

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

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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.

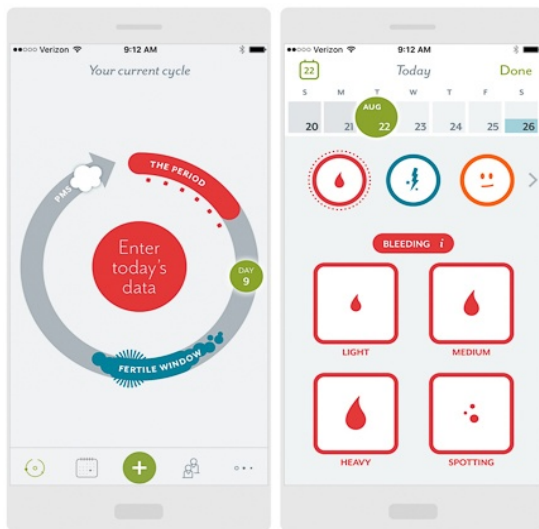


Figure 1. The menstrual cycle tracking app Clue. Left: an overview of the current menstrual cycle. Right: interface to input relevant data for the day.

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.

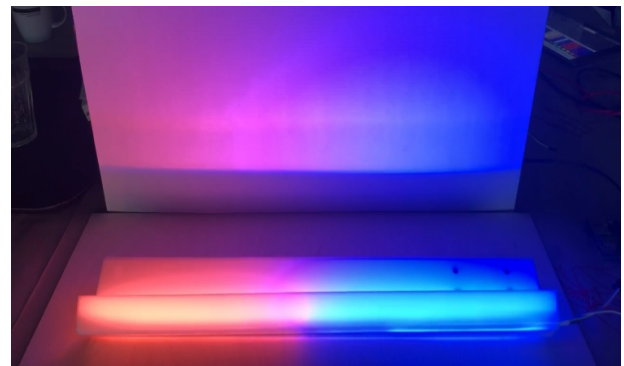
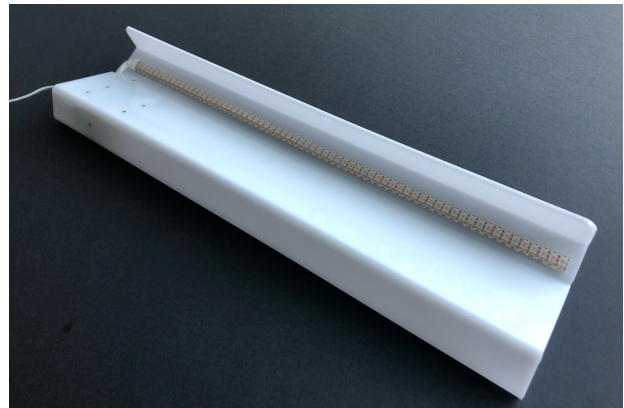


Figure 2. the lamp component of Ambient Cycle. Above: turned off. Below: in a colour transition between two phases.

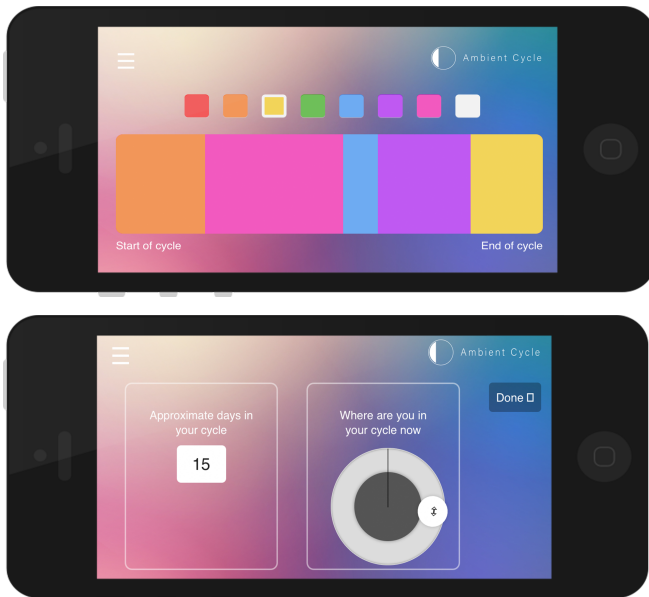


Figure 3. Ambient Cycle configuration interface. Above: choosing colors for the phase in the cycle. Below: choosing length and current position in the cycle.

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.

REFERENCES

- [1] Ananthanarayan, S. et al. 2014. Towards the crafting of personal health technologies. *Proceedings of the 2014 conference on Designing interactive systems - DIS '14*. (2014), 587–596. DOI:https://doi.org/10.1145/2598510.2598581.
- [2] Ayobi, A. et al. 2018. Flexible and Mindful Self-Tracking : Design Implications from Paper Bullet Journals. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*. (2018), To appear. DOI:https://doi.org/10.1145/3173574.3173602.
- [3] Ayobi, A. et al. 2016. Reflections on 5 Years of Personal Informatics. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '16*. (2016), 2774–2781. DOI:https://doi.org/10.1145/2851581.2892406.
- [4] Baron, R. 1985. An Introduction to Medical Phenomenology: I Can't Hear You While I'm Listening. *Annals of Internal Medicine*. (1985).
- [5] Bødker, S. 2015. Third-wave HCI, 10 years later--- participation and sharing. *Interactions*. 22, 5 (2015), 24–31. DOI:https://doi.org/10.1145/2804405.
- [6] Bødker, S. 2006. When second wave HCI meets third wave challenges. *Proceedings of the 4th Nordic conference on Human-computer interaction changing roles - NordiCHI '06*. October (2006), 1–8. DOI:https://doi.org/10.1145/1182475.1182476.
- [7] Boehner, K. et al. 2007. How emotion is made and measured. *International Journal of Human Computer Studies*. 65, 4 (2007), 275–291. DOI:https://doi.org/10.1016/j.ijhcs.2006.11.016.
- [8] Boehner, K. et al. 2007. How HCI interprets the probes. *Conference on Human Factors in Computing Systems - Proceedings* (2007), 1077–1086.
- [9] Boer, L. et al. 2020. Gut-Tracking as Cultivation. *DIS 2020 - Proceedings of the 2020 ACM Conference on Designing Interactive Systems* (2020).
- [10] Braun, V. and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 3, 2 (2006), 77–101. DOI:https://doi.org/10.1191/1478088706qp063oa.
- [11] Chrysanthou, M. 2002. Transparency and Selfhood: Utopia and the Informed Body. *Social Science and Medicine*. 54, 3 (2002), 469–479. DOI:https://doi.org/10.1016/S0277-9536(01)00033-8.
- [12] Crawford, K. et al. 2015. Our metrics, ourselves: A hundred years of self-tracking from the weight scale to the wrist wearable device. *European Journal of Cultural Studies*. 18, 4–5 (2015), 479–496. DOI:https://doi.org/10.1177/1367549415584857.
- [13] Descartes, R. 1968. *Discourse on the method and the Meditations*. Penguin UK.
- [14] Dunne, A. 1999. *Hertzian Tales: Electronic Products, Aesthetic Experience and Critical Design*. Art Books Intl Ltd.
- [15] Dunne, A. and Raby, F. 2013. *Speculative Everything: Design, Fiction, and Social Dreaming*. MIT press.
- [16] Dunne, A. and Raby, F. 2013. *Speculative Everything*. MIT Press.
- [17] Elsdén, C. et al. 2015. Beyond Personal Informatics : Designing for Experiences with Data. *Chi 2015 - Workshop Paper*. (2015), 2341–2344. DOI:https://doi.org/10.1145/2702613.2702632.
- [18] Epstein, D.A. et al. 2017. Examining menstrual tracking to inform the design of personal informatics tools. *Conference on Human Factors in Computing Systems - Proceedings* (May 2017), 6876–6888.
- [19] Flemings, M. et al. 2018. Crimson wave: Shedding light on menstrual health. *TEI 2018 - Proceedings of the 12th International Conference on Tangible, Embedded, and Embodied Interaction* (Mar. 2018), 343–348.
- [20] Fox, S. 2018. Design, maintenance, and the menstruating body. *DIS 2018 - Companion Publication of the 2018 Designing Interactive Systems Conference*. (2018), 375–378. DOI:https://doi.org/10.1145/3197391.3205386.
- [21] Fox, S. et al. 2019. Vivewell. *DIS '19: Proceedings of the 2019 on Designing Interactive Systems Conference* (2019), 541–552.
- [22] Gaver, W. et al. 2006. The History Tablecloth: Illuminating Domestic Activity. *In Proceedings of the 6th conference on Designing Interactive systems (pp. 199-208)*. ACM. (2006), 199–208.
- [23] Grönvall, E. and Verdezoto, N. 2013. Beyond self-monitoring: Understanding non-functional aspects of home-based healthcare technology. *UbiComp 2013 - Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (2013), 587–596.
- [24] Grosz, E. 1994. *Volatile Bodies: Toward a Corporeal Feminism*. Indiana University Press.
- [25] Hauser, S. et al. 2018. Deployments of the table-non-table. *In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (p. 201)*. ACM (2018), 1–13.
- [26] Heidegger, M. 2010. *Being and Time*. State

- University of New York Press.
- [27] Helms, K. 2019. Do you have to pee? A design space for intimate and somatic data. *DIS 2019 - Proceedings of the 2019 ACM Designing Interactive Systems Conference*. (2019), 1209–1222.
DOI:<https://doi.org/10.1145/3322276.3322290>.
- [28] Homewood, S. 2018. Designing for the Changing Body: A Feminist Exploration of Self-Tracking Technologies. *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. (2018), DC11:1--DC11:4.
DOI:[https://doi.org/10.1016/S0032-3861\(02\)00196-9](https://doi.org/10.1016/S0032-3861(02)00196-9).
- [29] Homewood, S. et al. 2019. Ovum : Designing for Fertility Tracking as a Shared and Domestic Experience. *Proceedings of the Conference on Designing Interactive Systems (DIS '19)*. (2019).
- [30] Homewood, S. 2018. Reframing Design Problems Within Women's Health. *Proceedings of DRS2018 Design Research Society International Conference* (2018).
- [31] Homewood, S. et al. 2020. Removal as a Method : A Fourth-Wave HCI Approach to Understanding the Experience of Self-Tracking. *DIS 2020 - Proceedings of the 2020 ACM Conference on Designing Interactive Systems* (2020).
- [32] Homewood, S. and Vallgård, A. 2020. Designers in White Coats: Deploying Ovum , a Fertility Tracking Device. *Conference on Human Factors in Computing Systems - Proceedings* (2020).
- [33] Höök, K. 2018. *Designing with the Body - Somaesthetic Interaction Design*. MIT Press.
- [34] Höök, K. et al. 2008. Interactional empowerment. *Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08*. (2008), 647.
DOI:<https://doi.org/10.1145/1357054.1357157>.
- [35] Howell, N. et al. 2018. Tensions of Data - Driven Reflection : A Case Study of Real - Time Emotional Biosensing. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. (2018), 1–13.
DOI:<https://doi.org/10.1145/3173574.3174005>.
- [36] Hutchinson, H. et al. 2003. Technology probes: Inspiring design for and with families. *Conference on Human Factors in Computing Systems - Proceedings* (2003), 17–24.
- [37] 'I felt colossally naive': the backlash against the birth control app: 2018.
<https://www.theguardian.com/society/2018/jul/21/colossally-naive-backlash-birth-control-app>.
Accessed: 2019-09-03.
- [38] Ihde, D. 1990. *Technology and the lifeworld : from garden to earth*. Indiana University Press.
- [39] Jacobson, A.E. et al. 2018. Mobile Application vs Paper Pictorial Blood Assessment Chart to Track Menses in Young Women: A Randomized Cross-over Design. *Journal of Pediatric and Adolescent Gynecology*. 31, 2 (Apr. 2018), 84–88.
DOI:<https://doi.org/10.1016/j.jpag.2017.09.009>.
- [40] JafariNaimi, N. and Pollock, A. 2018. Heart Sense: experiments in design as a catalyst for feminist reflections on embodiment. *DRS2018: Catalyst*. 2, June (2018).
DOI:<https://doi.org/10.21606/drs.2018.409>.
- [41] Khot, R.A. et al. 2013. SweatAtoms : Materializing Physical Activity. *Proceedings of The 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death*. (2013), 1–7.
DOI:<https://doi.org/10.1145/2513002.2513012>.
- [42] Khot, R.A. et al. 2014. Understanding physical activity through 3D printed material artifacts. *Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14*. (2014), 3835–3844.
DOI:<https://doi.org/10.1145/2556288.2557144>.
- [43] Kollenburg, J. Van et al. 2018. Exploring the Value of Parent-Tracked Baby Data in Interactions with Healthcare Professionals: A Data-Enabled Design Exploration. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. (2018), 1–12.
DOI:<https://doi.org/10.1145/3173574.3173871>.
- [44] Kuhn, T.S. 1970. *The Structure of Scientific Revolutions*. University of Chicago Press.
- [45] Lawson, S. et al. 2015. Problematising Upstream Technology Through Speculative Design: The Case of Quantified Cats and Dogs. *Conference on Human Factors in Computing Systems - Proceedings* (2015), 2663–2672.
- [46] Leahu, L. et al. 2008. Subjective Objectivity: Negotiating Emotional Meaning. *In Proceedings of the 7th ACM conference on Designing interactive systems (pp. 425-434)*. ACM. (2008), 425–434.
- [47] Leahu, L. and Sengers, P. 2014. Freaky: Performing hybrid human-machine emotion. *Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques, DIS* (2014), 607–616.
- [48] Leder, D. 1992. A Tale of Two Bodies: The Cartesian Corpse and the Lived Body. *In The Body in Medical Thought and Practice*. Springer, Dordrecht. 17–35.
- [49] Leder, D. 1990. *The Absent Body*. University of

- Chicago Press.
- [50] Leder, D. 2016. *The Distressed Body: Rethinking Illness, Imprisonment, and Healing*. University of Chicago Press.
- [51] Lupton, D. 2014. Self-Tracking Cultures: Towards a Sociology of Personal Informatics. *Proceedings of the 26th Australian Computer-Human Interaction Conference, OzCHI 2014*. (2014), 77–86. DOI:<https://doi.org/10.1145/2686612.2686623>.
- [52] Lupton, D. 2016. *The Quantified Self*. Polity Press.
- [53] McKillop, M. et al. 2018. Designing in the Dark: Eliciting Self-Tracking Dimensions for Understanding Enigmatic Diseases. *ACM SIGCHI conference on Human Factors in Computing Systems, CHI 2018*. (2018), 1–15. DOI:<https://doi.org/10.1145/3173574.3174139>.
- [54] Merleau-Ponty, M. 1962. *Phenomenology of perception*. Routledge.
- [55] Mukherjee, M. et al. 2019. MenstruLoss : Sensor For Menstrual Blood Loss Monitoring. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* (2019), 58.
- [56] Neff, G. and Nafus, D. 2016. *Self-Tracking*. MIT Press.
- [57] O’Kane, A. 2014. Using A Third-Wave HCI Approach for Researching Mobile Medical Devices. *Paper presented at the Workshop on ‘HCI Research in Healthcare: Evidence to Practice’ at CHI 2014, Toronto, Canada, April 2014*. (2014).
- [58] Odom, W. et al. 2018. Attending to Slowness and temporality with Olly and Slow Game: A design inquiry into supporting longer-term relations with everyday computational objects. *Conference on Human Factors in Computing Systems - Proceedings*. 2018-April, (2018), 1–13. DOI:<https://doi.org/10.1145/3173574.3173651>.
- [59] Odom, W. et al. 2016. From Research Prototype to Research Product. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI ’16*. (2016), 2549–2561. DOI:<https://doi.org/10.1145/2858036.2858447>.
- [60] Odom, W. et al. 2019. Investigating slowness as a frame to design longer-term experiences with personal data: A field study of olly. *Conference on Human Factors in Computing Systems - Proceedings* (2019).
- [61] Ohlin, F. and Olsson, C.M. 2015. Beyond a utility view of personal informatics. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers - UbiComp ’15*. (2015), 1087–1092. DOI:<https://doi.org/10.1145/2800835.2800965>.
- [62] Page, R. and Richardson, M. 2016. Co-creating narratives ; an approach to the design of interactive medical devices, informed by phenomenology. *DRS2016 Design Research Society 50th Anniversary Conference*. (2016), 1–12. DOI:<https://doi.org/10.21606/drs.2016.146>.
- [63] Price, J. et al. 1999. Openings on the Body: A Critical Introduction. *Feminist Theory and the Body*. Routledge. 1–14.
- [64] Rapp, A. and Tirassa, M. 2017. Know Thyself: A Theory of the Self for Personal Informatics. *Human-Computer Interaction*. 32, 5–6 (2017), 335–380. DOI:<https://doi.org/10.1080/07370024.2017.1285704>.
- [65] Rooksby, J. et al. 2014. Personal tracking as lived informatics. *Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI ’14*. (2014), 1163–1172. DOI:<https://doi.org/10.1145/2556288.2557039>.
- [66] Roseway, A. et al. 2015. BioCrystal. *International Journal of Mobile Human Computer Interaction*. 7, 3 (2015), 20–41. DOI:<https://doi.org/10.4018/ijmhci.2015070102>.
- [67] Schneider, H. et al. 2019. Communicating Uncertainty in Fertility Prognosis. *Conference on Human Factors in Computing Systems - Proceedings* (2019), 11.
- [68] Scientific research at Clue: 2018. <https://helloclue.com/articles/about-clue/scientific-research-at-clue>. Accessed: 2019-09-03.
- [69] Shildrick, M. 1997. *Leaky Bodies and Boundaries: Feminism, Postmodernism and (Bio) Ethics*. Routledge.
- [70] Snyder, J. et al. 2015. MoodLight: Exploring personal and social implications of ambient display of biosensor data. *CSCW 2015 - Proceedings of the 2015 ACM International Conference on Computer-Supported Cooperative Work and Social Computing* (New York, New York, USA, 2015), 143–153.
- [71] Søndergaard, M.L. and Koefoed, L. 2016. PeriodShare: A Bloody Design Fiction. *In Proc. NordiCHI 2016 Extended Abstract*. (2016). DOI:<https://doi.org/10.1145/2971485.2996748>.
- [72] Sorrell, T. 1987. *Descartes*. Oxford University Press.
- [73] Svenaeus, F. 2000. *The Hermeneutics of Medicine and the Phenomenology of Health*. Springer Netherlands.
- [74] The Data-Driven Life.: 2010. .
- [75] Tran, B. and Choi, L.N. 2018. Menstrual Maze.

- CHI EA '18: Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* (2018), 1–6.
- [76] Verbeek, P.-P. 2005. *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. Penn State Press.
- [77] Viseu, A. and Suchman, L. 2010. Wearable Augmentations: Imaginaries for the Informed Body. *Technologized Images, Technologized Bodies: anthropological approaches to a new politics of vision*. (2010), 161–184.
- [78] Wakkary, R. et al. 2015. Material Speculation: Actual Artifacts for Critical Inquiry. *Aarhus Series on Human Centered Computing*. 1, 1 (2015), 12. DOI:<https://doi.org/10.7146/aahcc.v1i1.21299>.
- [79] Wernimont, J. 2018. *Numbered Lives : Life and Death in Quantum Media*. MIT Press.
- [80] Woytuk, N.C. et al. 2019. Your period rules: Design implications for period-positive technologies. *Conference on Human Factors in Computing Systems - Proceedings* (2019).