chronic disease or one aspect of anatomy or morphology. This approach highlights how the body is not a neutral design space and supports designers in making choices about the body politics they want their devices to enact. The approach of designing for embodied subjectivity is explored and developed through the design of two self-tracking devices; Ambient Cycle, a menstrual cycle tracking device that visualises data through ambient colour changes in the home environment, and Ovum; a ceramic ovulation tracking device that

projects a magnified silhouette of the user's saliva sample out into the room, when the user is fertile, salt crystals appear in this projection.

Long-term deployments of Ambient Cycle and Ovum showed how the approach of designing for embodied subjectivity supported a less normative notion of the body by facilitating the tracking of a wide range of bodily experiences; facilitated conversations and reflections on body politics in society; and produced novel, positive, forms of interactions with the insides of bodies, rather than interactions that reinforced that the biological body was an aspect to be negated and controlled through self-tracking. In presenting the particular ways in which Ambient Cycle and Ovum failed to live up to participant's expectations of self-tracking devices, this research highlights how Cartesian dualist definitions of the body is still present and preferred in self-tracking practices, even when irregularity, uncertainty and inaccuracy is an inherent aspect of the body itself. Other contributions include accounts of the implications of designing for embodied subjectivity on the experience of the designer and the removal of technologies as a research method that produces knowledge through disturbing user's habitual relationships with their devices.

Sammenfatning

Self-tracking teknologier, som bruges til at analysere vores fysiologiske processer, vender kunstigt vrangen ud på vores kroppe. Feministiske teoretikere og fænomenologer viser os, at kroppen hverken er en ahistorisk, præ-kultural eller neutral størrelse, som kan udforskes ved hjælp af naturvidenskaben. Disse teorier afviser kartesisk dualisme, hvor selvet kan opdeles i et kognitivt sind og en mekanisk krop. De advarer også om, hvordan denne holdning kan føre til udviskning og undertrykkelse af kroppe, som ikke passer ind i den hvide, maskuline, sunde og raske norm, der foretrækkes i den vestlige verden. Derfor er det relevant at overveje de bestemte måder, vi forstår og definerer menneskekroppen på, når man designer self-tracking teknologier. Denne afhandling viser, hvordan eksisterende self-tracking teknologier kan opfattes som at behandle kroppen som et naturvidenskabeligt objekt, som skal måles og diagnosticeres ved hjælp af kvantitative og normative metoder. Denne tilgang til menneskekroppen risikerer at forstærke reduktionistiske og essentialistiske holdninger ved udelukkende at behandle kroppen som et objekt.

I et forsøg på at forestille mig alternativer til kartesisk dualistiske self-tracking teknologier, bruger jeg den feministiske teoretiker Elizabeth Grosz' teori om "embodied subjectivity" sammen med fænomenologiske teorier om, hvordan kroppens indre opleves. Ifølge Grosz' teori er kroppen som objekt og kroppen som subjekt uløseligt forbundet som et Möbiusbånd. Denne tilgang er relevant når design casen er et bestemt aspekt af kroppen eller anatomien, en kronisk sygdom eller et aspekt af anatomi eller morfologi. Denne tilgang understreger, hvordan kroppen ikke er et neutralt designområde og understøtter designere i at træffe beslutninger omkring, hvilken kropspolitik de vil have deres devices skal agere under. Jeg undersøger, hvordan man kan designe for at imødekomme "embodied subjectivity" og udvikler dette ved at designe to self-tracking devices; Ambient Cycle, en menstruations tracking device, som visualiserer

data igennem omgivende farveskift i hjemmet, og Ovum, en keramisk ægløsnings tracking device, som projicerer en forstørret silhuet af brugerens spytttest ud i rummet. Når brugeren har ægløsning, er der saltkrystaller i billedet.

Længere tids brug af Ambient Cycle og Ovum viste, hvordan tilgangen med at designe for øget "embodied subjectivity" understøtter en mindre normativ opfattelse af kroppen ved at facilitere en bred vifte af kropslige oplevelser. Det faciliterede samtaler og refleksioner over kropspolitik i samfundet og producerede nye, positive former for interaktioner med kroppens indre i stedet for at skabe interaktioner, der forstærker et syn på den biologiske krop som noget, der skal negeres og kontrolleres gennem self-tracking. Ved at fremlægge de aspekter af Ambient Cycle og Ovum, som ikke stemte overens med deltagernes forventninger til self-tracking devices, kaster denne forskning lys over, hvordan kartesisk dualistiske definitioner af kroppen stadig er fremherskende og foretrukne i self-tracking procedurer, selv når uregelmæssighed, usikkerhed og manglende præcision er uundgåelige, når man har med menneskekroppen at gøre. Der medfølger også andre overvejelser omkring implikationerne af at designe for embodied subjectivity for designeren og hvordan man kan fjerne teknologier som en forskningsmetode, der producerer viden ved at forstyrre brugernes vanemæssige forhold til deres devices.

Part 1.

Introduction

Over the last three years I have explored possible and preferable futures for the design of technologies that track inner-body processes. There are typically three cases in which technologies are used to provide information about the insides of the body. The first case is to be found inside the clinic. This is where healthcare professionals employ technologies to measure the body in times of ill health. An example of this is the heart-rate monitor positioned beside the hospital bed. The second use case is where technologies are prescribed by healthcare professionals to be used outside of the clinic either to prevent, manage, or improve ill-health. Patients use these devices on their own bodies. A common example is the glucose measuring device that is used in the management of diabetes. A third, emerging, use case is where users themselves adopt so-called self-tracking devices to gain more insight into their own health and bodies.

Self-tracking, which is also referred to as the quantified self, personal informatics or personal analytics, has long been practised through analogue means such as journaling, the use

of calendars, and writing down numbers by hand (Lupton, 2014c; Wernimont, 2018). Increasingly, developments in hardware and software facilitate a range of possibilities for collecting, measuring, computing and displaying self-tracked data through technological means (Crawford, Lingel, & Karppi, 2015; Lupton, 2014c; Wernimont, 2018). The majority of commercial devices and research on self-tracking attends to the self-tracking of steps, actions, moods and behaviours. However, due to both technological developments and advancements in biological science, self-tracking is also increasingly applied to inner-body processes in cases such as chronic diseases and syndromes such as migraines, digestive health and to track physiological processes such as pregnancy, heart rate, the menstrual cycle and menopause. These technologies are not prescribed by a healthcare professional, but rather purchased commercially and adopted by users of their own volition. These devices are either in the form of mobile apps, or hardware devices that are often paired with mobile apps. These technologies make visible aspects of bodies that were previously invisible; “what was depth is artificially made to surface” (Leder, 1990, p.53).

Devices that track the insides of the body either use clinical and quantitative methods to measure the body directly through sensors or employ user’s self-reporting of felt symptoms to understand and track what is happening in the inside of the body. Some self-tracking devices use a combination of these two methods. The research presented in this dissertation attended specifically to cases where users decide themselves to adopt self-tracking technologies to provide information about the insides of their bodies.

There are two particular implications of these types of self-tracking technologies. These implications represent my key areas of interest. The first implication of the adoption of self-tracking devices is the fact that these technologies use clinical methods within non-clinical settings. What was previously the domain of the clinic is now migrating into our homes, pockets and onto our bodies (Ludden & Vallgård, 2019). This means that interactions between users and their own data that would have previously been mediated by a healthcare professional now takes place between users and their technological devices. A range of other factors, such as variations across participant's, social contexts, resources, places and routines, also influence the experience of self-tracking in a non-clinical setting (Elsden, Selby, Durrant, & Kirk, 2016; Grönvall & Verdezoto, 2013). How these factors are addressed is a concern directed towards the design community. One such example of a designerly approach to addressing the non-clinical context that self-tracking is taken place within is the Philips uGrow baby development tracker (Figure 1.). The design of this device reflects the fact that multiple people will participate in tracking of the health of a baby (Kollenburg et al., 2018). The use of wood and the aesthetics of the device are used to reflect the domestic environment that uGrow will be used within. My own research-through-design process explores what these non-clinical contexts could mean for the design of self-tracking technologies in terms of their materiality, form and the interactions they afford between users and the insides of their bodies.

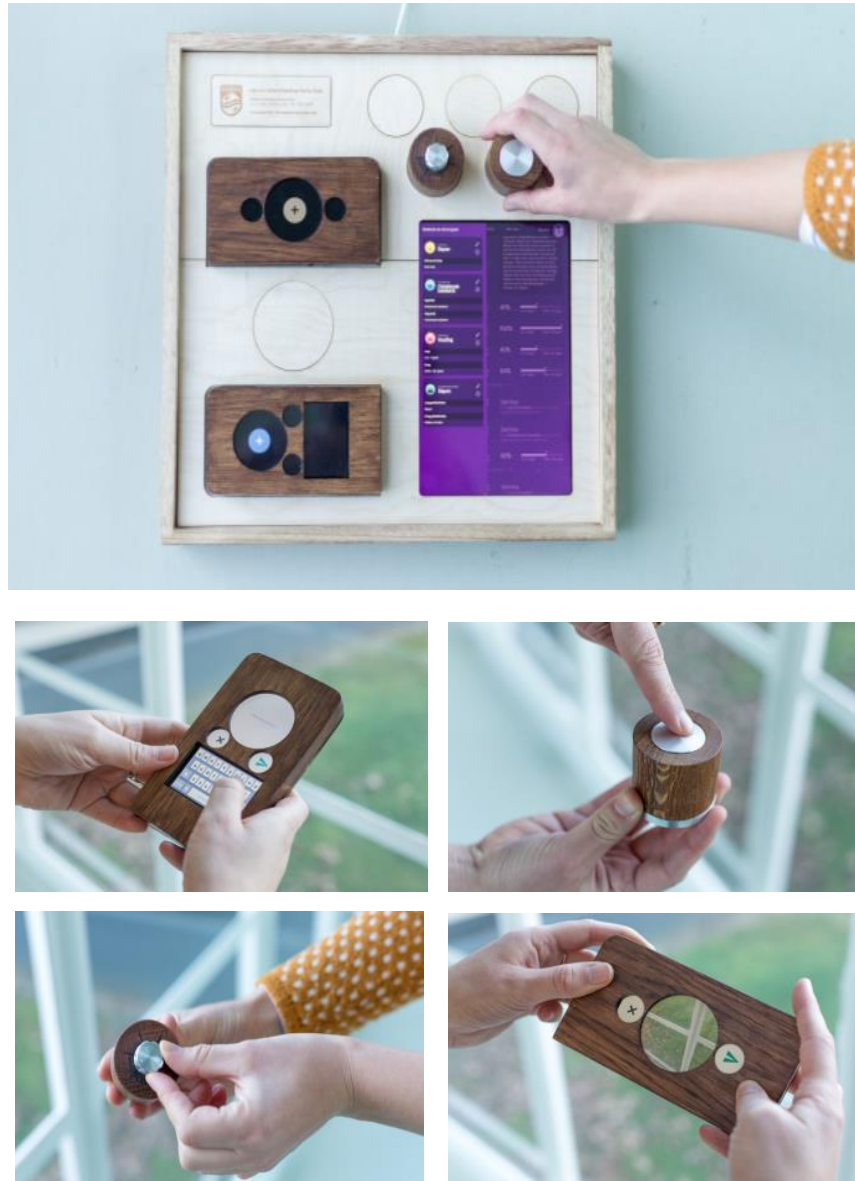


Figure 1. The Philips uGrow baby development tracking device (Kollenburg et al., 2018).

The second implication of a proliferation of technologies designed to track the inside of the body outside of the clinic is the fact that clinical processes are now being applied to track and measure healthy bodies (Lupton, 2013, 2014b). Self-tracking devices are not adopted as a form of necessary medical

intervention, but rather with other aims and motivations. This includes “documentary tracking”, where there is no goal beyond the act of tracking itself (Rooksby, Rost, Morrison, & Chalmers, 2014). By providing increasingly granular data on the insides of the body, these devices re-configure cultural and societal definitions of the “normal” and “healthy” body through their design (Chrysanthou, 2002). Self-tracking practices often act as a form of patient-led preventative health-care (Macri, Mirarchi, Pagliaro, Russo, & Vizza, 2015). The body is kept “healthy” through monitoring and “nudged” to adapt lifestyle choices in accordance with data (Schüll, 2016). Knowledge about the body is no longer only produced through felt sensations, but also through medical and scientific models based upon objective, biological facts. This means that user is both the active observer as well as the passive object being observed, and this influences how the body is experienced and conceptually understood (Ruckenstein, 2014; Smith & Vonthehoff, 2017).

My research works from a belief that medicine and science are never outside of culture, and that these cultures shape how the body is lived and understood societally (Harding, 1986; Lupton, 2012). I argue that the proliferation of technologies used to track the insides of the body in non-clinical context and in non-medical cases already facilitates new cultures around the body in Western society. Designers of digital technologies will be as influential as healthcare professionals in shaping these new cultures through the devices they design (Btihaj, 2018; Lupton, 2020). The pertinent question for designers then becomes; what kinds of cultures around the body do we want to support through the devices we design?

Research Perspectives

The research presented in this thesis is possible because of current research perspectives both in the self-tracking domain, and in the field of design within human-computer-interaction (HCI). Current perspectives in the domain of self-tracking show self-tracking to be a practice that fundamentally changes who self-trackers are and how they come to understand themselves, and current perspectives in design acknowledge that designers are influenced by, and go on to influence, cultural and societal norms and values through the devices they design. My own research perspective, which is influenced by my background and positionality, also shape the types of questions I ask and the ways in which I conduct research.

Research Perspectives Within Self Tracking

Research perspectives within the domain of self-tracking have changed over the last few decades. Rather than conducting research with the solutionist aim of producing efficient and accurate devices that result in better health and fitness outcomes, researchers instead attend to how self-tracking practices take place in situ (Ayobi, Marshall, & Cox, 2016; Elsdén et al., 2017; Morozov, 2013). There has been a move away from understandings of self-trackers as “rational data scientists” carrying out scientific investigations on themselves in a bracketed and controlled environment (I. Li, Dey, & Forlizzi, 2010). Designers are now recommended to consider the psychological, societal and cultural, and social factors of everyday life in both the design and in the evaluation of the use of self-tracking devices (Elsden, Kirk, Selby, & Speed, 2015; Epstein, 2015; I. Li et al., 2010). Terms such as “lived informatics” (Rooksby et al., 2014), “lived data” (Kaziunas, Lindtner,

Ackerman, & Lee, 2018), and “lively data” (Lupton, 2016a) all point to perspectives that attend to the phenomenological experience of self-tracking. For example, Sharon and Zandbergen, (2017) show that, although gaining objectivity and self-optimization through “data fetishism” may be a key initial motivation in the adoption of self-tracking technologies, self-trackers in fact use data in practices of mindfulness, as means of resistance against social norms, and as a communicative and narrative aid (Nafus & Sherman, 2014). This shift in perspective is also evident in the types of research methods used. Situated methods such as ethnography (Nafus & Sherman, 2014; Schwennesen, 2017) and autoethnography (Forlano, 2017; Salmela, Valtonen, & Lupton, 2019; Williams, 2015) are used to understand how self-tracking practices are carried out in the wild. This perspective has also resulted in the acknowledgment that episodic use and the abandonment of self-tracking devices is a normal aspect of self-tracking, rather than a failing in the design and usability of the artifact itself (Epstein, Caraway, et al., 2016; Epstein, Kang, Pina, Fogarty, & Munson, 2016; Gorm & Shklovski, 2017).

Current research on self-tracking shows that the design of self-tracking technologies influences the users experience of their own bodies and, consequently, how they understand themselves. These devices operate as a “laboratory of the self” (Kristensen & Ruckenstein, 2018). Identities, selfhoods and embodiments are produced through interactions with self-tracking devices (Lupton, 2014a, 2014c, 2020). Self-trackers are fundamentally changed by their interactions with devices. Sociologist Deborah Lupton argues that, although there is a large body of literature on the ways in which self-tracking is enacted through digital technologies, “little attention has been

paid to the ways in which the specific types of hardware and software that are used as part of the contemporary self-tracking cultures draw on, reproduce and in some cases reconfigure concepts of selfhood” (Lupton, 2014a, p.79). Similarly, Rapp and Tirassa (2017) describe how a theoretical foundation is missing to the particular type of “self” being designed for within self-tracking. They state that the discourse “emphasize(s) the benefits that allegedly derive from “self”-reflection and “self”-knowledge, but what is the “self” they are designed for?” (Ibid, p.337). Rapp and Tirassa argue that most understandings of the “self” in research on self-tracking are drawn from behavioural models. These are inadequate as they account for only external manifestations that account for what self-trackers do, but not who they are. Rapp and Tirassa propose that researchers should reject a behavioral, external perspective and instead adopt a wider philosophical and existential enquiry into how theories of self are used, developed and produced in self-tracking.

Though there are a number of examples of philosophical and theoretical enquiries into what understanding of self has been used in the design of self-tracking technologies, there are far fewer projects that take up this enquiry through the design of the self-tracking technologies themselves. Some researchers, including Rapp and Tirassa (2017), provide guidelines for how self-tracking technologies might be designed with phenomenological theoretical commitments. Similarly, Ohlin and Olsson also present guidelines for post-phenomenological approaches to the design of self-tracking devices (Ohlin & Olsson, 2015). One important exception is JafariNaimi and Pollock’s research exploring the results of adopting a feminist approach in the design of heart-rate tracking devices to as a

way of troubling the androcentric dominance of modern scientific lenses on the body (Figure 2.) (JafariNaimi & Pollock, 2018). They use a material engagement with the way in which data is interpreted by designing variations of heart-rate visualisation devices that aim to be evocative rather than authoritative. Through their research, JafariNaimi and Pollock call for an inclusive definition of science as a postcolonial, queer, and feminist enterprise through explorations into how physiological data is visualised and presented. This is done through exploring the relationship between matter and meaning. In my research, I have answered this call to interrogate the politics and cultures of science through asking philosophical and existential questions about the “self” being designed for. These questions are addressed through the process of designing critical and speculative self-tracking devices.

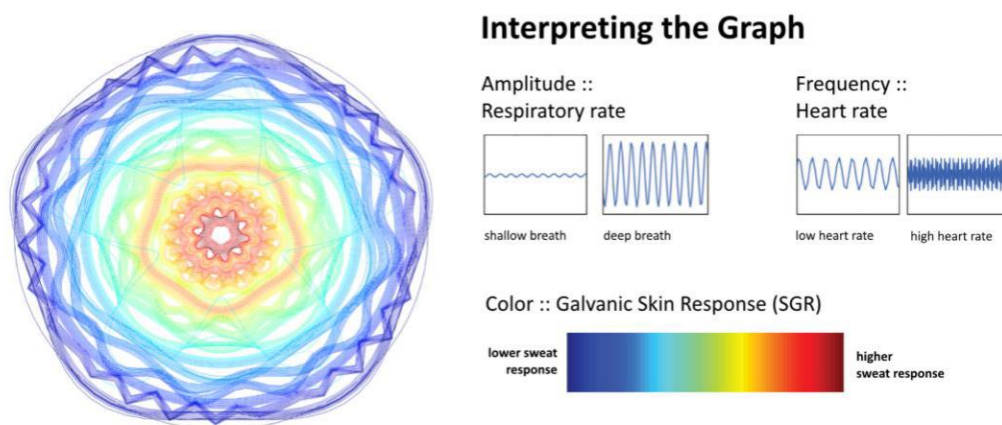


Figure 2. A diagram presenting the construction behind JafariNaimi and Pollock’s proposals for how physiological data might be visualised as flowers (JafariNaimi and Pollock, 2018).

Research Perspectives in HCI

My research is situated within current landscapes within the field of human-computer-interaction (HCI). Research perspectives in HCI have shifted in relation to how technologies have become embedded in all aspects of our lives; HCI is well into its 'third wave'. A third-wave approach to HCI acknowledges the emotional, embodied and social aspects of interactions with technologies, rather than focusing on technologies as tools for work and completing tasks (Bødker, 2006).

My own research draws on and develops third-wave perspectives that prompt questions about how technologies shape and define "the good life" (J. Bardzell & Bardzell, 2015). As technologies become increasingly ubiquitous, HCI researchers have begun to ask whether the design of technological devices really benefits all users. These questions require a humanistic approach to HCI and called for enquiries into the values embedded in and enacted by technological devices (J. Bardzell & Bardzell, 2015). Critical theories are often used to interrogate the mechanisms in which social injustices are reproduced through technologies (S. Bardzell, Bardzell, Forlizzi, Zimmerman, & Antanitis, 2012). This is evident in approaches such as reflective design (Sengers, Boehner, David, & Kaye, 2005), the CHI4Good and the HCI for development (HCI4D) movement (Toyoma, 2010), value-sensitive design (Borning & Muller, 2012), feminist HCI (S. Bardzell, 2010), and post-colonialist design and approaches (Irani, Vertesi, Dourish, Philip, & Grinter, 2010). These examples are often motivated by addressing under-served groups in HCI with the perspective that once we become aware of and reflect on the varying assumptions and biases embedded in our view of the world,

then we can re-configure our approach to developing technologies in order to combat injustice in society through taking up particular theoretical commitments. The research presented in this thesis builds on the perspective that the objects we design shape politics and cultures (Winner, 1980). This perspective acknowledges that cultural and societal norms and values are both embedded within and enacted by the devices we design (DiSalvo, 2012; Nunes et al., 2015). As Frauenberger states, "our choices matter, quite literally" (Frauenberger, 2019, p.17).

From the perspective that cultural and societal norms and values are both embedded within and enacted by the devices we design, the question of which conceptualisation of "self" designers are designing self-tracking devices for becomes more pertinent. Current research perspectives in self-tracking state that designers are not only designing technological devices, but also bodies and selfhoods (Lupton, 2016b; Smith & Vonthethoff, 2017). Johan Redström states that definitions are made through design (Redström, 2018). Designers of self-tracking devices are not only making definitions of the practice of self-tracking through their designs of self-tracking technologies, but they are also making definitions of bodies and body politics in society and culture. Current research perspectives in HCI would therefore state that the understanding of the "self" that designers design for is shaped by the cultural and societal norms and biases of the designer. These norms and biases are then embedded into devices that go on to shape culture through their use. There is a choice for designers to make between re-enforcing current cultures around the body and the "self" in self-tracking and re-imagining these cultures through their design work. Working from these perspectives, I first present a

critique of current, Cartesian dualist cultures around the body before adopting feminist and phenomenological theoretical commitments and applying these commitments in the design process of developing self-tracking technologies.

My Own Research Perspective

In order to counter the “god trick” and the “gaze from nowhere” that gives research an air of false objectivity, it is important to declare my own perspective as a researcher (Haraway, 1988; Bardzell and Bardzell, 2015). This has been an individual project in terms of the framing of the research topic and research program, but I have collaborated with others in the IxD Lab at ITU in the design and fabrication processes. My co-authors and collaborators have shaped my research, but since I am alone in writing this kappa, I will only account for my own research perspectives.

Digital humanities scholar Jaqueline Wernimont asks “(d)o we really want a suite of quantifying tools built largely by a long progression of white Christian men to be the dominant media for understanding and living human life? Can we imagine other possibilities?” (Ibid p.159). My own position as a woman, as a feminist, as an interaction designer, and as a researcher with a background in contemporary dance enables me to “imagine other possibilities” of self-tracking cultures through design. It is evident that these three factors have deeply influenced both the types of questions that I have asked as well as how I have conducted my research.

Being a woman and a feminist provides me with a critical eye due to my particular standpoint in the world (Haraway, 1988;

Harding, 1986). I see and feel injustices and gender inequalities in a way a male researcher would not. My position as a white woman also means that I perhaps do not see racial injustices in the same way as non-white researchers. It is possible that I would not have entered into research on women's health technologies, which have been my main domain, if I were not a woman with previous experience of these devices myself. My position as a person who menstruates has not only been a reason that I have entered into this domain but has also been a useful tool throughout this research. I have been able to use my own experience empirically through methods such as autoethnography.

It has only been in the last year or so that I have reflected on the extent to which my training and earlier profession as a contemporary dancer has influenced my work within interaction design. Because I am no longer dancing and using movement as a research method, I did not see the strong link between my past and present career. Dancing brought me to the field of interaction design, but it is not movement that is the linking factor. Looking back on my previous choreographic work it becomes evident that my interest was always in exploring how cultural and societal norms shaped the body. One of my earliest research projects during my bachelor's degree at the Northern School of Contemporary Dance addressed how movement is gendered. I began by studying empirical research on the variations between male and female skeletons and was surprised to discover the extent to which societal norms shapes gendered movement, rather than anatomical and skeletal differences. My choreographic practice then involved understanding ways in which my own movements were gendered. In the following years as a professional dancer and

choreographer I explored de-constructing sexualised movements in performances based upon research conducted in strip clubs. My main interest was how movement facilitate the transition between the un-sexualised body and the sexualised body. On reflection, it is no surprise that I have ended up with this thesis topic. It is clear that my interests and perspectives have led me to just another way to explore how bodies and conceptualisations of bodies are shaped by the cultures that they are situated within.

Motivation

As discussed, my research is motivated by a belief that developments in the field of self-tracking and medical technologies already signal the emergence of a new culture around the body; one that will be shaped by designers as much as doctors and biologists (Ajana, 2018; Lupton, 2014c). My motivation is that we, as designers, might use this momentum to re-configure, rather than just replicate, cultures around the body. By making feminist and phenomenological commitments, we may design better and more feminist futures for technologies that provide information about the body.

Through presenting untold stories about the histories of current technological devices, it is possible to understand the cultural underpinnings that have produced them. Providing histories allows designers the knowledge and choice to either re-enact or re-configure these cultures (Rosner, 2018). A key event in history that still shapes Western culture today was the adoption of the metaphysics of philosopher and scientist René Descartes who lived from 1596 to 1650 AD. Descartes' work

sparked a new understanding and application of science. One of Descartes' main proposals was that the "self" comprised a dualism of an irrational, animalistic, machine-like body and a rational, cognitive, ensouled, mind. He stated that the body was a machine that could be divided up, improved, and fixed through mechanical interventions. This statement conflicted drastically with pre-modern understandings of the body as a holistic entity, owned and governed by God, and shaped by its environment (Foucault, 1963; Drew Leder, 1992). This later sparked an epistemological and ontological revolution leading to the birth of modern medicine in the early eighteenth century (Drew Leder, 2013; Svenaeus, 2000). Through situating self-tracking within historical understandings of bodies and selfhoods, it is evident that Cartesian definitions of the self are still used today, and even exaggerated, in how the body is approached within HCI (Höök, 2018). From this perspective, the biological body is viewed as an object that can be neutrally discovered, controlled, and optimized through the application of biological science and quantification by the rational and cognitive self-tracking subject (Rose, 2001; Viseu & Suchman, 2010; Williams, 2015).

My motivation behind challenging existing cultures in the design of self-tracking technologies is a belief that the Cartesian dualist epistemology is problematic, both in how it supports a reductive and essentialising approach to lived experience, as well as how it perpetuates injustice in society. Philosopher Drew Leder describes Cartesian dualism as "onto-valuational"; Cartesian dualism was not only an approach to metaphysics and the ontology, Cartesian dualism also went on to shape and support certain power-structures and cultural and societal values (D Leder, 1990). Feminist theory and phenomenological theory both challenge Cartesian definitions of the "self" as a

dualism of a mechanical, animalistic body and a rational mind. Feminism is a political movement that interrogates gender relations in society with the goal of obtaining gender equality. Phenomenology is a philosophical study of lived experience that brackets off scientific and metaphysical knowledge of the world from the direct experience of the subject. Phenomenology holds that the world is always a world-as-perceived, rather than a scientific object or a thing-in-itself, thereby living up to feminism's ideals and criticisms that scientific depictions of the world are never value-free since there is no objective reality to be discovered. Feminism and phenomenology are mutually compatible; feminist theory compensates for the tendency for phenomenological theory to work from a universalizing, typically male, understanding of the body, and phenomenological theory compensates for feminism's lack of detail in accounting for the nuances of how the body is lived and experienced (Ahmed, 2006; Fisher, 2000; Grosz, 1994).

Phenomenological and feminist theory agree that mind/body binaries lead to man/woman, nature/culture distinctions and power structures (Grosz, 1994; Drew Leder, 1992). A dualist view that the mind is superior to the uncontrolled and animalistic body has been used to label the body as inferior. At the societal level, groups such as women, labourers, those with disabilities, and non-white people, who are more closely associated with their bodies, are defined as unruly and irrational and unsuited for positions of power (Grosz, 1994; Merleau-ponty, 1968; Shildrick, 1997). Descartes' ideas resulted in a preference for objectivity, rather than subjectivity in the production of knowledge about the world (Sorrell, 1987). Dualist understandings of the body therefore risk the promotion of a narrow biological determinism and essentialism. In this,

assumptions about who somebody is, are based upon their anatomy, due to the fact that the body as an object is seen to hold inherent “truths” about who that person is and how they will act (Price, Shildrick, Shildrick, & Price, 1999). This reductive and oppressive approach to defining humans has been used in un-inclusive practices such as equating sex to gender, and in the argument that women are unfit for positions of power due to their unstable, leaky and uncontrolled corporeality (Shildrick, 1997). Replicating dualism in the design of self-tracking tools risks replicating patriarchal cultures that support an oppression of those associated with their bodies. In light of this, my research is motivated by a desire to explore how non-Cartesian dualist self-tracking technologies might be designed.

As well as contributing to the domain of self-tracking, my research is directed towards researchers designing for the body within HCI. A final motivation behind my research is “the challenge to designers is to take seriously the valuation of the lived body and our capacity to act within designed systems and procedures.” (Loke and Robertson, 2011, p.182). Phenomenology has been an important source for designers to draw from, most notably within the field of embodied interaction design (Dourish, 2001; Svanæs, 2013). However, there have also been critiques that state that embodied interaction design lacked a body (Dourish, 2013). Kristina Höök states that “embodied interaction did not speak of our muscles, our nervous systems, the ways we can and cannot move, our skeletons, how emotions are processed throughout our brain, releasing hormones, activating muscles, attention and perception, and how those elements would change and be shaped by new interactions” (p. xxi). The fact that self-tracking centralises the body makes this

a particularly rich site in which to continue to develop the field of embodied interaction design.

The design space for the research presented in this thesis is the inside of the body outside of the medical domain. To date, embodied interaction design has taken seriously the flesh of the body as shaping perception; that the world comes into being through our embodiment, including through our bodily senses (Dourish, 2001; Svanæs, 2013). However, the insides of the body as a design space is still a burgeoning area of research (Homewood & Heyer, 2017; Z. Li, Brandmueller, Mueller, & Greuter, 2017). This is one motivation to adopt the philosophy of phenomenologist Drew Leder. Whilst Merleau-Ponty has been one of the main phenomenologists that the field of embodied interaction design draws from, Merleau-Ponty did not begin to attend to the insides of the body until his final, unfinished book “The Visible and The Invisible”, and these theories did not attend directly to how inner body processes shape perception (D Leder, 1990; Merleau-ponty, 1968). Leder builds upon Merleau-Ponty’s theories about how the body shapes experience of the world and offers a “phenomenological anatomy” that is relevant to apply to research on self-tracking technologies that address physiological processes. The domain of self-tracking the insides of the body represents a design space where phenomenological accounts of lived experience are contrasted with rationalist scientific information about what goes on beneath the surface. To apply phenomenological theories to physiological process creates an epistemological battle ground. My research is motivated by a desire to explore what is required to extend the phenomenological commitments of embodied interaction design to the domain of the insides of the body, and what the implications of this might be.

The Research Program

Rather than framing a design problem, and offering a solution to that problem through design, this dissertation presents a research program. A research program aims to raise problems and questions rather than solutions and answers (Redström, 2018). As Redström states, “we can use programs to articulate provisional foundations, to state worldviews that we want to explore as if they were true so as to learn something about what kind of design they would lead to” (Ibid, p,97). In adopting a programmatic approach to design research, I am able to take up an adversarial position as a designer through my four design experiments, and expand, multiply, intensify and complicate the issue at hand (Figure 3.) (DiSalvo, 2012).

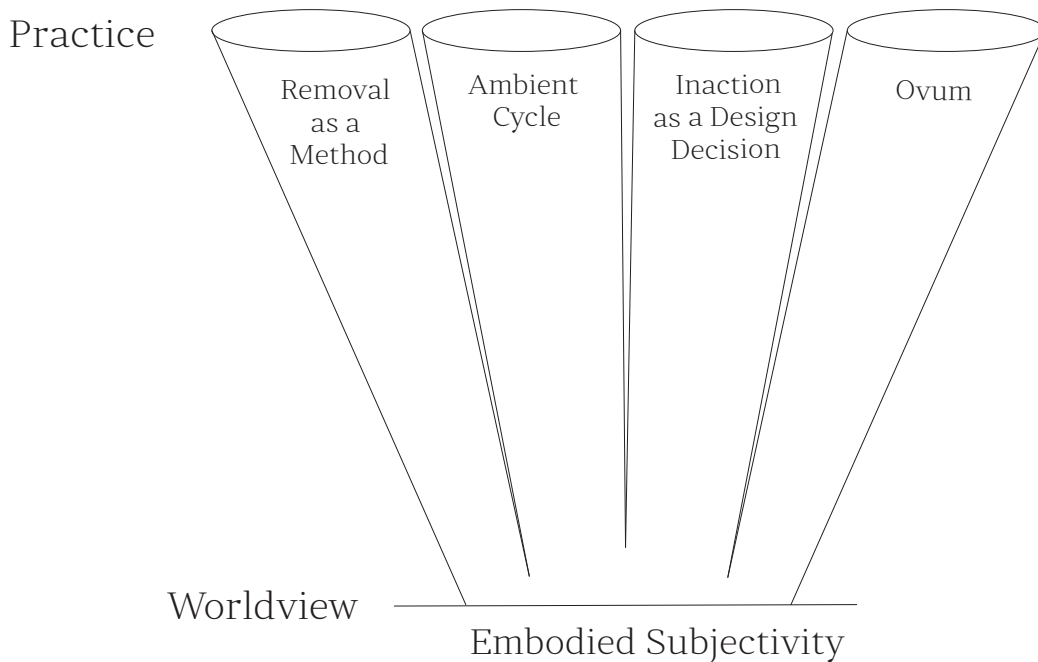


Figure 3. The research program with its four research experiments.

This research program is situated within a context where technologies are increasingly used to provide information about the insides of the body in non-clinical settings (Figure 3). Alternative futures for designs of self-tracking devices are explored through interrogating and challenging the cultural norms, biases and values that they represent and enact. Specifically, this research program is motivated by challenging and re-configuring existing, Cartesian dualist cultures around the body. As discussed, the problem with Cartesian dualism is that it splits the self into a rational, dominant, mind and an irrational, unruly body. This perspective objectifies and de-values the body and leads to the de-valuing of those who are more associated with their bodies such as women, people with disabilities and non-white people (Grosz, 1994; Price et al., 1999). In order to re-configure Cartesian dualist cultures in the design of self-tracking technologies, theoretical commitments to feminism and phenomenology are made; namely Elizabeth Grosz's theory of embodied subjectivity that states that selfhood is a mobius-strip-like relationship between the body as subject and the body as object (Grosz, 1994). This research program explores the ways in which these theoretical commitments can be adopted by designers through the design of critical and speculative prototypes. These prototypes can be deployed in order to understand how they are understood and used as self-tracking devices by participants. This research program aims to produce knowledge about the benefits, implications and limitations of the approach of designing for embodied subjectivity within the domain of self-tracking.

Design Cases

Within the larger domain of self-tracking the inside of the body, the particular cases I address are menstrual cycle tracking, menopause tracking and ovulation tracking. Menstrual cycles, menopause and ovulation are not medical syndromes but that the way they are experienced is informed by medical and scientific knowledge on the body (Lupton, 2015; Meyer, 2001). This means that the cases addressed in this thesis provide a means with which to explore possible implications of the increasing application of medical practices in non-clinical settings. Since these are not medical nor life-saving cases of self-tracking, we gained more flexibility in our design processes without coming up against ethical concerns.

A second implication of attending to these cases is that menstrual cycles, menopause and ovulation can all be defined as areas of “women’s health”. Although not all who identify as “women” have a female anatomy, and not all who have a female anatomy identify as a “woman”, these areas have been categorized as such (Balaam et al., 2017). One benefit to these cases is their ability to raise questions of body politics, particularly in regards to gender biases in how technologies for women’s health are designed (Teresa Almeida, Comber, & Balaam, 2016; Teresa Almeida, Comber, Wood, Saraf, & Balaam, 2016; Lupton, 2015; M. L. Søndergaard & Koefoed, 2016). Since women have been oppressed on the grounds of the particularities of their biological bodies, technologies designed for women’s health are particularly fertile soil for interrogations into the biopolitics enacted by self-tracking technologies (Almeida et al., 2016a, 2016c; Balaam et al., 2017).

Papers Included in this Dissertation

The following papers are chosen to include in the second part of this dissertation to represent the research conducted over the three-year research process.

Paper 1

Homewood, S., 2018. Reframing Design Problems Within Women's Health. In Proceedings of the Design Research Society Conference, DRS.

A feminist critique of menstrual cycle tracking technologies is used to investigate how the way that design problems are framed influences the artifacts produced and their impact within society. This paper argues that by re-framing design problems from the perspective of third and fourth wave feminism we can develop women's health technologies that are more affirmative, inclusive, intersectional, and which celebrate difference and reflect the complexity around what it means to be a woman in today's society.

Paper 2

Homewood, S., 2019, April. Inaction as a Design Decision: Reflections on Not Designing Self-Tracking Tools for Menopause. In Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems (p. alt17). ACM.

The experience of deciding not to design self-tracking technologies for menopause is documented in a reflective essay. From an investigation into current examples of menopause tracking tools, it became clear that applying self-

tracking to menopause was fundamentally inappropriate and at odds with feminist commitments. These technologies were found to risk resulting in more harm than good for users; both in essentializing and medicalizing a non-medical process, and in perpetuating notions of the bodily experience of the menopausal transition as a negative experience. The contribution of this paper is the knowledge produced through reflecting on inaction. These include ethical and value-sensitive reflections on which physiological processes self-tracking technologies are applied to.

Paper 3

Homewood, S., Karlsson, A., Vallgård, A., Removal as a Method: A Fourth Wave HCI Approach to Understanding the Experience of Self-Tracking. In Proceedings of the 2020 Conference on Designing Interactive Systems.

This paper offers a methodological contribution to a growing interest in understanding the lived experience of self-tracking as a form of entanglement. We propose removal as a method – the deliberate removal of technologies and the documenting of their absence – as a method for a fourth wave, entanglement HCI as proposed by Frauenberger, (2019). Removal disrupts habitual relationships with our everyday technologies, revealing otherwise hidden knowledges. Removal as a method exemplifies that “you don’t know what you’ve got till it’s gone”. We employ removal in two ways; hypothetically by collecting the reactions of twelve participants to our requests of them to stop menstrual cycle tracking as part of a long-term study; and through two auto-ethnographical studies documenting the first two author’s experience of removing their menstrual cycle

tracking apps. Removing the menstrual cycle tracking technologies ourselves allowed us more knowledge on how self-tracking shapes our experience of our bodies. Removing technologies that we are satisfied with is, not surprisingly, a study that participants are unwilling to sign up to. The reactions of potential participants to the request to stop tracking support our findings in the auto-ethnographies; our experience aligned with our participants' predictions. As an autoethnography for motivated researchers, we found removal as a method valuable in revealing aspects of our habitual relationships with technologies, and how they shape us in the long-term. Experiencing loss revealed the relevance of Grosz's theory of embodied subjectivity through highlighting how we relied on our menstrual cycle tracking apps to position ourselves in relation to chronological time, thus giving us a sense of control over our bodies, and how scientific information related to our felt sensations and had become embodied over time.

Paper 4

Homewood, S., Vallgård, A., Ambient Cycle: Putting Phenomenological Theories to Work in the Design of Self-Tracking Technologies. In Proceedings of the 2020 Conference on Designing Interactive Systems.

Ambient Cycle is a menstrual cycle tracking device that provides a continuous display of data in the home through coloured light. In this paper we present how the design and deployment of Ambient Cycle relates to calls for phenomenological approaches in the design of self-tracking devices. In contrast to current menstrual cycle tracking devices, we employed phenomenological commitments to develop a non-

dualist menstrual cycle tracking device. Findings from the deployment of Ambient Cycle in the homes of five participants for four months include the fact that a phenomenological approach facilitated the documentation of a diversity in subjective experiences of the enigmatic menstrual cycle; the tracking of positive as well as negative aspects of the menstrual cycle that challenges wider understandings of the body in society; and novel uses of self-tracked data, for example, as a therapeutic tool and as a way to communicate with co-habitants, as well as being a notification system. Findings from this deployment also related to the tensions around visualizing physiological data in a (relatively) public space. The ways in which Ambient Cycle did not live up to expectations as a menstrual cycle tracking device highlights existing cultures in self-tracking. The ambiguous and co-constructive design of Ambient Cycle led to mistrust of the information shown and feelings that the device was not “useful” as a menstrual cycle tracking device because it did not give a diagnosis of their bodies, but rather co-constructed knowledge with the user. Participants described wanting a device that could provide as sense of “control”.

Paper 5

Homewood, S., Bewley, H. and Boer, L., 2019, June. Ovum: Designing for Fertility Tracking as a Shared and Domestic Experience. In Proceedings of the 2019 on Designing Interactive Systems Conference (pp. 553-565). ACM.

This pictorial presents the design process behind Ovum, a fertility tracking device. We use a critique of current fertility tracking devices to understand the experiential qualities they

offer. We then used oppositional experiential qualities as a design brief for a fertility tracking device. Rather than a clinical, expert-led, and individual experience, we designed for a domestic, D.I.Y. and shared experience of fertility tracking. The contributions of this pictorial are the re-framing of the design space around at-home ovulation tracking devices and the presentation of our approach to this design space through documenting our design process. This included commissioning a ceramicist, iterating on possible 3D printed forms for the device, and findings ways that fertility tracking could be shared between two partners through projecting an enlarged image of the saliva sample out into the room. We use a discussion about how Ovum is a research product, rather than a research prototype, to unpack aspects of the design (Odom et al., 2016). This including the importance of the finish and feel of the device, and the packaging and leaflet that accompanied Ovum.

Paper 6

Homewood, S., Boer, L., Vallgård, A., Designers in White Coats: Deploying Ovum, a Fertility Tracking Device. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems.

This paper presents the findings from a three-month long deployment of the fertility tracking device, Ovum, with seven couples trying to conceive. Findings include the way that the experiential qualities aimed for in the design process translated into lived experience. For example: the multiple factors that both supported and obstructed a shared experience of fertility tracking; that the domestic design of Ovum was first appreciated for its aesthetics, and later criticized for its impracticalities; and that the fact that our participants had to

create their own meaning from their data produced feelings of insecurity. The contrast between the guidelines given to our participants in the pamphlet we designed to accompany Ovum and the more erratic and ambiguous results of their own devices provoked our participants to tinker with the testing process to achieve more accurate results by turning to us as experts, using one another to corroborate whether crystals were present in the projection, and triangulating results with other fertility tracking methods. We also contribute findings related to the fact that the ambiguous and erratic nature of the body changing over menstrual cycles influences user's judgements of fertility tracking devices that goes beyond a binary question of whether it "works", or "doesn't work". We conclude with a contribution of an account of our own experience as researchers in order to develop understandings of how designing for the body in emotional and medicalized cases such as fertility tracking places interaction designers in novel and complex situations.

Contributions

These key contributions of this PhD research span this first part of the thesis and the seven papers included in the second part of this thesis.

1. The knowledge produced through a critique of current self-tracking technologies.
2. A manifesto for the approach of designing for embodied subjectivity for designers.

3. Knowledge on the limitations, benefits and implications of the approach of designing for embodied subjectivity.
4. Removal as a methodological contribution.
5. The designed I as a contribution.

Theoretical Background

The aim of this chapter is to show that the body has never been, and never will be, a neutral design space. The theoretical background to the research presented in this thesis is a combination of feminist theory and the philosophy of phenomenology. These theories are compatible since they both question Cartesian dualism and objectivity in science. Feminism and phenomenology use subjective ontologies and epistemologies to attempt to account for how the body shapes experience of the world (Marshall, 1996). This chapter will first expand on the key argument for the research presented in this thesis; that current self-tracking devices reflect a Cartesian dualist definition of the “self” in self-tracking, and that this leads to a risk of objectifying, patriarchal and biologically deterministic understandings of the body in society. Feminist theorist Elizabeth Grosz’s proposal of selfhood as being an embodied subjectivity is then adopted and augmented with phenomenological theories as a theoretical background that can point to alternatives to Cartesian designs of self-tracking technologies.

What telling the story of a (very brief) history of Western cultures around the body in medicine will highlight is that the way the body has been understood has always been dependent on culture, and that there have been many different cultures around the body over the ages (Lupton, 2012). The biological body is never fixed, a-historical, or pre-cultural (Grosz, 1994). Our own current understanding and definitions of the body, and practices around the body such as medicine and health are contingent on cultural, societal, epistemological, and ontological factors (Drew Leder, 2013; Lupton, 2012; Svenaeus, 2000). By showing that there have been different cultures around the body in the past, this chapter highlights how we can and will have different cultures in the future.

The cases addressed in the research presented in this dissertation are; the tracking of menstrual cycles for self-knowledge; the tracking of ovulation with the aim of conception; and menopause. Though a brief history of Western medicine is used to situate self-tracking, it is not with the belief that these cases require medicine practices to “cure” or improve the experience of them; these are not problems, afflictions, or syndromes to be fixed or solved through the application of self-tracking technologies. Instead, it is proposed that current self-tracking technologies applied to these cases reflect and exaggerate dualist aspects of a Western culture of modern medicine and modern health practices.

Cartesian Dualism and the Body

How we have understood the body, medicine and health has changed drastically over time in line with culture (Lupton, 2012). I am British and my research is situated in Sweden and Denmark in a Western society, and this is reflected in the literature and histories that this research cites. This brief history is predominantly drawn from phenomenological philosophers Drew Leder and Fredrik Svenaeus' analysing the origins and impact of Cartesian dualism on medicine. These accounts are inherently critical to Cartesian epistemologies since the philosophy of phenomenology is based upon a critique of positivist and rationalist accounts of reality.

Western, pre-modern medicine was reliant on self-reported symptoms. Symptoms were often sent to doctors by letter, who then made diagnoses based upon these symptoms and replied with a prescription of herbs and treatments commonly available in nature (Svenaeus, 2000). Knowledge was based upon what had previously been seen to have an effect, or wider beliefs carried down through generations about the healing properties of plants and natural elements. These remedies often did more harm than good (Ibid). Tools and technologies that artificially or literally penetrate and measure the living body were considered blasphemous due to cultural belief systems around the body. Religious beliefs in many Western cultures positioned the body as being a sacred object owned by God (Drew Leder, 2016). Illness was believed to be a consequence of sinful actions and health was a reward for piety. The ancient Greek humorist approach to health was popular in Western medicine until the mid-eighteenth century and illustrates how the understandings of the body were integrated with societal

values at that time. The balance between the four bodily fluids, or humors; blood, phlegm, yellow bile and black bile, was integral to maintaining health and moral character. The balance of the humors was tied closely to the environment. Treatments aiming to re-balance the humors included the letting of bodily fluids, such as using leeches to suck our blood, and herbs and changes in diet. Physical, surgical, interventions into the body, such as amputation, were only carried out in order to avoid death and the professionals employed to carry out these procedures were held in low esteem within society. Since there was no knowledge or practices around sterilisation, physical interventions into the body often resulted in infection and death. A lack of anaesthetics also meant that surgery was extremely painful (Svenaeus, 2000).

Since the mid-seventeenth century it has namely been Descartes's dualist ontology of the self that has dominated conceptual understandings of the body within medicine (Foucault, 1963; D Leder, 1990). Descartes proposed that there was a metaphysical and mathematical truth to material objects in the world that was beyond sense-based knowledge. This contributed to the doctrine of the Enlightenment that held that science could provide an objective truth about the world. Descartes believed that there existed in human beings a mind, soul or reason that possessed information independently of that provided through the bodily senses (Sorrell, 1987). This rationalist approach to knowledge led to the conception that the self is split into mind and body, and that the mind could conceivably exist without a body at all. Descartes stated that the mind is therefore able to enforce rational control over the body, rather than the self being an integrated whole. Foucault describes how wider shifts in society and culture allowed the

patient to be understood as an individual as the grip of religious beliefs of the body as being the domain of higher powers began to release its hold (1963). Instead, the individual became “man-as-machine”, to be fixed when faulty through medical intervention (Foucault, 1963, 1979; Drew Leder, 2013). Believed to have been enabled by Cartesian thinking, modern medicine was birthed in Paris at the beginning of the 18th Century (D Leder, 1990; Drew Leder, 2013). This drastic re-conception of the body allowed the revolution in medical knowledge facilitated by dissecting the human body.

“The Cartesian mechanization of the material world helped overturn all prohibitions against tampering with nature. When the earth was thought of as sacred and ensouled certain invasive interventions, such as mining, were constrained — it was seen as an abortion, interfering with the gestation of metals in the earth’s womb. Similarly, there were often taboos against cutting up the live and dead human body. All these taboos can fall away, however, if natural bodies are simply mindless matter. The extracting and transplanting of organs becomes permissible. It would even be encouraged insofar as we are meant to defeat illness and aging, properly assuming the mantle of “lords and masters of nature.” Moreover, transplantation exemplifies the *modus operandi* of Cartesian science: to understand and control natural bodies by analysing them

into their component parts.” (Leder, 2016, p.124)

Previously, anatomical knowledge was drawn from the dissection of animals and what could be felt and seen in the living body. After this shift in the culture of medicine, it became permissible to dissect the deceased body, which became a vessel of knowledge. This allowed clinicians to actually see the effects of disease in dead patients. Parallels could be drawn between the experience of living patients, and how their disease was manifested in their bodies after they had died. Technological advancements driven by and enabling this new knowledge increased the transparency of the body through new tools and devices such as the stethoscope. The stethoscope put literal distance between the body of the patient and the doctor, and was originally invented out of a moral judgement that it would be inappropriate for a male doctor to place his ear onto the chest of a female patient (Svenaeus, 2000, p.30). This caused a schism between the patient as a material body and as a living subject. Self-reported symptoms were no longer a valuable source of knowledge; “perhaps the patient is also permitted some comments or at least questions in this conversation, but the attention is not primarily upon him anymore, but upon the variables given by medical technology.” (Ibid, p.32). The patient became an object of science, rather than a personhood. This revolution led to the body becoming understood as a mechanical collection of organs, rather than a holistic, and sacrosanct, whole.

“Descartes rejected the essential holism of Aristotelian “substantial forms” in favour of a reductionist strategy. A thing is viewed as the sum of its parts and forces in interaction; we

come to understand an object by “taking it apart” both in theory and practice.” (Leder, 2016, p.124).

Taking the body apart, and the quantification and the visualisation of the body became tools that appeared to provide objectivity; the ultimate dream of Descartes.

“Physicians sought to free themselves from not only the patient’s restricted perspective but also the subjectivity of their own perceptions. Only when translated into numbers did the illness seem to take a truly objective form.” (Ibid, p. 104).

Physician Richard Baron illustrates this with an example taken from his own experience working on a hospital ward. Baron’s patient continued to speak whilst Baron was attempting to listen to the health of a patient’s lungs through a stethoscope. Baron asked the patient to stop talking by saying “Quiet. I can’t hear you whilst I’m listening” (Baron, 1985 p. 606). Baron describes how this sentence illustrates the dichotomy inherent in modern medicine between the patient being both a material object and a living subject. As Leder warns, “notions of embodiment based upon the corpse can lead to an objectivist, depersonalized medicine.” (Leder, 1990, p.147). Baron describes how this move towards objectivity changed how health and disease were defined and investigated in modern medical practices. This move risks the exclusion of bodily experiences since they do not fit into defined medical models.

“What occurs is a shift in focus from the human experience of illness to various

technological facts of disease... our understanding of disease derives not from anything intuitive or anything the patient tells us, but rather from a reification of our model of the disease. Our understanding of the nature of disease is limited by our model, and entire aspects of the phenomenon of illness remain inaccessible to us" (Baron, 1985, p.607).

Another risk of the dualist conception of the body in medicine is the linking of the body to death. Leder describes how absence is an inherent aspect of our embodiment; our bodies are not always present to us; our world is experienced through our bodies when we are healthy (Leder, 1990). Heidegger's example of a working hammer being ready-at-hand and a broken hammer being present-at-hand is likened to the body in illness (Heidegger, 2010 in Leder, 2016, 1990). Due to the fact that we both have and are a body, we are both perceiver and perceived, and cannot be both at once. Our bodies are either perceiving the world or brought to conscious attention as an object to perceive. The example often given in phenomenology is Husserl's example of two hands touching. If we place our palms together, we can experience the act of touching with one hand, whilst the other hand can only be experienced as being touched.

Leder states that science comes out of lived experience (Drew Leder, 2016). Leder argues that the inherent absence of the body from our experience, except in illness and physiological change, is why Cartesian dualism has continued to be a powerful way of understanding the world (D Leder, 1990). This is despite revolutions in fields such as cognitive science that show

cognition to be an embodied process (Lakoff & Johnson, 1999). He proposes that these two distinct roles of the body as either perceiver or perceived is the root of the conception and popularity of mind/body dualisms; the perceiver role being the cognitive mind and the perceived role being the mindless matter. When we consciously pay attention to our bodies then our flesh loses the ability to perceive, and becomes an object to be perceived and manipulated through our cognitive attention; “the conscious self can thus feel separate from what it apprehends, neither fully understanding nor in control of visceral signals and functions” (Leder, 2018, p.7). If the body is understood as a mindless machine to be fixed through mechanical interventions and replacement of parts, then the preferable state of the body is absence. When machines function correctly, then they are not directly experienced, but rather become tools to experience other aspects of the world through. Leder uses the term “dys-appearance” – “dys” being a Greek word meaning “bad” – to describe the negative associations of the body when it becomes present; when there is an absence of absence. Illness and physiological change bring about dys-appearance (D Leder, 1990). The risk with this perspective is that all occasions where the body becomes present-at-hand prompts negative connotation; “the body, surfacing in dys-appearance, comes to be associated with deception and death and is consequently devalued.” (Leder, 1990, p.149).

Cartesian Dualism in Self-Tracking

I will now present how self-tracking technologies reproduce and extend current cultures of Western modern medicine. This culture imposes a specific notion of the body and the self. Whether or not self-tracking devices are marketed for medicine and health-related purposes, there are clear themes within self-tracking that reflect the rhetoric of Cartesian modern medicine. Cartesian trends within self-tracking are evident in the following ways.

The Body is Broken Up into Smaller Parts

The Cartesian dualist dream of breaking up the mechanical body into smaller and smaller parts reaches its full potential in self-tracking. Each aspect of the body is isolated, measured and categorized through sensors and self-reported data. This breaks the body as a whole down into its distinct functions and processes. This act is understood to reveal the true state of the body. Ana Viseu and Lucy Suchman describe how “technology vendors... assume the figure of a body that continually emits signs inaccessible without technological mediation” (Viseu and Suchman, 2010, p.4). Within the design of self-tracking technologies, there is little acknowledgement that the body is a synergetic organism or that each bodily process has an important influence on all other aspects of the body. The production of more and more granular data about each distinct aspect of the body is the ultimate goal of self-tracking. Through making the body “transparent” by allowing healthy users direct access to their bodily data, these devices have been described as re-defining health practices and risking the phenomenon of the “worried well” (Chrysanthou, 2002). As “health” becomes more minutely defined through quantification and datafication,

and is tested at increasingly frequent intervals, small variations in results from self-tracking devices can be understood as being diagnoses of poor health. As Natasha Schüll describes, “we are all potentially sick in which wellness depends on the continuous collection, analysis and management of personal data through digital sensor technologies” (2016, p.3). This is regardless of whether symptoms of poor health are experienced corporeally.

Re-enforcing Objectifying Practices

Self-tracking technologies exaggerate the objectification of the body; the self-tracker becomes both the observer and the observed as they are invited to take an objectifying view on their own bodies. Cartesian practices risk the body becoming a “piece of meat” (Drew Leder, 2013). The use of quantifying and visualization tools used in modern medicine are handed over to the layman to apply to themselves. Although self-reported symptoms and experiences are an important aspect of self-tracking, these are not typically presented in a way that would acknowledge that self-examination is a reflexive process. Nor is the interoceptive capabilities of the self-tracker an encouraged aspect of the reflection process; self-tracking devices do not lead the user through meditative exercises that would delve more deeply into the information that is provided from inner body sensations. Self-trackers reflect on their experience of their bodies through using modern medicine’s metrics and categories (Lupton & Jutel, 2015; Schwennesen, 2017). This re-enforces the experience that they are taking a passive, third person, clinician’s perspective on their own bodies. The self-tracking goal of self-optimization is objectifying in itself; the body becomes an object to be measured and compared against normative criteria (Morozov,

2013; Viseu & Suchman, 2010). As Chrysanthou describes, “the Enlightenment dream of social progress through knowledge becomes in the postmodern a fantasy of bodily perfection through information.” (2002, p.470).

Promising Control through Quantification

Quantification is a tool often employed in self-tracking since it makes the body computationally legible. Quantification has been described as a tool “intended to encourage people to act in certain ways” (Ruckenstein, 2014, p.4). Once the body is externalised through numbers and diagnoses, users experience a sense of order and control through gaining apparent objectivity from their biological bodies (Choe, Lee, Lee, Pratt, & Kientz, 2014; I. Li et al., 2010; Nafus & Sherman, 2014; Williams, 2015). This is reflected in the motto of the Quantified Self community; “Self-knowledge through numbers”. Quantified Self community members are pioneers in collecting extreme amounts of data about themselves in order to self-optimize and gain “control” over their own health and well-being (Wolf, 2010). This leads to the belief that self-trackers have the power to augment their bodies. Self-tracking makes habits visible in order for these habits to be broken. Through re-conditioning habits, and seeing the direct consequences of these lifestyle choices in their bodies, self-trackers understand what and who they might become (Lupton, 2017). Even tracking factors that cannot be directly affected or improved, such as menstrual cycles, provides users with a sense of control through the application of scientific knowledge and scientific measurement (Epstein et al., 2017).

Researchers have employed Foucault's theories on biopower to show how self-tracking technologies are biopolitical tools to push, persuade and impose the responsibility of care upon the individual (Foucault, 1979; Lupton, 2014c; Rabinow & Rose, 2006; Rose & Novas, 2008; Schüll, 2016). Post-enlightenment society encouraged self-autonomy and self-discipline of individuals for the sake of the wider community (Foucault, 1963, 1979). As Svenaeus describes, "man as a biological object - a living space of functions - is born contemporaneously with man as an autonomous subject - a modern individual who is the condition of knowledge" (Svenaeus, 2000, p.28). Descartes himself believed there to be a link between morality and health, and that rational self-control should be exercised over the body in pursuit of virtue (Sorrell, 1987). Self-tracking is described as being moralizing; a good citizen is one that takes care of their own health and body through self-tracking (Rose & Novas, 2008; Till, 2014). The expectation of the individual to take responsibility of care over themselves eases the burden on the state and facilitates the removal of funds for state-provided healthcare. This is one reason for the popularity of self-tracking programs instigated by insurance companies, where self-tracking devices can be used to quantifiably judge the level to which the user is taking care of their own health through their own lifestyle choices (Lupton, 2013, 2016b; Weiner, Henwood, Will, & Williams, 2017).

Reducing and Essentializing Lived Experience

As described above, dualist medical science practices are concerned with defining disease, rather than understanding the lived experience of patients. The result of this is that "our understanding of the nature of disease is limited by our model,

and entire aspects of the phenomenon of illness remain inaccessible to us” (Baron, 1985, p.607). Self-tracking technologies have computational limits that restrict a certain level of flexibility or complexity (Ayobi, Sonne, Marshall, Cox, & Centre, 2018). Inputs into self-tracking devices must be digitally legible. This means that the tracking of physiological processes and illnesses relies on symptoms and experiencing fitting into pre-determined models; for example, that pain is registered on a scale from one to 10, but not the specific qualities of pain. Quantification has been critiqued as being a reductive tool that de-corporealizes and decontextualizes bodies as one dimensional, externalized, “data doubles” (Ruckenstein, 2014, p.4). This risks a reductive approach to lived experience (Morozov, 2013; Sharon & Zandbergen, 2017).

Re-enforcing Dys-appearance

Self-tracking technologies maintain current medical cultures through evaluating the body through the lenses of pathologisation and diagnoses, rather than subjective lived experience (Reigeluth, 2014). This re-enforces the Cartesian understanding that the healthy body is an absent body, and the present-at-hand body is an undesirable body (D Leder, 1990; Svenaeus, 2014). Although self-tracking arguably makes the body more present to the user through the act of tracking, it is not with the aim of celebrating the ongoing healthy status of the body (Smith & Vonthehoff, 2017). Rather, self-tracking technologies risk medicalizing all aspects of lived experience. As feminist theorist Marion Young, (2005) points out, it is only the male body in its middle years that is not subjected to bodily changes. The female body is in a constant state of dys-appearance, with childhood, puberty, menstrual cycles,

pregnancy, menopause and finally aging and death making the body constantly present, rather than absent (D Leder, 1990). This linking of the body to death and negative aspects is therefore value driven. In lauding the absent body, Cartesian dualism privileges the male body and devalues the female body, as well as others historically deemed to be linked more strongly with the body such as labourers, those with disabilities and non-white people (Lennon, 2010).

The Self as an Embodied Subjectivity

If I want to avoid a Cartesian dualist approach, then I need to find an alternative worldview to design from. As discussed, self-tracking makes particularly pertinent the fact that the “self” is a combination of a biological body and a lived subjectivity; that we both have and are a body (Merleau-Ponty, 1962). There is the body as object being tracked, and the body as subject doing the tracking.

Negotiating these two facets of the body has been an important and contested area of feminist theory in terms of how gender is related to sex (Åsberg & Birke, 2010; Birke, 2000). A social constructivist approach to gender is to understand selfhood as formed by cultural and social factors, rather than positivist, anatomical truths. However, to view the self as being defined by social and cultural factors is an externalising view of subjectivity that brackets out the influence of the biological body. This risks leaving the material, biological body in the hands of oppressive patriarchal structures and androcentrism, where male experience is privileged over the experience of

others (Birke, 2000). Another critique of social constructivism is that it assumes that any object has the potential to become anything, which is clearly problematic; a body that has had a leg amputated cannot grow back that leg, nor can humans grow wings and fly (Grosz, 1994; Latour, 2003). On the other hand, if the user is to be defined solely by their biological body, then this risks realism that leads to biological determinism and essentialism. If it is understood that material objects hold inherent truths, then assumptions are made based upon the anatomy and biological factors, e.g. when those with a biologically female body are assumed to identify as “a woman” (Birke, 2000). It is in response to this “problem of the body in feminism” that Elizabeth Grosz offers her “corporeal feminism” in the form of the theory of embodied subjectivity (Grosz, 1994).

Grosz states that we can never experience our biological bodies ahistorically, pre-culturally, or “in the raw” (Ibid, p.197). Grosz proposes a theory of how the specificities of our biological body shapes our lived experience, and how our lived experience and social and cultural factors shapes our notions of our biological bodies. (Grosz, 1994). Grosz does not aim to categorically state, based on distinct anatomies, what a female body does or is, or what a male body does or is. Grosz uses a mobius strip model (Figure 4.) to describe how our lived experience (as subjects), grounded in the specificities of our biological bodies (sex, race, able-ness etc.), intertwines with our cultural and social understandings of our bodies, and they influence one another in turn. The analogy of etching is used to represent the way that the qualities of an etched image are produced as a totality both through what is inscribed onto the surface, as well as the quality of the material that is being etched upon. Grosz’s model is a tool to understand how politics become embodied, and how our

embodiment affects how we experience the world. A mobius strip has no beginning or end, and no distinct inner or outer side. Grosz states that this model can be used to understand lived experience as an “embodied subjectivity” (Ibid, p.22). This theory is adopted as an approach within the research presented in this thesis in order to explore ways to attend to the body as both subject and object within self-tracking without falling back into Cartesian dualism.

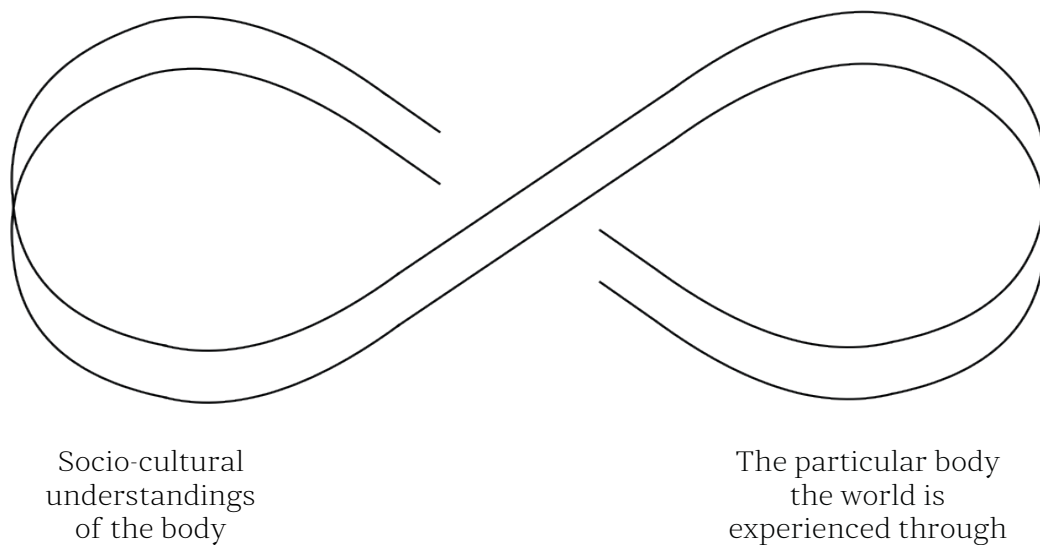


Figure 4. Grosz’s mobius strip model of subjectivity

Interview with Phenomenologist Drew Leder about Self-Tracking

Since designers are also making theory through their design process, then it is relevant to engage in conversations with those producing the theories that we are developing (Redström,

2018). The research presented in this thesis is partly informed by the work of philosopher Drew Leder. His work has addressed the phenomenological experience of the body; including the experience of the body in medicine and the body in prison. Our interview took place in Norway, November 2018. My motivation behind interviewing Drew was to understand his perspective on advancements in digital health technologies, including self-tracking technologies. Drew Leder's background and training both in medicine and phenomenology make him an expert in considering both how these devices re-configure both the medical encounter as well as lived experience of the body. We discuss the implications of the clinic-to-home shift that takes place with self-tracking and at-home health diagnosis devices, how employing devices to represent our bodies risks losing the richness of lived experience, and possible guidelines for the design of technological devices that reflect a phenomenological perspective on the body. Drew Leder's comments support but also challenged the assumptions and worldviews of my research program; supporting by pointing to the opportunity in considering alternative, multi-dimensional modalities when presenting self-tracking data back to the self-tracker, but also challenge the extent to which this could really mirror bodily experience in providing a rich experience of the biological body.

SH: Can you start by giving some thoughts about what happens when technologies come out of the doctor's clinic and into the home?

DL: There's two ways it could go. One would be a medicalization of the home and of one's own relationship with one's body. Because instead of presenting your body to be objectively examined when you visit a physician, that kind of medicalized

and objectifying gaze comes right into the home. Foucault said the truest success of a disciplinary institution is when the discipline is internalized. You place yourself under a kind of surveillance like the Panopticon, where the prisoner feels that he may be viewed at all times. What's important is not simply that he actually is viewed but that he internalizes a kind of self-monitoring and self-correction based on the notion that he may be viewed from outside. And so, you could say having these fundamentally objectifying and medicalizing apparatuses brought into the home or downloaded as apps on the phone, and then applied by the person themselves, would be an advancement on that kind of disciplinary surveillance and structure. So instead of being intermittent it is constant, instead of being confined to the space of the hospital or the doctor's office, it invades the space of the home. It's spreading out spatiotemporally and therefore becoming less escapable.

An opposite polarity would be to say that this was a movement toward autonomy, the patient deciding when and how and what to monitor. So, elements of the medical discourse and explanatory framework are now being, in a certain sense, liberated and utilized by the individual. And, again to refer to Foucault, he talked about how systems of power including disciplinary systems, are never absolute because people find ways of resisting power and operating at the interstices to challenge and change the format. So, this could be a form of resistance, how to take the power developed within a medico-disciplinary establishment and now utilize it instead as something that's empowering the individual. These kind of polarities, positive and negative, objectifying and de-objectifying, are part of more interesting discussion of what is precisely the technology at play, precisely the uses to which

they are being put by individuals. The devil is in the details, as the expression goes.

SH: So, I see a link between this and what you were talking about in your book, "The Distressed Body" (Drew Leder, 2016), about enriched materialism within medical practices. You write; "What is needed is a medicine that does not abandon functionality but is attendant to the play of beauty, meaning, and the healing arts, embedded in an enriched materialism" (Leder, 2016, p.83). Does this link to the idea of "the devil in the detail" of these devices?

DL: ... I think one of the reasons I'm pausing is because in that chapter I'm critiquing the device paradigm drawn from Albert Borgmann, "Technology and the Character of Contemporary Life". The device, whether it's a medical device or an iPhone or whatever, does have a certain kind of diminished materiality because the whole notion of it is that you're going to get access to a certain kind of commodity that you value. There is a separating of means from ends so that you have very little understanding and very little involvement in the way the device is producing music or medical data, for example. There's a kind of a de-materializing that is part of the idea or the telos of the most excellent devices. Ultimately you might have devices implanted underneath our skin so we wouldn't even be aware of any material object performing its tasks.

The materialism as we're getting through our computer screens and our TV, it's such a thin and superficial mode of world presentation, that it doesn't really qualify as a rich authentic materiality. These devices interface with us through surfaces, and that is the device paradigm at work —instead of having a

rich multi-dimensional material presence, like some amazing work of art you might find in a gallery, or a human being you might be sitting across from at dinner. However, when I listen to audiobooks on earbuds, I'm plunged into deep imaginative engagement with Jane Austen's world. Audiobooks have brought us all the way back to the context of storytelling, where it used to be that a story was told through the human voice with inflection, and then only later did we move to flat little characters drawn on a piece of paper that you simply sub-vocalized within your mind.

SH: OK so audio books are going back to the original tradition. And that's why it resonates with you as an enriched, non-surface experience?

DL: Yes. And it goes back to our childhood. We would be read stories by adults. It's a world I've re-entered by listening, but not because of the audio jack microphone interface and Apple. It's because I've embodied it into a world through the use of my own imagination.

SH: So, I'm thinking about how I could use what you've just been saying about richness of experience to apply the way we design technologies that reveal parts of our bodies back to us. For example, I can track my menstrual cycle, or visualize my heart rate over a whole day, or my blood levels, or my galvanic skin response. I was wondering if we could find the equivalent of the audio book in terms of finding a way to maintain the richness of experience in representing the body?

DL: Interesting question. Let's say, people who have no control over a phobia are given bodily information that allows them to

relax. In other words, their fingers are connected to electrodes and there's a tone that goes up every time they're more tense and it goes down every time they relax. They transfer that ability of lowering the tone even when they don't hear the tone. The thin surface of the biofeedback machine has played its useful role.

SH: And when you say thin you mean...?

DL: I meant phenomenologically thin, even though it's probably literally thin; the little electrodes you connect to your finger. But by thin I also mean uni-dimensional. Like if I have an anxiety attack my voice would crack, I would feel my heart beating faster, the world around me would be perceived as more threatening, you looking at me would be experienced as a threatening, objectifying gaze, and I would start to have a shame response that I'm so out of control. So, it would be very rich in depth and multi-dimensionality. But when the notion of anxiety is now translated into simply "the tone goes up", it's turned thin in the sense that it's a very small bandwidth uni-dimensional presentation of anxiety. So phenomenologically thin and metaphorically thin.

There's the issue of both the interface and how the information from that interface is subsequently embodied. The latter actually seems to me equally or more important. The rich materiality doesn't exactly come through the interface. It comes through your application of the information received through that interface. You, yourself, become the enriching materiality. But since the device interface has triggered, and is educating and eliciting your involvement, you might say "It's a totality; my breathing app and my breathing body together, are forming this

kind of enriched cyborg, which actually brings a deeper involvement with my body than if I disconnected from this interface, or if I'd never seen this app". So, it's a little paradoxical because we often think this cyborg relationship with one's device is going to reduce one's embodied presence.

On the other hand, could I really control and slow down my heart rate through amplifying my heartbeat through a loudspeaker, in the same way as the Hindu Yogi Master does through interoception after years of training? Or does the very fact that it comes back at me through an exterior route create a kind of alienation between me and the body? Perhaps whatever I do to alter my bodily functions through external means doesn't have a rich unity. Instead of that experience of "I am my body", now I just "have a body". In this case, my body's been alienated from me.

SH: Can you think of any kind of guidelines for designing self-tracking tools that provide an enriched materialism?

DL: It could have an inter-subjective component. It could have a spiritual component. It could have a personalized component. The most important things are that it would be multi-dimensional and integrated.

The constitution of a chair as an object in the world has an inter-subjective component. In phenomenology, there is also the sense that my experience of that as "chair" is dependent on getting information about it through many different sensory channels — and then my body seamlessly working as an integrated whole so that I'm not experiencing a visual chair, a tactile chair, I'm experiencing a single chair because the unitary

structure of my body renders it whole. So, it's not only multi-dimensional but in a way that gives rise to holistic integration. The vision of one eye doesn't give me a three-dimensional object, nor the vision of my other eye. Audition doesn't give it to me either. The only place where the three-dimensionality and solidity of the object emerges is from the holistic integration of them all.

Similarly, one might say a step-counting app helping you achieve 10,000 steps doesn't make it a holistic health app; the app facilitating you taking photographs of ten things you see during the day when you are taking those steps doesn't make it holistic; and the app facilitating having people you meet along your way record little messages doesn't. But it's possible that, somehow, if you have a rich enough multi-dimensionality and there's a way it's integrated into a unity, suddenly the multi-dimensionality of the day has been created.

SH: And then there's also the way we have the feedback loops that you discuss in "The Absent Body" (D Leder, 1990). Because with a holistic collection of the data, we should acknowledge the fact that our bodies have moods that alter how we experience the world and our own data. For example, when we have low blood sugar or when we have pre-menstrual tension, it changes the way that we see the world. Perhaps that fits into multi-dimensionality?

DL: Yeah it does. You're being gently guided how to be attentive to your own bodily reception. The app ideally would have to recursively start addressing how you are receiving the information on the app. In the 19th century it was not unusual for a patient to write down their symptoms and send it to a

doctor and the doctors replied with "it sounds like you have this..." The patient's experience and understanding and interpretation of what was going on with her was quite central to the medical process. Then if you go a stage further to, say, the middle of the 20th century, doctors were being trained in a very skillful use of listening to the chest and body. So now that doctor's embodiment and clinical skill is very central. But we've now marched on to the point where both doctor and patients' bodies have been put out of the process, and we're all just relying on technological data for diagnostic studies. People had an alertness to their own body. But we now have a finely grained, statistically formed, micro-apprehension of our body that was not possible until we, in some ways, became cyborgs. And so, there may be a way in which we can look backwards to explore how we come back to honoring and being in touch with the bodily experience of the suffering person and their own possible capacity to heal themselves. And, rather than being afraid of it as only alienating and Cartesian, we can lean into that cyborg-facilitated self-awareness positively.

Research Methods and Methodologies

A number of different methods have been employed when carrying out the experiments of this research program. These methods mainly come under the umbrella of research-through-design (RtD) (Frayling, 1994). Many other methods are outside, but supportive of, the RtD process. These included first-person methodologies such as autoethnography, and third-person methodologies where long-term deployment of Ambient Cycle and Ovum with participants were employed in order to explore what these artifacts become in practice. This chapter presents these different methods and how and why they were used in the research program.

Research-Through-Design

Christopher Frayling originally described research-through-design as taking place through explorations into the appropriateness and applicability of materials of different

properties, the development of new objects and technologies, and the documentation of design processes through research reports (Frayling, 1994). Frayling's argument was that, just as creativity was a key requirement of scientific research, research was carried out and knowledge was produced through creative acts such as design. Frayling argued that designers were already doing research, despite stereotypes influencing attitudes about where research is taking place (in the lab) and where it is not (in the studio). Zimmerman, Forlizzi, & Evenson, (2007) later developed this attitude in their model of interaction design for the HCI community. This model highlights how design goes beyond giving decoration and surface structure to technologies; the design artifacts themselves transform the world from its current state to a preferred state (Ibid, p.493).

Conventional design research in HCI typically held an underlying assumption that designers were attempting to make the "best" version of an artifact. This was either from an engineering perspective where efficacy and accuracy were used as success-criteria, or from a user-centred perspective, where usability and marketability were the goals. Research-through-design, or "creative design" (Löwgren, 1995 in Zimmerman et al., p.495), is a continuous reframing of the problem, constantly questioning the underlying assumptions during the design process. A related term used is constructive design research; "research in which [design] construction becomes a key means in constructing knowledge" (Koskinen, Zimmerman, Binder, & Redstrom, 2011, p.5). This was a shift to reflecting on the making process itself.

The research presented in this dissertation takes up a constructivist approach to design. The design experiments of

this research program were not attempting to produce a more effective, accurate, usable, or marketable version of a self-tracking device. Rather, the aim is to explore the process of defining what might be a preferable future for a world where self-tracking practices look to become more and more ubiquitous. The form, interaction gestalt, and temporality we give to computational devices influences how they are understood and used (Vallgård, 2014; Vallgård & Redström, 2007). The research presented in this thesis took place through experiments exploring how different theoretical commitments translate into the form, interaction gestalt and temporality of self-tracking devices.

The next chapter of this dissertation presents how the theory of embodied subjectivity was used in the design process. Grosz's theory was not written for designers, and the findings from the process of using and making theory through the design process are key contributions of this dissertation. Descriptions of how design decisions about materials, function, and form were made in line with feminist and phenomenological commitments are documented in paper 4, "Ambient Cycle: Putting Phenomenological Theories to Work in the Design of Self-Tracking Technologies", and paper 5, "Ovum: Designing for Fertility Tracking as a Shared and Domestic Experience". However, these papers do not present fully how these prototypes are related to the theory of embodied subjectivity. This was due to the fact that we wanted to make specific arguments with these papers, as well as the fact that the page limit restrictions of these papers shaped which theoretical backgrounds were included and which were not. One of the contributions of my research that summarizes our findings from the research-through-design process is a manifesto for

designing for embodied subjectivity. This manifesto arose from the experience of adopting the mobius strip model of embodied subjectivity as a definition of the “self” being designed for in the process of creating self-tracking technologies. This is a manifesto that could be adopted by other designers and reflects how the theoretical commitments translated into more practical design decisions.

Critical and Speculative Design

Critical design is often employed in research-through-design and constructive design to augment the ability of research-through-design to contribute to societal understandings of what we want our “preferred” future to be like (S. Bardzell et al., 2012). Critical design practitioners hold the belief that politics are imbued within and are enacted through objects. Anthony Dunne and Fiona Raby are understood to have coined the term “critical design” at the Royal School of Art in the early 1990s where they drew from design work from Italy in the 1960s and 70s and the field of design semiotics in the development of objects to be exhibited in gallery spaces that challenged assumptions of industrial and product design such as “user-friendliness” (Dunne, 1999). Dunne and Raby proposed “design as critique”; debates and enquiries into matters of concern can take place through the creative processes involved when designing objects (Malpass, 2017). They propose that through materializing societal issues through the design of objects, and the user experiences afforded by these artifacts, novel forms of knowledge can be produced on the topics at hand.

Matt Malpass proposes that speculative design is one form of critical design that asks “why we should adopt emerging technology and science, and what are the potential implications if we do?” (Malpass, 2017, p.56). Malpass states that speculative critical design “is used to identify and probe the values that user audiences hold in relation to scientific and technological progression and to propose alternative value systems to dominant technological ideology, envisioning technological futures that raise questions about existing conditions in the present” (Ibid, p.58). This facilitates the question; “is this the future we really want?” (DiSalvo, 2009, 2012). This use of design is as a litmus test for future technological and scientific possibilities (Auger, 2013). For example, a work related to my own research is Mogen’s Jacobsen’s “Pill Machine” commissioned by the Medical Museion Denmark, for the Mind the Gut exhibition (Jacobsen, 2017) explores possible designs for devices that diagnose gut health, a subject that troubles the mind/body dichotomy since recent research shows the how gut health and mental health are related (Figure 5.). The “Pill Machine” is a “strange, holistic” diagnostic device. A prescription in the form of a poem and medicine is given in response to information input by the user in innovative ways on the lifestyle, mental wellbeing and the environment of the user.



Figure 5. Mogens Jacobsen's "Pill Machine" installed in the Medical Museion, Denmark (2017)

Critical design has evolved since Dunne and Raby first coined the term. What is and what is not critical design is an area contested amongst the design community, with Cameron Tonkinwise stating that since design is about imagining and materialising what does not yet exist, then it is an implicit critique of what does exist. He states that if design does not critique, speculate, or provoke, then it is inadequate design

(Tonkinwise, 2015). One significant step has been the migration of critical design artifacts out of the gallery. For example, Marie-Louise Søndergaard used a Kickstarter page and an exhibit at a digital festival to collect reactions to her PeriodShare device; a menstrual cup that broadcasts the details of the users menstruation such as heaviness of flow onto social media (Figure 6.) (M. L. Søndergaard & Koefoed, 2016).

Once critical and speculative designs are out of the gallery setting, the virisimilitude of a designed artefact is something designers can exploit; if the device appears to be a real, functioning, commercial object, then different kinds of reactions are possible from a viewer or audience (Auger, 2013). Within design research in HCI, critical and speculative designs have also been used as functioning interactive objects to be deployed in the home for users to live with, e.g. Gaver et al., (2007, 2004); Hauser et al., (2018); Ovalle and Gaver, (2016). This has expanded the types of knowledge produced through critical design; debates are no longer solely based upon how the critical design artifact appears on a gallery plinth, but also how it feels in our hands, how it functions, its temporality and how it interacts with its environment and users. This has been the approach adopted in my research; it was important to produce critical and speculative designs that were fully functioning. This was in order to gain a deeper engagement from participants. Designing Ovum and Ambient Cycle as research products, with a high level of finish and functionality allowed participants to reflect on what the object were in the present, rather than what they might become (Odom et al., 2016).

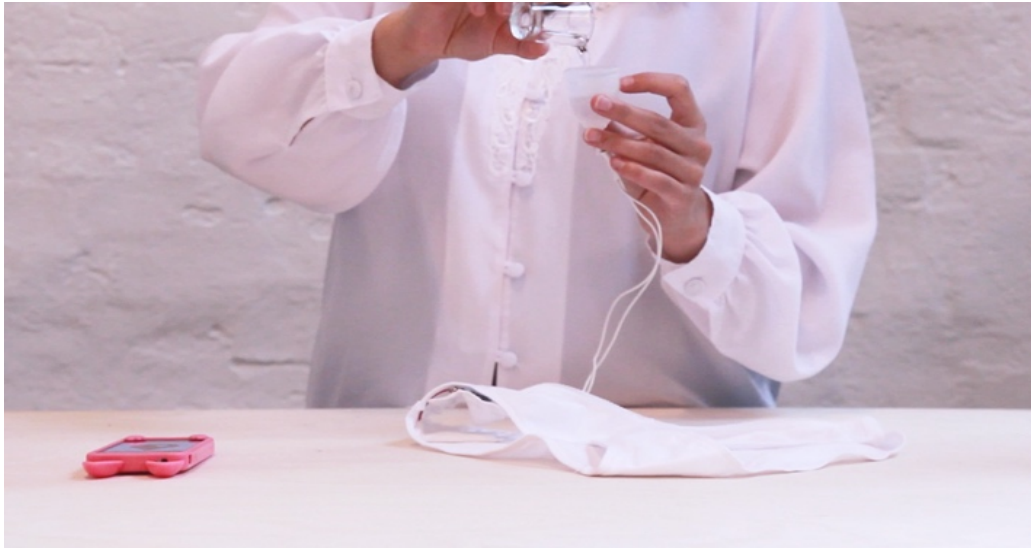


Figure 6. PeriodShare imagines a future where the amount of menstrual blood measured in a WIFI-connected menstrual cup would be shared by users on their social media profiles (M. L. Søndergaard & Koefoed, 2016).

The move of critical and speculative design artifacts out of the gallery and into the world has contributed to breaking down the socio-economic barriers that kept critical design solely for the privileged, academic and cultured few (Prado, 2014). However, Prado argues that there is still a need to ask the question “a preferable future for who?” within critical design. Whether

made explicit or not, making a difference between what is presently real, and what imaginary future is possible and preferable is a political (Mazé, 2016, 2019 p.24) and activist act (Heidaripour & Forlano, 2018; Julier, 2013). Prado states that the designers should disclose their own position when proposing different futures, and be aware of how their assumptions, politics, privileges and biases shape their conceptions of “preferable” (2014). Designers need to interrogate how their own politics and values are being enacted through their design work (M. L. Søndergaard & Koefoed, 2017). A key discussion in the critical and speculative design community remains to be whether designers are for (J. Bardzell & Bardzell, 2013), or against (Pierce et al., 2015) the requirement of critical theory in the critique taking place through design. This research program has employed a classical critical theory, feminist theory, to critique and propose alternative futures for the design of self-tracking technologies. Sticking to feminist commitments have meant that I have ensured that I have been self-reflective about my own assumptions and biases within the design process.

The design experiments conducted as part of this research program can be understood as critical and speculative design experiments. A critique of current cultures around self-tracking technologies is materialised through designing self-tracking technologies that propose alternative cultures around the body. One method used by Dunne and Raby is the A/B list that opposes the values of conventional, “affirmative design”, with critical design values. Dunne and Raby’s oppositional binaries include “problem solving/problem finding”, “consumer/citizen”, “makes us buy/makes us think” (Ibid, 2013). This strategy was directly employed in designing for oppositional experiential qualities in the design of Ovum. We first used an appraisal of

current fertility tracking devices to understand what experiential qualities were provided by the “affirmative” design, before finding opposites of these to aim for in our re-design of the saliva tracking microscope. Our A/B list was individual/shared, clinical/domestic, expert/DIY.

Feminist Design Research

Driven by a desire to right injustices based upon gender biases and patriarchal power structures, feminist HCI draws on feminist theory as a tool for an emancipatory critique (S. Bardzell, 2010; S. Bardzell & Bardzell, 2011; Rode, 2011). Shaowen Bardzell proposes that there are six qualities of feminist HCI; pluralism, reflexivity, participation, advocacy, ecology, and self-disclosure (2010). These qualities are related to both how research is carried out, e.g. through facilitating the participation of others in the design process, as well as how the researcher should understand their own role, e.g. through adopting a reflexive attitude and disclosing the extent to which the design is transparent about how it affects those who use it. In line with current third and fourth-wave feminisms, a pluralist, intersectional approach has been an increasingly called for within feminist HCI. The singular category of “women” is broken down and understood as a multiple rather than singular entity; race, able-ness, economic and geographical position and other such influencing factors are acknowledged as shaping the standpoint of the individual (Fox, Menking, Steinhardt, Hoffman, & Bardzell, 2017; Prado, 2014; Schlesinger, Edwards, & Grinter, 2017).

There is an increasing use of feminist theories and methodology in the design and re-design of artifacts and technologies within HCI. These examples often address technologies and devices designed for the female body and related experiences such as motherhood and women's health (Balaam et al., 2017). The motivation behind these cases is the belief that because women's bodies have not been as valued in society as the male body and have consequently been neglected as cases for design research (Teresa Almeida, Comber, Wood, et al., 2016; Balaam et al., 2017; S. Bardzell & Bardzell, 2011). Such cases include the re-design of breastfeeding pumps (D'Ignazio, Hope, Michelson, Churchill, & Zuckerman, 2016; Wardle, Green, Mburu, & Densmore, 2018), apps for users to share optimum locations for breastfeeding (Balaam, Comber, Jenkins, Sutton, & Garbett, 2015), the re-design of the speculum (Rossmann, 2008), the speculative design of devices attending to menopause (J. Bardzell, Bardzell, Lazar, & Su, 2019), the use of augmented reality technologies and e-textiles to improve women's health and body literacy (T. Almeida, Chen, Comber, & Balaam, 2019; Teresa Almeida, Comber, Wood, et al., 2016), and activist websites facilitating conversations about abortion rights (Michie, Balaam, McCarthy, Osadchiy, & Morrissey, 2018).

Feminist HCI also addresses cases beyond those tied to women's experience of the world. Such examples are the critique and re-design of digital personal assistants (M. L. J. Søndergaard & Hansen, 2018), and how feminist HCI principles might be used to create events that might disrupt existing cultures in maker spaces (Okerlund, Dunaway, Latulipe, Wilson, & Paulos, 2018). Feminist theory facilitates and demands an interrogation of how knowledge is produced. There are even proposals that third-wave HCI already uses feminist

epistemologies and is therefore a successor science as it questions the production of generalizing and objective knowledge about how technologies are used (Harrison, Sengers, & Tatar, 2011). D'Ignazio and Klein, (2016) propose six principles for feminist data visualization; to rethink binaries, embrace pluralism, examine power and aspire to empowerment, consider context, legitimize embodiment and affect and make labor visible. Related to my own research program, D'Ignazio and Klein state that a feminist approach to data visualization can expand understandings of how different epistemological commitments are made and acted out through design.

My own research employs feminism in a number of ways. Paper 1, "Re-framing Design Problems in Women's Health" uses feminist philosopher Sandra Harding's theories on objectivity in science to show that even how designers understand the body as a design space is influenced by the patriarchal society it is situated within. This paper recommends that feminist HCI not only attends to the way that research is conducted, but also how research problems are framed. Paper 2, "Inaction as a Design Decision" develops this inquiry through reporting on the experience of deciding not to design self-tracking tools for menopause. Inaction as a design decision was driven by the fact that I found the design space of menopause to be at odds with my feminist research perspectives and commitments. My feminist critiques of existing self-tracking devices show that there is still work to be done in creating self-tracking technologies that do not perpetuate the de-valuing and objectification of the body. As well as being a critical lens, feminist theory can also provide tools to negotiate and re-configure the aspects that are of concern to feminists (Birke, 2000; Price et al., 1999). This is the key motivation behind taking

up Elizabeth Grosz's theory of embodied subjectivity as a "corporeal feminism" that offers generative alternatives for more feminist futures (Grosz, 1994).

First Person Methodologies in Design

In recent years, experience-oriented third-wave HCI has led to an increase in first-person methodologies such as autoethnography and autobiographical design (A. Lucero et al., 2019). These methods are employed with the belief that the experience of the researcher themselves can be used as a source of knowledge. Autobiographical design is one such example that is a use-it-yourself approach that employs the specific situated knowledges of the researcher in long-term engagements with their own designs (Neustaedter & Sengers, 2012). Living with and using designs allows real-life needs and frictions to arise and be dealt with more rapidly (A. Lucero et al., 2019). Autobiographical design "benefit(s) from the intimate eye (and hands) of the autobiographical design researcher" (Desjardins & Ball, 2018). Whereas the aim of autobiographical design is to produce insights that might be used in the design process, autoethnographic research is a more flexible method deriving from anthropology. The situated and expert knowledges of the researcher is accessed and documented through detailed self-reported accounts (Ellis, 2004). Autoethnography is useful as a way to understand the lived experience of users where the labour of the user study would be too large to place on research participants, for example for long-term studies or those that would require a large amount of documentation (O'Kane, Rogers, & Blandford, 2014).

Autoethnographies have been carried out by researchers within HCI to explore domains such as biopolitics in weight loss through self-tracking (Williams, 2015), and living without a mobile phone (Andrés Lucero, 2018). Autoethnography is often used in place of other research methods, or to obtain insight into aspects more challenging for participants to articulate such as embodiment or emotions, or gaining empathy with those with a different experience of the world (O’Kane et al., 2014; Rapp, Marcengo, & Cena, 2016).

Within HCI, there has also been an increased awareness of how doing research impacts the researcher themselves. This discussion expands questions around ethical research practices by considering the wellbeing of the researcher themselves (Balaam et al., 2019; Wolters, Mkulo, & Boynton, 2017). Design practices such as reflective design could also be described as representing a form of first-person methodology, where the researcher uses self-reflection to gauge whether their own political and ethical commitments are challenged by the designs they are creating (Sengers et al., 2005). First person methodologies have also been used in gaining a deeper awareness of the bodily aspects of interactions with technological devices (Höök, 2018; T. Schiphorst, 2011). Schiphorst uses the term “somatic connoisseurship” to describe how designers can train themselves into becoming more somatically sensitive as a resource for design.

Throughout my PhD research, I have employed first-person methodologies in a number of ways. In paper 3, “Removal as a Method”, autoethnography was employed in the study of removal as a method – the deliberate removal of technologies and the documenting of their absence – as a way to explore how

menstrual cycle tracking had shaped embodied experience. This paper shows how removal as a method especially facilitates emotional, embodied and cultural knowledges on the lived experience of self-tracking. As discussed, paper 2, “Inaction as a Design Decision”, presents my value-sensitive reflections on the design process attempting to design self-tracking tools for menopause, culminating in my design decision to not design. Paper 6 reports on the findings from the deployment of Ovum and outlines how my own experience of how negotiating the inconsistencies around saliva tracking prompted feelings of discomfort – that I became a “designer in a white coat”. These experiences are documented as a contribution to HCI. Not only does this paper report on the possible benefits, implications and limitations of re-defining the “self” in self-tracking as an embodied subjectivity, but it also reports on what aspects other designers might experience if they are to adopt this approach.

Designing for Embodied Subjectivity

Designing for embodied subjectivity is an approach to designing for the body that emerged through my research and is still in formation. Rather than using a definition of the “self” in self-tracking as a Cartesian dualism of mind and body, designing for embodied subjectivity meant re-defining the “self” as a subject and an object in a mobius strip-like relationship. Grosz’s theory states that the lived experience of the biological body is shaped by external world, and that the world is experienced through the specificities of the biological body (Grosz, 1994). The work of Drew Leder and my interview with him were also used to augment our understanding of the nuanced ways in which the insides of the body is lived. Once we had made these theoretical commitments, we saw all interactions through this lens. We hold that all interactions with self-tracking technologies take place within the mobius strip. It is not that some devices enact this mobius strip better than others. Users of self-tracking technologies will always be an embodied subjectivity. We do not aim to design the best version of the mobius strip, nor do we

assume we can control what happens within each users mobius strip through the designs we produce.

Our design process was about understanding how our theoretical commitments became materialised. In practice, designing for embodied subjectivity was a process of re-corporealizing and re-contextualizing the body in self-tracking. Working with the theory of embodied subjectivity requires a broader understanding of what aspects contribute to self-tracker's self-understanding. In the mobius strip, there is no objectivity, only subjectivity. There is no "real" or "true" biological body being discovered or revealed through the act of self-tracking. All interactions with self-tracking technologies produce an esoteric biological body that is always a product of the social and cultural systems of power that it is situated within. Therefore, designing for embodied subjectivity means accepting that self-understanding takes place through a range of factors, not only data points gathered from the application of biological science. Designing for embodied subjectivity reflected what Drew Leder said in our interview about gaining a multi-dimensional, rather than abstracted and objective, experience of the body through technologies. This required three key considerations that appeared to create devices that aligned with the theory of embodied subjectivity. These considerations were not pre-determined nor taken up separately, but rather arose from the design processes themselves and informed and shaped one another in turn.

1. The embodied experience of the user: by using the subject's felt experience of their biological body, we could support them in co-constructing knowledge in relation to the scientific measurements done by the device. The danger of

Cartesian dualism being used to de-value the body and those associated with the body is avoided through framing the body as a generative aspect of the self-tracking practice, rather than an object to be objectified and controlled. This approach involved rejecting diagnostic and prescriptive tools, as well as designing tools that support the fact that the moods and physiological states of the body will influence how data are experienced.

2. The physical context and environment of use: the theory of embodied subjectivity states that external factors influence the experience of the body. We took this to mean that the physical environment that the tracking would take place should be an aspect that we considered in our design process. This resulted in the decision to situate the self-tracking practice. Rather than providing a device that could be used anywhere in any context, designing for embodied subjectivity required us to have a specific context of use in mind.
3. The social, cultural and societal context of use: we addressed the social context of the user in the design process with an awareness that our social and cultural contexts, norms and interactions impact how we understand our biological body.

Although our approach attends to these ways in which self-trackers come to know themselves subjectively, our design work also includes the measuring of the biological body through methods drawn from science. Self-tracking is a design space where the conflicting epistemologies and ontologies of phenomenology and positivist science are both at play. If we

were to reject the use of scientific methods to provide information on the biological body entirely, then we would be designing with a social constructivist understanding of the body. This would risk erasing the biological body entirely, as well as failing to produce devices that qualified as self-tracking tools. Designing for embodied subjectivity dictated that we must design for the relationship between the body as object and the body as subject. Ours was an exploratory task to see how these aspects might be negotiated. The first prototype, Ambient Cycle, uses the scientific knowledge that states that because menstrual cycles occur at regular intervals, a prediction of future cycles can be drawn from the documentation of past cycles (Johnson, Marriott, & Zinaman, 2018). The second prototype, Ovum, uses a fertility tracking method that signals when the body is fertile through the increase in salt crystals visible in the saliva sample when magnified through a lens (Salmassi et al., 2013). We employ these methods in their original forms but re-configure both how these methods are enacted and how the results of these methods are presented through our design work.

I will now present the two prototypes that resulted from our design processes, and how we designed for the embodied experience of the user, the physical context and environment, and the social, cultural and societal context of use. These design processes were informed by critiques of current self-tracking technologies, as well as our feminist and phenomenological commitments. These devices do not represent perfect materializations of the theory of embodied subjectivity and, as well as how these devices did align with our theoretical commitments, I will also present the many compromises that we made along the way.

Ambient Cycle

Ambient Cycle is the result of our attempt to design menstrual cycle tracking devices that reflect the understanding of the user as an embodied subjectivity.

Embodied Experience

We attended to the embodied experience of the user through exploring how the subjective, lived, experience of the menstrual cycle could be used in conjunction with menstrual cycle data. Digital menstrual cycle tracking technologies are usually in the form of mobile apps. The assumption that the menstrual cycle has a regular length facilitates the use of tracking the length of the menstrual cycle to predict when events such as menstruation, PMS and ovulation will take place in the future. Some menstrual cycle tracking apps also allow users to input data in regard to lifestyle factors such as exercise, sex, alcohol and food intake and sleep. The prototype Ambient Cycle comprises a web interface that can be accessed through a mobile phone as an app (Figure 7.) and a WIFI-connected lamp (Figure 9 and 10.). The user firstly inputs information about the average length of their menstrual cycle and how many days it has been since the beginning of their current cycle. This metric means that the device can stay in synchronisation with the menstrual cycle over the months to come. This was, however, an aspect that troubled us during the design process; not all menstrual cycles are regular, and we risked excluding some users. Since this is arguably the only aspect that meant that Ambient Cycle could still be described as a menstrual cycle tracking device rather than a journaling or documentation device, then this required us to compromise on our theoretical commitments in adopting this function. Our task was then

understanding how and whether we could mitigate and negotiate this through our design decisions.

The majority of current menstrual cycle tracking apps alert the user to when they will experience PMS, ovulation and menstruation through symbols and textual information based upon the data input into the app during past menstrual cycles. These can be used by the user to understand which stage of the menstrual cycle they are currently in, as well as preparing for future phases and adjusting plans accordingly. Rather than providing an interface that diagnoses which stage of the menstrual cycle the user is in according to these three distinct phases, we attempted to create a co-constructive form of menstrual cycle tracking. Current apps have set options that the user can choose to input into the device. Ambient Cycle was designed to represent a lived experience of the menstrual cycle, rather than representing the users lived experience of their menstrual cycle through scientific information and medical models of the menstrual cycle. Based upon their subjective memories of past cycles, the interface (Figure 7.) allows the user to choose which colours the lamp should show at different points in their menstrual cycle. No numerical data or scientific information is provided in the interface. Nor does the interface tell the user where they are currently in their menstrual cycle. The only data given to the user is through the colour shown by the lamp itself. This facilitates an entirely flexible and customisable mode of self-tracking. Users can choose colours to represent a variety of experiences in different ways.

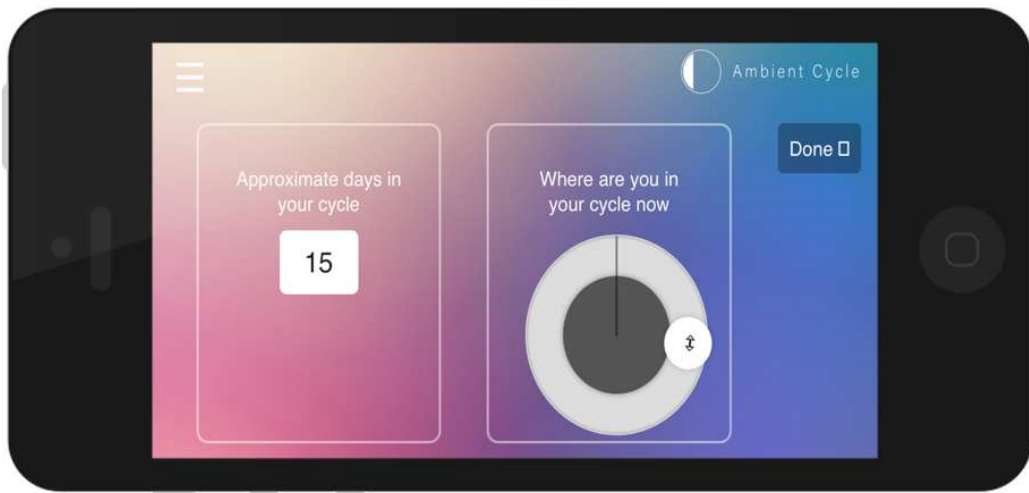


Figure 7. Ambient Cycle web interface



Figure 8. The device installed in the home.



Figure 9. The Wi-Fi connected lamp

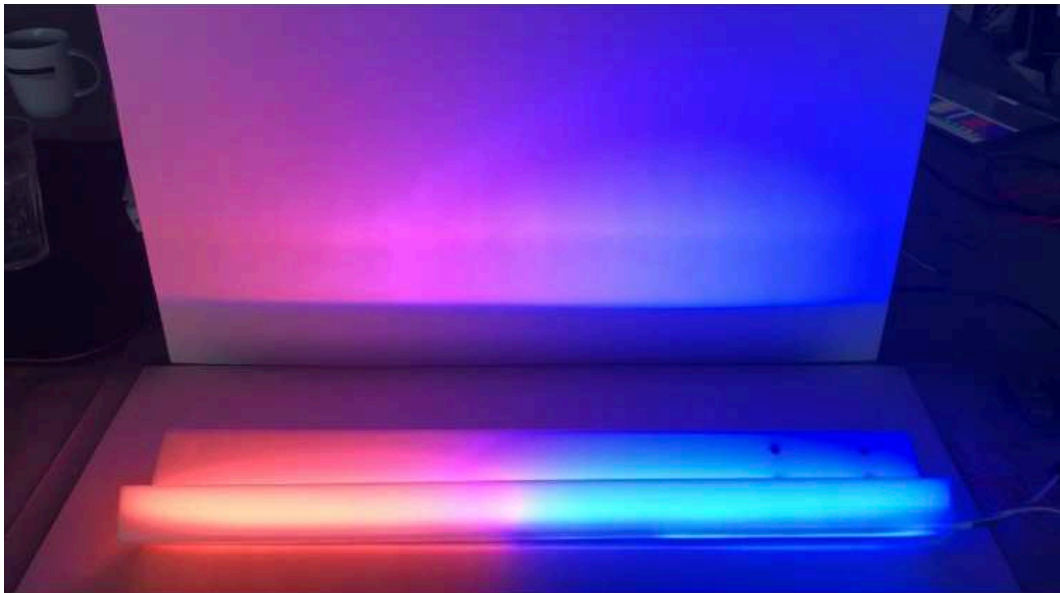


Figure 10. Colour transitions between cycle phases.

For example, the colour red could be used to represent blood and be used as a notification that menstruation will begin, or red could be used to reflect anger and irritation experienced during PMS. Ambient Cycle slowly transitions through this colour configuration and repeats it again at the beginning of the next menstrual cycle (Figure 10.).

Physical Context

One benefit of most commercial self-tracking technologies is that they can be used anywhere, allowing for a more constant collection of data. This, however, makes it an un-situated and de-contextualized act. One of my critiques of current menstrual cycle tracking devices as presented in paper 1 is that they act as diagnostic tools. As found by Epstein et al., (2017), users notice some aspect of their embodiment, and then use their device to diagnose and validate what phase of the menstrual cycle this sensation might be a symptom of. For example, a user might feel irritable, and open up their menstrual cycle tracking app to understand whether this irritability is due to PMS. This risks a medicalising approach to the body. Rather than understanding that the body is always in a state of flux, and that lived experience is shaped by an infinite number of factors, physiological changes and sensations are categorized and explained by scientific models of the body. We wondered if we might embrace the fact that the body is always in a state of flux by providing a constant flow of data. We used the home environment to do this with an awareness that the theory of embodied subjectivity dictates that our environments are one way we gain self-understanding. Although users obviously also spend time outside of the home, we felt that this was a way that we could situate the act of menstrual cycle tracking. We also

discussed using wearable devices to provide a more constant flow of data but felt that this was troubling in terms of the social, societal and cultural aspects we needed to negotiate; we risked our users feeling exposed by having a constant, public, visualisation of their menstrual cycle data attached to their bodies. The home represents a space that is both public and private; guests may visit, but they are more often than not invited into the space. We used an ambient display that provides a constant flow of data. Where the device is situated in the home is up to the user, for example whether it is used in the bedroom or more common areas of the home (Figure 8.). This allows for a more or less public presentation of menstrual cycle data.

Social, Cultural and Societal context

After making the decision that our design would use a public display of menstrual cycle data, we then considered how to negotiate and acknowledge the social, cultural and societal context that Ambient Cycle would be used within. Ambient Cycle was designed with an awareness that we share our lives with others, and that our interactions with other people also informs our subjectivity. Ambient Cycle makes public data which is normally kept private in a personal mobile phone. This is a design decision that reflects our feminist commitments; that the menstrual cycle is not a shameful aspect to be concealed because it is considered abject. However, giving other people access to our internal states works against societal norms around what we conceive of as private. Revealing our inner body states to others can result in feelings of vulnerability, and have even been weaponized in cases where employers have used un-consensually collected menstrual

cycle data against their own employees as a form of ‘menstrual surveillance’ (Mahdawi, 2019).

The fact that menstrual cycle data can be used to undermine rationality was one aspect that concerned us. We felt that this might be mitigated through the fact that colours represent an ambiguous representation of data. The user can choose who is able to read the data from the colour shown; e.g. they might choose to tell their family that “blue” means that they have PMS. Those who have not been told the meaning of the colours would not be able to crack the code to reveal where the user is in their menstrual cycle. We also negotiated the fact that users might feel uncomfortable having their inner states displayed publicly by ensuring that the lamp itself also had an ambiguous design (Figure 9.). The lamp comprises an LED strip housed in an acrylic casing to project the light on the surface, normally a wall, in front of it. To an untrained eye, Ambient Cycle just appears to be a lamp and would not raise questions about the true function of the device.

Ovum

Ovum is the result of our attempt to design fertility tracking devices used to aid conception that reflect the understanding of the user as an embodied subjectivity.

Embodied Experience

After carrying out a critique of existing fertility tracking devices such as urine testing devices and temperature tracking devices, we saw a need to find a less diagnostic and more co-constructive representation of the body in order to adhere to the commitments made when designing for embodied subjectivity. Urine testing ovulation sticks give a diagnosis in the form of lines shown when the luteinizing hormone is present directly before and during ovulation; and basal body temperature tracking through the use of thermometers uses the quantification of the body and accumulation of data points over time to calculate when ovulation took place based on the sharp rise in temperature following the release of the egg. Urine testing and temperature tracking devices act as the expert; diagnosing the state of the body and giving this diagnosis back to the user. We felt that this risked medicalizing and objectifying the body, rather than understanding the knowledge about the body as an object to be created in conjunction with the body as a subject.



Figure 11. Images of Ovum

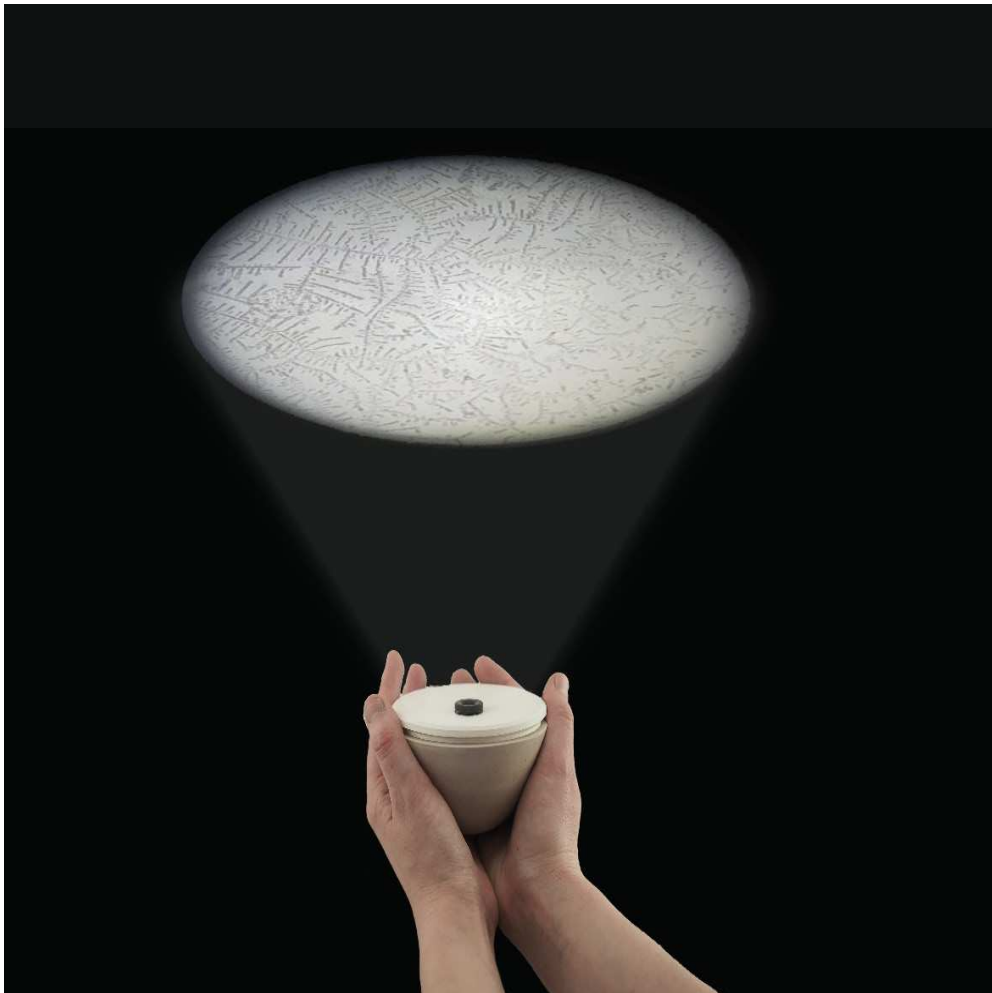
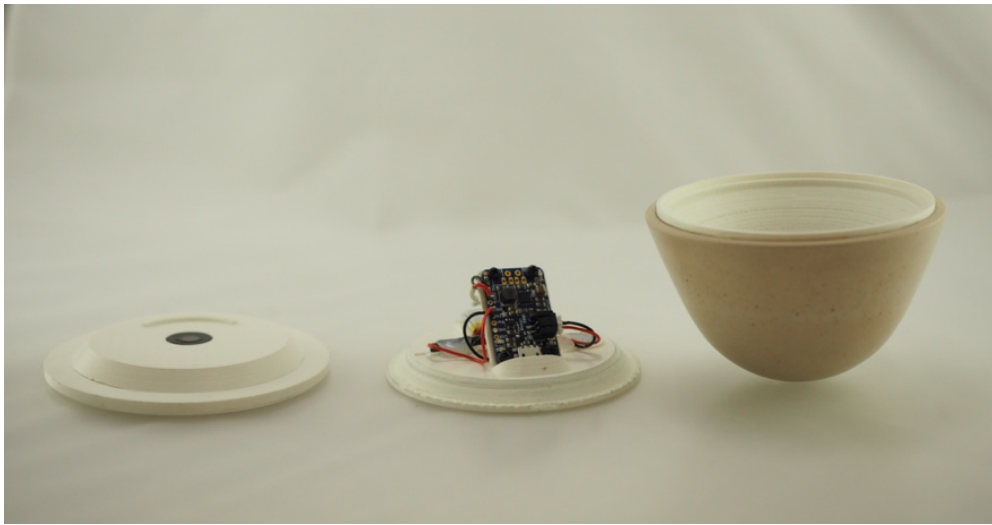


Figure 11. Images of Ovum

A.



B.



C.



Figure 12. Saliva samples during the menstrual cycle. A. shows before and after the fertile period, B. shows approaching ovulation and C. shows ovulation.

We chose to base our next design around the method of saliva tracking as it invites for a different engagement where the user becomes the expert in understanding their own information. Saliva tracking uses the inspection of saliva through a microscope throughout the menstrual cycle in order to understand when ovulation is taking place through the appearance and increase of fern-like salt crystals. These crystals appear 3-5 days before ovulation and signify that the body is fertile (Figure 13.). These crystals increase as the body approaches ovulation before fading away again after the egg is released. People attempting to conceive can use the appearance of these crystals to understand the optimal times for sexual intercourse or insemination.

Physical Context

Once again, we wanted to attend to the particular context that the tracking would take place within in light of the multiple ways we gain self-understanding when adopting the mobius strip understanding of subjectivity. Fertility tracking is typically done within the home. Rather than replicating the clinical and laboratory aesthetic of microscopes and other fertility tracking devices, we explored how the form and materials we employed in designing Ovum could fit the home context it would be used within. We felt this would challenge fertility tracking being thought of as a clinical act they were applying to their own bodies and change our participant's experience of fertility tracking through the design and materiality of the object itself. In order to achieve this, we iterated on vase-like forms to reflect a domestic aesthetic. This exploration also led us to commission a ceramicist to create the

rounded base of the device. Plastic and metal communicate functionality and are commonly used for medical apparatus. They are not materials chosen for their aesthetic or tangible qualities but rather their mouldability and sanitary properties. Ceramic gives the device weight and texture that would not have been possible with 3D printed forms (Figure 11.). Ovum proposes a world in which self-tracking devices are attractive and deemed appropriate enough to become ornaments displayed in the home.

Social, Cultural and Societal Context

The embodied subjectivity definition states that societal factors will be internalized and become an aspect of subjectivity. Therefore, considering the societal and cultural norms we wanted to enact through our designs was important. Ovum not only reflects the social situation it will be used within, but also challenges societal expectations around roles in fertility tracking. Existing fertility tracking devices are typically designed and marketed to be used by only one person; the person who will be becoming pregnant. This is despite the fact that conception is an act that generally, though not always, involves two people. Assuming that it is the partner that will become pregnant who is responsible for the labour of fertility tracking falls back into oppressive expectations around who is the primary carer of children. Since we wanted to design to reconfigure societal understandings of the person doing fertility tracking as being one half of a social relationship, the first move in our design process was to attempt to find a way to make the information given by the saliva tracking device shareable. Through projecting a silhouette of the saliva sample out into the room up to a diameter of 2 metres by shining light

back through the lens, Ovum aims to make fertility tracking a shared experience (Figure 12.). It must be the ovulating partner's saliva that is placed on the lens, but it does not necessarily have to be them, or them alone, analyzing the presence of crystals in the projection of the saliva sample.

Contributions

The following points are contributions offered by the research presented in this dissertation. These are contributions both to the field of HCI as well as to the domain of self-tracking.

Critique of Current Self-Tracking Technologies

Through the critiques outlined in the papers included in this thesis of menstrual cycle tracking, fertility tracking, and menopause tracking devices, themes arose that showed how these technologies risk essentializing how physiological processes were to be experienced through re-enforcing normative expectations of bodies; biological determinism by assuming the selfhood of the user from their anatomy; by medicalizing non-medical processes; and in perpetuating that bodily sensations are a negative experience. The theoretical background chapter of this kappa then extended these critiques through positioning these themes within Cartesian dualist cultures in modern medicine. There are two key dangers of Cartesian thinking. The first is that a Cartesian approach can be

used to create apparent facts and truths about the world without accounting for the influence of cultural and societal norms and biases on how knowledge is produced. The second is the fact that this way of understanding the world leads to oppressive binaries such as mind/body, culture/nature and man/woman. The interview with Drew Leder developed some of these themes through presenting Leder's own perspective on the design of self-tracking and medical devices from his position as a phenomenologist. Though other researchers have positioned self-tracking within histories of the use of quantification as a tool for biopower (Wernimont, 2018), and through charting the history of self-tracking devices as originating from entertainment devices (Crawford et al., 2015), as far as I know, no other literature has presented self-tracking devices that track inner physiological processes within histories and cultures of modern medicine in this way.

The critiques presented in this thesis contribute knowledge to discussions around what kinds of body politics designers want self-tracking technologies to enact. Showing how we have had different cultures around the body in the past highlights how we can have different cultures around the body in the future. These critiques illustrate how scientific knowledge and methods are never neutral, and when designers take up scientific knowledge and methods in the design of their devices, they have the choice of either adopting or rejecting cultures within science. This is also true of the body as a design space; we showed how self-tracking devices illustrate certain cultural and societal norms and expectations in their form, materiality and function. The knowledge produced through the feminist and phenomenological critique of self-tracking technologies contributes a critical stance that can be adopted by other

designers in working towards a more inclusive, non-Cartesian Dualist future through the design of self-tracking technologies.

A Manifesto for Designing for Embodied Subjectivity

The main contribution of this thesis is the approach of designing for embodied subjectivity. This approach can be seen as not only being a contribution to the design of self-tracking devices, nor solely to digital women's health, but also to cases where technologies are designed for a specific user group based upon their biological bodies. The motivation and context of this research was the increased use of technologies to provide information about the body outside of the clinical context. From our experience of working with the theory of embodied subjectivity in the design process, we can see this approach being applicable to other cases of designing for the body. This could be in situations where technologies are used to track and provide information about chronic illnesses or physiological processes. These are cases that risk biological determinism and essentialism where assumptions are made about users based upon their biological bodies and where the lived experience of users is reduced to medical models rather than embodied, subjective experience. The approach to designing for embodied subjectivity allowed for users to be defined by more than their bodies. Designing for embodied subjectivity rejected objectifying approaches and allowed for the multi-dimensional ways in which subjectivity is created to be acknowledged in the design process. Long-term deployments of Ambient Cycle and Ovum showed how the benefits of the approach of designing for

embodied subjectivity included the fact that it supported a less normative notion of the body by facilitating the tracking of a wide range of bodily experiences; facilitated conversations and reflections on body politics in society; and produced novel, positive, forms of interactions with the insides of bodies, rather than interactions that re-enforced that the biological body was an aspect to be negated and controlled through self-tracking. This manifesto is drawn from commitments that were required from us over the four design experiments in order to align with the theory of embodied subjectivity, including some that resulted from our deployments of our designs. This manifesto comprises commitments that should be made when designing for embodied subjectivity:

- We should not see the body as a design space as a-historical, pre-cultural or neutral; we should understand that we produce cultures through the devices we design.
- The biological body is not a negative aspect to control or compensate for, but rather a generative aspect that can be experienced positively.
- We should never define or assume who the user is because of their anatomy, morphology or physiology.
- We should not believe that objective knowledge about the body is better or more truthful than subjective knowledge.
- We should never take scientific knowledge on the body to be neutral or value-free - it is always contingent on the culture and society it is situated within.
- We should remember that subjective experience is not only drawn from external sources of knowledge. It is also drawn

from felt bodily sensations and lived experience of the body, and we should account for this in the design process.

- We should acknowledge that data on the body is used reflexively; our users are fundamentally changed by experiencing the data we provide them.
- We should consider the physical and social contexts that our designs will be used in.
- We should account for the cultural and societal contexts that our designs will be used within.
- We should not design devices that are essentialising or reductive; designers should take into account that the body is experienced in an infinite number of ways.
- We should reflect on our own ethical and theoretical commitments and remember that sometimes inaction is the best design decision.
- We should remember that our user research on our designs does not produce general or universal knowledge but rather situated knowledge.
- We cannot separate the scientific methods we employ from the devices we design.
- We should remember that our designs will be used within existing cultural and societal structures; our designerly intentions might be at odds with the expectations or desires of users. In order to create devices that are deemed useful and desirable, we should aim to find a balance to aid the transition from existing Cartesian dualist cultures around the body to

our preferred feminist and phenomenological cultures around the body.

The Knowledge Produced through Designing for Embodied Subjectivity

As well as the approach of designing for embodied subjectivity itself, the knowledge that has been produced through the various research exercises employed in this research program is also a contribution. We deployed Ambient Cycle in the homes of 5 participants for 4 months and Ovum was deployed for three-months with 7 couples trying to conceive. Through studies on these deployments, we came to understand how existing types of mobius strips were disrupted, and new types of mobius strips were created through using Ambient Cycle and Ovum. These findings are reported on fully in paper 4 and 6. I will now present how the knowledge produced by these findings are a contribution to HCI that presents the benefits, implications and limitations of designing for embodied subjectivity. This knowledge acts as an argument for adopting this method when designing for the body, as well as alerting designers to certain aspects that they might encounter if they are to adopt this approach. In line with my use of a research program, which inherently raises more problems than solutions, I will also present questions raised through my research program as contributions (Redström, 2018).

Designing for the Body Political

One contribution resulting from the approach of designing for embodied subjectivity is knowledge about how body politics

might be centralised when designing for the body. The theory of embodied subjectivity makes separating the body from body politics impossible; the body can never be understood “in the raw” (Grosz, 1994). Working with the theory of embodied subjectivity in the design process facilitated an awareness of how body politics and societal factors intertwined with the biological body throughout the design process. This allowed us to make choices and adopt a sense of responsibility about the cultures and body politics we wanted to enact through our designs. We became aware of the ethical moves we were making with every design decision. For example, the danger of Cartesian dualism being used to de-value the body and those associated with the body was avoided through framing the body as a generative aspect of the self-tracking practice, rather than an object to be objectified and controlled. We also chose to challenge androcentric, oppressive, gender roles in fertility tracking in the design of Ovum through aiming towards a shared experience and simultaneously challenged and negotiated societal taboos around menstrual cycles and the changeable body through the ambiguous design of Ambient Cycle.

My research contributes an example of combining methodologies, such as embodied interaction design (Dourish, 2001) and somaesthetic interaction design (Höök, 2018), where the body is understood as the mode for our being-in-the-world, with value sensitive, critical, approaches such as feminist HCI where there is an awareness of the politics enacted by the artifacts we design. This was done with the belief that the body is not an object that can be approached neutrally; all acts of designing for the body involve body politics. My research has shown how even the framing of design problems is subject to

cultural and societal values and prejudices. Body-based practices such as embodied interaction design and somaesthetic interaction design acknowledge how the fact we are embodied influences how we experience devices, but they do not concretely address body politics and biological specificity. Though Höök includes a final tentative chapter on the politics of the body at the end of her book “Designing with the Body”, this is not the starting point of the method of soma design. Value-sensitive and socio-material approaches such as feminist HCI and feminist science and technology studies (STS) acknowledge how the design of artifacts are related to politics and societal and cultural norms, but arguably fail to address the impact of our embodied state on how we experience the world. What designing for embodied subjectivity seems to facilitate is the opportunity to address the gaps in both of these fields.

The Implications of Using Science in Design

One of the aims of my research was to understand what it might mean to apply embodied interaction design approaches to the inside of the body as a design space. My research contributes knowledge on the benefits, limitations and tensions inherent in this exercise. This was not an easy task, and many compromises had to be made along the way. These compromises highlight tensions within the domain of self-tracking where Cartesian dualist epistemologies used in modern science encounter the phenomenological nature of lived experience. I have proposed that designers have a responsibility to consider the histories and cultures behind the scientific methods they take up, and a choice to whether they challenge or re-enact these cultures through the devices they design. One possible perspective to take on my research is that the prototypes Ambient Cycle and

Ovum re-package science through design; that the scientific method of saliva tracking to determine fertility, and the method of using the metric of a regular cycle to track and predict menstrual cycles, go uninterrogated. My research raises the question; is changing how scientific methods are enacted and how their results are visualised enough to re-configure the cultures that they originate from?

If we are to gather information about the body beneath the skin and beyond felt sensation, then scientific methods must be employed. As discussed, if we reject using scientific methods to provide information about the biological body entirely, then we would be designing with a social constructivist understanding of the insides of the body. This would risk erasing the biological body, as well as failing to produce devices that qualified as self-tracking tools. The first prototype, Ambient Cycle, used the scientific knowledge that states that because menstrual cycles occur at regular intervals, a prediction of future cycles can be drawn from the documentation of past cycles (Johnson et al., 2018). The second prototype, Ovum, used a fertility tracking method that signals when the body is fertile through the increase in salt crystals visible in the saliva sample when magnified through a lens (Salmassi et al., 2013). As presented above, we felt that adopting the expectation that the user would have a regular menstrual cycle contradicted our theoretical commitments to feminism; this design decision excluded those who do not have regular menstrual cycles. However, we could see no way of designing a menstrual cycle tracking device that did not use this model of the body. Saliva tracking was deliberately chosen as the method of ovulation tracking that we would work with as it represented a DIY, rather than diagnostic, approach where the user interpreted their fertile state

themselves. However, after deploying Ovum, saliva tracking appeared to be far more erratic than expected, and the leaflet that we designed to accompany Ovum was criticized by our participants as providing a too narrow depiction of what results could be expected, thus excluding many of their own results.

Biology is universalizing and deterministic in that its aim is to find trends and patterns in terms of how the biological body functions (Birke, 2000). Re-enforcing norms and excluding those who do not align with those norms is therefore perhaps an unavoidable consequence of applying biological science to the body. However, this does not mean that it is a tool that designers should not adopt. Rather than biological science being off limits for theoretical and ethical interrogation, biologist and feminist theorist Lynda Birke describes how there is an important place for feminists within the laboratories themselves (Birke, 2000). Scientists should be involved in working through feminist issues by interrogating and combatting androcentric biases embedded in the methods, apparatus and knowledge they use. Feminist biologists not only work around troubling histories and cultures within the static field of biology, but that they actively redefine biological science (Birke, 2000). Once biological science is taken out of the lab and clinic and migrates into the homes and pockets of users, then the same argument can be applied to designers of technological devices measuring and tracking the body.

Rather than re-packaging science, it is then possible that we are redefining science itself through how scientific methods are enacted and how results are visualised by our designs. Although it is impossible to employ the scientific knowledge that states that menstrual cycles occur at regular intervals without

excluding those with irregular menstrual cycles, we can avoid the whole device replicating problematic cultures through our design work. Becoming aware of and consciously negotiating epistemological, ontological and ethical contradictions through our design work is central to the approach of designing for embodied subjectivity. In the case of menopause, this resulted in the decision to not design at all. Although they have their failings, the designs Ovum and Ambient Cycle are more than diagnostic devices based upon biology as a deterministic and reductionist practice. These devices facilitate an experience of the insides of the body that goes beyond discovering truths and biological facts. In offering other experiences of scientific methods and knowledge, these devices perhaps redefine biology in line with what Lynda Birke is suggesting when she writes “we might begin to think of a biology as offering potential rather than limitation, that it might be ‘our biology that makes us free’ as a part of engagement with our worlds, rather than determiner of them” (Birke, 2000, p.156).

Knowledge on The Limitations of Proposing New Cultures Through Design

Critical and speculative design highlights complexity around how we define a “better” future, and the negotiations inherent in these definitions of “better”. DiSalvo detailed how Dunne and Raby’s exhibition on energy use and consumption offered an alternative future to fossil fuels that might largely be understood as preferable, but that the alternative proposal that we should instead use live animals for energy may seem repugnant and undesirable to visitors (DiSalvo, 2009). This effect of speculative design is exemplified in the cases of Ambient Cycle and Ovum. Designing self-tracking devices

drawing on feminist and phenomenological commitments might be preferable since they avoid biological determinism and essentialism and facilitated new interactions with bodies, but findings from their deployments showed how the consequences of this posed concerns for our research participants. A large part of the research included in this dissertation has been documenting the ways in which the prototypes Ambient Cycle and Ovum did not live up to our participant's expectations of what self-tracking technologies should do. The limitations and tensions inherent in the approach to designing for embodied subjectivity are also a contribution of this research. Though we chose and aimed towards re-configuring dualist and patriarchal cultures around self-tracking, our choices were not always reflected in the experience of our participants.

Because these devices were situated in the home environment, both physically and socially, other factors changed how Ovum and Ambient Cycle were used and perceived as self-tracking devices. For example, conflicting schedules and an ingrained sense of responsibility of the female partner due to the fact that it was their body being tracked, appeared to over-ride the ability of the design of Ovum to make fertility tracking a shared experience. There was also an inherent tension between Ambient Cycle being used to accurately represent the lived experience of the menstrual cycle and the fact that these colours were not appropriate for the home environment. Many participants turned off the device when Ambient Cycle was showing a colour that was unpleasant to live with. When asking one participant why she did not change the colours instead of turning the lamp off, she described how she couldn't change the colours because otherwise it would not have fitted with the

“logic” she had used to depict her menstrual cycle; “what I'm feeling is not pleasant, so I should choose a not pleasing colour”.

The majority of our participants found Ovum and Ambient Cycle insufficient as self-tracking devices as they wanted Cartesian answers to the questions that they were asking their bodies. In line with the approach of designing for embodied subjectivity, Ovum and Ambient Cycle provided ambiguity and openness rather than certain truths about the body. Perceptions about how accurate or useful Ambient Cycle was as a menstrual cycle tracking tool was affected by the fact that Ambient Cycle did not give any diagnostic or numerical data back to the user. Similarly, the fact that the saliva tracking method required participants to read their fertile state from the data themselves, rather than being given a clear diagnosis of “fertile” or “not fertile” by the device, also resulted in the opinion that the device was untrustworthy and lacked certainty. Although adopting a DIY form of fertility tracking was a design decision intended to place the user of Ovum in the role of the expert of their own data, this in fact had the opposite effect as participants adopted mitigating practices such as sending photos of the projection to us to analyse for crystals; using one another to validate whether or not crystals were visible; testing more than one time a day or at a different time of day; and using other ovulation tracking methods to triangulate the results in order to compensate for the ambiguity of the results from Ovum. The prototypes Ovum and Ambient Cycle appeared to sit in between devices that complete a task and devices that provide an entertaining and aesthetic experience for our participants. The “sculptural” form and aesthetics of Ovum was first appreciated by participants, before later being described as clumsy. As one participant described “honeymoon phase is over.

Now I just want it to be like what it is supposed to be.”. Over time, this participant did not value the aesthetic experience of using Ovum, but rather wanted the device to be a functional tool. Rather than seeing this as a usability failing on the part of the design, these findings relate to the limits of design in re-configuring societal and cultural attitudes. Although technological artifacts are one aspect of how culture is produced, there are clearly many other aspects in play.

These findings contribute to understanding what kinds of embodied subjectivities already exist. Removal as a method showed how past use of technologies influences current and future experiences of using technological devices. We were not introducing Ovum and Ambient Cycle to a new mobius strip of embodied subjectivity; rather, our designs were troubling what already existed. The autoethnographies in the paper “removal as a method” and our participant’s reflections to the experience of living with Ambient Cycle and Ovum document how insecurity and ambiguity is experienced negatively when we lose an apparently accurate reading of our own body. This showed how deeply a Cartesian dualist epistemology had been ingrained in expectations of self-tracking technologies. This is despite the fact that all of the studies presented in this thesis illustrated how the body is always more erratic and irregular than self-tracking technologies depict them to be. As one participant in the Ambient Cycle study stated after describing how she had been surprised when Ambient Cycle was more accurate than her menstrual cycle tracking app at predicting her menstruation “the thing is that I think it's accurate, but then it's not. And then I think it's my body “Oh my period came wrong this month”. It's always been very irregular. But that's also a

weird way of looking at it. Like the app is the correct... I mean it's my body that should be correct".

The fact that this research program was found to produce devices that were understood by some participants as inadequate self-tracking tools leads to the question: what would be required for Ovum and Ambient Cycle to be accepted as valid examples of self-tracking technologies? The findings from the research presented in this thesis point to the fact that a change in culture, and perhaps a return to pre-modern cultures as suggested by Drew Leder in our interview, would be required. Dismantling Cartesian dualism and its promise of objectivity would be core to this. Whether or not this change in cultural expectations about what can be expected from self-tracking could be brought about by the widespread introduction of feminist and phenomenological devices is a relevant question, but one that is clearly beyond the scope of the research presented in this dissertation.

What does seem promising is that, although designing for embodied subjectivity lacks the ability to provide objective "truths" about the body, it also facilitates other aspects that benefit users in different ways. These include the aspects previously presented as being examples of how Ovum and Ambient Cycle might be described as redefining biological science through understanding the body as a generative, rather than limiting, factor. For example, our use of ambiguity facilitated the representation and documentation of a non-essentializing, wide range of subjective experiences of the menstrual cycle through the use of Ambient Cycle. By avoiding addressing bodily experience as a negative "dys-appearance" of the body, we facilitated the tracking of positive and neutral

aspects of the menstrual cycle with Ambient Cycle (D Leder, 1990). For example, one participant chose to use green to represent the “good” phase after menstruation where she had more energy and said; “I’m going to pay attention if it’s really good these days”. This led to novel forms of interactions through self-tracking. Other examples of this was the use of Ambient Cycle to communicate hormonal states to other members of the household in order to encourage empathetic understanding, a reflexive use of data by using colours as therapeutic tools such as to calm or energize the users mood at different points of the menstrual cycle, and the fact that the “beautiful” experience of seeing crystals in the projection given by Ovum prompted participants to want to share the experience with their partners. Ambient Cycle and Ovum also both attend to the temporality of the body in novel ways; Ambient Cycle through giving a constant flow of menstrual cycle data at all points in the menstrual cycle, and Ovum for allowing the rise and fall in hormones around ovulation to be visible to the user. The designs resulting from designing for embodied subjectivity provided our participants with new ways of self-tracking and new experiences of themselves and their data. If the approach of designing for embodied subjectivity was adopted more widely in society, then these additional aspects would perhaps compensate for the negative experience of losing scientific objectivity when self-tracking the body; as Drew Leder stated in our interview “we can lean into that cyborg-facilitated self-awareness positively”.

The Impact on the Experience of the Designer

In reflecting on the approach of designing for embodied subjectivity, one important aspect that arose was how this

approach asked for a different kind of engagement from the designer. Amid calls for HCI experts to engage with research into medical devices (Nielsen, Christensen, & Sabers, 2017), my experience and research contributes how the sensitivities of the designer are a rich resource in re-configuring cultures of medicine through the design of self-tracking devices that do not only reproduce dualist understandings of the mind and body.

As discussed, modern medical and scientific training encourages a splitting of the body as subject from the body as object. Interaction design approaches within the third- and fourth-wave of HCI, and particularly the approach of embodied subjectivity, made this cut impossible. When designing for embodied subjectivity, designers cannot divorce the body as an object from the subjective experience of the user. Going back to Baron's example of saying "I can't hear you whilst I'm listening", due to my theoretical commitments, there was no way that I could separate the data being produced about the body as an object from the experience of my participants as subjects. This meant that my participant's reactions and concerns to the uncertain and unexpected results produced through saliva tracking were aspects I needed to negotiate throughout the deployment of Ovum. A different type of study would have disregarded this aspect of the experience of my participants as being one unavoidable consequence of the method. My study was not aimed towards understanding when they were and were not fertile, or how effective this method was for determining fertility. When approaching my participant's as embodied subjectivities and focusing on the experience afforded by my design, I could not divorce my participant's emotional reactions to their erratic results from the method of saliva tracking. Therefore, when designing for embodied

subjectivity, we cannot separate the scientific methods we employ from the devices we design. As outlined in paper 6, this was an uncomfortable aspect of the research. My own first-person accounts are not contributed with the aim of warning designers off the body as a design space, but rather highlights aspects to be expected when adopting the approach of embodied subjectivity.

Removal as a Methodological Contribution.

According to Frauenberger (2019), HCI has reached a model crisis; our models for understanding our empirical results are now beyond the scope of our frameworks and methods. Frauenberger proposes that we are coming into a fourth wave of HCI; entanglement HCI. This fourth wave adopts ethico-onto-epistemological perspectives, such as Grosz's theory of embodied subjectivity, in order to address the entangled nature of our interactions with technologies. Removal as a method is a fourth wave, methodological contribution in answer to the model crisis in HCI. Removal as a method is relevant to our current situation where we are never without our everyday technological devices. Removal as a method has the ability to disturb habitual, entangled, relationships with technological devices. This method is based on the belief that our entangled state means that we can never be objective or gain reflective distance enough to be able to articulate our habitual relationship with these devices. Removal is not seen as an act of deletion; it is not with the aim of reaching the state before the device had ever been used, or in the case of self-tracking, a

desire to return to the “natural” body. Rather, removal is a disruption that disturbs the relationship in order to produce knowledge on the nature of the entanglement.

The method of removal produced knowledge about the way that menstrual cycle tracking apps shaped particular embodied subjectivities. This method is a relevant for a range of cases, beyond self-tracking. Paper 3 discusses where this method is and is not appropriate, and the range of ways in which it might be applied. Removal could be used literally, either in autoethnographies by the researchers themselves or as a study with participants. Removal can also be in an imaginary sense; participants can be asked to imagine themselves without their devices. These reflections and reactions contribute knowledge about their entanglement with their devices, what aspects of use are most valuable, and the motivation for adopting their devices in the first place. Removal was also found to be a generative as a pedagogical tool with interaction design students to aid them on reflecting on their own use of technologies in their everyday lives.

Designed Artifacts as a Contribution

As the products of a research-through-design process, Ovum and Ambient Cycle are themselves a contribution (W. Gaver, 2012; Zimmerman et al., 2007). They represent self-tracking devices that acknowledge the user as being embodied, embedded, and influenced by social, societal and cultural factors. They act as critical and speculative designs in themselves by proposing preferable, feminist, futures for the

design of self-tracking devices. The fact that both Ovum and Ambient Cycle functioned as self-tracking devices in reporting the state of the biological body has also meant that these devices are more than fictional objects. Ovum has in fact crossed the boundary from being a speculative design as a Danish patent application (patent reference PA 2019 70393) has been filed by my university to protect the novelty of the design. This is with the aim of commercialising the device over the next year. Due to the intellectual property laws in Denmark, this has not been a choice of my own but rather that of my university; I am listed as the “inventor” of the device but do not own the patent. However, I have been part of this decision as I am interested in the process of commercialising a speculative design and hope to document and report on the process as a contribution to HCI in the future. Beyond expanding the design space of self-tracking devices through proposing examples for other researchers in design to draw inspiration from, there is therefore also potential for one of the contributions of my research to be the re-configuring of the types of commercial devices available on the market for consumers.

Re-framing and Expanding the Research Program

The knowledge produced through programmatic design research is understood as contingent, intermediary knowledge, rather than generalising knowledge on a particular topic (W. Gaver, 2012; Höök & Löwgren, 2012). One aspect of this is that the knowledge produced through the experiments challenge and develop the worldview that they derive from (Redström, 2018). This means that the limitations and implications of the worldview, as revealed through the design experiments, can then be used to re-configure the research program. Rather than understanding the beliefs and assumptions that make up designer's worldviews as static and fixed, this approach acknowledges the unstable and transitional character of theory (Ibid, p.95).

The research program adopted has already been re-configured once since this research began. The initial goal of my PhD research was to investigate the impact of the design of self-tracking technologies on 1. the lived experience of the user, and

2. societal and cultural understandings of the body. What quickly became clear in the initial design experiments was how these two factors were unavoidably intertwined; how the particular ways in which social and cultural aspects shaped the lived experience of the user, and how the lived experience of the user influenced how social and cultural perceptions are formed. This is where the limits of the worldview of this initial research program were revealed. Elizabeth Grosz's theory of embodied subjectivity provided a suitable theory to articulate and investigate the particular ways in which these two aspects were related. Adopting Grosz's theory signalled a re-configuring of the worldview of the research program. At this final stage of the PhD research, I can reflect on the research program I have been working within, how it has been re-framed and expanded through the four experiments, and possible directions that this research program might take in the future.

Challenging Assumptions with Participatory Methods

After reflecting on the research program, one aspect to consider is whether the way that this approach was carried out really aligns with its feminist and phenomenological commitments as it relies on the designers making assumptions about users. Imagining what experience a particular design decision will produce for an imagined user is integral to the interaction design process (Hallnäs & Redström, 2002). One aspect I now reflect on is the fact that the approach of designing for embodied subjectivity asks the designer to make more, rather than fewer, assumptions about the user. Cartesian dualist

designs of a self-tracking devices prioritise providing accurate truths about the body to the user in effective and efficient ways. The approach to designing for embodied subjectivity takes in the whole inner and outer life world of the user as shaping subjectivity, giving a vastly expanded design space for the designer to work within. In the design process, this was represented through considering the physical and social context that the device would be used within, as well as how knowledge drawn from lived experience of the body influenced the experience of data. This was one of the challenging factors of the application of the theory of embodied subjectivity in our design processes; we could not determine where the boundaries of our responsibility as designers lay. Since all aspects; social contexts, objects, spaces, power structures and morphologies, anatomies, and physiologies, were acknowledged as shaping the subjectivity of the self-tracker, we felt paralysed by the expanse of factors that the experience of our designs would be contingent on.

In order to ensure that we were not making Cartesian dualist assumptions about our imagined users, we stuck to our feminist and phenomenological commitments and used our own emotional sensitivities. If I see this approach as a contribution that could be adopted by other researchers, it then means that this research program, as it currently stands, places the responsibility to produce designs that lived up to feminist and phenomenological commitments solely on the head of the designer. This seemed troubling as it appears to be an approach that relies on the designer having adequate theoretical background knowledge on what is and is not feminist and phenomenological. This was one aspect I wondered about throughout the research program; what could lighten the

weight of responsibility on the designer to make the right kinds of assumptions in the design process?

As one quality of feminist HCI, pluralising research methods through employing participants in the design process seemed to be one way to negate the responsibility of designing devices that live up to feminist goals being solely with the designer (S. Bardzell & Bardzell, 2011). Co-design and participatory design methods provides a wider range of standpoints and pluralized voices and discussants to explore design possibilities and the implications of design decisions (S. Bardzell, 2018; Ehn, Nilsson, & Topgaard, 2014). One way in which I felt that this research program could be re-configured and expanded is through using the experience of participants from the very beginning of the design process. This would provide actual, rather than imaginary, scenarios that technological devices are used within. The ongoing collaborative ‘Gut Feeling’ project, which was initiated early in 2019 and involves other members of the IxD Lab at ITU, explores using participatory methods in the design of self-tracking technologies. The project is based on my proposal for exploring how new knowledge about how gut health influences mental health might be reflected in the design of self-tracking devices.

This project firstly involved our design team of seven people carrying out autoethnographies with lo-fi cardboard devices fitted with ethanol sensors that provided a number score for the ethanol present on our breathe. Our task during the two-week long study was to measure our breath twice a day and reflect on how the number given by the device could relate to our mental health and document our reflections in journals. Some suspension of our disbelief was required since we knew that

readings of ethanol levels do not directly link to gut health. This was a speculative exercise to understand how we might design for new scientific knowledge about the body.

This exercise led to us understanding that our relationships with our bodies are completely idiosyncratic, and how use of self-tracking technologies is motivated by a wide range of aims and desires. Some of our group wanted embodied interactions with their data in order to enhance their sense of self, and others wanted total objectivity and distance from their data; for the process to take place seamlessly in their lives with them only benefiting through improving their health. In order to gain a more expert perspective on the topic of the emerging scientific knowledge on the mind/gut connection, we collaborated with members of the 'Microbes on the Mind' project at the Medical Museion in Copenhagen. These were a mixed group of academics with backgrounds in philosophy, sociology, and public health from Copenhagen University as well as project leaders from the Medical Museion. We held an initial meeting and asked this group to complete the same autoethnographic study with the lo-fi prototypes. We then used their experiences and reactions to the cardboard box breathalysers to sketch prototypes that better fit each member's experience of their bodies and understandings of how their gut health interacts with their mental health. Formalizing these designs into interactive prototypes is still in process, and we will return to the members of the 'Microbes on the Mind' research group again with our finished prototypes in the coming months to gather their reactions.

Over the last year, 'Gut Feeling' has been a parallel project that has helped me reflect on the differences between designing

from the lived experience of the users outwards, as we have done with the 'Gut Feeling' project, and designing a prototype with certain theoretical commitments and then seeing what this prototype does in the lives of users, as evident in the studies of the deployments of the prototypes Ovum and Ambient Cycle. There is an expectation that pluralising the design process through involving marginalised voices will produce more democratic design processes and will produce designs that better serve a wider range of users (S. Bardzell, 2018; Ehn et al., 2014). The findings from the 'Gut Feeling' project were that this was an agonistic exercise (Björgvinsson, Ehn, & Hillgren, 2012; Disalvo, 2010). The experience of the body is completely subjective, and self-tracking is a very idiosyncratic process taking place in many different contexts and environments with completely contrasting desires and aims. This means that inevitably, each self-tracker would require their own design of self-tracking device to create truly intersectional designs. Once subjectivity is understood as being shaped by a whole range of factors, and not just scientific facts about the physiological state of the body, then how can one person's subjectivity be likened to another? This raises the question: how intersectional can designs of self-tracking technologies really be? Though one answer may be in creating designs that are open enough to be used in a range of contexts, this would risk a universalising approach by once again categorising users by one aspect of their biological body; something that this approach has worked hard to avoid. One possibility is that there is a chance that trends and themes may arise between potential users; perhaps there are there commonalities between self-trackers that were not shown within our Gut Feeling project as the sample group was too small.

Expanding this research program through the ‘Gut Feeling’ project has allowed me to explore how participatory methods could lessen the weight of responsibility on the designer in making the right kinds of assumptions about users, i.e. those informed by feminism and phenomenological perspectives. This has led me to understand that participatory methods are useful in producing knowledge on actual contexts that self-tracking takes place within, attitudes towards self-tracking, and the diverse subjective experiences of the body, but that these methods are not generative in producing designs that can fit into multiple users’ existing contexts and desires for self-tracking. Further work developing this research program will include exploring how to negotiate the spectrum between designing universalising devices and designing idiosyncratic self-tracking devices that only work for one individual. This represents a shift in the research program towards aiming to produce devices that users might find desirable and useful. This has not been the aim of this research program since I did not adopt a specifically user-centred approach, but rather a more open exploration of the implications of designing self-tracking technologies with non-Cartesian ethical, epistemological and ontological commitments.

Embodied Subjectivity and Qualitative Research Methods

As a further development to the research program employed in the research presented in this thesis, it seems relevant to re-think the 3rd person methods employed to understand research participant’s experiences of designs. Using Grosz’s theory

means that this research represents a feminist new materialist approach (Lupton, 2019). In taking up a feminist new materialism ontology as a designer, realities, ethics and values are understood as produced through objects and praxis. Feminist new materialism is an approach that understands that meanings and realities come to be through intra-actions between humans and non-humans (Barad, 1996). This reflects a “new empiricism - attempts to retain an empirical, material element without abandoning social construction” (Alaimo et al., 2008, p.5). This also reflects approaches such as actor-network-theory as applied by Latour and Woolgar to explain the different realities of science produced through the inscriptive devices of the laboratory (Latour and Woolgar, 1986), and Anne-Marie Mol’s use of praxiography to show how realities of diseases are not explained by medical practices and beliefs, but rather they are produced in them (Mol, 2002). These approaches, and the use of ethnography highlight the messiness and human factors influencing how knowledge is produced (Law, 2004). Feminist new materialism takes up this perspective but highlights the ethics and values embedded and produced (Frost, 2011; Grosz, 1994; Haraway, 1988). These theories are widely used in STS and as have also been used as a tool for analysing intra-actions between self-trackers and their data (Lupton, 2019).

Commitments to worldviews adopted in a research program were not set aside once the design work is done. The definition of the “self” in self-tracking as an embodied subjectivity was carried through into the interviews and analysis of qualitative data drawn from the deployments of Ambient Cycle and Ovum. This led to an understanding that research activities were not producing full representations of participants’ experience of

the world, but rather producing insights into static sections of the mobius strip. Interviewing participants was like cutting into the mobius strip, rather than observing it in motion. From this perspective, the way that the research was carried out was understood as influencing the knowledge produced. This was illustrated by one of the couples participating in the Ovum deployments; they commented on the fact that that our insisting that both of them attend every interview had provoked reflections and discussions outside of the interviews between them about how the labour was unbalanced in their previous fertility tracking practices. This represents how approaches and theoretical commitments used in design research are not only influencing factors through the designs themselves, but also through the research methods employed.

On reflection, periodic interviews, and particularly those taking place through video calls where my own somatic sensibilities were removed, might not be the optimal way in which to understand user's embodied subjectivities. Just as removal as a method was appropriate for producing knowledge about how our past use of self-tracking devices shaped our embodied subjectivities, then I need to find methods appropriate for accounting for how the devices designed and deployed within this research program shape our research participant's embodied subjectivities. The tension is then in finding methods that are appropriate for long-term deployments, and that allow for objects to fade into the background in user's lives rather than remaining novelty objects that participants are frequently being asked to reflect upon. For example, Schiphorst's use of sensitizing activities that aided participants in gaining a heightened awareness of their inner sensations are not appropriate when deployments take place over many months (Schiphorst, 2009).

The Research Program Updated

After reflecting on the research program employed thus far, it is now possible to create a new research program that represents my future work. This new research program further develops the approach to designing for embodied subjectivity. The main aspect to be explored through this new research program is how self-trackers' desire for certainty about their bodies might be negotiated when designing for embodied subjectivity. There is a gap between current cultures around the body and the alternative culture proposed through designing for embodied subjectivity. This research program will explore how this gap might be bridged. A key question will be; how can we design self-tracking devices that are deemed useful and effective to users without falling back into Cartesian dualist approaches? Participatory methods such as workshops will be used to explore this gap with a more user-centred approach. These workshops will also produce knowledge on how designers might facilitate a plethora of different experiences of the body whilst avoiding universalising designs that group users by a particular facet of their bodies. A final aspect of this research program would be in developing methods that can better account for the embodied subjectivities of research participants.

The Research Program in a Commercial Setting

Over the next year, the commercialisation of Ovum will run parallel to conducting the updated research program presented

above. However, I see promise in developing the research program within the commercialisation process itself. This will mean that the commitments of the research program will need to encompass the demands of developing a commercial device and marketing strategies. Whether or not a research program is still a relevant framework to use when commercialising designs is a relevant question to consider. However, as my main motivation behind this process is to ultimately understand the implications of taking critical and speculative designs to market, this thereby qualifies this as a research activity, and therefore still an aspect of the research program.

One of the most interesting aspects of this commercialisation process so far has been following how the aspects that were part of my feminist and phenomenological commitments become marketing and patenting opportunities for the Business Development team at my university; such as the aim to make the experience of fertility tracking a collaborative experience, and the homeware aesthetics of the device. Another interesting aspect is how the Business Development team describe Ovum as being an “entertainment device”; despite it functioning to the same degree of accuracy as a microscope, which they perhaps would not describe with the same terms.

Entering Ovum into the commercial market will also produce knowledge about how the balance between the benefits and limitations of Ovum from the perspective of a commercial customer. I have stated that one way that the lack of certainty offered by designing for embodied subjectivity is compensated for is by offering novel experiences of the body. As Ovum is taken to market, this will be an interesting aspect to follow: do the feminist and phenomenological qualities of Ovum outweigh

its limitations as a Cartesian dualist device in terms of how attractive it for commercial consumers?

Conclusion

This dissertation has presented the argument that the body is not a neutral design space. The body is not a fixed, a-historical or pre-cultural object to be discovered neutrally through science. This argument becomes more pertinent in light of the increase in design and application of technologies that provide information about the insides of the body outside of the clinical context. I began this thesis by outlining how Cartesian dualist cultures around the body are reflected and exaggerated through self-tracking technologies and practises. Feminist theorists and phenomenologists state that Cartesian dualism risks essentialising and reductive approaches to lived experience and the oppression and erasure of bodies that do not live up to the male, white, able-bodied, norm. If the “self” is no longer understood as a separated cognitive mind and mechanical body, then alternative approaches to the relationship between the body as subject and object are required.

The research program presented in this dissertation explored what employing Elizabeth Grosz’s theory of selfhood as being an embodied subjectivity might produce as an alternative

definition to the “self” in self-tracking within the design process (Grosz, 1994). Grosz states that lived experience is a result of a mobius strip-like relationship between the body as subject and the body as object. Grosz’s feminist theory was augmented with phenomenological theories and an interview with phenomenologist Drew Leder that provided a more nuanced understanding of how the insides of the body are experienced.

The approach of designing for embodied subjectivity was developed through the design of two self-tracking devices; Ambient Cycle, a menstrual cycle tracking device that visualises data through ambient colour changes in the home environment, and Ovum; a ceramic ovulation tracking device that projects a magnified silhouette of the user’s saliva sample out into the room, when the user is fertile, salt crystals appear in this projection. This approach also resulted in the design decision to not produce self-tracking tools for menopause do to the fact that doing this would have contradicted the feminist and phenomenological research commitments. The theory of embodied subjectivity was also used in understanding the results of removal as a method, which involved an autoethnographic study of deliberately stopping menstrual cycle tracking. This approach helped articulate how our use of menstrual cycle tracking apps had influenced our embodied states, even after these devices were removed, and how cultural and societal norms and expectations had become embodied.

What designing for embodied subjectivity allowed was an awareness of the multiple factors that shaped users sense of self, not only the diagnostic and prescriptive methods of science. The theory of embodied subjectivity produced designs and methods that both acknowledged the inner body sensations

and bodily experience of the user on their experience of the outer world, and how the experience of the outer world, including societal and cultural aspects such as body politics, became embodied and influenced the lived experience of the body. This approach allows designers to become aware of, and make choices about, the kinds of body politics they wanted to enact through their designs. A manifesto drawn from our experience of designing for embodied subjectivity that can be taken up by other designers is one contribution of this dissertation. This approach seems relevant where the group of users or the design case at hand is a particular facet of the body or anatomy; a particular chronic disease or one aspect of anatomy or morphology.

Drawing from the deployments of the prototypes Ovum and Ambient Cycle in long-term studies, this thesis outlined the obstacles and benefits and limitations of adopting the definition of the “self” in self-tracking as an embodied subjectivity. Findings showed how the approach of designing for embodied subjectivity supported a less normative notion of the body by facilitating the tracking of a wide range of bodily experiences; facilitated conversations and reflections on body politics in society; and produced novel, positive, forms of interactions with the insides of bodies, rather than interactions that re-enforced that the biological body was an aspect to be negated and controlled through self-tracking. However, this research also showed that user’s expectations of what kinds of knowledge is possible through self-tracking will have to be negotiated if designers are to adopt this approach. In presenting the particular ways in which Ambient Cycle and Ovum failed to live up to participant’s expectations of self-tracking devices, this research highlights how Cartesian dualist definitions of the

body is still present and preferred in self-tracking practices, even when irregularity, uncertainty and inaccuracy is an inherent aspect of the body itself. Other contributions of my research include first-person accounts of the implications of the approach of designing for embodied subjectivity on the experience of the designer, and a discussion of tensions around using science in design and how the embodied subjectivity approach might be redefining biological science through changing how scientific methods and results are enacted and represented once they are situated in non-clinical settings.

The final chapter of this thesis presents ongoing and future work. The research program that I have used thus far is configured in light of the findings from my research experiments. This updated research program includes investigating further how participatory methods might be used when designing for embodied subjectivity. This research program will also explore the gap between current Cartesian expectations of what self-tracking technologies should do in terms of providing certain and diagnostic readings of the body, and the feminist and phenomenological future that I am proposing that replaces universalizing objectivity and certainty with ambiguity and co-constructed knowledge. The commercialization of the Ovum prototype will provide one context for this updated research program. I will follow how the theoretical commitments made during the design process become marketing strategies and how the reactions of potential customers to Ovum as a commercial fertility tracking device produces knowledge on the benefits and limitations of the approach of designing for embodied subjectivity from a user-centered perspective.

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Part 2.

Paper 1.

Homewood, S.

Reframing Design Problems Within Women's Health.

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Reframing Design Problems Within Women's Health

HOMEWOOD Sarah

IT University of Copenhagen
shom@itu.dk
doi: 10.21606/dma.2017.337

This paper begins by offering a feminist reading of the visible increase in design research within the category of “women’s health”. A critical feminist reading of menstrual cycle tracking technologies is then used to investigate how the way that we frame design problems influences the artifacts produced and their impact within society. I argue that by re-framing design problems from the perspective of third and fourth wave feminism we can develop women’s health technologies that are more affirmative, inclusive and which celebrate difference and reflect the complexity around what it means to be a woman in today’s society. I illustrate the potential of this reframing by presenting three approaches to the design of menstrual tracking technologies that better adhere to current feminist ideologies.

Women’s health; design problems; feminism; menstrual cycle tracking technologies

Introduction

Women make up half the population, and are not a minority. The female body is capable of experiencing more actions, processes and transitions than the male body, such as pregnancy, breastfeeding, menopause, post-partum trauma and menstrual cycles. These physiological processes create many more openings for the application of technology and design than for the male body. As the creation and development of digital artifacts is an act of design (Löwgren and Stolterman, 2004), it becomes relevant to address and critically appraise the design process behind the application of technology to the female body and its particular physiological processes.

According to search results for “women’s health” as author-defined keywords in the American Computer Machinery (ACM) Digital Library database, research defined as relating to women’s health did not appear until the 1990’s and dramatically proliferated from there on, particularly within the last ten years. Currently there are five thousand articles using “women’s health” as an author-defined keyword (ACM, 2017). This database holds most major conferences and journals on research into new technologies. The subject of women’s health has been an increasingly present topic in workshops and publications presented at international conferences within the fields of human-computer interaction (HCI) and interaction design including two CHI workshops in the last five years dedicated solely to women’s health (Balaam, 2013, 2017). Experiences in women’s health such as



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breastfeeding have been reimagined through participatory design of breast-pumps (Ignazio, Hope & Churchill, 2016) and Feedfinder (Balaam et al., 2015), a mobile application that facilitates the sharing and reviewing of public places suitable for breast feeding. Research related to menstrual cycles includes the design fiction PeriodShare (Søndergaard & Koefoed, 2016) that uses the taboo around menstruation to address the conventions of privacy around bio-data, and the Menstrual Machine (Ozaki, 2010), a speculative wearable device that simulates the experience of menstruating. The form, aesthetic and functionality of menstrual cycle tracking technologies has previously been discussed within HCI and interaction design in papers such as Epstein *et al.*, 2017.

Feminist HCI and interaction design has also emerged in recent years and there are many parallels and causal links between the two trends. HCI and interaction design have gained an “increasing awareness and accountability for its own social and cultural consequences” (Bardzell & Bardzell, 2011 p.675). Following this, the application of feminist theories has been used within design research in order to reach societal goals such as gender equality. Feminist theories have been used to highlight the influence of the position of the researcher on knowledge produced (Prado, 2014), and to include the marginalized within the design of technologies (Ignazio, Hope & Churchill, 2016).

In this paper, I will apply a collection of western feminist epistemologies to discuss the causes of latency in the research and development of women’s health related technologies and possible reasons why and how women’s health has become an emergent trend. A critical feminist reading of menstrual cycle tracking technologies is then used to question the implications of how design problems are defined. I then illustrate that a critical stage of analysis when defining what we posit as a design problem can yield innovative, affirmative and feminist design artifacts that celebrate difference and inclusivity.

“Women’s Health” as an Emergent Trend

Why Did It Take So Long?

One way of grounding causes for latency in the development of technologies for women’s health could be through the concept of the “othering” of women that is widely used and discussed within feminist theory. The term “othering” comes from Simone de Beauvoir’s statement “He is the Subject, he is the Absolute, she is the Other” (1949). With this statement Beauvoir claims the view the world holds prioritizes the experiences of men. This is extended by Rosemary Garland-Thompson’s definition of the norm, or “normate”, as the white, young, healthy, heterosexual North American man (1997). Women are categorized alongside the remaining population including people from other races, sexual orientations and people with disabilities. These outlying groups are deemed abnormal or “extraordinary” (Ibid). A similar search for “men’s health” in author defined key words in the ACM Digital Library returned only one result. However, if we follow Beauvoir and Garland Thompson then it could be said that a search of the ACM digital library for the keyword “health” would return research that were androcentric, this term refers to the prioritising of male experience over female experience that results in the marginalization and subjugation of women. These “health” technologies would therefore hold a bias towards male experience from the ideation phase to the methods applied in user research. Epstein et al. (2017), describe how when Apple launched their Healthkit app in 2014 they excluded menstrual cycle tracking from the features it provided, only adding it later following a public outcry. This case highlights assumptions held within the development of technologies about the body of the user. If the male body represents the norm, then an intentional effort is then required to design specifically for the female body. This directed effort could even be labelled as a separatist act, where men are excluded from the design process and discourse. As stated in Bardzell, 2010, a separatist act goes against the “universalizing aspirations” of technology where technological artifacts should be relevant and useable by all, regardless of sex, gender and culture.

Why and How Women's Health Became an Emergent Trend

The question of why and how women's health has become an emergent trend can be answered through the use of particular feminist theories on scientific research. I will now propose that an increase and improvement of research on women's health within design fields can be seen to be evidence of the application of the epistemologies of feminist empiricism, feminist standpoint theory and the use of feminist design methodologies. This analysis brings to light the role that feminism has played in driving change up to this point. This allows reflection on the current status quo and makes visible the work that is still to be done within design research in order to work towards feminist goals within society.

Feminist Empiricism

Feminist theorist and scientist Sandra Harding outlines existing feminist epistemologies that aim to correct androcentric methods and cultures within scientific research (1986). I will apply these epistemologies, or perspectives on the production of knowledge, to design. The first perspective Harding presents, feminist empiricism, "argues that sexism and androcentrism are social biases correctable by stricter adherence to the existing methodological norms of scientific enquiry" (Ibid, p.24). Applied to the fields of design, feminist empiricism holds that androcentrism and sexism could be correctable through an increase in the diversity of those working within the field. Therefore, an increase in research on women's health could be due to social movements such as women's liberation that have resulted in more women taking up jobs as designers and researchers. Feminist theorist Sara Ahmed (2006) uses the term "orientations" to discuss the fact that our perception of the world is influenced by "what we can face at any given moment in time." (Ibid, p. 547). For female designers, the female body is present to them in different ways than to male designers. Female designers therefore may feel motivated to attend to the female body through the design of women's health-related technologies. Bardzell (2010) describes the increase in inclusivity within HCI and interaction design as evidence of pluralism. Pluralism is the opposite to universalism and "embrac(es) the margins both to be more inclusive and to benefit from the marginal as resources for design solutions" (Ibid, p.1306). It could therefore be argued that designers as a population have become increasingly gender diverse, and this has allowed for the development of non-universalising technologies specifically designed for women's health.

Feminist Standpoint Theory

The second perspective outlined by Sandra Harding is feminist standpoint theory. This theory recognises that knowledge is constructed, not found (Harding 1986), and that the location and perspective of the researcher will influence the qualities of knowledge produced. From this perspective, an increase in research carried out by female designers can therefore be posited as producing a higher quality of research on women's health. Rather than leading to essentialism by stating that men are disqualified in the design of technologies for women's health, this epistemology celebrates the situated knowledges (Haraway, 2006) of female researchers in developing technologies for women's health that better suit women and the female body. An example of the application of standpoint theory and situated knowledges is the project FemSpec (Rossman, 2008). FemSpec re-imagines the design of the speculum, which was historically designed from a dominant medical and masculine position without consideration for the comfort of the female patient. The company behind FemSpec, FemSuite, is comprised of one male and two female gynaecologists. FemSuite utilized their own personal experiences as well as the experiences of female research participants to design an improved speculum that, through a process of participatory design and subjective experiences, improved the experience of cervical examinations that are a vital aspect of women's health.

Feminist Methods of Enquiry

Feminist methods of enquiry can be seen to have improved research on women's health through the application of feminist research methodologies and methods. Although the increase and improvement of research on women's health within HCI and interaction design can be seen to be

evidence of feminist empiricism and feminist standpoint theory epistemologies, Harding critiques both epistemologies by stating that neither change the “existing methodological norms of scientific inquiry” (1986), p.24). Donna Haraway’s analysis of the influence of the researcher’s own lens of dominance evident in methodologies and methods used within a primate study in the 1930s (2006) reveals the “embodiment of social relations in the content and basic procedures of a natural science in such a way as to expose the fallacies of the claim to objectivity” (Ibid, p.12). Within design research, it has been shown that certain methodologies can support feminism through their ability to expose the influence of the researchers own lens of bias and privilege on knowledge produced (Søndergaard & Koefoed, 2017). Ignazio, Hope and Churchill (2016) and Prado (2014) have proposed that methodologies such as participatory design and critical and speculative design offer feminist tools that include women as a marginalised group in the design process and imagine alternative futures in order to reject the reification of existing biases within society. Bardzell (2010), offers a “set of feminist interaction design qualities intended to support design and evaluation processes directly as they unfold” (Ibid, p.1301). Bardzell proposes that the application of qualities such as *advocacy, ecology, embodiment, participation and self-disclosure* can yield a generative approach to feminist HCI and interaction design. These feminist methods of enquiry can be seen to combat androcentrism through *how* research is conducted. These examples provide roadmaps for those wishing to conduct feminist research and can be seen to have improved research on women’s health through the questioning of “existing methodological norms of scientific inquiry” (Harding, 1986, p.24).

Menstrual Cycles as a Design Problem

As argued above, feminist empiricism, feminist standpoint theory and a range of feminist design methodologies are apparent causes behind the increase and improvement of research on technologies for women’s health. However, Sandra Harding discusses how androcentrism often lies in the defining of the problem area where the research will take place; “a key origin of androcentric bias can be found in the selection of problems for enquiry, and in the definition of what is problematic about these phenomena” (1986, p.25).

How design problems are conceived and considered within design theory has changed drastically over the decades. In the 1950s and 1960s first generations of design theorists and practitioners “viewed design as a process of systematic problem solving” where the designer was an “objective, scientifically trained expert” (Löwgren & Stolterman 2004, p.154). Later generations rejected the perspective that there are pre-existing problems to be solved by designers through rational and objective dissemination and thought, and instead acknowledged that it is the designer themselves who create and define design problems.

Design problems are "indeterminate" and "wicked" because design has no special subject matter of its own apart from what a designer conceives it to be... in the process of application, the designer must discover or invent a particular subject out of the problems and issues of specific circumstances. (Buchanan, 1992, p.16).

If we follow the fact that design problems are solely conceived of by the designer, then this highlights the influence of the individual designer’s social and cultural positions and beliefs and politics on the resulting artefacts of the design process. Through using menstrual cycle tracking technologies as an example, I now propose that androcentrism can still be seen to be evident in how design problems are framed within the development of technologies for women’s health.

Menstrual Cycle Tracking as Biopower

Menstrual cycle tracking is not a new phenomenon; women have tracked their menstrual cycles through analogue methods for centuries. Though the digitisation of menstrual cycle tracking technologies allows new functions and possibilities, current technologies still closely resemble analogue tools. The key differences between digital and analogue tools is that digital tools are screen based, interactive, provide apparently scientific information about each phase of the menstrual

cycles and that they can predict the timing of the menstrual cycle through the use of algorithms and data-gathering. If menstrual cycles have historically been used as an argument for the subjugation of women (Shildrick, 1998), and analogue menstrual cycle tracking tools work towards the concealment of menstrual cycles in society (Bobel, 2010), then it can be seen that menstrual cycle tracking technologies that closely resemble their analogue forebears, are designed as solutions to the same longstanding problem of the uncontrolled and objectionable female body.

Epstein et al. state “women often track their menstrual cycles without an explicit goal of action, but instead for awareness of their place in their menstrual cycle.” (2017: 6876). It could be argued, however, that “awareness” is a goal in itself, not only for the individual but also for society. It has been discussed that there is a wider societal goal behind self-tracking that relates to Foucault’s concept of biopower (Leder, 2016; Lupton, 2016; Schüll, 2016). The term biopower refers to the promotion of the practice of self-discipline on an individual scale as a tool to govern the population (Foucault, 1990). In the context of biopower, self-tracking technologies provide us with the tools to monitor and discipline our bodies, as the uncontrolled body, such as an overweight, ill or erratic body that is seen to place economic burden on the wider society is viewed as undesirable and uneconomical (Lupton, 2016, p.52).

Historically, the female body has been considered to be uncontrolled. This has been used as an argument for the subjugation of women;

for women losing control is only to be expected. Though past explanations, such as the concept of the wandering womb, have been superseded by new constructions of female disorder, sophisticated medical references to hormones, pre-menstrual tension, menopausal irritability and the like are no less rooted in an essentialist view of women’s bodies and women’s nature.” (Shildrick, 1998, p. 27).

In light of this, it could be said that menstrual cycle tracking technologies represent tools of biopower used to control and mitigate the symptoms of the menstrual cycle in order to allow the female, menstruating body to perform in society as a non-menstruating body, male, body. Although not all female bodies menstruate, for example pre-pubescent girls, trans-women or post-menopausal women, generally the societal understanding of the non-menstruating body is the male body. A non-menstruating body can therefore be seen to be the desirable and “normate” (Thomson, 1997) body within an androcentric society, where the male body is valued above all others.

Androcentrism Evident in Menstrual Cycle Tracking

I will now present evidence that menstrual cycle tracking technologies re-enact androcentric ideals throughout three key phases of the menstrual cycle.

Menstruation

One key motivation for many users of menstrual cycle tracking technologies is being able to predict the onset of menstruation (Epstein et al., 2017). This is in order to ensuring that they are prepared with the appropriate tools such as tampons, sanitary towels or menstrual cups to prevent menstrual blood seeping through their clothes and being visible by others or transferring onto furniture. Menstrual blood is currently considered taboo in many societies and cultures across the world, and a backlash against these taboos has been the Free Bleeding movement what gained popularity in Western societies in 2014 when Kiran Gandhi ran the London Marathon with her menstrual blood visibly flowing through her clothes (Gandhi, 2015). Free Bleeders take pride in the visibility of menstrual blood, often using social media as a platform to share images and videos of themselves. The concealment of menstrual blood can be seen to be the concealment of female embodiment in favour of a non-menstruating, controlled, male embodiment.

Ovulation

The expectation for the menstrual cycle to be controlled by individuals is also motivated by the fact that the ovulation phase of the menstrual cycle dictates the body’s fertility. Most forms of

contraceptives, such as hormonal contraceptives and IUDs, are still designed to be used by the female body, with the exception of condoms. Menstrual cycle tracking has long been used as a form of fertility managements, particularly within certain religions such as Catholicism. Advancements in technology and data science have resulted in the development of algorithms and digital temperature tracking technologies that now mean that menstrual cycle tracking apps can be marketed as a secure form of contraception. The Natural Cycles Bluetooth enabled thermometer and accompanying app gained FDA approval in 2017 (Berglund-Scherwitzl et al., 2015). This product heralds a whole new future of contraceptive technologies. Deborah Lupton's review (Lupton, 2015) of sexual and reproductive self-tracking apps found that apps on the subject of sex and fertility designed for women focused on medicalisation and risk of disease and pregnancy. For men, these apps were designed with an emphasis on physical performance, duration and competition. For the individual woman to be able to control their own fertility and reduce unwanted pregnancies is clearly beneficial for the wider society economically. Fertility management as biopower is therefore seen to be designated to women through the use of menstrual cycle tracking technologies.

Pre-Menstrual Syndrome

A third aspect of the menstrual cycle that can be seen to be controlled through menstrual cycle tracking is pre-menstrual syndrome (PMS). PMS is commonly defined by symptoms such as irritability, tender breasts and bloating and occurs around a week before menstruation. Though the existence of PMS is contested in certain areas of scientific research (Romans et al., 2012), PMS is an accepted phase of the menstrual cycle in societal discourse. Most menstrual cycle tracking apps include some form of PMS logging tools and use this to predict when PMS will occur in future cycles. Epstein et al.'s study (2017) found that menstrual cycle tracking allows users to understand, and sometimes mitigate, their own emotions. As one of participant in their study stated "sometimes I'm really emotional and irrational and I can look at my tracker, see that my period is due in a week or less and chill out and realize I'm PMSing instead of having real feelings." (ibid, p.6879). The labelling of emotions experienced during PMS as un-"real" relates to a common theme in societal discourse where PMS is represented as a phenomena that takes over the body and renders it altered from its "real" state and thus uncontrolled and devoid of rationality.

The Testy Totem app (Testy Totem, 2017) is designed for "husbands/boyfriends/partners whose significant other exhibits PMS, or moodiness associated with their menstrual cycle." The app asks the user to input details of the menstrual cycle it would like to track, such as average length and the beginning of menstruation in order to synchronise with it. Red, green and yellow images of Totem's with varying facial expressions then indicate which stage of the menstrual cycle the person they are tracking is in. "Green means everything is normal, the time of the month two weeks or more away. Yellow indicates that you or your totem is within two weeks of their menstrual cycle, and Red means you or your partner is one week from starting menstruation, the phase of the cycle most commonly associates with PMS or Pre-Menstrual Syndrome". The term "normal" to represent the non-PMS stage of the menstrual cycle labels the PMS-ing body as being ab-"normal", just as their PMS-ing body was un-"real" for Epstein et al.'s participant. Whether this technology is designed for the benefit of both the user and the partner being tracked is doubtful. Testy Totem does not appear to be designed as a collaborative tracking tool such Clue Connect that lets the user track their own menstrual cycle share their data with others (Clue, 2016). Theoretically the Testy Totem could be used without the consent or knowledge of the partner, thus representing a technology for un-consensual surveillance. The design, function and language used by Testy Totem gives a clear indication of how PMS and women experiencing PMS are perceived by the designer(s), predominantly as a negative phenomenon which requires management. Though the description does not explicitly say what the goal of the app is, the in-app explanation advises the user to "BE ON YOUR TOES" and "KEEP YOUR MOUTH SHUT" when the cycle that they are tracking is in the PMS phase. It therefore appears that the app is designed for users to be able to adapt their behaviour according to their partner's menstrual cycle, therefore controlling the influence the menstrual cycle

of their partner has on their relationship. This relates to the direction that Epstein et al.'s participant gave to themselves to "chill out" once they are aware that their behaviour is due to PMS, thereby encouraging them to mitigate their own behaviour for the sake of others in society through the concealment of PMS and enacting a non-menstruating body instead.

A Feminist Re-framing of the Design Problem of Menstrual Cycles

Here I will return to Harding's statement "A key origin of androcentric bias can be found in the selection of problems for enquiry, and in the definition of what is problematic about these phenomena" (1986, p.25). In avoiding androcentrism in the framing of menstrual cycles as a design problem, designers must aim to find a feminist alternative. As will be discussed below, after a brief presentation of conceptualisations of menstrual cycles in second and third and fourth-wave feminism, this can be a complex but generative task.

Androcentrism is not the sole possible framing relevant to menstrual cycle tracking technologies. Menstrual cycle tracking technologies can also be seen to be in accordance with the ideologies of early second-wave feminism. During this movement in the 1960s, women were encouraged to transcend their embodiment in order to reach political and public equality with men (Beauvoir 1948). For second-wave feminist theorist Shulamith Firestone (1971), gender equality would require the introduction of extra-uterine gestation that would relieve women of the burden of child-bearing. The goal for second-wave feminism was equality in all areas of work, family life and in public through eradicating the female gender and all its qualities entirely. Evidence of this can be seen through the introduction of tampons, that allowed women to conceal their menstrual blood entirely, and how The Pill was manipulated by women to skip the pause that allows menstruation that is built into the monthly prescription (Bobel, 2010). However, this ideological dream was later criticised by a large part of feminists as it implied that the "true potential" that could be reached through transcending the female body was the male body, thereby re-enacting androcentric bias in society.

The current, fourth-wave of feminism is still being shaped, but is grounded heavily in third-wave feminism, which emerged in the 1990s and is a notoriously difficult to define due to its emphasis on inclusion and non-boundary feminism (Snyder, 1995). Themes running through third-wave feminism are intersectionality; a result of a critique of feminist standpoint theory's universalizing labelling of "women" as one group. Intersectional feminism posits that all categories of race, class and sexuality must also be taken into account when considering the subjugated situations of women. As Claire Snyder writes; "By occupying female subject positions in innovative or contradictory ways, third-wavers unsettle essentialist narratives about dominant men and passive women and shape new identities within the interstices of competing narratives. There is no one way to be a woman." (1995 p.185). The emphasis on inclusion and choice of the individual at the core of third-wave feminism means that it is equally as feminist for women to choose to conceal their menstrual cycles, aligning themselves to the second-wave ideology of transcending their biology, or for women to bleed freely in public and choose not to adhere to societal taboos through discussing and displaying their menstrual cycles with pride (Bobel, 2010). This means, therefore, that there is not one clear, feminist framing of menstrual cycles as a design problem, though choice and inclusion are clear elements which distinguish feminist design problems from androcentrically biased design problems within this context. What will be presented now are three illustrations of future designs of menstrual cycle tracking technologies that can result from the re-framing of menstrual cycles as design problems that adhere to current feminist ideologies whilst continuing to reject androcentric ideals and the subjugation of women.

Sharing the labour of fertility tracking

By framing menstrual cycle tracking as a design problem that acknowledges that conception involves both men and women, fertility can be re-framed as a shared responsibility. As shown in Deborah Lupton's analysis of sex and fertility apps (Lupton, 2015), the majority of current apps designate the responsibility of fertility management to women. One example of menstrual cycle tracking

technologies that share the labour of fertility tracking could be technologies that notify both partners when ovulation is imminent. This allows both partners to either plan or avoid sexual intercourse during this time without the female partner acting as gatekeeper to their own bodies by permitting or rejecting sexual intercourse. As discussed above, apps such as Clue already offer users the opportunity to share their menstrual cycle data with others. This development allows users to share their menstrual cycle data with their partners, friends and family and was “the most requested feature since we initially launched Clue back in 2013.” (Clue, 2016). In contrast to the example of Testy Totem (2017), also presented above, where the surveillance of the menstrual cycle was non-consensual, users of Clue Connect have sole access until they invite people to share their data and can block this access at any time. The fact that this was “the most requested feature” shows that this is a facility that is appreciated by those that use menstrual cycle tracking technologies and points to further design work that could be done in this area. A related design example that addresses gender equality in fertility control is (Homewood & Heyer, 2017), where speculative design is used to imagine the impact on future users of the contraceptive microchip implant that will be released onto the market in the next few years. The contraceptive microchip implant lasts for sixteen-years and is accompanied by a remote-control component that enables users to control the flow of contraceptive hormones into the user’s bloodstream in order to permit or prevent conception. Within this project, the remote-control component was imagined as two necklaces, one necklace to be worn by each partner. When fitted together, these necklaces could disable the microchip implant and therefore allow conception. This imagining of the remote-control component proposed a more collaborative and mutual control of contraceptive methods through use of ritual. Both Clue Connect and the speculative remote-control component can be seen to reflect current feminist ideologies that reject the designation of labour around pregnancy and childcare solely to women through the sharing of the labour surrounding fertility tracking and fertility control.

Alternative Representations of Menstrual Cycle Data

The majority of current menstrual cycle tracking technologies are in the form of apps. These apps are available to users on their smart phones and are mostly kept private. In order to investigate conceptions of privacy around menstrual cycle tracking data, Søndergaard and Koefoed (2016) created PeriodShare, a design fiction of a connected menstrual cup that measures how much the user menstruates and posts this information to social media. This design fiction rejects societal taboos around menstruation in order to question what the form of representation of menstrual cycle data says about our relationship with the menstruating body in society. As shown by PeriodShare, through rejecting the concealment of menstrual cycles by visualising menstrual cycles data in public and visible ways, it could be possible to invert the taboo surrounding the subject of menstrual cycles in order to ask questions about how the menstruating body is viewed in society. In a society where there were no taboos or acts of concealment surrounding menstrual cycles, a multitude of design openings would present themselves; homes, clothing and public environments could be re-imagined to adapt to the changing body over the menstrual cycle. This could lead to a new wave of technologies that change with us and reflect the unstable nature of the female, and male, body. These technologies could hold inconceivable benefits for us and our relationships with technologies. As there is no one way to be a woman, all of these technologies would be customisable to how publicly visible user wish their menstrual cycle data to be. Menstrual cycle data could be abstracted to become unreadable to others, or represented more literally to give clear signals to those around them. To sum up, through considering menstrual cycles minus the surrounding taboo as a design problem, more innovative and feminist menstrual cycle tracking technologies could be constructed that may benefit women, and men, in our everyday lives and in our interactions with technology.

Re-Defining Normal

All aspects of menstrual cycle tracking technologies, from the algorithms used to make predictions, to the information given at every phase of the menstrual cycle, is built upon a framing of menstrual

cycles as a design problem that conceptualises the “normal” menstrual cycle as regular. This means that many women, especially those with conditions such as Polycystic ovary syndrome (PCOS), are not able to use current menstrual cycle tracking technologies as they do not have regular menstrual cycles. This clear exclusion of a whole group of women can be said to work against the inclusive ideologies of third-wave and fourth wave feminism. There is therefore much work to be done in the development of menstrual cycle tracking technologies that do not rely on a regular, “normal”, menstruating body, and are more suited to the subjective experience of every menstrual cycle and are customisable as such. This can be done by considering irregular rather than regular, subjectively experienced menstrual cycles as design problems.

Another re-framing of menstrual cycles in relation to what is considered “normal” is the delinking of gender from menstruation. Trans men who do not identify as female also menstruate. Menstrual cycle tracking apps have been shown to use gendered aesthetics and terminology that assumes that the user identifies as female (Lupton, 2015; Epstein et al., 2017). These apps re-enforce gender assumptions in society and exclude those who do not equate menstruating with being female. For trans men, menstruation can bring gender dysphoria and is often avoided by the use of synthetic hormones (Williams, Weinberg & Rosenberger, 2013). Through re-framing menstrual cycles as non-gendered physiological process, more inclusive menstrual cycle tracking technologies could be developed that no longer link menstruation with identifying as female. There may also be promising design openings to follow through addressing the emotional impact of the onset of menstruation for trans men. These technologies might help to avoid gender dysphoria and distress experienced.

Through rejecting the framing of menstrual cycles as design problems that assume that there is a “normal” menstruating body, menstrual cycle tracking technologies can be designed to include a wider range of people who menstruate. This will prevent the exclusion and pathologization of the irregular or non-gendered menstruating body and thus fulfil the inclusive and diverse ideologies of third and fourth-wave feminism.

Conclusion

This paper has used particular western feminist theories to reason the increase and improvement of “women’s health” in design research and HCI. As Harding (1986) stated, androcentrism often lies in how a design problem is defined. Therefore, in further pursuing feminist goals within design, it becomes relevant to address androcentrism within the definition of design problems. Since design problems are defined by designers (Buchanan, 1992, p.16), designers can choose to either re-enact or challenge prejudices and inequalities in society through how they (we) frame aspects of the world around us. Were designers to choose to reject androcentrism in their framing of design problems, then a feminist framing can be applied. This paper has proposed that the complexities of third-wave, and consequently fourth-wave, feminism can be seen as generative to a design process. In current feminism discourse there is not one category of women, there are many, and there is no one way to *be* a woman. Feminist technologies designed for women’s health must reflect that. A feminist re-framing of menstrual cycles as a design problem is illustrated through three examples of menstrual cycle tracking technologies that celebrate difference, inclusiveness and complexity around what it means to be a woman in today’s society.

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About the Author:

Sarah Homewood is a PhD Candidate at the IxD Lab, IT University of Copenhagen. Informed by her background in contemporary dance, her interaction design research often addresses themes such as embodiment and self-representation.

Paper 2.

Homewood, S.

Inaction as a Design Decision: Reflections on Not Designing
Self-Tracking Tools for Menopause.

In Extended Abstracts of the 2019 CHI Conference on Human
Factors in Computing Systems.

Inaction as a Design Decision: Reflections on Not Designing Self-Tracking Tools for Menopause

Sarah Homewood
IT University of Copenhagen
Copenhagen, Denmark
shom@itu.dk

ABSTRACT

This reflective essay documents an attempt to design self-tracking technologies for menopause. This process culminated in the decision to not design. The contribution of this essay is the knowledge produced through reflecting on inaction. From an investigation into current examples, it became clear that applying self-tracking to menopause was fundamentally inappropriate. These technologies were also found to risk resulting in more harm than good; both in essentializing and medicalizing a non-medical process, and in perpetuating notions of the bodily experience of the menopausal transition as a negative experience.

CCS CONCEPTS

• **Human-centered computing > Interaction design > Interaction design theory, concepts and paradigms;**

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KEYWORDS

Menopause; women's health; reflective HCI; non-design; undesign; menstrual cycles

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INTRODUCTION

The field of human-computer interaction (HCI) is typically faced towards the development of the new and the novel. It is evident, particularly within the CHI community, that with every year that passes, we apply technological solutions and augmentations to an ever-expanding array of cases. This reflective essay addresses how the reverse of this; inaction, can be a contribution to the field. I contribute my reflections on my own decision not to design self-tracking technologies for menopause. I examine what knowledge is produced in the stage before we design. This knowledge broadly refers to ethical questions around designing for menopause. Menopause is defined as the period of life when there has been a stretch of time longer than one year since menstruation has taken place. A myriad of physiological and emotional phenomena accompanies this change. These include but are not limited to; hot flushes or night sweats; disturbed sleep; feeling tired or worn out; trouble remembering or concentrating; loss of interest in sex; vaginal dryness or pain with sexual intercourse; uncontrollable loss of urine; mood swings; feeling irritable; aches and pains; headaches; or heart palpitations [12]. "Peri-menopause" or "the menopause transitional" phase is a general term that refers to the period before menopause where symptoms correlating to hormonal changes begin. Peri-menopause can begin up to ten years before menopause takes place.

Since the act of not-designing does not produce any artifact to disseminate knowledge, literary accounts such as this are key in disseminating knowledge. Reflective essays facilitates a first person, often more narrative, and reflective perspective [39]. I use this medium to communicate my thoughts and feelings. Through telling the stories of our experiences as designers within the field of HCI, we are able to share our personal reflections as human shaping our complex digital landscape, including our decisions to not design at all.

INACTION AS A DESIGN DECISION

Within HCI, a prevalence of research addressing the systems of power and norms enacted by technologies reflects changing expectations of the designer as a reflective, value sensitive, and critical actor [9, 11, 24, 34]. Baumer and Silberman propose that designers have a responsibility to not only consider

how to design technologies for specific contexts, but whether to do so at all. Similarly, Pierce presents the "undesign" of technology through a range of inhibiting techniques including inaction; "the notion of inaction as design action could be a useful construct for consideration of the limits of design action, and the appropriateness of such (in)action" [28]. Baumer, Silberman and Pierce agree that designers have a responsibility to consider carefully whether or not to continue the ever expanding application of technological fixes to all parts of lives. They recommend a reflective awareness for situations where the addition of technologies could be "inappropriate or potentially harmful". Baumer and Silberman discuss how the fact that technology works within metrics and comparisons of these metrics enforces a reductive approach to complex situations; designers must be aware of the particular lens that technologies cast on a design space. Baumer and Silberman also warn of solutionism, the desire to reduce complex phenomena into problems to be solved by the addition of technologies.

The wider context that this project fits into is a research-through-design program exploring how the design of self-tracking technologies influence both the social constructions of the body and also the lived experience of the self-tracker [16]. After having just completed a project designing speculative menstrual cycle tracking technologies, I arrived at menopause with the assumption that a similar approach could be applied. However, once I had conducted a review of current projects and products and mapped out the design space of self-tracking technologies for peri-menopause, I found myself wavering and eventually decided not to act. I will now present my concerns regarding designing self-tracking technologies for the menopausal transition. The knowledge produced by this project lies in the reasons behind my inaction. In attempting to design for menopause, I came to the realization that it was something that I could not do without compromising my research approaches and beliefs. These approaches and beliefs included a commitment to feminist and phenomenological approaches to designing for the body [17].

In order to avoid designing harmful or inappropriate technologies, Baumer and Silberman propose asking these three questions; "Is there an equally viable low-tech or no-tech approach to the situation? Might deploying the technology result in more harm than the situation the technology is meant to address? Does the technology solve a computationally tractable problem rather than address an actual situation?" [10]. I will use these three questions to unpack my decision to not design and finally reflect on not-designing and its limitations. The research activities that these reflections are drawn from include; reviewing current menopause tracking technologies, interviews with founders of menopause tracking apps, interviews with medical experts in menopause, talking to people who are currently experiencing the menopausal transition about their experiences, and following online forum discussions about menopause. The findings from these activities will not be laid out in full, but rather the key themes and trends will be presented. Predominantly these will be those that arose from a review of current self-tracking tools for menopause as a form of interaction criticism [8].

Motivation behind Founders of Commercial Examples

- MySyster's founder: "I came up with the idea for a perimenopause app after seeing the period trackers popular among women in their teens and twenties and wondering, 'Where's mine?'" [6]
- Menopause View's tagline is: "Knowledge is power, we're here to help" [4]
- Hot Flash Sisters' founder: "And what happens when we go to the doctor? We're asked the date of our last period...Someone needed to make an app for this!" [2]
- My Pause app 'About' section: "No one can predict exactly what your experience will be, so the more information you have at hand about your symptoms and the possible solutions, the more in control you can be." [5]
- Clue article on using the app for menopause tracking: "By understanding these signs, and discussing them with other women, you will immediately feel more in control." [1]



Figure 1: Menopause Ticker counting down to one year without menstruation

Is there an equally viable low-tech or no-tech approach to the situation?

Commercial menopause tracking apps include MySysters, Menopause View, Hot Flash Sister and MyPause. These apps are designed specifically for peri-menopause and menopause tracking functions. They include the option to log peri-menopausal symptoms and menstruation. As evident in the motivation behind Hot Flash Sister and MySysters apps (see sidebar), these apps are designed to mimic menstrual cycle tracking apps. Menstrual cycle tracking apps predict the timing of future menstrual cycles through employing self-reported data and algorithmic calculations. Menstrual cycle tracking apps are built upon the belief that menstrual cycles are cyclical and occur at relatively regular intervals (though this is not the case for all). Since menopause is defined by the irregularity, and eventual cessation, of menstrual cycles, the predictive function of menstrual cycle tracking is redundant. Menopause tracking apps are therefore solely functional for the logging of symptoms and menstruation. As mentioned in the motivation of the Hot Flash Sisters' founder, this information can then be used to inform visits to the doctors. They become a memory aid, rather than providing any autonomous function. Menstruation logging tools also come in the form of menopause "tickers". Tickers allow you to "Count-down to Menopause" through recording your last menstruation and counting down to menopause (which is officially 365 days after the last menstruation) [3]. These websites provide you with the code of your own ticker to integrate into your blog or website. These tickers can be customized and many come labelled with positive messages about menopause (Figure 1.) Fundamentally, since it is not appropriate to apply an algorithm to predict future menstrual cycles during the menopausal transition, paper calendar or note taking tool to record the most recent menstruation and symptoms could replace these apps. The information apps provide is valuable in informing the user of the menopausal transition, but could easily be disseminated through literature or a website. The only foreseeable benefit, apart from the mobile phone offering a handy tool for documentation, could potentially be the use of the apps to collect of data for large scale studies on menopause, though this is not yet implemented.

Within most current tools, categories of pre-defined symptoms are given in order for users to document and communicate their lived experience of menopause. There are two reasons behind this categorization; that it uses a simpler interface and provides more options computationally, and that it is a way to educate the user on possible peri-menopausal symptoms that they may hypothetically experience. These pre-defined symptoms run the risk of excluding some people's lived experience of menopause if they do not find their symptoms on the list. A tactic for avoiding this essentializing of experience might be a more open form of symptom tracking. This would require a more flexible and customizable format that would not enact universalizing ideals on how the menopausal transition was experienced. However, without any framing, this would culminate in an ambiguous and undefined

design. The logging of peri-menopausal symptoms could therefore be replaced by an analogue diary or journal.

Might deploying the technology result in more harm than the situation the technology is meant to address?

Deciding not to design self-tracking tools for the menopausal transition is a value-driven as well as rationally driven decision. The motivation behind my project was to offer a menopause tracking device that enacted feminist and phenomenological perspectives on the body. However, from my research into existing commercial products and research on design for menopause within HCI, I found the application of digital self-tracking tools to not only be redundant, but also to be driven by troubling perspectives and demands on the menopausal body.

Current academic research projects designing self-tracking tools for menopause include an ongoing multidisciplinary consortium project designing technological "solutions" for the menopausal transition [33, 38]. This project uses persuasive design to "empower and coach" women into adapting their lifestyle choices; such as increasing exercise, stopping smoking and improving diet. In this case, self-tracking is applied with a set end goal; to mitigate poor metabolic and cardiovascular health that accompanies menopause. Users are coached towards good health through symptom monitoring and personalized goal setting based on self-reported data. This design strongly resembles self-tracking weight management and exercise apps and wearables, with the addition of a peri-menopausal symptom tracker. Taking a critical eye to this project, the clear message is that it is the responsibility of the individual to maintain their own good health over the risky period of the menopausal transition. This perpetuates the biopolitical conception of the ideal citizen as being responsible for their own duty of care in order to ease the burden of care from the state [13, 27, 29, 32]. The harm possibly produced by taking this perspective on designing self-tracking tools is the risk of self-blame if self-tracking fail to persuade the user to turn towards healthier habits, as is very often the case within self-tracking [14].

The fact that defining and logging peri-menopause symptoms provides a sense of control is reflected in the motivation behind commercial apps, e.g. "knowledge is power" (see sidebar). A complex aspect of symptom tracking throughout the menopausal transition is that symptoms are often also common in non-menopausal contexts; e.g. anxiety, depression and loss of libido and insomnia. Enigmatic symptoms are one factor that prompts people to validate their lived experience of symptoms through medical information [15]. Self-tracking has been shown to "empower" and "give control" to people within their management of complex chronic diseases such as multiple sclerosis and diabetes [7, 37]. Menopause is clearly not a disease and it is problematic to treat it as such. Giving validation to the lived experience of peri-menopause through labeling symptoms can be seen as a form of medicalization. Medicalization refers to the treatment of human conditions as medical conditions. Several menopause research projects within HCI cite the increasing life expectancy of women as their motivation to

design. Some state explicitly that their motivation is the fact that longer-living women will now spend a third of their life in a post-menopausal state [22, 23, 38]. To frame this as a motivation to design is to say that the menopausal transition is a factor that requires mitigation by the addition of ameliorative technologies. Taking a critical eye to this motivation brings the definition of a healthy female body into question. Menopause is framed by these technologies "as a malfunction, rather than a change in function or the cessation of an unnecessary function (i.e. menstruation)" [31]. From a critical feminist perspective, this approach reflects a long-standing, androcentric view of the female body as unstable and therefore irrational and unsuitable for positions of power [35]. The peri-menopausal and menopausal body is being held up against the norm of both the regularly menstruating body and the stable male body, and found inferior.

Even the term "symptoms" perpetuates the concept that the menopausal transition is to be suffered; symptoms become a problem to be solved rather than merely a consequence of a process of change. Phenomenologist Drew Leder offers the term "dys-appearance" to describe how the culture of modern medicine in the west has resulted in a negative reaction to the emphasized experience of the body. The body appears to us predominantly during physiological changes, such as puberty and menopause, and illness. An exaggerated awareness of the body culminates in a desire to regain control through medical intervention. Within a society that prioritizes cognition over embodied knowledge, bodily absence is our desirable state [19]. Symptom tracking makes felt experience present to the user as something to be categorized, logged and then mitigated. This supports conceptions of exaggerated bodily experience as a negative aspect, rather than accepted as part of a holistic lived experience [20]. Designing symptom tracking tools, therefore, might result in more harm than good; both in essentializing and medicalizing the non-medical process of menopause, and in perpetuating the exaggerated bodily experience that occurs during the menopausal transition as a negative experience.

Does the technology solve a computationally tractable problem rather than address an actual situation?

Lee et. al use focus group interviews to validate a potential design for an application that, amongst other functions, diagnoses which stage of menopause the user is in by the symptoms they self-report [22]. The menopause staging system is usable without the use of technologies, however, Lee et al.'s design offers the automatic quantification of the body, without any effort or calculation on the part of the clinician. The hypothesis is that knowing which stage they are in will improve their user's experience of peri-menopause. The staging system on which Lee et al. base their design was put together at a multidisciplinary workshop with experts within the field of menopause in 2001 where they constructed a staging system for reproductive aging from -5 (early reproductive age) to +2 (late post-menopausal age) [36]. The reporting of the staging system in the original document makes it clear that this is not a hard and fast framework that can be applied to all cases; "Not all women

have symptoms as they transition to the menopause, and women with symptoms experience them in different combinations and with different levels of intensity. These symptoms are subjective by their nature, which makes quantification difficult. It has been observed that symptomatology varies markedly between ethnic groups, cultures and socioeconomic groups, and even in different climates. Furthermore, these symptoms do not track closely with the menstrual cycle or endocrine changes during the menopausal transition." [36]. This throws into doubt the possibility of using self-reported symptoms to accurately or usefully diagnose a particular stage of reproductive aging to a user, as even one of Lee et al.'s participants stated; "my periods happened every 30 days regularly and then it disappeared all of a sudden. I don't know if there really are such thing as transition stages." [21].

Quantification, a common tool within self-tracking, allows for the reduction of the menopausal body into a numerical form without the intervention of a clinician. This places the tool of quantification into the hands of the user and allows for self-comparative and diagnostic work to take place. Lawson et al. show that there is a strong desire for quantification with little scientific justification and warn that "if there is little incentive for ensuring a consistent level of scientific accuracy in quantified data interpretation, it seems unlikely that companies would bother to engage in the expensive and time consuming trials necessary to demonstrate this" [18]. Quantification is a method aiming for efficacy and accuracy rather than the representation of lived experience [26]. Knowing oneself and validating lived experience through quantification speaks to a Cartesian understanding of the body in medicine [30]. Numerical representations of the body are taken as "truth" and as higher in the hierarchy in knowledge than embodied experience [13, 25]. Rather than addressing the menopausal transition, quantitative approaches to the body prove to offer an efficient and pragmatic solution to computationally sorting collections of symptoms.

Summary

Current examples of self-tracking tools designed for the menopausal transition clearly play a role in user's lives, else they would not be adopted. This is despite the fact that they could largely be replaced by analogue tools. It is the fact that these technologies are adopted that reveals societal notions around menopause. I have found these notions of peri-menopause to be; something that requires control through knowledge, a negative experience to be mitigated through compliance of the individual, something to be validated through the categorizing of lived experience, and as a computational problem to be solved.

REFLECTIONS ON INACTION

Within this project I have encountered the decision between either designing 1. for the current wishes of the user, current trends, and opportunities provided by digital technologies, or 2, designing devices that do no harm in a wider society. Most of the time there is no friction between these two options;

what is desired by the user does not cause harm in society. However, this was not the case with my attempt to design self-tracking tools for the menopausal transition. I found that applying self-tracking technology mechanisms in any way at all would have re-enacted biopolitical, essentializing, subjugating, and androcentric perspectives on peri-menopausal body within society. They only re-ified the status quo; that menopause was a problem to be fixed by the addition of technology.

The decision to not design signals my own value-judgement as a designer. In this case, my values were drawn from a commitment to a feminist and phenomenological perspective on the body. Discovering the limits and the boundaries of my own research beliefs has been a novel experience. I experienced that these limits and boundaries were really *felt*. Attempting to find a way to design self-tracking technologies for menopause gave me an uncomfortable feeling in my stomach. My initial reading of this uncomfortable feeling was that I was out of my depth and unqualified to address such an emotionally charged and complex topic because I am not yet peri-menopausal. It took taking a reflective stance on what I'd learned from existing examples, and laying out the design space of self-tracking for menopause, to understand the true causes behind my gut feeling.

As a research-through-design practitioner, not producing an artifact to communicate knowledge and act as the vehicle for further research has felt disappointing, and often like a failure. At the early stages I blamed myself for having been naive about the appropriateness of menopause as a design case. However, it has been through gaining an understanding of my decision to not design that I have come to better understand my wider research program and beliefs. In particular, deciding not to design self-tracking tools for menopause has shown me the limits of the appropriateness of self-tracking. I do wonder if I myself were peri-menopausal, would I have acted differently? In my current situation, I see the menopausal transition as a natural and normal stage of the life process. Since I do not see it as a problem, I am not interested in providing a solution. Were I acting from a direct, perhaps negative, experience of the menopausal transition, perhaps my positionality would have countered my research beliefs and pushed me to design to improve my own experience.

As a final note on not designing; writing this essay as a way of documenting my decision to not design has provided me with a rich structure for reflection on my perspectives and position as a designer. Baumer and Silberman state "just as much as we value design implications, we should similarly value the implication not to design." [10]. For every ten published research projects, there must be one discarded project that never made it to the design process. Were all designers to unpack their abandoned projects and the reasons behind the abandonment, what rich knowledge we would produce about the limits of the application of technologies. We might also save some wheels from being re-invented.

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Paper 3.

Homewood, S., Karlsson, A., Vallgård, A.

Removal as a Method: Understanding the Lived Experience of
Self-Tracking.

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Removal as a Method: a Fourth Wave HCI Approach to Understanding the Experience of Self-Tracking

Sarah Homewood
IT University of Copenhagen
Copenhagen, Denmark
shom@itu.dk

Amanda Karlsson
Aarhus University
Aarhus, Denmark
akarl@cc.au.dk

Anna Vallgård
IT University of Copenhagen
Copenhagen, Denmark
akav@itu.dk

ABSTRACT

This paper offers first-steps guidance towards the development of a methodology that embodies theoretical proposals for a fourth-wave, ‘entanglement’ approach to HCI. We propose the removal of technologies and the documenting of their absence as a method. Removal disrupts habitual relationships with our everyday technologies, revealing otherwise hidden knowledges. Removal as a method exemplifies that “you don’t know what you’ve got till it’s gone”. We apply removal to the case of menstrual cycle tracking in two ways: literally through two autoethnographies, and hypothetically through semi-structured interviews. We show how this method especially facilitates emotional, embodied and cultural knowledge of the lived experience of self-tracking and we unpack some opportunities, implications and limitations in its use. Finally, we present how this method might be adopted by others and propose cases in which removal as a method might be applicable to study of a wider range of technologies beyond self-tracking.

Author Keywords

Self-tracking; fourth wave HCI; menstrual cycle tracking; autoethnography; non-use; feminism;

CSS Concepts

• Human-centered computing~ Interaction design process and methods

INTRODUCTION

As the field of self-tracking matures, it becomes necessary to reflect on how research on the self-tracking phenomenon is being conducted, and what impact our methods have on the knowledge we produce [29]. In recent years, qualitative and ethnographic methods have begun to replace more quantitative measures within the study of the self-tracking [1].

This shift in methods is driven by a shift in perspectives. From predominantly perceiving the user as a rational actor making informed decisions with the aim of self-improvement, we now see the self-tracker as collecting personal informatics through “a range of lived activities” [51], without necessarily having a specific goal to achieve [17]. Once we move on from viewing self-tracking through the lens of optimization, we can address how self-tracking shapes lived experience [10]. This is challenging, however, because the body within self-tracking is both the focal point (object) as well as the medium of perception (subject) [12, 27, 41, 59]. Indeed, self-tracking produces particular ways of being-in-the-world as we reflexively experience external information about ourselves. The status of the body as subject and object also has an impact on how we understand our own data. According to Lupton, this process is a “highly sensory experience” [38], one which involves negotiating and making sense of external sources of information in conjunction with bodily experience. This shift in perspective within research on self-tracking reflected the third wave of human-computer interaction (HCI) [6]. This wave prioritized phenomenological enquiries into the emotional and social effects of using technologies, rather than enquiries into functionality and usability [14, 15, 45].

With our research, we support Frauenberger’s proposal that HCI is entering into a fourth wave of ‘entanglement HCI’ [22]. We not only support Frauenberger’s proposal, but also develop it by proposing the initial steps in the development of a method suitable for a fourth wave of HCI. According to Frauenberger, ‘entanglement theories’ such as post-humanism, feminism, and post-phenomenology should be adopted and applied to the subject of science and technological innovation [2, 22]. This wave understands relations between humans and objects as producing realities through their intra-actions [2]. Knowledge is shown to be socially constructed, and objects are shown to be political actors. These theories all reject a positivist, Cartesian understanding that there is an external reality that can be conquered by the inquiring, cognitive mind. Frauenberger describes how HCI can be understood as having outgrown its epistemological and ontological commitments as it is “systematically struggling to keep up with what is empirically observed” [22]. Frauenberger proposes that as technologies literally became entangled in and with our bodies and everyday lives, what is empirically observed becomes less possible to understand and explain without the

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use of entanglement theories; we have reached what Kuhn refers to as a “model crisis” [31].

The fact that societal and technological developments mean that we are now *never without* our technological devices therefore makes a shift to a perspective on users and their devices as “entangled” relevant, particularly within the domain of self-tracking. The complex relationships between people and their data produce complex lived experiences. Approaches to understanding the lived experience of self-tracking up to this point have included the active and passive collection of data that contextualizes users’ self-tracking practices [23, 62]. More traditional methods of self-reporting have been applied through autoethnographies, surveys and diary studies, for example [16, 50, 66]. While these methods can reveal some aspects of the sensorial and emotional effects of technologies on lived experience, we suggest that they are limited by the fact that once technologies have been enfolded and embedded in our lives, we are not good at understanding and articulating the particular ways they affect us. This is due to the fact that we are situated within these complex entanglements of our own data [37].

In this paper we propose removal as a method – the deliberate removal of technologies and the documenting of their absence, in order to further research that aims to understand the lived experience of self-tracking. Following Frauenberger, we adopt ethico-onto-epistemological commitments. The theory of ‘embodied subjectivity’, derived from feminist philosopher Elizabeth Grosz, is employed to explore the effects of being without menstrual-cycle tracking devices. On the question of how subjectivity is produced, she proposes a theory of ‘embodied subjectivity’, especially as a way of countering dualist understandings of the cognitive mind and the mechanical body [24]. Grosz describes how selfhood is produced both through the specificities of the biological body as an object, e.g. sex, race, dis/ability, and the body as living subject, with social interactions and societal and cultural aspects shaping the subject’s sense of self. Grosz describes this relationship between the body as subject and the body as object as being like a mobius strip. The biological, material body can never be experienced “in the raw” but always through the lens of culture, and the particular biological body and anatomy that the self is experiencing the world through will influence how the world is perceived.

This feminist theory combats societal understandings of the body as inferior to the cognitive mind, and thus the devaluation of those associated more closely with their bodies, such as women, labourers, those with disabilities, and non-white people [24, 33, 48, 61]. In line with fourth-wave HCI, this is a move that rejects culture/material dualisms in how we attempt to understand use of technological devices [22]. Rather than seeing removal as a deletion of a device, as though it were possible to return to a state pre-use, or even reveal a “natural” body, we apply removal to disturb existing entanglements in order to produce knowledge about the

particular ways in which we are entangled. To use Grosz’ theory; we use removal to disturb our mobius strips of selfhood [24].

We use the method of removal in two autoethnographical accounts documenting the absence of menstrual cycle tracking apps. These accounts are supported by the reactions of eight current users of menstrual cycle tracking apps to the request to stop tracking. We find that removal as a method produces knowledge about the embodied, emotional and cultural factors shaping the lived experience of self-tracking. We reflect on the benefits and limitations of removal as a method and its relevance to other cases. We conclude with guidelines for when and where to apply removal as a method, and how to do it in four different ways.

RELATED WORK

Although it has not been articulated as such, removal has been a method employed by researchers within information studies and HCI in a number of ways.

Cases of researchers using their own experience of removal as a research method include Science and Technology Studies researcher Phoebe Sengers’ experience of removing herself from her typical work and home environment whilst conducting fieldwork on the isolated Change Island in Newfoundland, Canada [55]. Sengers’ removed situation allowed her to reflect on her habitual relationships with work and time. This facilitated a critical stance that led to a change in everyday practices and wider societal reflections on how the design of software shapes “being modern”. Sengers uses these reflections to propose the design of technologies that help us create constraints on our choices in order to avoid overworking and the constant strain of decision making.

Interaction-design researcher Andrés Lucero conducted an autoethnography of living without a mobile phone episodically over the span of nine years [35]. Lucero’s experience prompted him to reflect on the social factors that allowed him the freedom of not having a mobile phone over this time period. One example of this was the support of his immediate family; “If I was a single parent, I could not be constantly disconnected”. Another was how being isolated from the changing design of everyday technologies informed his work as a researcher – “allowed me to focus on developing ideas and improvements for mobile devices that were revolutionary in nature, and not constrained by the status quo”.

In his 1990 book “The Age of Missing Information”, environmentalist Bill McKibben explores the effects of our society “moving steadily from natural sources of information toward electronic ones, from the mountain and the field toward the television.” [39]. McKibben juxtaposes his experience of spending 24 hours on a mountain top with watching 24 hours of recordings from each of his ninety-three television channels, which he had his neighbours and friends record on VHS while he was up on the mountain. McKibben first removed himself from the technological

world, then dived back into it, in an extreme way. Insights from this experience include how television places the viewer in the center; disconnected from the natural world and community, and from the detrimental impact this has on our sense of responsibility for the natural environment and climate change.

More broadly within HCI, Satchell and Dourish [53] and Wyatt [67] give categories to different types of non-users. They discuss what can be gained from understanding why people do not use technological systems, whether this is through adopting and then abandoning them, or never using the system at all. Similarly, Baumer et al. [4] shows us how understanding non-use contributes to our awareness of appropriateness of use in specific contexts, and how non-use can be performative; such as an act of defiance akin to striking. Others within the field of psychology have studied the effects of stopping use of social media [63, 65].

Within the field of self-tracking and personal informatics, there has been an increasing awareness of self-tracking practices as episodic. Episodic use includes lapsing of use, switching between devices, and abandonment [8, 18, 20, 32]. Though relevant, these examples differ from our proposed method as they address cases where self-tracking devices have been abandoned by choice of the users due to causes such as a change in lifestyle or dissatisfaction with the technology itself [8]. This fact thereby influences users' reflections and attitudes, predominantly inasmuch as these users will reflect back on the device through a negative lens. Other research on episodic use has reported cases where self-tracking technologies have trained users to a point where they become obsolete [18]. These examples point to the fact that self-tracked data does indeed have an after-life; lessons learnt from data collection do shape the future lives of self-trackers. As Williams described after calorie counting and measuring his meals; "I can't un-know the weight of things" [66]. In this paper, we aim to explore not only *whether* data shapes us after we stop self-tracking, but the qualities of *how* this information expresses itself within lived experience. As Kaziunas et al., describes it; "the dynamics of this livedness" of data [28]. We propose that, due to the entangled nature of interactions with self-tracking technologies, an entanglement, fourth-wave HCI method is required.

REMOVAL AS A METHOD

Interaction design is traditionally focused on the development or evaluation of new technologies, new constellations of existing technologies, or new contexts of use. Removal as a method is a qualitative method that is applied on an individual scale. This produces idiosyncratic accounts that allow situated knowledge to contribute to a wider understanding of how technologies shape lived experience [66]. Within interaction-design research, we often hear the call for more long term studies of users' interactions with technologies [47, 64]. These studies attempt to understand how technologies are embedded in our lives over longer periods of time. We propose an alternative

form of study that addresses long-term relationships with technologies without necessarily being a long-term study itself.

Removal as a method - the deliberate removal of technologies and the documenting of their absences - provides a clear case of "you don't know what you've got until it's gone". Once we have lived with technological artifacts for some time, use of them becomes habitual; interactions become automatic, and relationships and attitudes become embedded and invisible [30]. The fact that interactions and relationships become habitual affects users' ability to reflect on the artifacts themselves and the role they play in their lives. We propose that this impacts user's abilities to communicate these reflections to researchers conducting qualitative studies on these artifacts.

Removal as a method represents a type of defamiliarization [3, 5]. Through removal, we are given a critical distance from the habitual that allows us to reflect on our interactions with technologies with fresh eyes. Removal disrupts the habitual. Anybody who has ever lost their mobile phone can relate to the fact that the loss of our everyday technologies makes our dependencies upon them evident. The outcomes of disruption can reveal otherwise hidden aspects of how the technologies we adopt in our daily lives shape us and our lived experience; both in the short term and in the long term.

We applied removal as a method in three different ways:

1. The imagined loss of the technological device before removal takes place.
2. The immediate reaction to losing the technological device after removal.
3. The adaptation to living without the technological device after removal in the long term.

These three applications produce different types of results and findings to generate wider reflections on removal as a method and the nature of our entanglements with technologies.

CASE STUDY: THE REMOVAL OF MENSTRUAL CYCLE TRACKING TECHNOLOGIES

We have applied removal as a method both literally through two autoethnographic studies (one short-term and one long-term), and hypothetically in semi-structured interviews with eight users of menstrual-cycle tracking technologies.

Literal Removal as a Method

During the autoethnographies the two first authors of this paper removed their menstrual cycle tracking apps from their lives. Autoethnographical methods used in the field of personal health technologies have been seen to allow researchers to carry out research in ways that could be not requested of research participants due to the heavy work load required; to value the subjective experience of the researcher as equal to that of other participants; and to use the collection of "idiosyncratic accounts" to evaluate the impact of personal devices on our lives [11, 46, 49, 66].

Autoethnographic removal as a method is the opposite of autobiographical design, where researchers adopt the technologies that they are designing in order to gain long-term and personal insights for use in the design process [44]. Due to the fact that the first two authors menstruate and use menstrual cycle tracking technologies, and that our professions as fulltime academic researchers allow us the time and attention required for a full and rich autoethnographic study, we therefore qualified as suitable participants for the study. The fact that we are researchers also means that our knowledge of the field is deeper than the average user of menstrual-cycle tracking technologies, and that our accounts probably do not resemble those of the wider population. This reflexivity does not undermine the validity of these accounts, but rather positions them as expert accounts that include a greater depth of reflection and critical thinking.

We entered our autoethnographic study with no expectations of how long it was to continue. Gaver warns that this type and level of engagement from researchers should only be conducted from a place of genuine interest or need, rather than for “research points” [44]. After one month, the second author (A2) left the study and returned to using Clue as she found the costs to her quality of life were too high. The first author (A1) continued the autoethnographic study in living without Clue for a further year and a half. To avoid autoethnographic note-taking acting as a form of menstrual cycle tracking, we refrained from recording fieldnotes until the end of each phase of removal; we both recorded fieldnotes after one month when A2 left the study, and A1 recorded additional fieldnotes at the end of the year and a half. To prevent influencing one another’s experiences, we had no contact during the initial study. Reflections back on our individual experiences were recorded in separate documents and then compared and analyzed thematically by the first and second authors.

Imagined Removal as a Method

Users of menstrual cycle tracking apps were interviewed with the aim of recruiting them to participate in a study after seeing the value of removal as a method within our autoethnographies. This would have entailed them stopping their menstrual cycle tracking practices for a negotiable amount of time. Participants were aged between 22 and 37 and located in Aarhus and Copenhagen, Denmark. During the semi-structured interviews, it became apparent that too few would be willing to give up their practice of tracking their menstrual cycle for the sake of our study for a diverse range of reasons. We will discuss the limitations of removal as a method in this respect below. This led to autoethnography being our sole literal application of removal as a method. However, reactions from our interview participants still signal the roles that menstrual-cycle tracking apps play in shaping lived experience.

Asking the participants to remove their menstrual cycle tracking apps prompted them to put themselves into a

fictitious scenario and predict the impact of this scenario practically and emotionally on their lives. We found that many predictions of the implications of stopping self-tracking that were troubling and of concern to participants presented themselves within our autoethnographies.

Menstrual Cycle Tracking Technologies

In order to understand the implications of the removal of menstrual tracking technologies, it is important to understand more about the menstrual cycle tracking technology that was removed. Not all self-tracking technologies are designed with the same goals and there are different types of self-tracking practice [42]. The goal for menstrual-cycle tracking is the act of tracking and documenting itself. Rooksby et al. describe this type of tracking as a form of “documentary tracking”, where there is no set goal in mind and tracking is seen to be done by people in order to “tell stories about themselves” [48: 1168]. Menstrual-cycle trackers are seeking self-knowledge and self-awareness rather than self-improvement and optimization [19, 25].



Figure 1. Screenshots from the Clue app showing the main page and the emotion logging page of the app.

Menstrual cycle tracking apps use algorithms based on collected and self-reported data to predict and visualize the emotional and physiological state of the user at each stage of their menstrual cycle through written notifications or symbols (Figure 1.). Although certain menstrual cycle tracking apps have recently been approved as methods of contraception by the FDA [43], these technologies will not be discussed in this study.

Both authors of this paper previously used a menstrual cycle tracking app called Clue. Clue is currently one of the most popular menstrual-cycle tracking apps in Western Europe with more than five million users worldwide [9]. Clue is not to be used as a form of contraception. Clue collects user-reported data on factors such as length of menstruation, mood, sexual activity, exercise and alcohol intake (Figure 1.). Users can decide what kind of information they want to track and Clue’s algorithm collects this data and uses it to

predict future cycles; as stated on Clue's website "The more you use Clue, the smarter it gets" [9].

A1, aged 27 at the beginning of the study, had been using Clue for three years before this study began. Before Clue, she had not tracked her menstrual cycle digitally nor in an analogue calendar. A1 used Clue to track aspects such as heaviness and length of menstruation and for registering when she experienced PMS and increased libido during ovulation.

A2, aged 40 at the beginning of the study, had also used Clue for three years before the study began and had tracked menstruation by marking the first day of menstruation in a calendar since her menstruation began. A2 used Clue to track heaviness and length of menstruation, pain (i.e. breast, cramps and headaches), the consistency of cervical mucus, and emotions and energy levels.

FINDINGS

We will now present some findings that resulted from our short and long-term autoethnographic applications of removal as a method, and reactions from our eight interview participants to the request to stop tracking.

Gone but Not Forgotten

Our autoethnographic study showed that once we had internalized menstrual cycle information, we did not need to access it again in order to interpret our physiological sensations. This information, (such as ovulation increasing libido, or PMS being experienced as depression or anxiety) remained in our memory and influenced our experience of our bodies. We continued to interpret our visceral sensations in relation to our memory of our previous menstrual cycles and the textual and graphical information and predictions of patterns Clue had provided us.

During our interviews with our potential participants, many also predicted that they would not forget what they had learnt from their menstrual cycle tracking apps. P6 predicted that she had been tracking so long that she had learnt and internalized her menstrual cycle data, thereby possibly making the app obsolete. P2 also believed that she had internalized the information provided by the menstrual cycle tracking app. This led her to wonder whether it would be difficult to refrain from reading her felt experience of her menstrual cycle through the lens of the information she had previously been exposed to; *"I think I would try to find this, like, knowledge of like "this is probably because, my, this hormone is going down" even if (the information about her menstrual cycle) is really difficult to remember"*. P4 initially stated; *"I've trained myself to analyze down how (inner sensations) fits with my hormones and my cycle"*. However, after some moments pause, she wondered out loud whether removing her app would allow her to *"just feel... things... how I actually feel it"*. This shows that for P4, there is still a natural, unchanged, body beneath the act of tracking; she does not believe that her use of technologies changes her at a fundamental and ontological level.

Returning to Bodily Sensations

In our autoethnographies, we both found how, although we could remember enough to interpret our bodily sensations, losing the ability to track changed our experience of our bodies. During the first month after removal, A1 documented *"I am hyper aware of every twinge of pain in my stomach as it gave me hope that my period would come soon"* and A2 stated *"Hyper aware of my body. I believe I can describe every kind of cervical mucus my body delivers while I sleep"*. When we discussed stopping menstrual cycle tracking with our participants, several predicted that their bodies and physical sensations would become more present to them after stopping their menstrual cycle tracking practices. P6 considered that not using her app could prompt her to *"think more about what's happening in my body"*. Removal as a method provides a collection of examples of how technologies shape our felt experience of our bodies, even after they are removed. This shift in focus was uncomfortable and strange. As A2 stated *"It has been a rare experience like being forced to use a muscle in your body that you normally don't use (...) like putting away your glasses and forcing the eye to see by itself"*.

A1's longer term experience revealed a shift from using information remembered from Clue to interpret sensations to having *"embodied"* the information. For A1, after a year and a half of interpreting sensations, a stage of reflection was no longer required in positioning felt sensations within the menstrual cycle; *"I don't feel something, then try to analyze it like I did at the start. The sensation and what that sensation means occurs to me at the same time"*. With this development, the uncomfortable emotions around the stage of analysis where she felt *"out of control"* had faded into a *"neutral awareness"*. She still used the internalized information to read her bodily sensations, but she was more confident in her ability to do so.

Losing Certainty

Returning to felt sensations during the initial month after removal provoked negative emotions for us both. A1 described experiencing *"withdrawal symptoms"* from her app. A1 later reported *"When my period came, I felt a rush of relief. I was once again able to know for certain where I was in my menstrual cycle and regained control of my body"*. One motivation behind the bodily *"control"* so desired and valued by us and our participants was the fear of not knowing when menstruation would begin. Not knowing left us in a state of being unprepared and without our usual paraphernalia to conceal our menstruation. A2 began carrying tampons everywhere from the first week of her cycle in order to avoid this happening.

P3 self-reported as having mild obsessive-compulsive disorder and linked menstrual cycle tracking to preferring *"to be more organized"*. She thought that stopping tracking *"would make me a bit more, uhh, maybe uncertain"*. This theme of uncertainty was echoed by P4; *"I would think it was a little bit bad (to stop tracking) (...) now I've been used to*

have some certainty or security even in some way”. P5 was overall relatively ambivalent about her dependency on the app, but still stated “it’s very nice just to be able to look at”. P1 reacted to the proposal of stopping tracking by saying “that would be kind of horrible for me”. P1 then qualified this by stating that her app had an invaluable function for her; “oh I’m feeling this so I can input it here and if I go to the doctor I can remember exactly when and like what I was feeling”. However, as we continued the interview it became clear to P1 that her relationship with her app was not purely functional; “I mean, yes, I think I am a little too addicted to my phone so, like, it would be good if I wasn’t- because also this question you made right now made me think “wow, I’m really dependent on these apps, I should chill with that (...) I want to put more and more info, in a way I think to control my life. To have more control of what is going on with my body”.

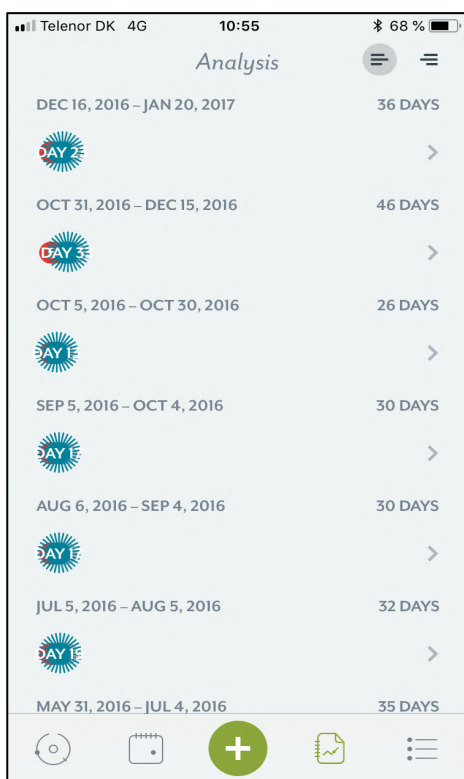


Figure 2. Screenshot from the A1’s app showing the lengths of previous menstrual cycles.

At the end of the autoethnography A1 returned to her Clue app. She was surprised to find out just how irregular her cycles had been while she had been tracking her menstrual cycle (Figure 2). A1 had never consulted this information while using Clue. What she had taken to be accurate information and used as a guide to predict when her menstruation would begin was revealed as being built upon much more erratic data than she had expected.

Troubling Subjectivity

Once we had removed our menstrual cycle tracking app, we lost the ability to track and predict our hormones changing

over chronological time. This prevented us from validating how we experienced the world through our menstrual cycle data. For example, we could remember that PMS happened on day 20 of the cycle, but we no longer knew when day 20 occurred. This provoked negative emotions; “Losing track of time felt like losing track of me, losing control over my body” A2. P2 predicted that unlabeled and unexplained sensations would be deemed as “illogical”; “I think I would be trying to uhh, to give myself, or to find a logical explanation as to why I was a bit sore or why I was a bit emotional or why I was feeling very pumped and on”.

Losing the ability to explain her subjective experience through her app was particularly distressing for A1 during the first month after removal. “I started doubting decisions I had made; am I feeling like this because I just moved in with my partner?... I asked my partner to check where I was in my cycle but not to tell me. I wanted him to know that this (PMS) wasn’t the real me, but just my hormones... but I felt as if he had some power over me. It felt unfair that he could understand my behavior when I couldn’t”. Over the following year and a half, however, A1 described taking a “less diagnostic, and more holistic approach”, to the question of whether or not her emotional experience was influenced by her hormones. Her “holistic” view allowed her to understand that her subjective experience of the world was influenced by her changing hormones, but that she would never really know what their influence was, and so was less keen to find a diagnosis.

ANALYZING AND ARTICULATING OUR ENTANGLED FINDINGS WITH AN ENTANGLED THEORY

In order to provide an example of what removal as a method can contribute, we will now analyze our findings through the lens of one example of what Frauenberger refers to as an entanglement theory [22]. As discussed, we support Frauenberger’s statement that, in order to avoid a model crisis, entanglement theories are required to understand findings about users’ entangled relations with technological devices [22, 31]. These theories argue that humans and their things are ontologically inseparable from the start. We will now show this in practice in order to analyze and further articulate our findings from removal as a method.

A range of theories could be used to discuss the findings of removal as a method in different use cases and domains. In this particular case, feminist philosopher Elizabeth Grosz’s theory of embodied subjectivity is useful in unpacking how removal as a method provided access to the entangled nature of interactions between users and their technological device in the domain of menstrual-cycle tracking [24]. Although this is not an example of the theories given by Frauenberger, we deem it a relevant theory as it includes ontological, epistemological and ethical considerations. We have argued that removal as a method is a good method to understand entanglements and we will now use Grosz’s theory of subjectivity to articulate and analyze these entanglements.

In her book *'Volatile Bodies: Towards a Corporeal Feminism'* Grosz firstly shows how, throughout history, philosophers' conception of the "natural" and "universal" body has actually been the male body [24]. She states that this has led to the erasure of the female body and ignorance around how sexual specificity shapes subjectivity. For example, although phenomenologist Merleau-Ponty stated that the body is our mode of being in the world, he did not address how the differences between our bodies will produce different ways of being in the world, nor how the social standing of that body influenced its embodiment [40, 41]. To rectify this, Grosz contributes the theory of embodied subjectivity. Embodied subjectivity is a model of selfhood as a mobius-strip like relationship between the body as subject and the body as object. Grosz proposes that our experience of the world is shaped by the anatomical and physiological specificities of our bodies, and how we understand our anatomical and physiological body is shaped in turn by cultural and societal factors in turn. Grosz states that a *neutral, natural, a-historical or pre-cultural body does not exist*. Grosz's mobius strip model describes the reality of our body as an entanglement of our flesh, bone, muscle and blood with the cultures and societies we are situated within. Grosz's theory is particularly relevant to self-tracking, where the body as object is presented to the self-tracker through technological mediation. Since Grosz states that we can never experience our bodies "in the raw" [24], even our experience of our inner body is shaped by external factors. Grosz's theory troubles the assumption that the self-tracker can neutrally discover their body through the use of self-tracking devices.

Removal as a method showed how using menstrual cycle tracking technologies fundamentally change how the body is understood, even after they these technologies are removed. From Grosz's perspective, adopting menstrual cycle tracking technologies creates a different kind of embodied subjectivity than if menstrual-cycle tracking devices had never been employed, or if an analogue calendar had been used instead. We do not say that removing the Clue app from our lives allowed us to go back to the embodied subjectivity that we had before we adopted a menstrual-cycle tracking app, but rather we use the method to understand *the particular ways* in which Clue had shaped us.

Internalized Epistemological Hierarchies

Grosz's theory highlights how epistemologies are always culturally contextual. Methods of enquiry are always shaped by cultural and societal values and biases. This means that the body can never be neutrally discovered through those methods of enquiry such as self-tracking technologies. This was exemplified by the fact that removal as a method showed how our menstrual cycle tracking apps had given us a sense of control and certainty about our bodies. To contextualize this mode of within cultural factors; gaining control and certainty over the unruly body through objectification is a key aim of Cartesian dualism. Descartes' theory of the "self" being split into the cognitive mind and the irrational body is

still evident today in how the body is understood and treated, especially within medicine and the way we design for and with the body [26, 33, 34]. Within this epistemology, subjective, felt knowledge about the body is devalued in favour of objective, rationalist scientific knowledge about biology and anatomy [60].

The ways in which stopping tracking, and even the idea of stopping tracking, brought the body into "hyper awareness" and prompted uncomfortable and negative emotions, shed light on how self-tracking reflects epistemological hierarchies. Our study showed the extent to which we accepted and relied upon a scientific depiction of our bodies rather than our felt sensations. Once we had lost access to external sources of information about our bodies, we were forced to turn inwards and return to signs and signals coming from the insides of our bodies in order to know where we were within our menstrual cycles. Removal as a method revealed that our use of self-tracking technologies had made our felt, embodied experience strange. Removal revealed that we had outsourced the task of tracking our menstrual cycle to our technological devices. When we removed our devices, the task did not disappear. Rather, the task was delegated back to us, only this time with fewer resources and inferior tools, i.e. physiological sensations and bodily fluids rather than quantified data and predictive algorithms.

This was exemplified when A1 returned to her Clue app and looked up her past data to find it was much more erratic than expected. The fact that she had not interrogated this collection of data when using the app reflects her unquestioning trust. She never felt she had cause to question that her menstrual cycles were perhaps not regular enough to produce meaningful predictions. This was despite the fact that she often found the predictions to be inaccurate, e.g. menstruation often took place up to a week after the predicted data. When her period was late it caused her to question her own menstrual health, or even worry that she was pregnant, rather than question the validity of the prediction. Irregularity was seen as being caused by the body rather than questioning whether her menstrual cycle was regular enough to make using apps such as Clue meaningful.

Internalized Cultural and Societal Ethics and Values

Our research shows how technologies reflect and perpetuate cultural ideals and taboos that then manifest in the lived experience and subjectivities of users. One aspect that was of concern to us and our participants was that we could no longer predict when our menstruation would begin. The female body is understood to be particularly "leaky". Menstruation, childbirth and its changeable hormonal states mean that the female body lacks the control of the male body [57]. Grosz states that the body and lived experience of the body is socially constructed and shaped according to norms and taboos [24]. Grosz uses the contrasting examples of saliva and tears to show how bodily fluids are perceived through cultural norms [24]. For example, through our social conditioning we understand that it is not acceptable to

publicly show menstrual blood [54, 58]. Amongst other things, menstrual cycle tracking apps are used to avoid public displays of menstrual blood, and therefore relate to cultural expectations of bodies as being controlled [25]. The prospect of socially disgracing ourselves through breaking social norms and taboos shaped our lived experience of our menstrual cycle as something uncontrolled and unruly. Although anxiety around the onset of menstruation can also relate to the possibility of pregnancy, were there no more taboo around publicly leaking menstrual blood than there is around sneezing, then knowing when menstruation would begin would not be such a large concern to those tracking their menstrual cycle.

Our study showed how body politics around controlling unruly and leaky bodies had become internalized by users of menstrual cycle tracking technologies. This is Foucault's ultimate definition of biopower; when disciplinary forces are adopted and enforced by the individual themselves [21]. This is a common critique of self-tracking technologies in terms of the individual maintaining fitness and health through adopting self-tracking technologies for the sake of the state [7, 36, 52]. Our study points to how the cultural and societal expectation of self-control is also enacted in the self-tracking of physiological processes such as menstrual cycles. This is in spite of the fact that these processes cannot be optimized or controlled by the user through tracking.

Augmented Ontologies

Removal as a method highlighted the different ontologies at play, both between us and our participants, as well as how our ontological understanding of ourselves changed after removal. For example, P4's reflection that removing her menstrual cycle tracking app would allow her to "really feel" her body represents that she understands there to be an ontologically un-affected body beneath her use of her menstrual cycle tracking app. If she could remove the knowledge of her body that she has built from using her app, then she would be able to access her "natural" body.

One way in which we and our participants had used menstrual cycle tracking apps was to allow us to reflect on how hormones influence how we experience the world [19]. Our own sense of self was augmented by our use of our apps. A1 felt that she was not "*the real me*" when she had PMS, and her app could be used to validate who she really was in relation to her hormones. As P2 predicted, she wanted a "*logical*" reason for her emotional experience. This provides a literal example of Grosz's mobius strip in action; we used the external information from our menstrual cycle tracking apps in conjunction with our lived experience to form our understanding of ourselves. Our ontological understanding of ourselves was revealed to be a static self that morphed into something that was not "us" when we were influenced by our hormones. The menstrual cycle tracking app could be used to keep a hold of who we really were once we could account for our hormonal influences.

Our menstrual cycle tracking apps had defined a logic for how and when PMS was to be experienced. Once our external data had been removed, the "PMS" phenomenon became blurred and illogical. It seeped into other aspects of life by making us unsure of the source of our emotions and undermined our own sense of rationality and self. This was exemplified by A1's questioning of her decision to move in with her boyfriend. She looked to other parts of her life to validate her negative emotions.

Over the year and a half that she lived without a menstrual-cycle tracking app, A1's negative reaction to losing Clue faded into a more holistic approach to her menstrual cycle. She still used the internalized information to read her bodily sensations to know where she was in her menstrual cycle, but she was more confident in her abilities, and so did not experience negative emotions of feelings of loss. She became more accepting of not having a certain reading of her body. One reason that this was acceptable for A1, but not acceptable for A2, was possibly that A1 had only begun tracking menstruation when she started using Clue for three years before the study began. A2 had been using a paper calendar to predict her menstruation since she had begun menstruating. A1's embodied subjectivity had been changed by using Clue, but since it was a relatively recent change, perhaps she was more open to her reality of her menstrual cycle being an uncertain phenomenon. A1 could more easily accept an ontological understanding of herself as being in a state of change. Since she could no longer validate who she really was in relation to her PMS, then she took a more "*holistic*" view on herself as a changeable being.

REFLECTING ON REMOVAL AS A METHOD

As a method that supports Frauenberger's call for the need for a conceptualization of a fourth wave, entanglement HCI, removal as a method facilitated insights into the particular ways in which users are entangled with their everyday technological devices. The research we have presented in this paper present the first tentative steps in the formation of this method. However, we see promise in it as an example of a fourth-wave approach to HCI that emphasizes the epistemological, ontological and ethical aspects of interactions with technologies. Using one such entanglement theory, Grosz's theory of embodied subjectivity helped articulate and understand these entanglements in the case of self-tracking through the mobius strip model; the body as subject and object were in a constant state of becoming through and with one another.

Removal as a method is appropriate for an entanglement HCI as it "serves to decentre the human as the sole source of activity and to elevate the role of the non-human world from a passive backdrop to human activity, to active contributors to relational action as it unfolds" [21]. To remove one physical artefact as a method seems at odds with the entanglement HCI perspective. Removal as a method might appear to be a solely subject-oriented method that focuses on the person, rather than a method that understands that

realities, subjectivities, and agency is created through interactions between people and objects [2, 22]. What removal showed, however, was the qualities with which relationships with objects become part of webbed entanglements, through which we experience and make meaning of the world. Not only do the findings from our use of removal as a method support Frauenberger's call for the necessity of different conceptual perspectives in HCI in order to avoid a model crisis, but we also offer a humble proposal for how we might *do* entanglement HCI research in practice. Our research is driven by the question: shouldn't our research methods adapt to new paradigms in HCI? Once we adopt the conceptual perspective that users are entangled in their interactions with devices, then we must question whether our research methods are adequate for understanding these entanglements.

Removal as a method produced specific types of knowledge about the gaps that are left in webs of relations with our devices once they are removed. A1 and A2's autoethnographic experiences of removal showed how their use of menstrual cycle tracking apps had irrevocably changed their ontological understanding of their bodies. Removal as a method revealed the dominance of scientific knowledge on the body, resulting in a sense of a "loss of control" when this scientific information was removed. Removal as a method highlighted these different ontological and epistemological perspectives, and the ethics behind these different ways of understanding the world. These findings particularly revealed how societal and cultural values and biases had been internalized and played out in our interactions with technologies. Not only are technologies designed with particular political and ethical worldviews, but how users employ and *become with* their technologies also reflects the society and culture they are situated within.

The aim of employing removal as a method was not to dissuade participants from using menstrual cycle tracking apps, but P1's reaction showed how even the question of removal allowed space for critical reflection. Removal as a method produced unexpected insights for P1; *"this question you made right now made me think "wow, I'm really dependent on these apps, I should chill with that" "*. This was also evident in A1's experience after returning to the app and discovering how irregular her data had been in the two years of using Clue. This undermined the validity of the app that had caused her unnecessary anxiety about her menstruation not starting on the predicted date. This shows how removal gives space for critical reflection on what we gain and what we want from our relationships from our technological devices.

EXPANDING AND APPLYING REMOVAL AS A METHOD

This paper presents the first steps in developing this method. Clearly, this method would have to be applied to many different cases before we could make generalized statements about its value, limitations and implications as a fourth-wave method. We believe that removal as a method could be

applied to other cases to understand entanglements between users and other types of technological devices. We will now tentatively present where, when, and how removal as a method could be employed.

Where to use the method

In the case presented above we have applied removal as a method to self-tracking. Self-tracking devices are specific type of technologies, which, the method revealed, had strong influences on our emotions, our embodied experience, and social and cultural readings of the body. The method proved effective in uncovering some of these otherwise difficult aspects to get access to in studies of technologies. We see no reason to believe the method could not as easily be applied to other self-tracking technologies, or in fact any type of technological device. The type of device, the context of its use and the intention of the study would then dictate the types of knowledges produced. This was visible in how the existing examples of removal as a method we build upon produced different types of knowledge, e.g. Lucero's study of his lack of a mobile phone [35], McKibben's removal of information [39] and Sengers' removal of her typical working environment [56].

When to use the method

Since removal as a method works by disrupting our habitual relationships with technological devices, the method requires users to have lived with the technology for long enough to have formed such habits in their everyday practice. What is classified as a habitual relationship is unclear, though it could be defined by frequency of use or how integral the device is to the life and activities of the user.

When not to use the method

It is clear that removal is not a method to be applied to novel technologies. This is because habitual relationships will not yet have been formed. Another obvious limitation applicable to the literal form of removal as a method is that this method is only relevant to non-vital cases of technology use. For example, asking somebody with diabetes to stop glucose monitoring could clearly lead to dire consequences.

How to use the method

Based on our preliminary work with the method this far and our reflections on the outcome, we see four ways of applying removal as a method.

1. The first way would be to ask participants to imagine living without their device. Asking participants to stop using a technological artefact that they are happy using apparently crosses borders for some – five out of eight of the participants we interviewed declined to stop tracking for the sake of our case study. We found, however, that in cases where people decline to remove the technology from their lives for the sake of a study, their reactions to such requests still revealed important relationships and practices and are thus relevant in and of themselves. Indeed, throughout this paper, we have presented predictions from our participants about how they would react to removing their menstrual cycle tracking apps that very often accurately reflected A1 and A2's experiences

during the long-term and short-term autoethnographies. Interviews with those who decline could therefore form the initial stages of a larger study if not be a study in and by itself.

2. A second form of removal as a method would be to conduct studies with those willing to literally remove the technology in hand. This could be set up as a diary study with in-depth interviews in the beginning and end and possibly during depending on the length of the study. This form was what we set out to do at first but have not tried in practice. The risk here, of course, is that the participants who would be willing to stop using the technology would be those with a less dependent or invested relationship with the technology compared to those who declined.

3. A third option – a middle ground – could be designing the disruptions of the habitual as forms of restrictions. For example, rather than asking participants to stop using their mobile phones for a week, we could instead limit the amount of internet access they would have over that week. This would require them to limit their use to prioritize what they considered the most vital tasks in order to prolong their internet access. This would thereby produce knowledge on their unrestricted and habitual use of their mobile phones by revealing what tasks and applications they prioritized when their use was limited. As McKibben writes at the end of his account of living with, and without, television; “we can’t go live in the woods by a lake – but we can go there long enough to listen, to hear.” [39].

4. A fourth option is the autoethnographic version of removal. Within this category, we applied the method in two ways, a short term, one-month long autoethnography, and a longer-term autoethnography spanning one-and-a-half years. These two versions address two distinct stages of removal. The short term reveals the immediate reaction to removal; where lack and absence is highlighted. A longer-term removal shows how we negate and work around absence, and what the aspects that we do and do not miss tell us about our habitual use of technologies. As discussed above, particularly in the case of self-tracking, use of technological devices produces particular ways of being-in-the-world. A degree of reflexive attentiveness is required to mark the various *ways* in which technologies shape this being-in-the-world. Researchers can afford this reflexive attentiveness in ways that could not be asked of research participants [35, 66]. However, it must be considered that since researchers will typically be experts in the field of the technology being removed, their account will not resemble that of the wider population. The accounts produced through these autoethnographies are to be treated as particular rather than as generalizable experience.

Finally, an important aspect of how to use the method is how to set up data collection. Overall, we recommend typical autoethnographic tools such as keeping reflective field notes [13]. The design of these methods would depend on the individual study. One curious implication with our particular application of removal as a method was the fact that when it

comes to the removal of self-tracking tools, including mood tracking and journaling technologies, there are some considerations to be made around how to document the absence of the technology. In these cases, the act of keeping autoethnographic notes risks replacing the technology that is being removed. For example, had we recorded every day of our lives without our menstrual cycle tracking technologies, we would have ended up documenting our menstrual cycles. Rather than documenting removal, this would have merely replaced the technology being removed. This was our motivation behind our only recording fieldnotes at the end of the autoethnographic studies. Although this can be seen as a limitation in the context of typical autoethnographic practices, we also see benefits in allowing the loss of technological devices to become a background event. Just as long-term deployments of designed artefacts are used with the intention that the devices will fade into the background of user’s lives over time [64], so should the absence of devices also move beyond novelty and conscious awareness during long-term applications of removal as a method. Therefore, we recommend that this be considered in the collection of data derived from removal as a method with all types of technological devices..

CONCLUSION

This paper marks only the beginning of exploring the qualities of removal as a method. With this paper, we both support and develop proposals for a fourth-wave, entanglement, HCI. Frauenberger proposes that we have reached a model crisis, where current conceptual understandings and practices are no longer able to account for our relationships with technologies as they become increasingly intertwined with our bodies and lives in general. To this shift in paradigm, we contribute a method as an answer to the question; how might we *do* entanglement HCI in practice? Shouldn’t our research methods be updated in line with new paradigms in HCI? We propose the deliberate removal of technologies and the documentation of their absence with the belief that this disrupts habitual relationships with our everyday devices. We applied removal as a method to the case of menstrual-cycle tracking in two ways: literally through two autoethnographies, and hypothetically through eight semi-structured interviews. The disruption of habitual relationships with technologies revealed aspects of how we are epistemologically, ontologically and ethically entangled with our everyday devices. This knowledge helped us understand the lived experience of menstrual cycle tracking. We have proposed that removal as a method is applicable to enquiry into other cases of technology use and have presented here some of its opportunities and limitations.

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Paper 4.

Homewood, S., Vallgård, A.

Ambient Cycle: Putting Phenomenological Theories to Work in
the Design of Self-Tracking Technologies.

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Honourable Mention Award

Putting Phenomenological Theories to Work in the Design of Self-Tracking Technologies

Sarah Homewood

IT University of Copenhagen
Copenhagen, Denmark
shom@itu.dk

Anna Vallgård

IT University of Copenhagen
Copenhagen, Denmark
akav@itu.dk

ABSTRACT

Existing self-tracking devices have been criticized for perpetuating a dualist, rather than phenomenological, understanding of the self as a separated mind and body. In this paper we answer calls for a phenomenological approach to the design of self-tracking devices. Ambient Cycle is a menstrual cycle tracking device that provides a continuous display of data in the home through coloured light. Through its design and long-term deployment, we found that a phenomenological approach facilitated; 1. the documentation of a diversity in subjective experiences of the enigmatic menstrual cycle; 2. the tracking of positive as well as negative aspects of the menstrual cycle, which challenges wider understandings of the body in society, and 3. novel uses of self-tracked data. We also expand on existing uses of phenomenological theories within HCI to include those that address interactions with the insides of our bodies.

Author Keywords

Menstrual cycles; ambient displays; ambiguity; self-tracking; quantified self; phenomenology;

CSS Concepts

• Human-centered computing~User studies • Human-centered computing~Interaction design theory, concepts and paradigm

INTRODUCTION

As self-tracking devices and practices continue to proliferate, there is an increasing interest in the ways that self-tracking technologies are designed. Beyond exploring the decisions that designers make in terms of the form, functionality and materiality of self-tracking technologies, researchers such as Rapp, Tirassa [64] and Lupton [51] have called for clarity around the epistemological and ontological approaches that designers adopt when developing self-tracking technologies. They state that since self-tracking technologies shape self-

hood, then designers should be aware of the particular notion of “self” that they are designing for.

Research on self-tracking and the development of self-tracking technologies has predominantly been motivated by increasing productivity and improving health through implementing strategies for behavioral change [3]. In recent years, there has been a call for more-than-utilitarian approaches to the design and evaluation of self-tracking devices [23]. Within this trend, a third-wave HCI, and even fourth-wave HCI [31], approach has been adopted in order to understand how technologies are used in everyday life and the emotional and social aspects of use [5, 6, 17, 57]. As Rooksby, J. et al. describe, users are not rational data scientists and so utilitarian methods of evaluation are inadequate when the goal is to gain a full understanding of how medical and self-tracking devices are used [65].

Phenomenology is a field of philosophy that has proved a useful perspective from which to understand and even re-imagine interactions between users and their self-tracking technologies. Within phenomenology, scientific truths about the world are bracketed off, and the study is upon the nature of our idiosyncratic lived experiences – the world is always what it is perceived to be by the individual [26, 49]. Phenomenology highlights the fact that our experience of the world is shaped by the fact we are embodied – our perception is created through our body’s sensing capabilities [54]. Researchers such as Page & Richardson [62] call for a phenomenological “attitude” in order to facilitate a rich understanding and articulation of the life world of users of devices that interact with the body. Post-phenomenology, the study of the particular nature of our relations with technologies [38, 76], is adopted by Ohlin & Olsson to gain a richer understanding of how self-tracking technologies, such as a running app, mediates our interactions with the world and our lived experience of our bodies [61]. Rather than a behaviorist and utilitarian concept of “self”, Rapp and Tirassa specifically call for a phenomenological definition of the “self” within the design of self-tracking technologies [64]. Rapp and Tirassa call for a phenomenological and constructivist approach to the “self” in self-tracking as one that is “actively (re)constructed by the individual” rather than an “externalistic” understanding of human beings; they recommend that the user is understood as a social, situated and temporal being. Although these examples contribute recommendations and guidelines as to why and how

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phenomenological theories might be applied, none report on the actual experience of putting phenomenological theories to work in the design of self-tracking technologies.

With this paper we aim to address this gap by reporting on the experience of designing and deploying a menstrual cycle tracking device informed by phenomenological commitments. Design has been shown to be a fruitful way to explore possible and preferable futures of technologies [14, 16]. In line with other design research within HCI, e.g. [22, 25, 35, 58], our design work is explorative, rather than solution-driven. We are not aiming to solve problems. Designed probes can materialise speculations on possible futures in order to gather reactions, reflections and criticisms [8, 15, 25, 36, 78]. Making speculative ideas material, and to a level of finish that makes it possible to deploy them in long term studies allows for reflections that go beyond initial reactions [29, 36, 59]. There are a plethora of related projects using design as a research method to explore the domain of self-tracking. For example, the use of 3D printing to visualise physical activity and sweat [41, 42], the use of bullet journals to inform the design of flexible and mindful self-tracking tools [2], projects inviting users to craft their own health data [1], speculative and critical explorations into the labelling and actuating of bodily experiences around urination [27], and the design of a physical device to facilitate the shared tracking of the health of babies in the home [43]. Other research projects have included the design of speculative prototypes addressing taboos and cultural norms around the body such as Period Share, a menstrual cycle cup that posts intimate details of the wearer's menstruation to social media [71], and Loupe, a wearable gut-tracking device that addresses stigma around gut health [9]. In contrast to these projects, our research is motivated by exploring the underlying epistemological and ontological commitments we as designers make when we design self-tracking technologies. As Rapp and Tirassa put it – the specific theory of “self” in self-tracking that we are adopting in our design work [64].

The design artefact that is the focus of our research, Ambient Cycle, is a wi-fi connected lamp that changes colour in sync with the user's menstrual cycle. In this paper, we firstly present the phenomenological commitments that we made before the design process began. We then present how these commitments played out through our design decisions and the compromises we had to make in the process. We finally report on the results of the deployment of Ambient Cycle in the homes of five participants for four months in order to understand how our phenomenological commitments translated into our participants' experiences. Through our research, we aim to answer the questions; how can we put phenomenological commitments to work in the design of self-tracking technologies? And what were the implications and limitations of designing with these commitments?

PHENOMENOLOGY AND SELF-TRACKING

Self-tracking devices have been criticized for perpetuating a dualist, rather than phenomenological, understanding of the self [61, 64]. Dualism refers to the belief that the mind is separate from the body and originates from the philosophical and metaphysical theories of René Descartes from the 17th Century. A key aspect of Descartes' theory was how the soul was located in the mind and that the mind could function independently from the body [13, 72]. This resulted in a conceptualization of the body as animalistic and irrational [24, 63]. Once Descartes' theories were taken up, the sensing body was no longer assumed to be where an understanding of the world was constructed. Descartes stated that truths about the world existed independently of what could be directly experienced. He stated that these truths could be discovered through cognitive effort and scientific methodologies. The popularity of Descartes' theories, amongst other factors, led to the development of modern science and modern medicine [44, 49, 73].

Philosophers in the field of phenomenology and feminist theorists have both critiqued Cartesian dualism as being a problematic approach to conceptualizing selfhood. Phenomenology is the philosophical study of experience and consciousness founded by Edmund Husserl in the late 19th Century. Phenomenology works against a dualist understanding of the self as a rational mind dominating a docile body [13, 49, 54]. A phenomenological approach frames the self as a complex intertwining of the self as object and subject, and holds that subjectivity is produced through this intertwining of consciousness and flesh, since the body is both the site of our consciousness and our mode of being in the world [54]. Phenomenology states that Cartesian dualism leads to a reductive understanding of selfhood and lived experience, and results in a conception of the body as a machine to be fixed and optimized [33, 49, 54]. Feminist theory has highlighted how dualist understandings of selfhood results in particular societal norms and biases. Feminist theorists have shown how a reductive and mechanical approach to the body has been used to denigrate and de-value the body, and groups such as women, labourers, those with disabilities, and non-white people who are more closely associated with their bodies in society [24, 63, 69]. The hierarchy of the mind over the body dualism also leads to men/women, culture/nature [48].

In the context of self-tracking, Cartesian dualism is still evident. Dualist approaches to designing self-tracking technologies employ behavioural and cognitive understandings of the user [64]. This is an attitude that states that it is possible and beneficial to control the unruly body through making it transparent and malleable through collecting and acting upon self-tracked data [11, 40, 56]. Control is enforced through the collection of increasing amounts of increasingly granular data on the body [77]. There is a rhetoric that this data can lead to self-knowledge, and consequently self-control and optimization [74].

Applying phenomenological theories to the domain of self-tracking creates an epistemological battle ground. Cartesian dualism represents a positivist epistemology where it is believed that universal truths about the body can be discovered through scientific inquiry. Self-tracking technologies adopt and apply scientific knowledge and methods and brings these “truths” about the body to the self-tracker through technological mediation. On the other hand, phenomenological approaches reject the fact that a “true” body exists outside of what is experienced by the subject. This paper reports on our attempt to explore the relationship between these two conflicting epistemologies through the design of a self-tracking device designed with phenomenological commitments.

FIVE PHENOMENOLOGICAL COMMITMENTS

In putting phenomenological theories to work, we specifically adopt Rapp and Tirassa’s concrete recommendations for phenomenological approaches to the “self” in self-tracking [64]. In order to do this, they recommend that designers acknowledge the “past, present, future, and interconnected self” when designing self-tracking technologies. Rapp and Tirassa also argue that the understanding of the “self” should not be understood as being a crystallized entity that can be revealed through self-tracking, but rather; “as multiple and mutable,... actively (re)constructed by the individual” [64: 368]. Finally, Rapp and Tirassa argue that the “self” is always interconnected and cannot be separated from other people since “the construction of our self is inextricably connected with those of other people” [64: 345]. Therefore, the phenomenological commitments we take directly from Rapp and Tirassa are that: *we are always our past, present and future selves; knowledge is co-constructed; and the body is interconnected.*

Because we address the case of menstrual cycle tracking, which is an example of the self-tracking of the insides of the body, we augment Rapp and Tirassa’s recommendations with the theories of phenomenologist Drew Leder [49]. To Rapp and Tirassa’s guidelines, we find value in adding the commitments: *the body is always in flux* and *we are reflexively influenced by our inner states*. Leder addresses the experience of the insides of the body and constructs a phenomenological anatomy based on felt sensations as well as external sources of information. This approach emphasizes the idiosyncrasies of our subjective experience of our bodies, rather than understanding experience through universalizing models drawing from biological science and modern medicine [48]. It is not that phenomenologists do not believe scientific facts to be true, but rather that these facts only gain their meaning in the context of lived experience. It is not the goal of phenomenologists to find truths about the world, but rather to develop deeper understandings of experience.

Leder states how even though the shifting states of our internal body shapes our interactions with the world, we cannot experience them directly [49]. Our body’s outer

surface is where our major senses lie and thus where we have the most distinct sensations. In comparison, our awareness of the inside of our body is *indistinct* and *qualitatively reduced*. Self-tracking troubles the notion of what is “true” about the body since the data collected from the body is not necessarily felt or directly experienced through bodily sensations. Leder states that we use our perceptions of the outer world to gain awareness of the insides of our bodies, and in turn, we contextualise and understand information about the human body through our felt sensations and experiences. One example Leder gives is the fact that we do not have a direct felt sensation of having low blood sugar through felt sensations of our arteries and veins. Instead, when the words on the computer screen become blurry, we extrapolate that it is because our blood sugar is low because we have learnt from science that this is how this phenomenon is experienced. To summarise, the phenomenological commitments that we take into our design process are that:

1. *Knowledge is co-constructed:* The knowledge of the self is constructed, rather than discovered, through external sources of information and internal sensations.
2. *The body is interconnected:* Interactions with other people influence self-understanding. We are an interconnected self.
3. *We are always our past, present and future selves:* Notions of the past and future self influences the present experience of the self. (i.e. who the user imagines they used to be, and who they might become, influences how they understand themselves in the present.)
4. *The body is always in flux:* Although it is not always experienced as such, the body is always in a constant state of change.
5. *We are reflexively influenced by our inner states:* Our internal states influence our sense of self and our experience of our world.

MENSTRUAL CYCLES AS A DESIGN CASE

We address menstrual cycle tracking as a case of self-tracking the inside of the body. A menstrual cycle begins on the first day of menstruation and ends the day before the next menstruation begins. The menstrual cycle includes events such as: menstruation, when the lining of the womb is shed, which typically lasts for 3-8 days; ovulation, when an egg is released around the middle of the cycle and the point when the body is fertile; and PMS (pre-menstrual syndrome), when hormonal shifts can result in feelings of irritation and depression in the last days before menstruation.

Menstrual cycle tracking has historically been carried out by using a paper calendar; the dates of menstruation were recorded and used to predict the next menstruation based upon what the user found to be the average length of their menstrual cycle. Developments in computational tools and algorithms allowed an automation of this process; technological devices collect data over multiple cycles to

provide a more accurate average cycle length metric. Apps have been found to be preferable to paper tracking methods for younger people [39] and facilitate the wide scale collection of menstrual cycle data for research purposes [68].

The emotional, physiological, and theoretically predictable nature of menstrual cycles provides novel design opportunities [18, 28–30]. In contrast to other health and fitness tracking devices, commercial menstrual cycle tracking apps, with the exception of those used for fertility management, are not used with any particular goal beyond the act of tracking itself [18]. Menstrual cycle apps allow users to input data such as dates of menstruation and symptoms such as PMS, pain and a range of health and sex data (Figure 1.). The app then uses an algorithm to predict the timing of the events such as PMS, ovulation and menstruation in next menstrual cycle based on this self-reported data. These apps are based upon the assumption that each menstrual cycle is, on average, the same length and therefore will occur regularly.

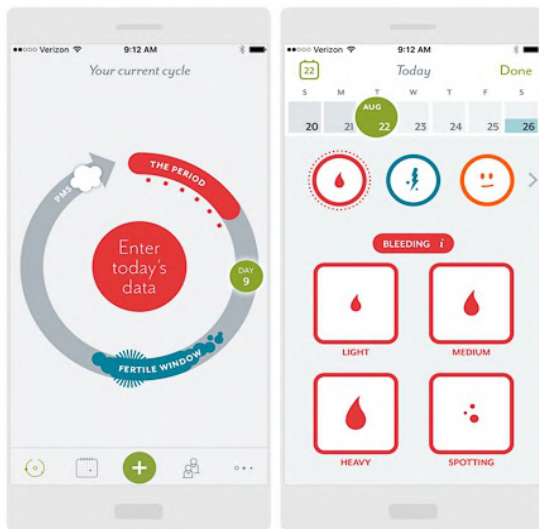


Figure 1. The menstrual cycle tracking app Clue. Left: an overview of the current menstrual cycle. Right: interface to input relevant data for the day.

In recent years, design research on menstrual cycles within HCI has proliferated [30]. These projects have included critical and speculative designs of menstrual cycle tracking technologies [21, 71], toys for menstrual health education [75], textile based design experiments to measure menstrual blood loss [55], design interventions to challenge politics behind the availability of menstruation products in bathrooms [20], the use of workshops to explore challenging the taboos and negative connotations of menstrual cycles in society [80]. However, few projects have focused specifically on the design of menstrual cycle tracking tools. One notable exception is Crimson Wave, which visualises which stage of the menstrual cycle the user is in through cycling through pre-programmed red, white, and pink coloured lights [19].

AMBIENT CYCLE

Ambient Cycle is a menstrual tracking device that – like others – relies on self-reported data to give the user a prediction of when the next phase of the menstrual cycle will occur. Ambient Cycle is comprised of a Wi-Fi enabled Raspberry Pi microcontroller with a LED strip that is configured through a designed webpage that can be used as an app. The interface firstly asks users to input information on the average length of their cycle and which day of the cycle they are currently on. The user can alter these metrics at any time if the device becomes out of sync. The interface then allows the user to choose which colours Ambient Cycle will show over different phases of the menstrual cycle by colouring in a bar that represents the length of one menstrual cycle (Figure 3). We did not use an algorithm to predict the length of the menstrual cycle, as implemented in most menstrual cycle tracking apps, mostly due to the fact that over a four month study, the algorithm would not have been able to collect enough data to provide a more valuable prediction than using the “average cycle” metric collected from participant’s existing menstrual cycle tracking methods. The microcontroller and LED strip are embedded in an acrylic, line-bent form to form the lamp part of the design (Figure 2). The lamp is designed to be placed 20cm away from the wall, and the projected colour reached up to 2 metres high depending on the ambient lightness of the room. The lamp itself is 60cm wide.

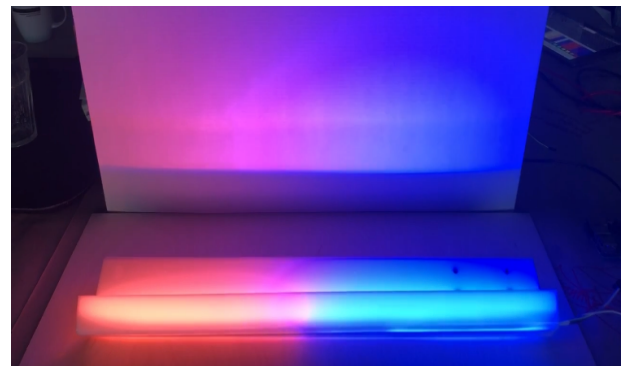
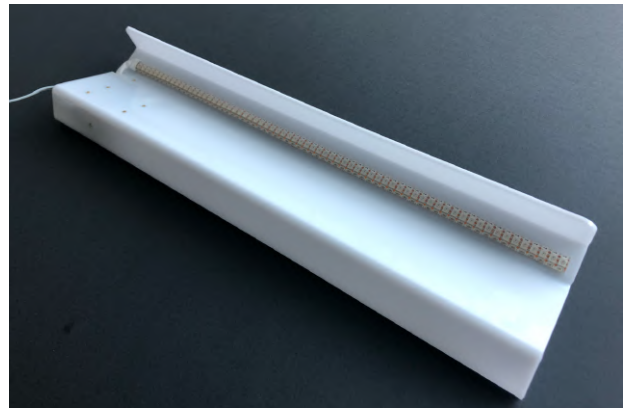


Figure 2. the lamp component of Ambient Cycle. Above: turned off. Below: in a colour transition between two phases.

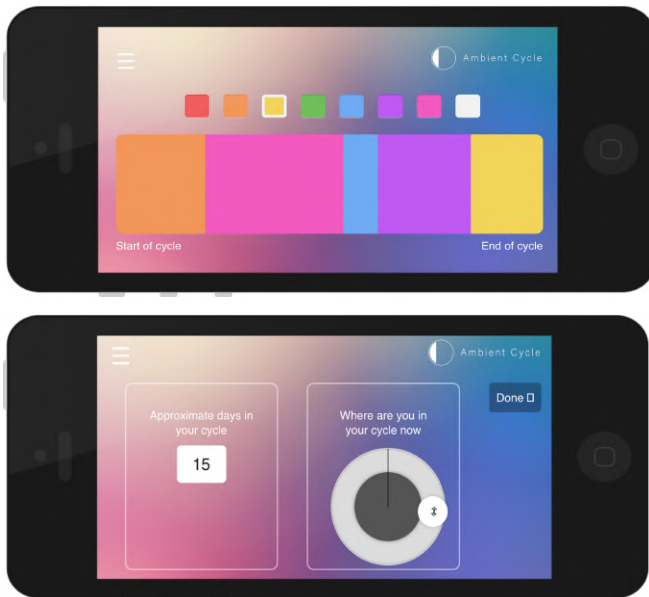


Figure 3. Ambient Cycle configuration interface. Above: choosing colors for the phase in the cycle. Below: choosing length and current position in the cycle.

PUTTING PHENOMENOLOGICAL THEORIES TO WORK

We will now unpack how our commitments were realised and materialized in the final prototype, Ambient Cycle.

1. Knowledge is Co-Constructed – Using Ambiguity and Negotiating Conflicting Epistemologies.

Commercial menstrual cycle tracking apps use textual and graphical methods to show where the user is currently in their menstrual cycle and predictions of future cycles as well as scientific information about the menstrual cycle. We designed Ambient Cycle with the aim to leave the interpretation and use of menstrual cycle data as open as possible in order for users to co-construct knowledge *with* the device. Rather than being a device to diagnose which stage of the menstrual cycle the user is in, Ambient Cycle works with the lived experience and felt sensations of the user to co-construct the experience of the menstrual cycle. The mobile interface (figure 3.) deliberately does not include scientific information about the menstrual cycle, nor does it show time markers such as days or weeks. The only markers are “Start of Cycle” and “End of Cycle”. This was a decision made in order to maintain an understanding that data shown by Ambient Cycle would only be a rough estimation of their menstrual cycle as it was lived by them.

In designing Ambient Cycle, we discussed ways of representing data beyond textual and graphical interfaces, which can be criticised for being too prescriptive and diagnostic [32]. Ambient Cycle, thus, only displays data through the colour projected by the lamp, no other information is given. We found coloured lighting to be the mode that could fit the home environment in an appropriately ambient form (i.e. not too disruptive or distracting) whilst still being able to represent data in a meaningful way, as explored by [66, 70].

As described, the user firstly needs to input information about the average length of their menstrual cycle and how many days it has been since the beginning of their current cycle. This metric means that the device can stay in synchronization with the menstrual cycle over the months to come. This was, however, an aspect that troubled us during the design process; not all menstrual cycles are regular, and we risked excluding some users in creating a device that did not function accurately when their menstrual cycle occurred irregularly. A phenomenological approach means bracketing off scientific truths about the body that are outside of lived experience and instead understanding knowledge to be co-constructed through lived experience. Since using the metric of an average menstrual cycle in order to predict future cycles is arguably the only aspect that meant that Ambient Cycle could still be described as a menstrual cycle tracking device, then this required us to compromise on our phenomenological commitments and employ this “truth” about the body that might not align with our user’s lived experience.

2. The Body is Interconnected – Designing with Public Displays of Data in the Home

In representing the phenomenological theory that we are interconnected, and that our self-understanding is built from our interactions with other people, it seemed meaningful that the data should be shared with other people. Leder states that we understand ourselves through our interactions with others [49]. This is why we decided to situate the device publicly in the home. One risk with this design decision was that the user might feel exposed from having data, which is culturally conceived of as private and taboo, shown publicly or semi-publicly. Culturally, such knowledge has often been used to undermine the rationality of the behaviour of the primary user; for example, they might be treated differently if a co-habitant read that the primary user were in their PMS phase and therefore may be more irritable and emotional than usual [30, 69]. However, one way we negotiated this was by using ambiguous displays of data through changes in colour. A “key” is needed to be able to interpret the colour shown. Visitors to the house or co-habitants would not know what the device was or what the colour represented if they were not told explicitly by the user. Neither does the lamp itself communicate its true function.

3. We are Always Our Past, Present and Future Selves – Using Memories to inform Future Experiences

As stated, when designing Ambient Cycle’s interface, we decided not to provide any external sources of information, such as scientific information, or information on how the ‘normal’ menstrual cycle functioned. This was in order to harness user’s notions of their past and present selves in configuring the device. When users configure the colours to be shown over their menstrual cycle (Figure 2), they are providing an illustration of how they recall their lived experience of their menstrual cycle. They use their memory of their past experience of their menstrual cycle to configure how they will experience the menstrual cycle in the future.

Rather than following the template for how a ‘normal’ menstrual cycle is experienced, Ambient Cycle employs user’s past experience and future ideas about themselves in the hope of providing a more subjective and idiosyncratic depiction of their experience of their menstrual cycle.

4. The Body is Always in Flux – Designing with Constant Streams of Menstrual Cycle Data

Another aspect we wanted to address was that the body is always in a constant state of flux. This is rooted in Leder’s theories of how the body fades into absence when we are healthy, and only becomes present to us in a negative sense in ill health or physiological change [49]. Rather than understanding physiological changes and sensations as categorized and explained by scientific models of the body, we wanted to represent that the body is always in a state of change. We did this through providing a constant flow of data through the use of ambient light that changed colour autonomously and continuously over the menstrual cycle.

5. We are Reflexively Influenced by Our Inner States – Employing Affective Feedback Loops

We imagined that our design could not only be used as a notification system in line with commercial menstrual cycle tracking apps but could also be used to reflect the user’s emotional experience of the menstrual cycle. This means that the device goes beyond being a notification system. This reflects Leder’s concept that the way that we experience information about our bodies is influenced by our particular emotional and physical states. Through allowing data to reflect emotions, we acknowledge the reflexivity of data – we are changed by experiencing data about our bodies, but the state of our bodies also changes how we experience data.

DEPLOYING AMBIENT CYCLE

In order to understand the implications and opportunities of designing with phenomenological theories, we deployed the final version of Ambient Cycle in the homes of 5 participants for 4 months. Participants were recruited through posts on social media. All participants live in Southern Sweden and are aged between 24 and 42. All participants lived in shared accommodation with either roommates, (P1, P3,) or their families (P2, P4, P5).

Interviews with each participant took place at the time when the device was installed, and again at the end of the study. The interviews were semi-structured and lasted between 30 - 60 minutes. The initial meeting also involved setting up the device and connecting it to the participants Wi-Fi, installing the app on their smart phone, showing them how to configure the device, and how to alter the brightness of the lamp through the app. The initial interview covered their current and past menstrual cycle tracking practices and included them talking through their initial configuration of the device. During this process, we asked questions such as “*Why are you choosing to have this colour here?*”. Participants were given no guidelines as to their daily interactions with the device but were shown how they could independently reconfigure the device if they chose to during the study. Our

final interview followed up on comments made during the first interview and asked open questions such as “*how have you found using Ambient Cycle?*”.

Due to the long duration of the study, and reticence in our participant’s reactions, our participants were able to continue with their current menstrual cycle tracking practices throughout the four-month long deployment if they wished. All participants were currently using a form of menstrual cycle tracking app. P1 and P3 had been using theirs since 2014, P2, P4 and P5 since 2016. All participants used their apps to notify them of their next menstruation. P1, P2, P3 and P4 used their apps to validate their experience of PMS (pre-menstrual symptoms); these participants would feel irritable or depressed and use their apps to see if PMS could be an explanation for these emotions. P5 mainly used hers as a fertility aid to keep a record of her menstrual cycle for her doctor and to track her ovulation for the planning of future pregnancies.

We used thematic analysis to categorize and draw findings from our raw data [10]. The interviews were transcribed directly after they took place. The themes used as headings in the next section were developed over the interviews and were used in a final coding of all data by the authors. Thematic analysis is a method commonly used within design research involving deployments of design probes within HCI, e.g. [53, 60, 67]. Thematic analysis can draw out the details of the phenomenological experience of participants from an essentialist perspective, but also allows the researcher to surface why the participant says what they are saying from a constructivist approach [8].

FINDINGS

In this section we will outline how the phenomenological commitments we designed with translated into our participants experience over the four-month-long deployment.

Relating Lived Experience to Colours and Vice Versa

A common way that participants chose to use Ambient Cycle was as a device to reflect their lived experience of their menstrual cycle, both emotionally and physiologically. The aim with this use of Ambient Cycle was to gain as close a resemblance to their own sense of self as possible; “*Yeah. that looks like me. Is this me?*” P3. Participants used their memory of how they felt at certain times of the menstrual cycle, as well as information they had taken in from their use of their menstrual cycle tracking apps and other sources of knowledge; “*(choosing yellow) Yeah I read about like how you’re supposed to feel in the first two weeks of your cycle you’re supposed to feel more energy. Normally I do. And so, it would be nice to be able to like maximize that*” P1. Multiple participants chose the same colours to represent the same phases of the menstrual cycle. P2 and P1 both chose pink and purple for their ovulation revealing cultural associations with colours referring to particular aspects; in this case “*feeling sexy*” P2. Pain was also a common aspect to be represented in the colour configuration. Though, what

“pain” was referring to differed between the participants. For some, pain was physical pain related to menstrual cramps before and during menstruation. For others, pain was emotional pain when they experienced depression or anxiety. P3 had to make a decision between whether to represent her physical pain, or her anxious emotional experience during menstruation.

Several participants also used the colour configuration to improve their experience of the menstrual cycle. P1 used white light and slower colour transitions to deliberately combat anxiety during PMS, and blue during times of high energy because “*I need to also stop doing so much and cooler colours also like help me to calm down*” P1, and greens and yellows during times of low energy “*because I want to remind myself that yes, I can actually do stuff. Even if you don't feel like it*” P1. P5 also used white light at the end of her cycle “*to cheer me up*”. These comments reflect a belief that the colour of the light shown in the home could influence their mood. This shows that our participants were using the data reflexively; that they were aware that their experience of the data would be in relation to their emotional and physical state, and that this data would change how they would feel.

In the final interview, most participants described not liking the colours that they had previously chosen to show over their menstrual cycle in our initial meeting. Although all participants had been informed and instructed on how they could change the colours during the study, only P1 actively changed these colours, the rest of participants turned off and did not use the lamp during the periods where colours they disliked were shown. Asked why she did not change the colour P3 told us; “*I wanted it to be coherent with my logic. My logic was like; I choose a color that matches my feeling these days... What I'm feeling is not pleasant so I choose a not pleasing colour*”. P3 later wondered “*maybe I could choose the colors the other way around. Like for the days that I'm feeling bad I could choose a color that is calming me down... Yeah I didn't think of that but yeah I could have followed that logic. Like the light as an ally*”.

Stretches of time where participants did not want to represent any particular stage of the menstrual cycle were also included in their configuration of the app. This was either through not having any colour shown, and therefore the lamp being off, or through showing white. These phases were where participants described not being affected by their hormones to the same degree as the rest of the cycle. For example, P3 described the phase just after menstruation as her “normal” time and therefore wanted Ambient Cycle to show white, which she saw as being a non-colour.

Reflecting on Temporality

Configuring representations of internal states externally made more sense for some participants than others. P1 told us in the final interview that she had reflected on how pre-configuring the colours shown by Ambient Cycle did not align with how she experienced herself; “*like I wanted the*

lamp to reflect how I felt at that moment, not how I thought I would feel at a certain time and what color would reflect that” P1. P1 reasoned this as being associated with her indecisive nature. Choosing colours for her future self did not make sense, since she knew how changeable her moods were.



Figure 4. Ambient Cycles installed in four participant homes.

At the final interview, P3 thought that “*maybe the extra information (provided by Ambient Cycle) would be that I can know the different stages all along the cycle... Or even if you didn't actively look for the info, you're like reminded. And with the other one (her menstrual cycle tracking app) you have to actively think "oh do I want it?"*” P3. The fact that Ambient Cycle offered her information over the whole cycle offered new opportunities to “*observe yourself more*”. P3 told us how she used her own menstrual cycle app only on days when she had pain or was feeling “bad”. Seeing where she was in her menstrual cycle for the whole cycle prompted her to reflect on phases of the menstrual cycle she would not have previously considered; “*I chose green for very good days and then I would be like "Ah so I'm going to pay attention if it's really good these days"*”.

Negotiating the Social Context

All participants independently based the decision on where to place Ambient Cycle on the fact that it should be in the room where they spent the most time. For all except P3, this was the communal living room. P3 placed hers in her bedroom (Figure 4). In the first interviews, after configuring Ambient Cycle, P1 looked at the lamp in the space and said; “*I can already think like OK I'll probably change the lighting from green. Probably social stuff will influence it*” P1. Having a lamp that was meant to reflect her inner state became a playful tool for P1; “*at the start I was like "No I can't change colors" because I was being a bitch... I was the person who had control over it*”, however over time P1 began to change the colour of Ambient Cycle to a more pleasant colour when socializing in that room. Ambient

Cycle became a common topic of conversation, with visitors asking P1 *“Is this your vibe right now?”*.

P5 posted a photo of Ambient Cycle on Instagram with the caption *“Research in Process”* since she wanted to share with her friends the fact that she was taking part in this study. However, when discussing sharing her menstrual cycle data with visitors to the apartment, P5 said; *“I think it would be different if I had my parents in law. But actually, they have been here quite frequently... I think I forgot to tell them. But that would have been different to say ‘oh it's just my menstrual cycle, (laugh)’”* P5. P5 would have felt embarrassment to discuss the topic with her parents-in-law, but the ambiguous design of Ambient Cycle had camouflaged the device within her home. A key function for Ambient Cycle for P2 and P4 was to alert their families to the fact that they had PMS; *“Well I'm also thinking of its benefits for my family... if it becomes blue when I have PMS I could tell my kids ‘see I have PMS you know it's blue so be gentle.’”* P2. P4 described how she felt embarrassed to discuss her PMS at the beginning of her relationship with her husband, but that that was no longer an issue, however; *“for the kids it would be great. If that was red then everybody could see that. And then it could help in a way”* P4.

Reflecting on Accuracy and Usefulness

During our first interview, it became clear that Ambient Cycle was not what P2 expected. She had expected; *“to see if I can get to know myself from the outside. But now I'm actually getting to know this (Ambient Cycle)... But now this is interesting because I think this would make me more aware of myself. Like now I've used (her menstrual cycle tracking app) as a control device”* For P2, a control device meant a device that she could use to validate her lived experience of her body through telling her which stage of her menstrual cycle she was in. Although Ambient Cycle works in an almost identical way to menstrual cycle tracking apps, having to configure the device herself and choose which colour to show at different phases gave P2 the feeling that she was the one now controlling the device. Her reflection that this would make her more *“aware”* represents the fact that Ambient Cycle requires more self-reflection and engagement than menstrual cycle tracking apps, where options of what to input into the app are pre-selected.

P5 stopped using Ambient Cycle after it became out of sync with her menstrual cycle after two months. However, P5 told us how one cycle later she had once turned Ambient Cycle on at the request of her young son who enjoyed the rainbow effect shown when the device was turned on. She found the light shown by Ambient Cycle to be pink. According to her configuration, this meant menstruation was occurring. She checked her app and it said that it was another week until menstruation. She doubted the information from the lamp but still packed sanitary towels in her bag for her trip the next day *“because it felt like maybe it can know... but then I actually had my period, so the lamp was more accurate than the app. Like that's really strange. Hmm. That might be like*

the only time I really connected it to my period. But then I sort of felt it was wrong, but it was right!”. This led to wider reflections on her use of her menstrual cycle tracking app; *“The thing is that I think it's accurate. But then it's not. And then I think it's my body ‘Oh my period came wrong this month’. It's always been very irregular. But that's also a weird way of looking at it. Like the app is the correct... I mean it's my body that should be correct”* P5.

DISCUSSION

Through our research we asked; how can we use phenomenological commitments in the design of self-tracking technologies? And what were the implications and limitations of putting phenomenological theories to work in the design process? We use the experiences of our participants to propose some answers to these questions.

Designing with Conflicting Epistemologies

Ambient Cycle employed ambiguity in order to allow the user to co-construct their understanding of their menstrual cycle from the display of data. Ambiguity has been used in the field of affective computing through the approach of interactional empowerment [34]. This approach conceives of emotion as co-constructed through interactions, where the user is a collaborator in constructing an understanding of their own emotions. This is in contrast to the approach that holds that affective devices purely detect and discover the “real” or “true” emotions of its user [7]. Similarly, [46, 47] employed ambiguous representations of fear to explore how emotions are co-constructed through interactions with sensing technologies. There is a difference, however, between the tracking of emotions and the tracking of physiological states. The main difference is that it is possible to use clinical procedures to validate the physiological status of the body. In contrast, there is no absolute truth of emotion beyond the lived experience of the emotion [46]. As mentioned, taking up phenomenological commitments when designing self-tracking technologies to surface information about the inside of the body creates an epistemological battle ground. Phenomenology holds that “the world is always a world-as-perceived, not a scientific object or a thing-in-itself” [48: 63]. Self-tracking the insides of the body requires using scientific knowledge and methods in order to surface information about the body that is not directly experienced through felt sensation. We came up against this conflict in epistemologies when we had to make the decision about whether or not to use the “average menstrual cycle” metric in order to keep Ambient Cycle in sync with future menstrual cycles. This is arguably the only facet of Ambient Cycle that ensured that it qualified as a menstrual cycle tracking device that could autonomously stay in sync user’s menstrual cycle. Our concern with assuming that our participants would have regular menstrual cycles was that it would exclude those who didn’t. This would obstruct the user in co-constructing knowledge about their menstrual cycle with the device, as well as perpetuating inaccurate and problematic expectations of the menstruating body as regular [30]. We described our

use of the “average menstrual cycle” metric as an unavoidable “compromise”.

Modern medicine has been criticized by phenomenologists for being de-personalizing and Cartesian; the body as an object is held in higher esteem than the patient as a living subject [4, 50]. Proposed as an alternative to a Cartesian approach to the body in ill health, medical phenomenology is an approach that attempts to emphasize the subjective experience of the patient [4, 73]. Scientific information about the body is still employed in understanding illness, but the patient’s phenomenological experience of the illness is given equal value in the treatment process. Our own approach to self-tracking reflects a medical phenomenological approach to the body. Rather than understanding the menstrual cycle solely through a medical and scientific model, we attempted to design a device that acknowledged each user’s subjective experience of menstrual cycle. We aimed to do this by using our phenomenological commitments. We do not deny that science can produce truths about the insides of the body that facilitates deeper knowledge about ourselves. It is this information that allows menstrual cycle tracking devices to exist at all. What we argue is that the way that this knowledge is used and communicated does not have to replicate its Cartesian dualist roots. In the same way that a phenomenological approach changes how doctors treat their patients, as designers of self-tracking devices, we can make the choice to facilitate a more phenomenologically oriented experience of self-tracking for our users.

Public Displays of Private Data Requires Negotiation

One of our phenomenological commitments was to design for the “self” in self-tracking as an interconnected and socially situated being, rather than solely as an object for scientific appraisal. Instead of keeping menstrual cycle data in the user’s smart phone, we used a public ambient display of data in order to facilitate an intersubjective and shared experience of menstrual cycle tracking. The most concrete example of how this design decision played out in the experience of our participants was P2 and P4 both using their Ambient Cycle devices as a way to non-verbally alert their family to their emotional state in order to engender empathy and mitigate their behavior towards them during PMS. Though this use of Ambient Cycle apparently did not arise over the long-term study, and we did not interview other members of the household to understand their experience of Ambient Cycle, it still points to an interesting implication of displaying physiological data within the home, and one ripe for further inquiry; ultimately that others can gain a deeper understanding of how our internal states are shaping us without the need of direct or verbal communication. On the other side of the spectrum, we also saw how ambiguous displays could negate the taboo around showing private data such as menstrual cycle data within the home. This was shown by P5 realizing that her parents-in-law had been present when Ambient Cycle was on, but that they had been unaware of its true function.

This study has also highlighted tensions around using displays of physiological data relating to individual bodies in shared spaces. Typically, data visualized within the home is relating to shared aspects; the temperature, the weather, the contents of the smart fridge, etc. To use a shared space to visualize the data from one individual troubles accepted social dynamics. As discussed by P3, Ambient Cycles public display of data required negotiation in terms of creating a pleasant environment for all, whilst still staying true to the representation of the menstrual cycle of the primary user. This was illustrated by P1’s playing with her power over the colours shown by Ambient Cycle when visitors were present. When faced with this dilemma, rather than changing the colours shown, turning off Ambient Cycle was the most common solution. We suggest that future design work could generatively address this limitation. Particularly in terms of negotiating how to maintain a flexible enough range of options with which users could articulate their experiences of their bodies, whilst still providing a design that would be appropriate in a shared home environment.

Co-constructive Methods Risks Mistrust and Obsolescence

One of our commitments was to design for an understanding of the self as being co-constructed, rather than an understanding that a true self was being revealed through self-tracking. This commitment was reflected in our decision to not give users any scientific “facts” about the menstrual cycle, but rather to allow them to create their own subjective representation of their experience through choosing the colours Ambient Cycle would show. One consequence of this appeared to be that these design decisions led to mistrust and feelings that Ambient Cycle was obsolete. A consequence of Ambient Cycle’s use of ambiguity was articulated by P2’s questions around what the device actually *does* for her. She expected the device to be able to tell *her* something about her body, but instead she felt *she* was having to tell *Ambient Cycle* something about her body. Commercial menstrual cycle tracking tools are not only used for logging symptoms; they also provide predictions of future menstrual cycles. Although Ambient Cycle does replicate the predictive model of apps through using changes in colour to alert users to the different stages of their menstrual cycles, for someone who described herself as “*goal-orientated*”, P2 felt that losing a textual interface and a quantified representation of the menstrual cycle was a loss. The form that the data took shaped how valid she understood the data to be.

Although quantifying, algorithmic, menstrual cycle tracking technologies are often inaccurate [67], and this has led to severe consequences in the case where they are used for contraception [37], P5’s surprise at discovering that Ambient Cycle was more accurate than her other app shows the unquestioned efficacy communicated by menstrual cycle tracking apps and self-tracking technologies in general. Quantification has most typically been the tool used to translate physiological processes into data within self-

tracking. Quantification has been accused of enacting certain biopolitical acts on the user such as enforcing norms around “health”, reducing the complexity of lived experience, and encouraging self-surveillance and self-control [11, 79]. Quantification is normative, since it uses metrics to categorize bodies and is used to compare one body to another against some notion of “normal” [52, 79]. Culturally, it communicates certainty and scientific practices [12]. This influences how the information is received; quantified data is perceived as valid purely because of its numerical form [45]. We are not denying that Ambient Cycle quantifies the user’s menstrual cycle. The “*average days in menstrual cycle*” value is used to create a looping function to repeat in synchronization with future cycles. This is the same as the method used by menstrual cycle tracking apps and analogue paper calendar methods. What we see through our participant’s experience was that the lack of quantified data in the input stage (when users configure the colours shown by device through the mobile interface) and in the output stages (the data being displayed through coloured light), resulted in assumptions of inaccuracy and judgements of obsolescence. This leads to our recommendation that self-tracking technologies must negotiate this when leveraging ambiguity in order to co-construct knowledge about the body with the user. Designs must be open and non-prescriptive enough to be allow users to co-construct the user’s understanding of themselves, but not so open or lacking in autonomy that they are deemed inaccurate or obsolete in comparison with self-tracking devices designed with a Cartesian dualist approach.

Ambiguity Can Pluralize Ways in Which Menstrual Cycle Tracking Tools Are Employed

Our phenomenological commitments resulted in a design that did not attempt to categorize and diagnose the body in terms of medical knowledge on the menstrual cycle, but rather supported subjective experiences of the menstrual cycle. This approach appeared to support the diverse ways that our participants employed Ambient Cycle as a menstrual cycle tracking device, beyond replicating commercial apps in logging and predicting distinct menstrual cycle phases. For example, physiological pain, energy levels, and emotions such as anxiety and low moods were all aspects included and represented in totally idiosyncratic ways within our participant’s configurations of their devices. Rather than giving a medical definition of user’s experiences, using a choice of colours gave a more affective, flexible, and expanded vocabulary for representing lived experience.

Menstrual cycle tracking presents an enigmatic case where concrete physiological events, such as menstruation, are accompanied by felt sensations and emotional shifts that could be provoked by a range of events, not only hormonal changes. Self-tracking tools for enigmatic conditions such as endometriosis have used the collection of different types of data and triangulations across these data types to produce tools flexible enough to account for subjective experiences of the conditions [53], and logging tools such as bullet

journals have been leveraged to create flexible and self-tracking tools to avoid excluding user’s lived experience through too-rigid pre-defined designs [2]. To this work addressing the self-tracking of enigmatic physiological processes, we recommend and contribute ambiguity as a promising tool to employ in the design of tools that facilitate and support a range of diverse experiences and uses of self-tracked data.

Phenomenological Approaches Allow Novel Interactions with Physiological Data

One key result of our research is the diverse ways in which our participants used their menstrual cycle data. This included reflecting their emotional and physiological states as described above, but also included using the colours as therapeutic aids, and the use of the device to communicate their internal states to others. This highlights the expanded design opportunities possible when designers treat the “self” in self-tracking as more than an object to be understood through the application of medical science. The commitment to design for the body in flux was drawn from phenomenologist Drew Leder’s description of the fact that our bodies become present to us in a negative way when we experience them changing or becoming sick “The body, surfacing in dys-appearance, comes to be associated with deception and death and is consequently devalued.” [47:149]. This perpetuates the Cartesian concept of the body as a machine – when we experience our bodies in this way, we see them as broken machines that require fixing. If we take up this perspective, then we can frame menstrual cycle tracking apps as attempting to reverse a negative experience of the body by regaining control through “validating” felt experience of the body with medical knowledge.

The fact that Ambient Cycle showed data over the whole menstrual cycle, rather than being a tool to validate and diagnose distinct phases facilitated P3’s use of Ambient Cycle to run self-experiments to see if she really did feel good during the week after menstruation as she assumed that she did. Ambient Cycle was also configured to represent “normal” phases of the menstrual cycle; i.e. phases where the strongly hormonal (experienced as negative) aspects of the menstrual cycle were not present to the users. These examples show where the tracking of neutral or positive experience of the menstrual cycle was facilitated by the design of Ambient Cycle. This is not an aspect reflected in the design of commercial menstrual cycle tracking apps. We do not celebrate or acknowledge the positive effects of hormonal changes because of societal and cultural norms around the body, just as we do not go to the doctor when we are well. Our research shows how when we use phenomenological rather than Cartesian dualist approaches, new opportunities for how we design for the body arise. By highlighting positive rather than only negative aspects of our lived experience of our bodies, we re-configure negative connotations and allow for new understandings of the body to arise.

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Paper 5.

Homewood, S., Bewley, H. and Boer, L.

Ovum: Designing for Fertility Tracking as a Shared and Domestic Experience.

In Proceedings of the 2019 on Designing Interactive Systems Conference.

Honourable Mention Award

Ovum: Designing for Fertility Tracking as a Shared and Domestic Experience

Sarah Homewood

IT University of Copenhagen,
Rued Langgaards Vej 7,
Copenhagen 2300, DK
shom@itu.dk

Harvey Bewley

IT University of Copenhagen,
Rued Langgaards Vej 7,
Copenhagen 2300, DK
harb@itu.dk

Laurens Boer

IT University of Copenhagen,
Rued Langgaards Vej 7,
Copenhagen 2300, DK
laub@itu.dk

ABSTRACT

Medical devices are moving out of the clinic and into the home. The design of these devices shapes our experience of interacting with our bodies. We attend to ovulation tracking devices that aid conception. We present Ovum; a research product that will be deployed in a long-term, qualitative study with couples trying to conceive. The contributions of this pictorial are the framing of the design space around at-home ovulation tracking devices and the presentation of our approach to this design space through working with oppositional experiential qualities by designing for fertility tracking as a shared, domestic and do-it-yourself experience.

CSS Concepts

- Human-centered computing~Interaction design theory, concepts and paradigms

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Authors Keywords

Form giving; fertility tracking; research product, research-through-design; conception; ceramics; industrial design;

INTRODUCTION

Developments in the fields of digital technologies, health data analysis and the medical sciences have led to an increasing number of commercially available medical testing and tracking devices [10]. These devices represent a form of patient-driven health care that bring knowledge about the inner workings of the body into the home [19]. This development points to emerging cultures around health in society [11]. As technological devices start to move along the clinic-home continuum, their design also warrants continuous reconsideration in terms of the experiential qualities and the social constructions that they produce [1,5,12]. The influence of the material and form representations of the body on user experience has been explored in projects such as [6, 7, 13, 18], whilst [8] and [4] explicitly explore the design of the domestic data-collecting device itself. We follow by proposing that interaction design research can facilitate designing for the emotional, social and relational aspects of devices that test and track our bodies in our own homes [9, 14].

In this pictorial we address at-home ovulation tracking with the aim of conception, rather than contraception. Ovulation tracking has long been practised through the charting of the

menstrual cycle and other physiological changes. Modern methods employ clinical tools for the detection and monitoring of fertility in the home, which have been described as a complex, knowledge-intensive, and highly personalized practice [3].

Through iterative explorations of materials and form, and in collaboration with a ceramist and industrial designer, we develop the saliva ovulation-tracking device “Ovum”. The format of a pictorial allows us to elaborate on this form-giving process, and to represent the complexities of designing and related considerations [2,16]. We conclude with an analysis of how the framing of Ovum as a research product [15] firstly informed our design process, and secondly supports approaching it as a research vehicle. This vehicle will be used to understand how the design of fertility tracking devices impacts users’ experience through deployment in a long-term, qualitative study with couples attempting to conceive.

We begin this pictorial by analyzing the design and experiential qualities [9] facilitated by current devices to unpack how these devices shape emotional and relational aspects of fertility tracking. We use this analysis to point to alternative experiential qualities not facilitated by these devices that are then used to inform the design of a fertility tracking device that enacts alternative processes of reading the body.

FERTILITY TRACKING DEVICES



URINE TRACKING

Function: These devices determine when ovulation is taking place through testing for Luteinizing Hormone (LH) in urine. The LH surge typically takes place in the middle of the menstrual cycle, about 24 -36 hours before ovulation, the most fertile period during the menstrual cycle. Urine testing previously took place in the doctor's surgery before coming onto the commercial market for at-home use.

Form: Testing sticks either come in digital or analogue form. Analogue versions are a strip of paper that show a line in the middle of the strip if LH is detected. This line is often faint and a cause of confusion for users. Digital versions have a re-usable reader that negate the ambiguity of the analogue strips through translating the test result into clear indicators on the LCD screen such as smiley face or line.

Interaction: First thing in the morning, the strips are either placed in the urine stream or in a cup of urine. Three to five minutes later, the device will show whether LH is present or not, therefore signalling whether the body is approaching ovulation. This information fades after a few hours and the test strips are discarded after each use.



TEMPERATURE TRACKING

Function: The basal body temperature (BBT - the lowest body temperature over a 24 hour period) rises sharply on ovulation. This means that daily temperature taking first thing in the morning, and the charting of the fluctuations over the month, can reveal when ovulation takes place. Once this information has been gathered over a few months, it can be used to predict when ovulation takes place within the menstrual cycle. Specific thermometers are required for BBT tracking as they require extreme accuracy to pinpoint the change in temperature. Recently, bluetooth thermometers that synchronize with apps have entered the market. These apps track the temperatures recorded and use algorithms to predict future cycles.

Form: Plastic and metal thermometer with a numerical LCD display. An app or a paper chart is used to record the temperature value each day in order to track patterns around ovulation.

Interaction: The temperature is taken first thing every morning. This number is then input into the app or chart. Since various factors other than ovulation also affect the basal body temperature, this method is not suitable during sickness, with a hangover, or less than 4 hours of sleep.



SALIVA TRACKING

Function: As estrogen levels rise in the 3/4 days leading up to ovulation, an increase in electrolytes (salts) cause changes in the consistency of cervical mucus and saliva. This change is visible when saliva samples are inspected through a lens or microscope. Fern shaped crystals increasingly appear as the body approaches ovulation and fade away after ovulation has taken place [17]. Saliva tracking previously took place in the doctor's surgery under a microscope.

Form: Commercial devices are sold for at-home use and are typically comprised of a 60x lens, a battery powered LED and a plastic "lipstick" style casing. One device we purchased arrived with a chart that users could use to record the results over the month as well as other physiological changes such as temperature and changes in cervical mucus.

Interaction: First thing in the morning, the user removes the lens from the casing and places a drop of saliva on the glass plate. This is left to dry and then replaced. A button on the bottom of the tube turns on the LED. The user can then peer into the tube and inspect the saliva sample through the lens.

GROUPED EXPERIENTIAL QUALITIES OF EXISTING FERTILITY TRACKING DEVICES

BINARY

Temperature and urine tracking provides a binary representation of the body as being divided into two non-fertile/fertile categories. Saliva tracking shows more nuance between these stages as the crystals increase towards the most fertile period.

EXPERT

The temperature and urine testing devices still hold some expert authority through the fact that the analysis takes place through chemical and algorithmic processes. Only the result of these processes are communicated back to the user. This black-boxes the hermeneutic processes that take place and re-enacts the clinical expert-to-patient relationship.

REAL-TIME INFORMATION

Saliva tracking and urine testing provide a real-time reading of fertility. This is in contrast to temperature tracking, where it is only the rise in temperature after the release of the egg that can be tracked and used to algorithmically predict the next month's fertile period. Temperature tracking assumes that the menstrual cycle is consistently regular, which is often not the case, and therefore can result in inaccurate information about the timing of ovulation.

CLINICAL

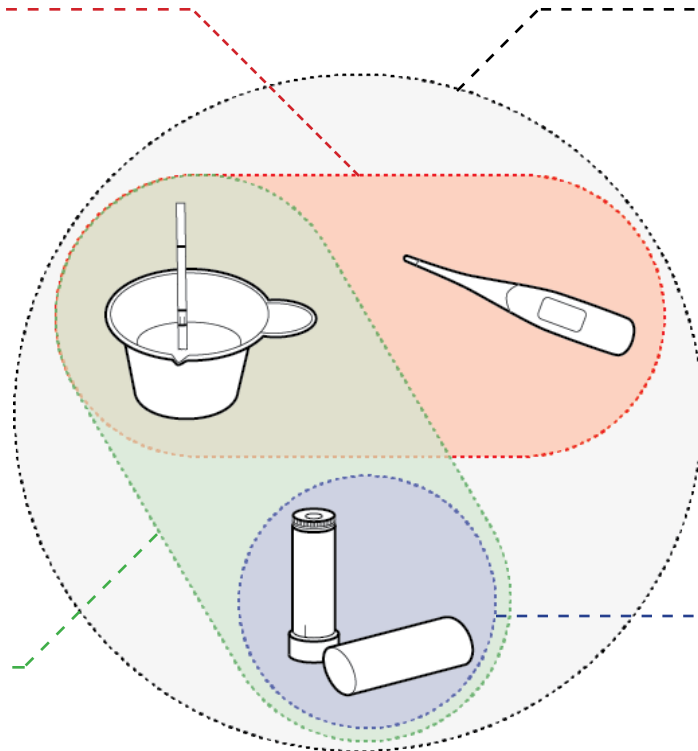
Thermometers, chemical tests and microscopes all represent clinical instruments. Fertility tracking and the act of heterosexual sexual intercourse that leads to conception are not medical procedures. Insemination is a more complex case where clinical aspects are often more pronounced. The dissonance between medical apparatus applied to non-medical phenomenon provokes certain understandings of the body that lead to medicalization.

INDIVIDUAL

Although it is mostly two people involved in the act of conception, these devices are designed for one person. The marketing accompanying these devices assumes it will be a woman purchasing and using devices, and there is no acknowledgement of the second partner. The exception to this would be apps that accompany temperature tracking devices which can be configured to send notifications to partners when the user is fertile. The fact that the mini-microscope is disguised as a lipstick also communicates that this is a private act to be hidden from others.

DO-IT-YOURSELF

Saliva tracking represents the only form of fertility tracking where the sensemaking process is reliant on the user. The lens amplifies, rather than translates. With the use of magnification, this device allows the user to deduce directly from a saliva sample when they are fertile. This places the user in a different role and relationship to the act of fertility tracking - they have agency in reading their own body. This is represented by the fact that the user must focus the lens themselves in order to sharpen the projection. This is in contrast to the other examples where the information is mediated by the device and is still framed as the expert.



ARTICULATING THE DESIGN BRIEF

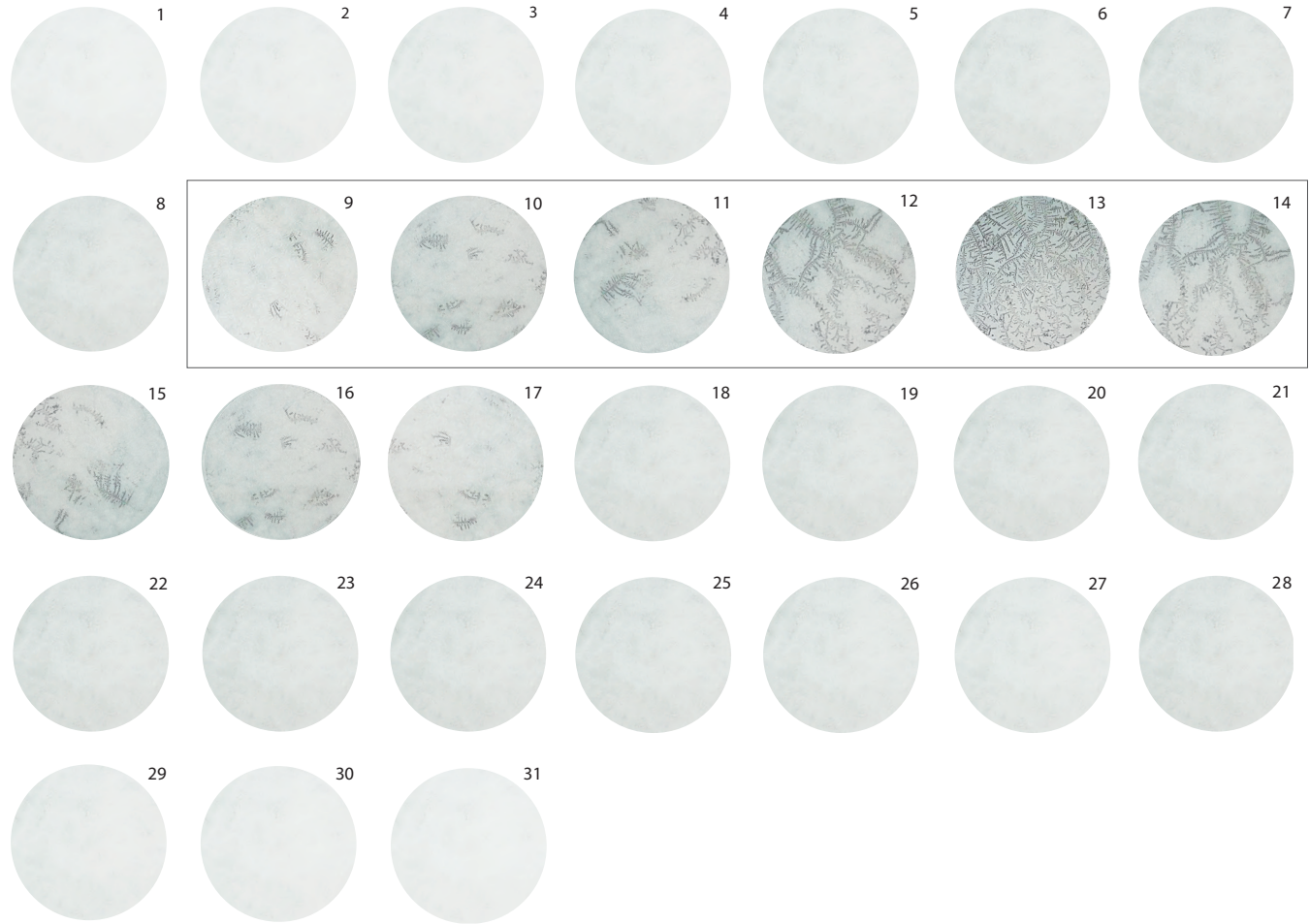
As shown in our analysis above, different experiential qualities are produced through the various methods and devices designed for fertility tracking. From this we draw out some alternative or under-explored qualities in order to frame a design space and design brief for our design.

1. The home is predominantly a shared environment, and particularly in the context of ovulation tracking, since two people are typically involved in the act of conception. From our analysis, we can see that this is not reflected in the design of fertility tracking devices, where the responsibility and labour of tracking is placed upon the partner who will become pregnant. Motivated by this, we bring the shared act of fertility planning into our design space.

2. Since these devices are to be used within the home, and in order to address the clinicalization of fertility tracking through the tools that are employed, we address these devices as distinctly domestic objects. This includes exploring the impact of the materials and form on the aesthetics of the devices within this context.

3. To challenge the expert role played by temperature and urine tracking devices, we expand on the D.I.Y. experience afforded by saliva tracking. The fact that this device provides unmediated access to information about the insides of the body, solely through magnification, removes the relationship between the device and the user as expert and layperson. The user of saliva tracking devices becomes an expert in reading their own samples.

SALIVA SAMPLES OVER THE MENSTRUAL CYCLE



This figure visualises how saliva samples might look over a 30-day menstrual cycle. Day 9-14 shows the fertile period, with ovulation taking place on day 13 when maximum ferning crystals are visible [17]. The fertile window begins approximately 3-5 days before ovulation and continues to a point approximately 1-2 days (oocyte lifespan) after ovulation.

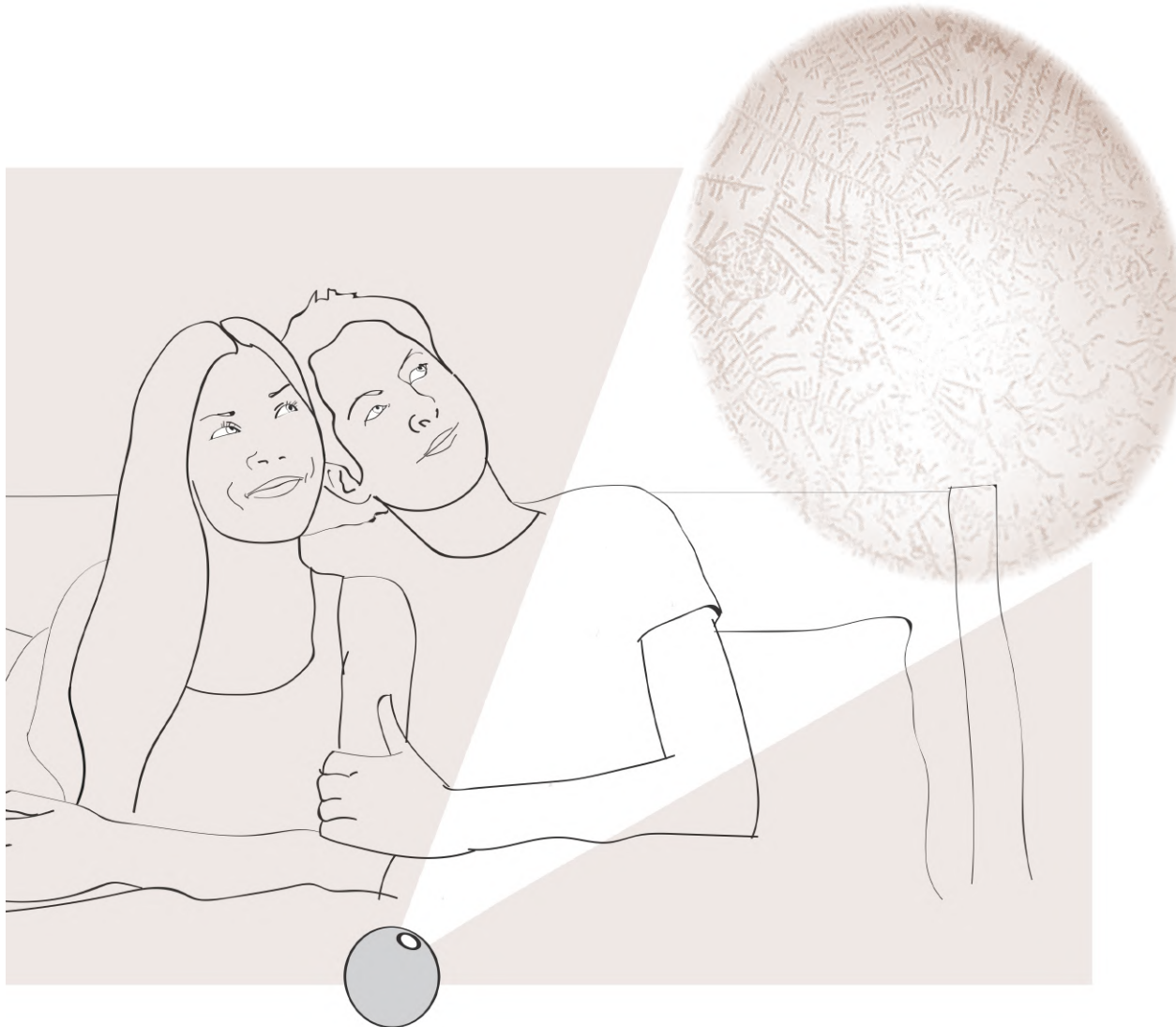
INDIVIDUAL	→	SHARED
CLINICAL	→	DOMESTIC
EXPERT	→	D.I.Y.

DESIGN BRIEF: FROM INDIVIDUAL TO SHARED

In designing for the shared rather than the individual, we address conception as a shared act that includes the emotional, relational and sensual aspects of conception. This is instead of reducing conception to a biological process that is typically the emotional burden of the partner who will become pregnant [3]. We explored how the saliva sample could be visualized beyond peering into a microscope. We found by taking out the lens and

using a very strong LED to shine back through it, the saliva sample could be projected to around 2 metres onto a ceiling or wall. This affords for the process to be shared with others. This projection can be sharpened with the focusing ring to provide a precise image. The fact that the projection requires darkness to be visible puts an interesting constraint on the use of the device. That the projection looks like the moon also brings poetry and

romance to the experience. This is reflected in the use scenario below, which became part of the design brief to communicate the concept to the design team. We acknowledge that heterosexual sex is not the only type of activity that leads to conception. Though this is not shown in the scenario, this method can also be used for tracking ovulation in cases where conception will take place through in vivo insemination.

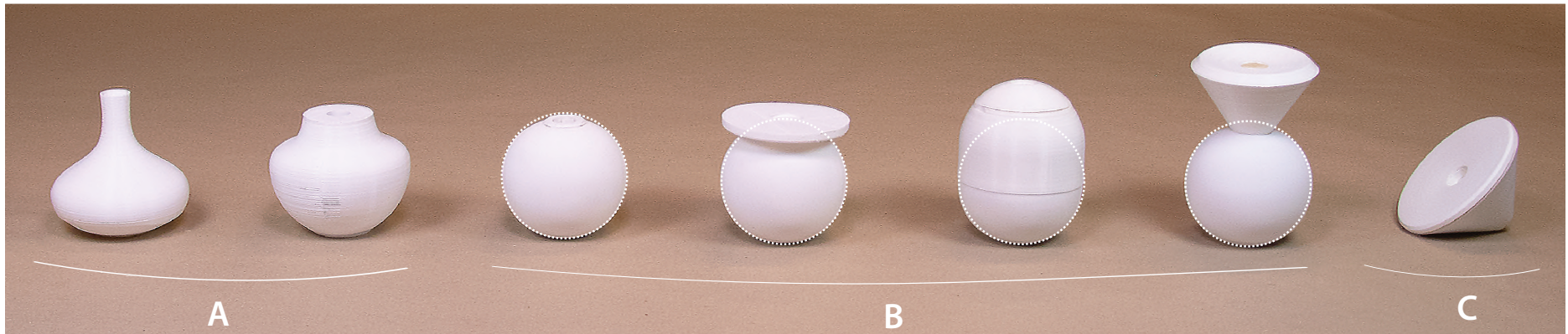


A woman wakes up, and rolls over. She leans sleepily over and picks up the device from her bedside table. She uses the duvet to dust off the glass lens and spits gently onto her index finger. She strokes her saliva onto the lens and places it back down to dry. She sits up and continues on with her day.

It is the end of the day. The woman yawns as she makes her way to the bedroom. Her partner is already in bed. She picks up the device and passes it to him as she gets under the cover. Her partner turns off the bedside light and turns the device on. The woman rolls over and places her head on the man's chest. The ceiling is filled with a constellation of interconnecting crystals. The man places the device back on the night stand as he turns to kiss the woman. He reaches down and gently slides a hand up her thigh.

Afterwards, the man lifts his head, switches the device off, and lies back down. He wraps his arms around the woman as they fall asleep.

DESIGN BRIEF: FROM CLINICAL TO DOMESTIC



A - Home Ware Inspired

To begin unpacking a domestic rather than clinical aesthetic, we sketched and 3d printed rounder prototypes inspired by Scandinavian home ware such as vases and pots. This was in order to contrast the lipstick disguise of the commercial devices that were designed to be secreted away in handbags and are clearly heavily gendered towards the female user. In following the brief of shared versus individual and domestic versus clinical, and since saliva testing devices do not need to be used in the bathroom, we wanted to create something that wouldn't look out of place on the bedroom night stand. However, on reflection, these forms seemed like an attempt to disguise the device as a vase, thereby possibly re-enforcing taboos around fertility tracking as something to be concealed.

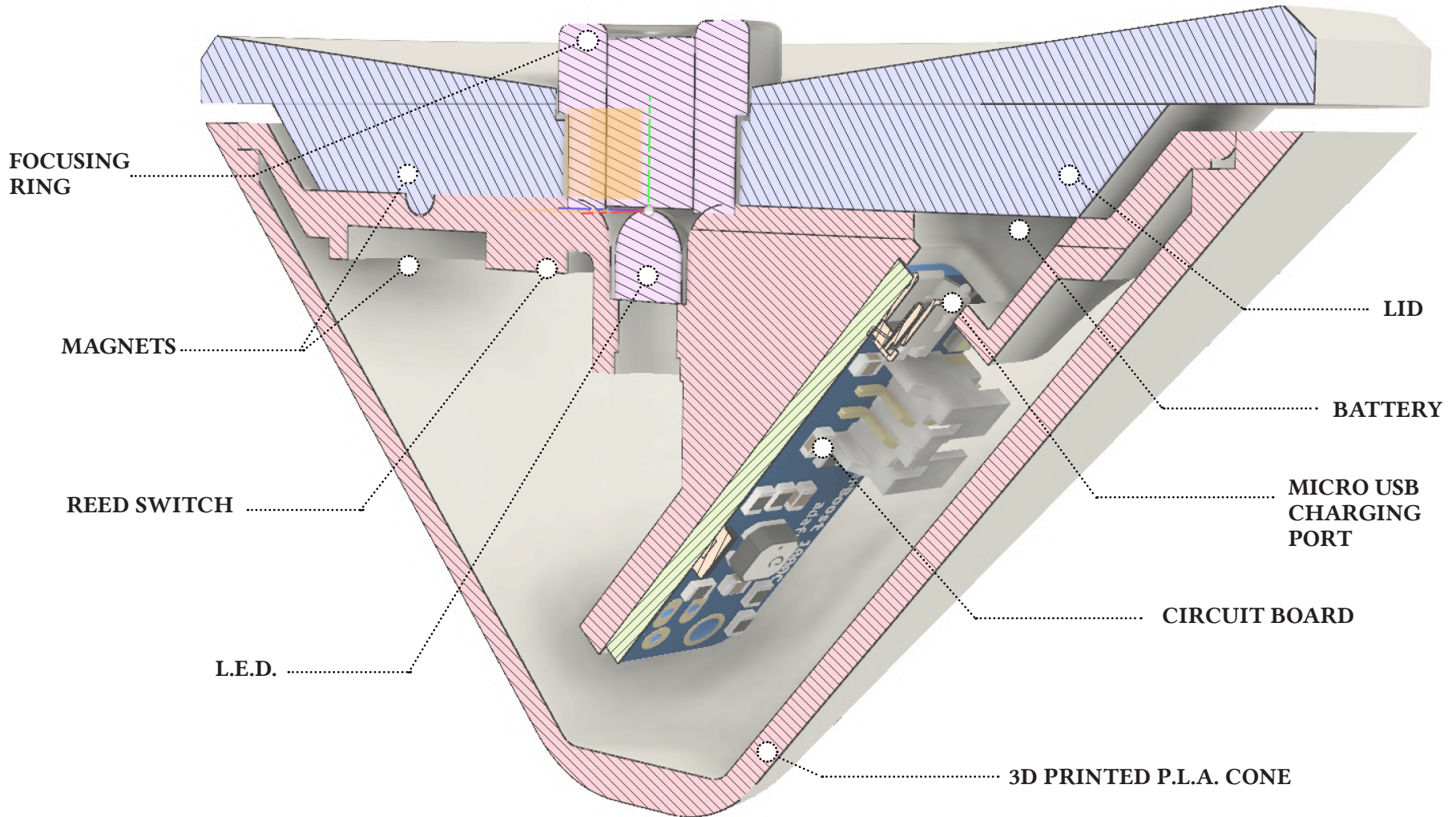
B - Ceramic Sphere Base

Here we introduced a ready-made ceramic sphere that allowed us to expand on the domestic theme. Ceramic gave a different feel through the texture, weight and warmth of the material. This went beyond 3d printed plastics. Ready-made objects were a convenient way to explore ceramics as we did not have easy access to a ceramic studio. This was also where we implemented the magnet-enabled reed switch that allowed the top part of the device to act as both the switch for the LED, as well as the place where the user deposits their saliva sample. We played with adding different 3D printed forms which held the electronic components. Once we had moved away from vase-like shapes, our designs were increasingly inspired by images of satellites and telescopes. We felt that these were in harmony with the moon-like projected image.

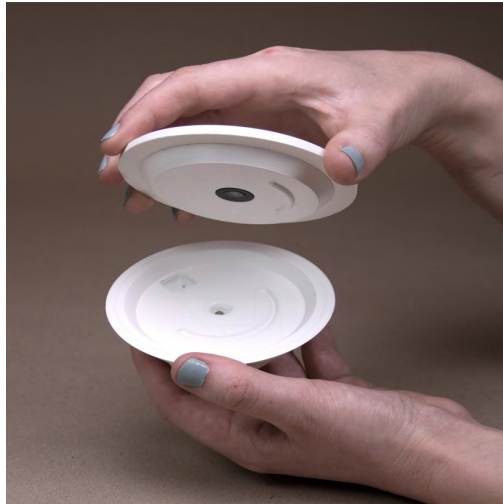
C - A Serendipitous Rolling Cone

The cone placed in the sphere was intended to complement the upwards movement of the projection. However, in order to fit the internal components, the cone became too large and the overall form off balance. We serendipitously removed the top and decided it had a stronger quality as a stand alone object without the round ceramic sphere. The cone on its own felt compact and dynamic. The fact that it does not stand vertically and instead rolls around gives it its own movement and expression. The device demands to be held in order to steady the projection of the saliva sample. We were interested in the fact that this seemed to invite an active rather than passive relationship between the user and the device.

ASSEMBLY



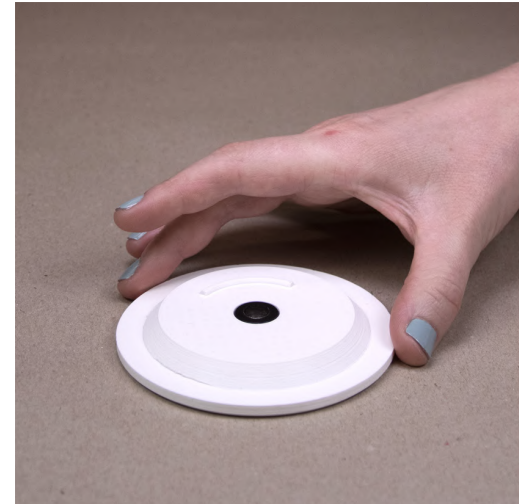
HOW TO USE THE DEVICE



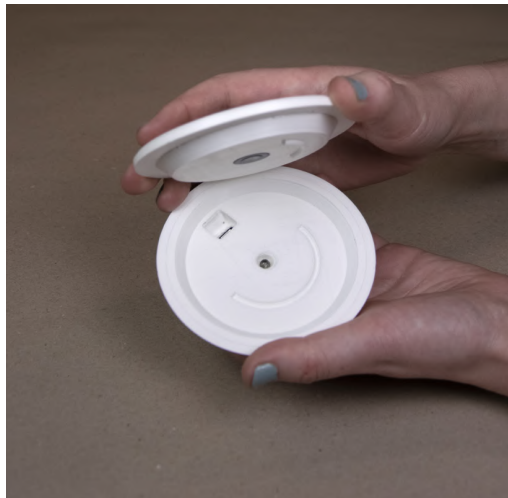
Remove the lid and turn it over.



With the tip of your finger apply a drop of saliva that covers the glass surface.



Leave to dry for at least 10 minutes.



Replace the lid.



Once it's dark, find a flat, preferably white surface to project onto, such as a ceiling.



Twist the lid to turn on the light. Use the focusing ring to sharpen the image.

COMMISSIONING A CERAMICIST

Despite appreciating the qualities of the rolling cone prototype, we wanted to bring back the ceramic element that we had lost once we had removed the spherical base. We missed the weight, warmth and texture of ceramic in comparison with the 3d printed plastic cone, so we commissioned a ceramicist to remake the conical form in ceramic. Because we still needed the measurements to be accurate to fit the electronic components, the lid and inside supports would remain 3d printed in P.L.A. Collaborating with crafts-people that have expertise outside the realm of interaction design allows for new possibilities of forms and materialities [20]. Spending time in the ceramicist's studio allowed us to

understand what forms and finishes were possible. This included choosing the glazes and finishes by looking at other examples to know what kind of aesthetic, texture and thickness we wanted.

The constraints given to the ceramicist included the fact that we wanted: a shape that would not stand still vertically; the basic concept of the conical shape; and the diameter of the top of the cone that would be connecting with the 3d printing part. Other than that, and because it was an unpredictable shape to throw by hand and fire in the kiln, we left the overall form up to the ceramicist to experiment with. This resulted in a rounder shape than we had imagined, but we also appreciated the

qualities of this version, which still gave some movement and expression. The rounded form and instability still invited for the object to be held, and even felt more suitable to be cupped in the hand than the previous conical version.

The ceramicist helped us decide what glaze to apply. This could significantly change the look and feel of the object. The most organic glaze spoke to us as being most appropriate for an object that would live in the bedroom; we discussed how other glazes looked more suitable for kitchenware. The fact that the glaze also let the gritty texture of the clay come through also gave an interesting contrast to the smoother 3d printed PLA.



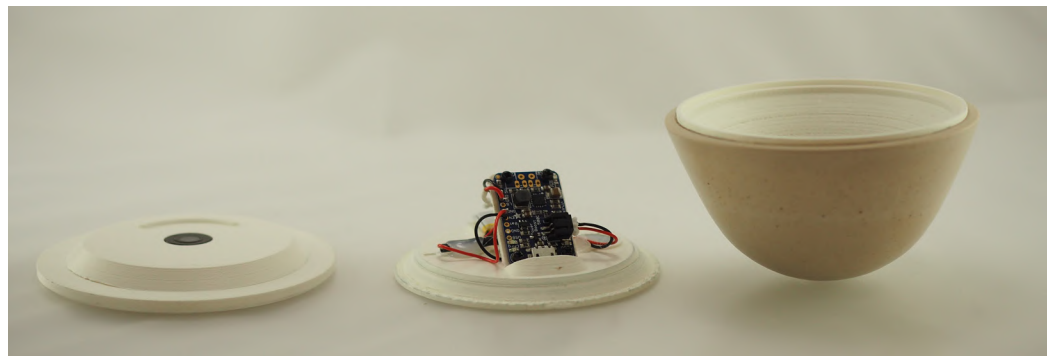
Trying out different glazes that would suit the P.L.A.



The finished domes cooling after being fired in the kiln.



Testing the fit of the domes and the 3d printed parts





OVUM AS A RESEARCH PRODUCT

Our intention is to carry out a long-term qualitative study which will see the finished device deployed in the homes of couples trying to get pregnant. Odom et al. discuss how long-term studies require the development of research products, rather than research prototypes [15]. Four interrelated qualities define research products; finish, fit, independent, and the fact that they are inquiry driven. Considering in what ways Ovum represents a research product can help us articulate qualities of Ovum and how it facilitates the subsequent qualitative study.

Independent

Since research products will be deployed in participants' homes for long stretches of time, they must be able to be used independently, without the intervention of a researcher. This is reflected in the sturdy design of the object, something that was particularly worked upon by the industrial designer. Ovum can be used over and over again



with no wear on the device. The fact that Ovum is rechargeable by using a micro-USB cable also means that it can be easily maintained by the participants independently.

We see an important aspect of independence as also being in the way Ovum is presented to our participants. The packaging includes a leaflet that provides a full explanation and instructions for use. The packaging is designed with the aim of being able to post it to our participants without having to provide further information. We included simple instructions and diagrams and tested these to ensure they were clear and effective.

Finish

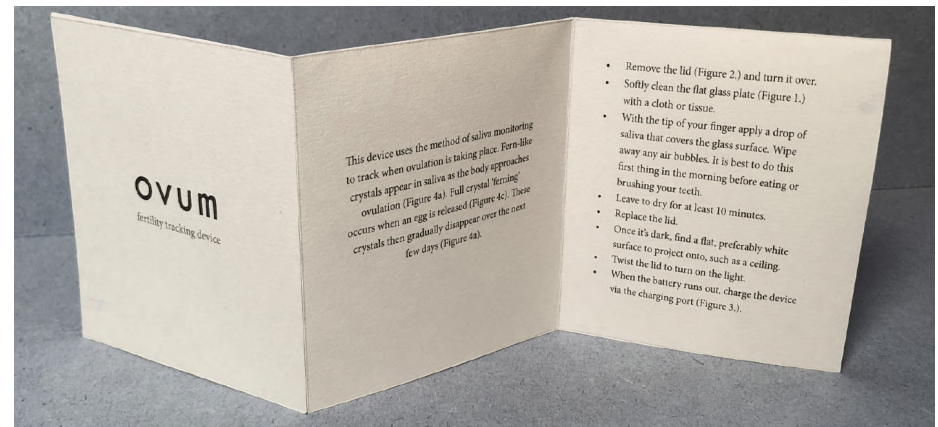
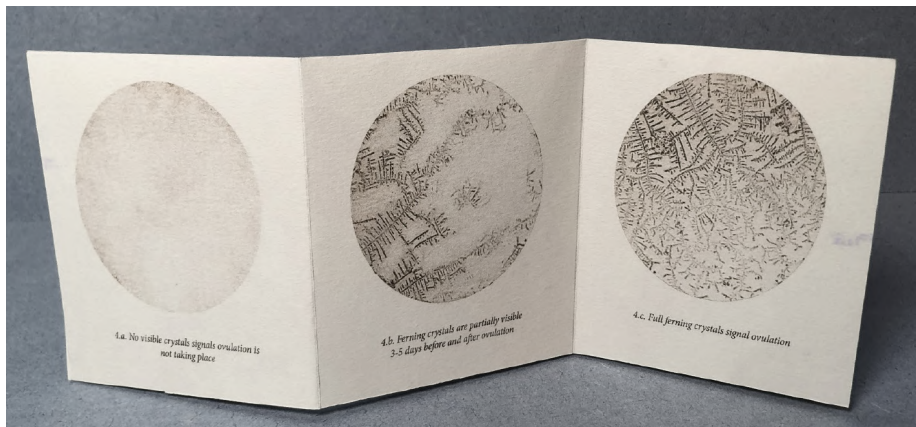
The finish of a research product allows users to focus on what the object already is, rather than what it might become. This demands that research products have a higher quality of finish than research prototypes. Having an industrial designer on our research team facilitated this; Ovum was designed to look and feel like a commercial product. We



also took time in designing the logo and packaging and explanatory leaflet as if it were an off-the-shelf device. Since saliva tracking is not a well known method of fertility tracking, we were motivated to produce a research product that felt credible and reliable in order to give our participants confidence in the unfamiliar process. In other words, we hoped that giving credibility and familiarity to the object in our participants' hands would give users trust in the unfamiliar method of saliva tracking.

Fit

The fit of a research product refers to how well it balances being a device that is not too strange, nor too familiar, for participants to reflect on. The fit of the product was something we addressed by including non-essential aspects such as the micro USB charging port. This gives the device a more commercial feel that resembles rechargeable devices that we use in our everyday lives, such as portable speakers and electronic toothbrushes. The ceramic components of Ovum also help the device fit into the home



setting, whilst still being unfamiliar enough as a fertility tracking device to provoke reactions from our participants.

Inquiry driven

Ovum is fundamentally an inquiry driven object since it is designed as the vehicle for exploration of a defined area of research. In this case, we use the deployment of Ovum to investigate how self-tracking devices shape both the lived experience of the body, and societal conceptions of the body. During our long-term study, we will collect participants' experience of fertility tracking with Ovum over a three month long period. These experiences will reflect on how the experiential qualities that we worked with within our design brief translate into the lived experience of using Ovum. For example, whether the participants' current roles during fertility tracking are affected by having the saliva sample projected, or how having a real-time, D.I.Y. reading of fertility shapes users' understanding of themselves in reading the body.

CONCLUSION

The main contribution of this pictorial is the framing of the design space around at-home ovulation tracking devices and the presentation of our approach to this design space through working with oppositional experiential qualities. This approach could be applied to other self-tracking domains that are highly medicalized. The

research product Ovum is an exemplar of this process. By working in opposition to the experiential qualities facilitated by current at-home fertility tracking devices, we have produced a device that re-configures the act of fertility tracking. Ovum points to the fact that at-home testing devices are embedded within, and consequently impact on, the complex social contexts of our own homes and relationships. Ovum is designed as a result of framing fertility tracking as a D.I.Y., domestic, and shared rather than an expert-led, clinical and individual experience. How these oppositional experiential qualities translate into the lived experience is the focus of a subsequent long-term, qualitative study with couples trying to conceive.

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Paper 6.

Homewood, S., Boer, L., Vallgård, A.

Designers in White Coats: Deploying Ovum, a Fertility
Tracking Device.

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Designers in White Coats: Deploying Ovum, a Fertility Tracking Device

Sarah Homewood

IT University of Copenhagen
Copenhagen, Denmark
shom@itu.dk

Laurens Boer

IT University of Copenhagen
Copenhagen, Denmark
laub@itu.dk

Anna Vallgård

IT University of Copenhagen
Copenhagen, Denmark
akav@itu.dk

ABSTRACT

As self-tracking practices continue to proliferate, there has been a call for a consideration of how the design of these devices influence the users experience of themselves and their bodies beyond utility, efficacy and accuracy. The research product Ovum was designed to facilitate a DIY, shared, domestic experience, rather than an expert-led, individual, clinical experience of fertility tracking. Ovum uses the method of saliva sampling to determine ovulation. This paper unpacks the findings from a three-month long deployment of Ovum with seven couples trying to conceive. Besides an evaluation of the device in terms of the three experiential qualities aimed for in the design process, we report on the consequences of executing a design deployment that resembles a clinical trial. We contribute our experience in order to develop an understanding of how designing for the body places interaction designers in novel and complex situations.

Author Keywords

Self-Tracking; Ovulation; Women's Health; Research through Design; Menstrual Cycles; Fertility;

CSS Concepts

• **Human-centered computing~Interaction design~Interaction design process and methods**

INTRODUCTION

With a proliferation of self-tracking practices, there has been a call for a consideration in terms of how the design of these devices influence users' experience of themselves and their bodies beyond utility, efficacy and accuracy [30, 41, 45]. HCI researchers can support the trial of medical devices to understand core everyday use issues and improve their design [37]. Interaction design, and particularly research through design, has been increasingly employed within HCI to offer alternative designs of devices that track and interact with the insides of the body. These include critical and speculative imaginings of new futures of self-tracking devices [19, 27, 49]; to explore alternative

visualizations of physiological data beyond the screen [17, 25, 31]; to design an inclusive experience of tracking ambiguous and enigmatic diseases [4, 5, 35]; and to allow users to design their own self-tracking systems in order to make sense of their own data [1].

Fertility tracking has been a topic increasingly present within the field of self-tracking within HCI [9, 12, 22, 28, 48]. Fertility tracking is used to determine when the egg is released from the ovaries and can be done with the aim of conception or contraception. The two most common methods for fertility tracking are: urine testing for a rise in the luteinizing hormone that occurs 24-36 hours before ovulation, and temperature tracking which algorithmic methods to predict fertility using the sharp rise in basal body temperature after ovulation. If the user has a regular menstrual cycle, they can use this rise in temperature to predict the date of the next ovulation. The laborious nature of having to track temperature daily has resulted in the design and marketing of a range of wearable Bluetooth connected thermometers that automatically sync their data with apps such [3, 53]. Digital and connected urine testing devices such as [10, 13] are marketed to negate ambiguity in reading the results of paper urine testing sticks. These devices show a smiley face on a small digital screen integrated within the device when the results show that the user is fertile.

We previously designed Ovum, a fertility tracking device designed to aid conception, rather than to be used for contraception. More information about this process has been reported in a previous publication [21]. Fertility tracking has been shown to be a complex, emotional and highly personalized act [12]. Rather than only designing for utility, efficacy and accuracy, we want to understand how the ways that self-tracking devices are designed shape users' experience of this complex act. We wanted to understand what would result from using oppositional qualities in the design of self-tracking devices. We expanded the design space around self-tracking through challenging current designs of self-tracking devices. Ovum is the result of a research through design process where we attempted to design for fertility tracking as a DIY, shared, domestic experience, rather than an expert-led, individual, clinical experience. This paper reports on the next stage of this research project; the results of a three-month long deployment of the research product, Ovum, with 7 couples attempting to conceive. We first present the design and why

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and how it uses the fertility tracking method of saliva tracking. We then present our findings in terms of how the experiential qualities we intended towards in the design process translated into the lived experience of our participants. Our discussion reflects on our findings and how the results produced by Ovum throughout the study produced a situation where our participants understood the study as a clinical trial rather than a design deployment; despite our efforts, our participants saw us as designers in white coats. We contribute our experience in order to develop understanding of how designing for the body places interaction designers in novel and complex roles and situations.

OVUM

We will now briefly present the research product Ovum and the method of saliva tracking in order to provide background to the study.

Saliva Tracking

Ovum uses saliva tracking as the method for testing for ovulation. Saliva tracking is ideally done first thing in the morning or at least two hours after eating or brushing teeth in order to avoid contamination of the saliva sample. A drop of saliva is placed on a glass plate and left to dry for at least 10 minutes. Levels of estrogen and adrenocorticotropic hormone increase before ovulation and this stimulates the release of aldosterone. This hormone increases the salt levels in saliva. It is this crystallization of the increased levels of salts in the body fluids that cause ferning pattern visible under a microscope (Figure 1.) [2]. These ferning crystals appear 3-5 days before ovulation (Figure 1b.) and increase as ovulation occurs (Figure 1c.) before disappearing 1-2 days after (Figure 1a.).



Figure 1. Saliva samples during the menstrual cycle. 1a shows before and after the fertile period, 1b display approaching ovulation and 1c shows ovulation.

The history of saliva tracking can be traced back to 1969 when salt crystallization in 1000 women was found to correlate with the fertile period of the menstrual cycle [15, 51]. Salivatory tracking has been found to ascertain a woman's fertile period with a success rate from 86.5% [44] to 90% [15]. However, [7] found this method to be inaccurate; ferning patterns were found in saliva samples of two women during infertile phases of their cycles, and in samples taken from men, pregnant women, and babies. On the U.S. Food and Drug Administration (FDA) site for saliva tracking, it is stated that *"This test may not work well for you. Some of the reasons are; not all women fern; you may not be able to see the fern; women who fern on some days of their*

fertile period, don't necessarily fern on all of their fertile days" [43]. Despite this, commercial saliva tracking devices such as Ovatel report that they have FDA approval "with 98% accuracy" [42].

Saliva tracking previously took place in a doctor's surgery with medical grade microscopes, before mini-microscopes such as [14, 34, 42] began being marketed for at-home use in the late 1980s [11]. These mini-microscopes have been found to be equally effective as clinical apparatus in gauging the presence of ferning crystals [51]. Mini-microscopes are lipstick sized devices that include a small lens with a glass plate beneath it and a focusing ring to manipulate and focus the lens. At the bottom of the tube is an LED light. The lens is lifted out of the device, a drop of saliva is placed on the glass plate and replaced. After the saliva sample has dried it can be inspected through peering into the lens and turning on the LED. This allows the sample to be inspected for crystallization.

Salivatory tracking is recommended for fertility tracking with the aim of conception, rather than contraception. This is because sperm can survive up to 7 days inside the vagina after being ejaculated. Ferning begins to occur 3-5 days before ovulation. Therefore, even if the last instance of sexual intercourse took place before the ferning crystals appeared, sperm might still be alive and able to fertilize the egg as it is released from the ovaries.

The method of tracking ovulation through saliva has recently entered into the HCI domain due to the possibility of integrating artificial intelligence into the process of reading the saliva sample e.g. [26, 56]. Cameras and image processing methods can be used to recognize the density of salt crystals present in the saliva sample. This is used to predict in how many days ovulation will occur.

Designing for a D.I.Y., Shared and Domestic Experience

As reported in [21], our aim was to open up and expand the design space around fertility tracking through designing for more than utility, efficacy and accuracy. Our research group comprised of two interaction designers and one industrial designer and our study was guided by and adhered to our university's research standards. We will now present our design decisions that resulted in the Ovum device.

D.I.Y.

As mentioned, the most common methods for determining fertility are urine testing and basal body temperature tracking. Despite the fact that these devices are marketed for their apparent clarity of results, it appears that ambiguity is a common factor in fertility tracking, across all the different methods [54]. For example, although urine testing devices are advertised as having a 99% accuracy rate [13], users of urine tracking methods use forums to post photos of their testing strips in order to crowd source opinions about what they display. [48] directly designed for uncertainty within temperature tracking of ovulation through showing percentages of certainty with the predictions of ovulation.

This was in order to investigate the implications of avoiding an unrealistically accurate depiction of the menstrual cycle.

We felt that the method of salivatory tracking accounts for ambiguity in fertility tracking through allowing the user to draw their own conclusions from the data. Rather than presenting the body as fitting into distinct diagnoses of “fertile” or “not fertile”, saliva tracking allows for a more flexible and idiosyncratic depiction of fertility over the menstrual cycle. We therefore chose it as the ovulation tracking method we would design around. Our intention was to use interaction design methods to re-design existing mini-microscopes used for saliva tracking. The saliva tracking method that we would employ is precisely the same as used by mini-microscopes. i.e. using a 60X magnifying lens to inspect saliva samples.

Saliva tracking demands that the user analyze their own sample for ferning crystals in order to draw their own conclusions as to their fertile state. The results are not mediated by the device. This is with the exception of the saliva tracking devices mentioned previously that include cameras and image processing to computationally evaluate the saliva sample and transmit the results to the user. Salivatory tracking places the user in a different role and relationship to their data - they gain agency and expertise in reading their own fertile state.



Figure 2. Ovum projecting the saliva sample onto the ceiling.

Shared

In designing for more than utility, efficacy and accuracy, we considered the social context that the device would be used within. Though it is possible for individuals to conceive alone through insemination, it is typically a process that involves two people and we design specifically for these cases. Rather than peering into a microscope, Ovum was designed to project a 60X magnified silhouette of the saliva sample out into the room. The user removes the top disc of the device, places their saliva sample on a small glass plate, waits for it to dry then replaces the disc and turns it into place to turn on the LED. The light from the LED then shines back through the lens a projects a silhouette of the saliva sample to a size of 2 meters onto the ceiling or wall.

Making the sample large and present in the room for more than one person to appraise was a decision based on our desire to trouble the fact that ovulation testing devices were found to be marketed solely to the partner who would be carrying the baby [54]. This risks reinforcing societal expectations that, from the very moment of conception, the burden of care of the child is the responsibility of the partner that will become pregnant [33]. We aimed to propose a shared act of fertility tracking, which would share the experience of childcare, right from the very first instance of the planning and preparation for conception.

Domestic

We found the design of fertility tracking devices to replicate either medical devices, or in the case of mini-microscopes, lipsticks in order to disguise the fact they are related to fertility tracking. Our design process was focused on understanding what factors play into the experience of self-tracking and how these factors could better be reflected in the design of the self-tracking devices. Since ovulation tracking is typically done in the home, the design of Ovum draws from homeware objects such as vases and ornaments in its form and materiality. We commissioned a ceramicist to create a ceramic base for the device that gives it a heavier weight than other fertility tracking devices. The rounded base invites for an intimate interaction with the device as it demands to be held in order to keep the projection steady (Figure 3.).



Figure 3. Ovum being turned on by rotating the top disc.

DEPLOYING OVUM

Ovum was deployed for three-months with 7 couples trying to conceive. The aim of our study was to understand how the oppositional experiential qualities that Ovum was designed with would translate into the lived experience of users. We did not carry out our design process with the expectation that our design intentions would translate accurately into actual use. Though designers are aware of their inability to design or dictate how objects are used and what experience they provide, it is an essential part of the design process to follow some imagined notion of a user in a certain context having a certain experience [46]. Hallnäs and Redström propose that designers consider how objects are “present” in the lives of users through designing with an awareness that objects are

the bearer of certain expressions [18]. We believed that putting Ovum to actual use through long-term deployments might help us gain an understanding of the implications of our use of oppositional experiential qualities within the design of fertility tracking devices.

We designed packaging for the device that resembled a commercial device in quality and durability (Figure 4.). The instructional pamphlet that accompanied the device was also designed so that Ovum could be used out-of-the-box, without an onboarding process, though we did go through the instructions with participants during the initial interview (Figure 5). Producing a research product with a high level of finish, rather than a lo-fi speculative prototype, was driven by a desire to allow our participants to reflect on how Ovum compares with other commercial examples [21, 39].



Figure 4. An unboxing of Ovum.

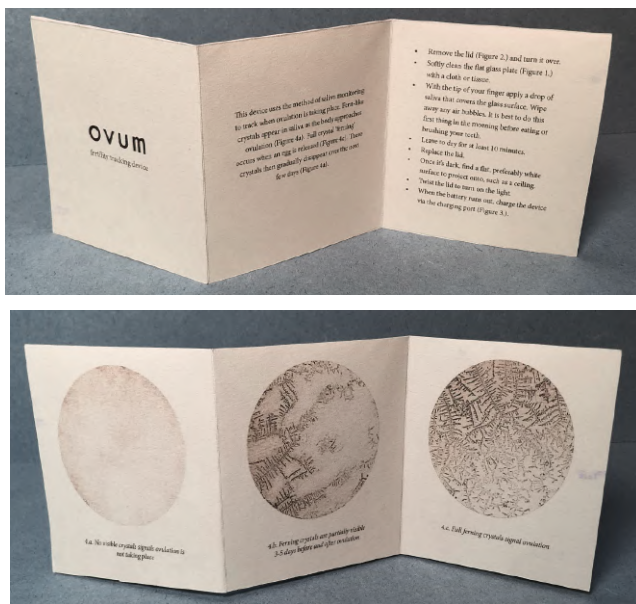


Figure 5. The pamphlet accompanying Ovum giving a short explanation and instructions for use.

Recruiting Participants

We used posts on social media sites to recruit participants. Our criteria for participants was that they were a couple who were attempting to conceive. Prospective participants were given a questionnaire to fill in their ages, how long they had been attempting to conceive, what fertility tracking methods they had used, and why they wanted to participate in the study. We then used this information to select 9 couples from

the 22 questionnaires we received to participate in the full study.

Participants were selected based on the fact that they had not been attempting to conceive for more than 10 months. This was to avoid cases where fertility might be an issue warranting further medical intervention, or where fertility might be very emotional due to them having experienced long periods of failing to conceive. All participants were living in Sweden. All were cis-gendered, heterosexual couples, though we did not choose participants based upon these criteria. Ages of participants ranged from 23 to 43.

Ethical Considerations: Getting Informed Consent

A number of steps were taken in order to ensure that we obtained informed consent from our participants. All participants were explicitly informed that they would be part of an interaction design study, rather than a clinical trial on the method of saliva tracking. None of the participants had previously heard of or used the method of saliva tracking. An information sheet about the method of saliva tracking was provided before the study began that referenced medical science articles outlining previous studies investigating the efficacy of the method, e.g. [7, 43, 44, 47]. Participants were also informed that this is a method that has been shown to be ineffective for a percentage of bodies and that it was not 100% accurate at predicting fertility. It was clearly stated to participants that being part of this study would not guarantee conception. All participants understood that they could leave the study at any time. All participants were able to continue with existing fertility tracking practices throughout the study.

Drop-Outs and Pregnancies

Out of the 9 couples we selected from the questionnaires, two left the study just before it began due to pregnancy. Out of the seven couples remaining, three dropped out within one month of the deployment beginning; one due to pregnancy (P7), one due to the fact that *“(trying to conceive) has been very emotionally punishing in the last months”* (P5), and one because of an unexplained *“change in circumstances”* (P3). Emails asking for follow up interviews were unanswered by all participants. Earlier email correspondences and data from the initial interview with these three couples will be included in this paper.

Research Design

Interviews took place via video call or telephone. 25-60 minute-long, semi-structured interviews took place with each couple at three different intervals; firstly, when participants had initially received the device in the post, secondly, at the end of the first month, and finally, at the end of the third month. An email correspondence took place throughout the study between the first author and participants in order to arrange interviews and to answer any additional concerns or questions. Both members of the couple were present at every interview, though correspondences were always between the first author and the female member of the couple.

We used thematic analysis to categorize and draw findings from our raw data. Analysis of the data was an ongoing process. Interviews were transcribed directly after they took place throughout the study and were used to inform the questions asked in the following sessions. For example, following up on statements and probing themes surfaced in the previous interviews. The following themes developed over the study and were used in a final coding of all raw data. Thematic analysis is a method widely used within design research within HCI, e.g. [35, 40, 48]. Thematic analysis can both draw out the details of the phenomenological experience of participants from an essentialist perspective, but also allows the researcher to surface why the participant says what they are saying from a constructivist approach; *“thematic analysis can be a method which works both to reflect reality, and to unpick or unravel the surface of ‘reality’”* [8; 9]. We wanted to understand the details of our participant’s lived experience of Ovum in terms of how the experiential qualities had translated into actual experience, but also uncover wider implications and influencing factors on their experience, including cultural and societal factors.

FINDINGS

As outlined above, we analyzed the results of the deployment of Ovum in terms of the themes arising over the interviews and the three experiential qualities aimed for in the design of Ovum. Through our qualitative research, we understood that there were a number of mismatches between the qualities that we were designing for, and how Ovum actually became part of our participants’ lifeworld. These mismatches not only highlight our assumptions as designers, but also how fertility tracking is actually carried out and aspects of fertility tracking that are shaped by other external factors, beyond the scope of the design of the device. PX refers to the participant couples. “A” refers to the female member of the couple and “B” refers to the male member of the couple.

Domestic

The ceramic and rounded design of Ovum proposes different designs for fertility tracking devices beyond clinical aesthetics, pure functionality and hard plastics. Ovum’s aesthetics were discussed in our interviews from a few different perspectives.

Initial Reactions

Initial reactions to the device upon its arrival included; *“It feels Scandinavian. It’s a clean and nice. I like it.”* (P2A), *“it’s also nice to have on your nightstand without it not looking good, it looks like a decoration piece”* (P2A), *“But I love the design... It’s just very cute. It’s like a home decoration piece in a way. It also looks like it’s something that I want to keep because it looks so nice”* (P6A). The fact that Ovum was designed to resemble homeware rather than a clinical device resulted in the device being camouflaged in the home; *“it’s very discreet. I don’t think anyone would know what it was.”* (P4A).

A Soft Science Project

P6 had a turbulent journey in terms of their experience of the design of Ovum. During the second interview, one month after using the device P6A told us; *“It also looks like it’s, I don’t know how to explain but it’s like it’s a science project thing. It’s like it can do this amazing thing blowing up stuff in the ceiling, but it still looks very chic ... In Swedish we have this saying, it’s like ‘mjuka värden’. It’s like soft values... it’s more like a soft science project in a way. I don’t know how to explain it. It’s a softer way of doing it, and how it looks adds on to that feeling”*.

However, when asked to further elaborate on what about Ovum offered these “soft values”, P6A altered her opinion; *“I think maybe it’s because I am doing the other tracking thing as well. If I was just doing this it would be much more pressure on that, on this device like this is the device to give me the answer”*. P6A later commented; *“Maybe this, the design of it wears off after a while. I’m still pretty new to it. I still think it’s like super cute. If I’ve been tracking it for like half a year maybe I would see it differently because then it would be more like something I have to do”*. P6A then went on to describe critically how this method required more effort than temperature tracking.

Two months later, during the final interview, we asked P6A for her final opinions about the “soft values” that Ovum offered; *“Yeah I actually changed my opinion. Because what I liked about it was like yeah how it looked. Now I think it’s a bit more clumsy. Because I don’t really know how to store it... Yeah and it’s also too heavy. What I first like enjoyed about it was that it was like a sculpture. Now it’s more like ‘OK. This is not so handy.’ And if I want to travel this is like too much to bring with me. Also, because I looked at other devices since we talked and see like more smaller things that looks a bit easier to get around... Now that I have had it for a while. So, the first, yeah, honeymoon phase is over. Now I just want it to be like what it is supposed to be.”* (P6A).

Shared

We designed Ovum with the aim of facilitating shared experiences between our participants. This was through projecting the saliva sample out into the room. Participants were not directed to use the device together, but we did ask about their distinct roles in fertility tracking during the interviews.

Collaborative Acts

From our findings, we can see that a number of factors led to fertility tracking being a collaborative act. These factors included the fact that the emails and interviews included both members of the couple (P1). The fact that the saliva sample was projected appeared to facilitate a shared experience for some participants as they wanted to share the “cool” (P4A), or “beautiful” (P6A) image of the projected saliva sample when crystals were visible. A key factor that led to a shared experience was the fact that Ovum gave ambiguous results. The primary user would ask their partner in order to gain a

second opinion on whether crystals were visible or not (P1, P2, P4, P6).

P1 were the participants with the most active collaborative involvement. For example, P1B set a calendar reminder each morning to remind P1A to use Ovum, and during the first cycle was often the first one to look at the projection since P1A would take a saliva sample and then leave for work. Collaborative acts were less present for P2, P4 and P6, though all described both looking at the projection at one time or another over the study. For P1B, collaborating in the tracking process represented support in terms of their relationship; *"From my perspective the only thing I can do to be supportive is just to be that coach, like remind, you know... I think some- sometimes I feel like, when she's going on with all this stuff. There's not so much I can do. But I have a little part. I have a little part and that little part is important."* (P1B).

For P1A, participating in the study resulted in broader reflections on gender roles in fertility tracking; *"if I would rewind history I would do it earlier, I would take this conversation about how can we both be a part of this earlier. Like this is our journey together. I just thought that it was my responsibility. But it isn't! To check it out and to have control over it and it's my cycle and I have to know. But I don't have to, we, we can do it together."* (P1A).

Uncollaborative Acts

A range of causes behind a lack of collaboration arose through the interviews. The most common reason for uncollaborative tracking was conflicting schedules (P1, P2, P4, P6). The male partners would either wake up before or after the female partners and this would mean that they were not present for the tracking process.

P1A felt there was limit to P1B's involvement because it was her body that was the focus of the tracking. This perspective was also voiced by P2A; *"It's usually the women that needs to handle a lot of the things in their bodies. I'm just carrying everything as we're working a lot with my body. I think that it's like imbalance in my body or it's just not having been the right time or the right connection and so I'm just trying to learn about my body"*. This represents how, although P2 are not sure about the reason they have not yet become pregnant, P2A feels she is still taking responsibility through gaining body literacy. P2A later described how she felt that P2B was collaborating in the attempt to become pregnant by eating healthily and keeping up an active lifestyle rather than participating in the act of fertility tracking itself.

P4B's comments reflect his understanding of fertility tracking as a private act, and that it would be a violation of this privacy for the partner doing the testing to share the information with the partner. When asked about his role in their previous experience of urine tracking, he said; *"She showed me once, but we still have a few personal things (laugh), which is to say that she doesn't show me everything"* (P4B). Our conversation with P4 about their roles in their

fertility tracking practices led to P4A voicing a sense of responsibility for not involving P4B; *"I don't know if I think you'd be super interested. I think you want to know if I'm ovulating... So maybe I'm not very good at including him, more than you not being a part of it"* (P4A).

D.I.Y.

The Do It Yourself (D.I.Y.) aspect of the method of saliva tracking was the reason that we initially chose the method for our design. In contrast to other methods, there is no diagnostic process in the testing procedure, only magnification; users are forced to use their own judgement in reading what the information means.

Initial Optimism

Initial reactions from participants after receiving the device were that it was *"easy"* (P1A, P2A, P6A), *"clear"* (P2A, P6A), and *"user friendly"* (P4A). These opinions refer both to interactions with the device and with the method of saliva tracking. It quickly became evident to us that we could not easily separate these two aspects of the device. Since saliva tracking is not a well-known or experienced method of fertility tracking, reactions to it were strong and in fact were the major topic of our interviews.

P1A, P2A and P4A described the benefit of being able to test when in any physiological state and at any time. This is with the restriction of not using the device until two hours after eating or brushing teeth. These statements related to the fact that they had all previously used basal body temperature tracking, which must be done as soon as the user wakes to reach the lowest body temperature possible, and temperature tracking cannot be used when the user is sick, hungover, or has slept for less than 6 hours since these factors affect the temperature of the body. P2A also pointed out how urine tracking also restricts the user from urinating up to four hours before testing in order to strengthen the urine sample.

Initial reactions also reflected the fact that the saliva tracking method reflects hormonal changes in real time; *"The crystals build up, it's giving you more information than the LH surge which is maybe a shorter timeframe and you maybe you miss your ovulation so in that way it's good and easier to use also."* (P2A). This is in contrast to basal body temperature tracking which only shows when the egg has been released, and urine tracking, which only shows the hormone surge 24-36 hours before the egg is released. Saliva tracking provides a longer depiction of the fertile window.

Erratic Results

Initial perceptions of the device changed over the three-month study. This was due to the fact that the method of salivatory tracking proved to give inconsistent results for all participants at one time or another. All but one participant (P1) that completed the full three-month study did experience Ovum to function as expected for at least one menstrual cycle. P7 also appeared to achieve the predicted results, but since they became pregnant during that first cycle, we cannot know if the subsequent cycles would have

followed this pattern. However, during the times when the results were not as expected, what seemed to be a scientifically proven and valid method of tracking fertility proved to be far more ambiguous and erratic than we had expected from reading the scientific studies outlined earlier in this paper.

The pamphlet that accompanied the device gave images as to what the expected projections would be over the menstrual cycle (Figure 5.). This was the only visual guide provided to offer guidance on what to look for in the projection. Most participants voiced insecurity about reading their own samples since they did not align with the images provided in the pamphlet; *“You know it's like you stare at it so much so you don't really know in the end what you're looking at. So, in that way this is harder because it's not very clear yes or no. It's like depending on what you see and since I haven't seen it like in the example, I don't know where I'm at.”* (P6A). Since participants' projections did not match up to this illustration, this pamphlet was critiqued for providing a too-narrow range of possible results; *“it will be good with some note (in the pamphlet) ... Like it can be different. It can vary from woman to woman and also that it can look in different ways. It's not like these three are: that's it!”* (P6A).

Is it Ovum or My Body That's Wrong?

Ambiguity in the results shown by Ovum were received as signals that it was their own bodies that were producing these erratic results. *“I'm just wondering does the saliva tests indicate something like if I have a hormonal problem or I don't have enough of let's say progesterone. It's quite interesting to know but it's not worrying me.”* (P1A). *“Well I'm thinking if there's any like hormones that I'm deficient in that is not producing that type of crystals in the saliva?”* (P2A), *“like is there something wrong with my saliva. Am I not producing enough of whatever it is I'm supposed to produce?”* (P6A). These reactions show that fertility tracking devices can become diagnostic tools when bodies do not behave in line with the expectations of the device.

Clinical Trial or Design Deployment

Saliva tracking was a novel method for all participants, who had no knowledge of what existing saliva tracking devices looked like or how they functioned. This meant that our participants did not separate issues around the method of saliva tracking from the design of the device. P2 and P4 explicitly referred to the study as a “clinical trial”. This was despite our participants having been informed at the beginning of the study, and throughout, that they were not participating in a clinical trial of the method of saliva tracking, but rather an interaction design study on the device.

Experimental Practices

The lack of expected results altered our participant's perceptions of Ovum over the course of the study. To mitigate this sensation of unease, a number of experimental practices arose.

P6 began running their own experiments by testing twice every morning, with a half-hour break in between, without brushing teeth or eating. This gave different results and typically the second procedure gave the results expected. This inconsistency in results led to a judgement of the device being time consuming since it took double the time and was deemed untrustworthy since getting two different results undermined the replicability of the results. P4 also experimented with testing in the early evening after returning from work instead of the morning as recommended in the pamphlet.

To negotiate the ambiguous results of the projected saliva sample, P7, P4 and P1 emailed photos of their projections with questions for us about whether there were crystals visible. For example; *“I want to hear your opinion. Is it ovulation time now?”* (P7A email), *“I sent pictures to you... they look kind of different because they can be pointy or they can be bendy”* (P4A email).

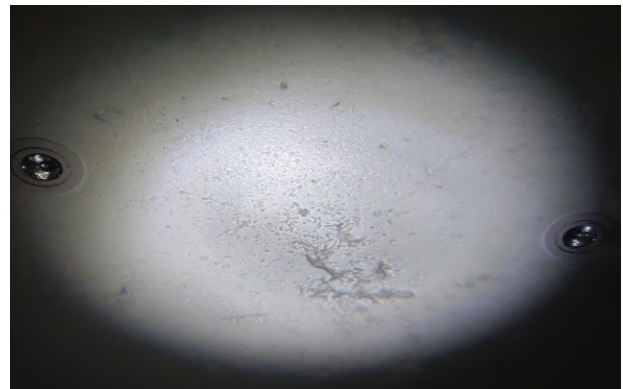


Figure 6. Image of P1's projection sent via email.

At some point or other, all participants integrated other methods into their fertility tracking practices alongside Ovum. This included basal body temperature tracking, urine testing, and cervical mucus tracking. Integrating other methods ranged from continuing previously used methods, to re-introducing old methods to compare the results offered by Ovum. Motivations for continuing or re-introducing these other methods included the goal to corroborate what was shown by Ovum: *“I'm just trying to find like signs of it. I'm trying to find a pattern.”* (P2A); to make up for a mistrust of Ovum: *“I wouldn't trust just this device but I would, I think it's fun to use it with other like body temperature and other stuff. I wouldn't trust just this one”* (P6A); and as seeing changes in cervical mucus was unavoidably evident for P4A when going to the toilet since she had learnt how her cervical mucus changed over the menstrual cycle. Visiting the gynecologist also changed how Ovum was understood by our participants. P2's reading from Ovum was evaluated as “correct” by the gynecologist who agreed that ovulation was just about to take place, and P4's as “incorrect”, she had another 5-6 days to go before ovulation, in spite of her reading of Ovum that had told her she was just about to ovulate.

Ambiguity and Fertility Tracking

In addition to supporting the fact that ambiguity appears to be a common aspect of fertility tracking, we also found that our participants' attitudes towards their bodies pointed to the fact that ambiguity is an integral aspect of self-tracking more generally. Despite the ambiguous, and occasionally erratic, nature of results shown by Ovum, out of the 4 participants who completed the full 3-month long deployment, 3 of the participants asked of their own accord to continue to use the device after the study was over. P1, P4 and P6 continued after the study had ended. P1 returned their device after two months saying they "*weren't seeing anything new*". P4 and P6 currently still have theirs at the time of writing in August, 2019. Emails to P4 and P6 asking for updates on using the device in the long term were unanswered. When asked about their motivation for wanting to keep the device, all three said that they suspected their cycles had been abnormal for a range of reasons over the last three cycles. Since results can also vary over menstrual cycles due to the changeable nature of the body, our participants wanted a longer deployment for the sake of their own experimentation. This illustrates that users of fertility tracking devices do not judge the device's efficacy based on a binary notion of the device "working" or "not working" with one short period of use; different menstrual cycles could provide different results.

DISCUSSION

Our research answers calls for designers to consider how the design of self-tracking devices influence users' experience of themselves and their bodies [30, 41, 45]. These calls state that designers should think beyond the efficacy and accuracy of the self-tracking devices that they produce. Our research explored the implications of expanding the design space of self-tracking through challenging the experiences facilitated by existing self-tracking devices. Above we presented our findings that relate to how the experiential qualities we worked with in the design process translated into actual use and other findings that arose during the deployment. Our discussion reflects on these findings. We also contribute a discussion of how designing for the body places interaction designers in novel and complex roles and situations.

From Sculptural to Clumsy

We situated the act of fertility tracking in the home through the form and materiality of our design. Rather than producing a device that replicated a clinical experience of self-tracking, we aimed for domestic and homeware aesthetics through using ceramic materials and a rounded form. Our findings showed that our participants' experience of the design of Ovum changed over time. Ovum's aesthetic qualities were initially appreciated and seen as desirable aspects of the device. However, over the three-month deployment, more practical aspects became more important; such as the fact that it was challenging to transport the device because of its form. Rather than continuing to appreciate the experience provided by Ovum, our participants appeared to move towards a desire for a practical tool to provide information on their fertile state.

Our findings contribute knowledge about the limits of design in reconfiguring what self-trackers desire from their devices. Although we have shown how designers can offer different types of experiences of self-tracking through their design work, we found that users inevitably desire devices that provide information rather than experiences. If designers are to design for more than effective and accurate self-tracking devices, then this phenomenon must be considered. Our findings show the importance of long-term deployments of fertility tracking devices to surface issues that only arise once the aesthetic qualities of self-tracking devices have worn off.

Limitations in Sharing Fertility Tracking

In aiming for more than efficacy and accuracy through designing for different experiences than those offered by existing self-tracking devices, we also situated self-tracking within a social context. We aimed to make fertility tracking a shared, rather than individual, act through projecting the saliva sample out into the room. Though we did not directly instruct our participants to use Ovum together, the roles that they played in their fertility tracking practices were discussed in our interviews.

There was evidence that aspects of the design of Ovum led to a shared experience, e.g. where our participants wanted to share the "beautiful" experience of seeing crystals in the projection with their partners. However, overall, the female partner was still the primary user of the device. Our findings show how many factors influence social aspects around self-tracking. This includes how self-tracking practices are shaped by daily routines, such as the fact that conflicting schedules were a key reason for both partners not being involved in the tracking over time. The fact that it is one body that is the key site of fertility tracking was also a factor mitigating shared fertility tracking practices; it did not occur to our participants that this should be a shared experience because only one person's saliva was required. P4's reflection that she was responsible for not involving her partner in her tracking practice and P1's irritation at the inequality in gender roles in fertility tracking reflect that participating in the study itself altered opinions on roles within fertility tracking. To summarize, although designers have the agency to reconfigure social practices of self-tracking through proposing alternative experiences, designing for self-tracking as a social act requires the negotiation of existing societal norms and assumptions.

Supporting and Undermining the User as Expert

Saliva tracking became the method we chose to design with because of the fact that it allowed for a DIY, rather than expert-led, reading of the body. Over time, we imagined users of Ovum becoming experts in reading their own bodies as they gained a familiarity with their own patterns of ferning crystallization. We imagined that they would co-construct their knowledge of their own fertility with the Ovum device. In fact, we did see our participants using self-experimentation to become experts in reading their own fertile states. This supports research that states that

researchers deploying technologies designed for the body must expect and be prepared for participants to tinker with the devices in order to make ambiguous results make sense for them [24]. P6 and P4 both tinkered with their devices by testing more than once a day and at a different time of day.

Methods that support users in co-constructing knowledge with technological devices have used ambiguity in order to harness user's own abilities to make meaning from data. This has been shown to foster engagements and allow users to appropriate technologies into their own lives [16, 23]. *Interactional empowerment* is an approach to affective computing that uses ambiguity in order to construct understandings of emotions [50]. The difference between tracking emotions and tracking physiological processes, such as menstrual cycles, is the fact that it is possible to use clinical procedures to ascertain whether physiological processes are taking place. We saw how our participants used several different tracking methods at the same time in order to make sense of and validate their data. To use Anne-Marie Mol's terminology; multiple bodies (or realities of the body) are being produced through the various methods of fertility tracking [36]. In the case of Ovum, whether or not Ovum correctly revealed that the user was fertile and approaching ovulation could be confirmed or contradicted with an internal inspection. This would allow a clinician to physically see the egg ready to be released out of the ovary.

It is possible that, since our participants were not able to do internal inspections on themselves, they felt that they were not qualified as experts in knowing their own fertility. The ambiguity of reading the saliva sample became an "insecure" (P4) and "confusing" (P3) process, which they knew could be undermined by a trip to the gynecologist. P7 and P4 negotiated the ambiguity of the results of using Ovum by emailing us asking us to read the results of their saliva sample for them. Here they expected that we could read their results more accurately than they could. In contradiction to our desire to design Ovum to facilitate a DIY, rather than expert-led, experience; ambiguity led to us researchers being placed in the expert role, rather than our participants. Overall, although we aimed for our participants to *feel* like experts in reading their own bodies through using the method of saliva tracking, the ambiguous nature of the method itself appeared to result in the opposite effect.

Designers in White Coats

The ambiguous aspects of the method of saliva tracking outlined above had consequences for our own experience as researchers. In particular, the fact that our participants turned to us as experts in the method of saliva tracking, thereby seeing us as designers in white coats. We contribute aspects of our experience of deploying Ovum that might be encountered by designers adopting scientific and medical knowledge about the body in their design work.

There has been a call for researchers within the HCI and interaction design community to include their own emotional experience within their publications [6, 20, 29, 38, 55].

Accounting of the emotional experience of doing research can contribute to a fuller documentation of the research process, and can enable researchers to learn how emotion is used and what it produces within the research process [6]. Within the scope of this research, accounting for our own emotional experience allows us to point to key issues of designing and deploying devices that replicate medical and clinical apparatus, without the training of medical researchers. Our experience is drawn from the fact that we were designing for the body. These experiences resulted from the multiple complexities around deploying a self-tracking device within the emotional, complex and serious domain of fertility tracking [12]. If we were designing a tracking device attending to another facet of life, for example air quality, we would not have been placed in the same role.

Our experience represents the relationship between design research and medical science. Since we are not experts in biology, we relied on scientific research to ground our designs. Ovum was built on our confidence in the method of saliva tracking. This trust came from reading the multiple clinical trials of the method. Although we knew that the method had been reported as inconsistent [7, 43], the accuracy rates of 86.5% [44] to 90% [15] and the fact that FDA approved saliva tracking devices existed [42], convinced us that it was a valid enough method to design with. Our study did not show the method of saliva tracking to be invalid, nor was that the goal of the study. However, since, on occasion, the results of saliva tracking were not as expected, this required mitigation and management on our part as interaction designers. Though it is possible that our participants did have menstrual cycles and hormonal compositions that were incompatible with the method of saliva tracking, determining this was not the aim of our study. Since we, as interaction design researchers, do not have a medical or scientific training, we were unqualified to answer questions and concerns raised by participants about whether their erratic results were related to underlying health or fertility issues. We declined to answer questions beyond what we knew about what the saliva tracking method itself was measuring. When asked questions about what the erratic results might mean for their fertility, we repeated the fact that we were not medical experts and therefore could not answer their questions.

To hear our participants openly worry that the results of saliva tracking might be a diagnosis for something being "wrong" with their bodies felt uncomfortable. [48] discovered the same tendency of participants to take ambiguous results around fertility as signs of ill menstrual cycle health. This highlights the fact that every time we design an artefact we make a definition [46]. Through designing Ovum and its accompanying pamphlet, we defined what a normal result of saliva tracking should look like. When our participants felt that they did not fit the "normal" definition, then this re-enforced diagnoses of abnormality and ill health.

As well as presenting the implications of designing for fertility tracking as a shared, domestic and DIY experience, a key contribution from our research is offering a situated study of the actual user experience of the method of saliva tracking. The user experience of saliva tracking was as an ambiguous and erratic method, and this had an impact on our study as a whole. In line with our participant's criticisms of the pamphlet accompanying Ovum, one way to avoid this might be by providing more clarity about the ambiguity of results of saliva tracking methods throughout the whole study, and not only in the initial stages when recruiting participants. By providing a less reductive and normative depiction of results for participants to compare themselves against in the pamphlet, we might have avoided Ovum becoming a diagnostic device. However, since saliva tracking appeared to be an accepted and scientifically validated method from our prior research, and it was only in our long-term, situated, study that these aspects arose, we were not aware of the ambiguous and erratic nature of saliva tracking when carrying out our design work. Rather than simply being a re-design of an accepted self-tracking device, our experience highlights the consequences of implementing scientific validated knowledge in design work, and how long-term deployments can reveal particular aspects of scientific methods in practice.

We discussed how, if we were running a clinical trial rather than a design deployment, then we would have been less emotionally involved in the process. Medical trials of saliva tracking use comparisons with other clinical methods to confirm whether or not the method can be used to predict and track ovulation. This is a stark contrast to our methods where we drew our findings from the self-reported experience of the users. Arguably, researchers in the field of medicine who run clinical trials are trained to separate the flesh of the body from the person who is living through that body [32, 52]. Interaction design research uses qualitative methods to attempt to understand the lived experience of technologies with the goal of gaining a rich understanding of the emotional and idiosyncratic experience of the user. Our backgrounds as interaction design researchers have led to us developing a heightened ability to listen out for and empathize with our participant's emotional experiences. This meant greater emotional engagement on our part. We were designing for the user as not only a body, but also a person with emotions, relationships and a specific context.

P2 and P4 both referred to the deployment of Ovum as a clinical trial; they could not divorce the information being provided through the method of saliva tracking from the design of the device itself. We do not suggest that designers can train participants to distinguish what is a reflection on the design aspects, and what is a reflection on the self-tracking method. One way to avoid the uncomfortable aspects of being a designer perceived as a healthcare professional might be to employ healthcare professionals to refer participant's queries and concerns to, rather than referring to the information given in scientific papers.

However, this would not remove the task of the designer in taking the self-tracking method into account as an integral aspect of the study. When studying the user experience of self-tracking devices, we can see no way of divorcing the method of reading the body from the device it is enacted through. Rather, this paper highlights to designers taking on this type of research how married these two aspects are.

CONCLUSION

To the increasing body of work on the research through design of self-tracking and fertility tracking devices, we contribute a study on the deployment of Ovum. Ovum is a saliva tracking device designed for fertility tracking as a DIY, shared, domestic experience, rather than an expert-led, individual, clinical experience. Ovum was designed in order to investigate how designing with oppositional experiential qualities impacted the experience of self-tracking. This paper unpacked the findings from a three-month long deployment of Ovum with seven couples trying to conceive. Findings included the way that the experiential qualities aimed for in the design process translated into the lived experience of the participants. For example: that the aim of creating a shared experience of fertility tracking facilitated conversations around the labour of fertility tracking; that the domestic design of Ovum was first appreciated for its aesthetics, and later criticized for its impracticalities; and that the fact that our participants had to create their own meaning from their data produced feelings of insecurity that led them to turn to us as "experts". The contrast between the guidelines given to our participants in the pamphlet we designed to accompany Ovum and the more erratic and ambiguous results of their own devices provoked our participants to tinker with the testing process to achieve more accurate results, to turn to us as experts, and to triangulate results with other fertility tracking methods. We also contribute findings related to the fact that the ambiguous and erratic nature of the body changing over menstrual cycles influences user's judgements of fertility tracking devices that goes beyond a binary question of whether it "works", or "doesn't work".

We conclude with a contribution of an account of our own experience as researchers in order to develop understandings of how designing for the body places interaction designers in novel and complex situations. This research has shown how when we design for the body, we encounter issues and topics not present in other design spaces. In the case of this study, designing a fertility tracking device based upon an accepted method of saliva tracking resulted in the negotiation of emotional and complex topics when the method produced ambiguous and erratic results. In other situations, when digital devices do not provide expected results, their validity is doubted. In the case of tracking bodies, unexpected results translated into diagnoses of abnormality and ill-health. As interaction designers, negotiating these aspects was emotionally taxing. We discuss how this is due to our training in honing our skills in understanding our participant's emotional experience of technological devices.

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