Configuring the body as pedagogical site: towards a conceptual tool to unpack and situate multiple ontologies of the body in self-tracking apps

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ABSTRACT

This paper focuses on the relationships among education, self-tracking technologies, and body practices, addressing an ongoing debate about the 'disciplinary versus empowering' role of health tracking technologies in teaching people how to live. Using a Feminist Science and Technology Studies approach (FSTS), it inquires into the understandings promoters of such technologies have about the body as a 'pedagogical site' in the specific context of fertility tracking apps. Drawing upon empirical data from a multi-sited ethnography of technology fairs and experts' congresses, this study offers an analytical tool (the Body Tracking Configurations Matrix) to unpack and situate the multiple ontologies of the body in fertility tracking apps.

KEYWORDS

Feminism; biopedagogies; self-tracking; digital health; mobile apps

Introduction

The field of digital health and education uses the concept of 'biopedagogies' to refer to the pedagogies by which a learner's body is turned into an object of intervention that needs to be made 'fit' (Azzarito 2009; Rail and Jette 2021; Williamson 2015) – an ideal body epitomized by 'efficiency, productivity, and beauty ideals' and juxtaposed against the 'fat or "bad" body', characterized by 'laziness, gluttony, and lack of control' (Azzarito 2009, 192). While earlier studies using a biopedagogical lens have primarily focused on rhetorical strategies used in public health discourses to promote fit bodies, more recent studies, and particularly studies on fitness-tracking apps, have started to offer accounts of the ways self-tracking users might resist or negotiate representations of the 'idealized body' embedded in these technologies (Depper and Howe 2017; Fotopoulou and O'Riordan 2017; Ward et al. 2018). However, users' experiences have mainly been viewed as a 'response' (i.e., accept, resist, negotiate) to representations of the 'healthy body', thereby overlooking other ways users engage and live with their self-tracked data.

Accordingly, the fields of critical digital health studies and education studies have widely debated the role of digital health technologies in teaching individual consumers how to live a healthy (a.k.a. 'good') life. The central question has been: *to what extent are individuals empowered or disciplined by these consumer technologies?* Social science research on technology users' micropractices tends to recognize users' noticeable learning outcomes (Fotopoulou and O'Riordan 2017; Lupton 2020) whereas studies on structural power dynamics consider the instrumentalization of behavioral learning that is associated with the commodification of health care (Lupton 2014; Till 2014). As Ruckenstein and Schüll point out (2017, 263), a polarized research field encourages such opposing arguments to run parallel to each other, rather than examining their intersections. Thus, there is a call to move beyond the 'disciplinary versus emancipatory' critique central to such debates (Fors and Pink 2017; Henwood and Marent 2019; Rich and Miah 2014; Sharon 2017; Weiner et al. 2020).

This paper attempts to answer this call by using a feminist science and technology studies approach (FSTS) (McNeil and Roberts 2011) to examine the relationships among learning, self-tracking technologies, and menstruating bodies. Menstrual cycle self-tracking apps represent a novel research object for exploring how app designers envision users' 'problems' and develop innovations to 'solve' them (Fox and Epstein 2020; Healy 2020; Lupton 2016a; Novotny and Hutchinson 2019). These apps differ from most self-tracking apps in that their aim is not to track a behavior but rather to provide users with an 'awareness' of a physiological state (Epstein et al. 2017, 1). Typically promoted as a tool for menstruation management, an aid for conception or an alternative to hormonal contraception, these apps are positioned within an emerging market coined 'Femtech' (Tin 2016) which encompasses various consumer products meant for 'women's healthcare' (i.e., cis women's imagined biological and physical needs), including, but not limited to, 'fertility solutions', 'pregnancy and nursing care' and 'sexual wellness' (CB Insights 2017). While many of these apps often combine different types of use (menstruation management, conception, contraception), here I focus on those

primarily promoted as an alternative to hormonal contraception, also called 'fertility' apps for pregnancy prevention.

My analysis builds on FSTS, a field of research established by scholars such as Haraway (1991) and Star (1990), who 'do not reject science and technology, but [instead] try to negotiate a critical politics in use and development, paying attention to the possibilities of places of scientific, technological or medical practice for different women' (Thompson [previously Cussins] 1996, 577). In this study, I draw specifically on Lucy Suchman's tripartite notions of 'figuration', 'configuration', and 'reconfiguration' as a methodological tool 'for studying technologies with particular attention to the imaginaries and materialities that they *join together*', and how these relationships might be reassembled. A more detailed account of this feminist approach is presented in the next section. This paper uses these concepts to explore the following question: *To what extent do promoters of consumer self-tracking technologies configure users' bodies as pedagogical sites?* To answer this question, I conducted a 'multi-sited ethnography' (Marcus 1995) of fertility self-tracking apps at five international congresses and technological fairs (see Table 1).

What follows is a brief review of the 'biopedagogical lens' and how it can be enriched with an FSTS approach, followed by an overview and contextualization of the data and research methods. The analysis will show that the promoters of fertility tracking apps have varied perspectives on whether and how the body should, or could, become a pedagogical site vis-à-vis their technologies. I will discuss the multiple and – at times – oppositional 'versions' of the body that promoters envision and ultimately materialize through their technology (Mol 2002, 142). Then I present the 'Body Tracking Configurations Matrix' as a heuristic tool that researchers can adopt to unpack the multiple versions of the body configured by promoters of self-tracking software. I conclude with a discussion of how the Body Tracking Configurations Matrix may contribute to the development of more emancipatory sociotechnical arrangements.

Theoretical perspectives

Scholars point out that the biopedagogical lens can be overly focused on 'negative ideological forces' (Fors et al. 2020, 28) and 'techno-dystopian' readings of dominant discourses (Rich and Miah 2014, 307), and have therefore advocated for sociomaterial approaches that explore how technologies, bodies, and values are entangled in specific learning arrangements. Engaging in such approaches, researchers have started to investigate how different values about the learning subject are inscribed in sociotechnical artefacts, paying attention, for example, to the ways these values are embedded 'within the confines of [an] app' (Decuypere 2019, 4), in promotional material (Berg 2017, 8), or in the everyday practices they mediate (Fotopoulou and O'Riordan 2017).

Shifting the ethnographic gaze to different entities, Lupton suggests the notion of 'digital data assemblages' to investigate the reciprocal learning relationships, in which personal data, algorithms, and people 'learn from each other' (Lupton 2016b, 2). In these assemblages, data

may be seen as 'digital companion species' [Lupton 2016b, 4], entites 'that have a life of their own' (3), that can learn from humans while humans learn from them (4). This shift opens up for what Fors and Pink call 'alternative routes to knowing' (2017, 7), in which self-tracking technologies' interest does not lie in their ability to 'teach users how to behave correctly' (9), but in their 'participat[ion] in the constitution of new possibilities that enable people to learn about, and configure, their everyday health in new ways' (1).[1] These approaches open up space beyond the usual disciplinary versus emancipatory critique of self-tracking technologies by recasting the political valence of self-surveillance into a potentially positive and desirable learning process that may be at once constraining and liberating and that can be acted upon[2].

In this paper, I will deploy Lucy Suchman's tripartite conceptual tools of 'figuration', 'configuration', and 'reconfiguration' (2007, 2013) to extend prior sociomaterial studies of learning and self- tracking apps. I build on this scholarship in three main ways. First, I engage with the concept of 'figuration' to 'zoom out to a wider view' of self-tracking apps, 'cutting the network' differently (Suchman 2007, 283) to better account for the fluidity and multiplicity of the ways 'humans and machines are figured together – or *con*figured – in contemporary technological discourses and practices' (Suchman 2013, 49). Secondly, I adopt the concept of 'configuration' to unpack how different self-tracking bodies emerges as 'ongoing consequences of specific socio-technical encounters' (Suchman 2013, 50). Finally, I use these multiple configurations to develop an analytic matrix that researchers can use to not only evaluate power relations that are constituted through self-tracking apps but also 'articulate the material semiotic reconfigurations required for their transformation' (Suchman 2013, 58).

Data sources and research methods

Technological fairs and medical experts' congresses are ideal spaces to study emerging sociotechnical configurations. On these sites, promoters often define, through 'demonstrations', the relations and actors that their technology brings together (Rosental 2021, 152). Thus, I conducted ethnographic observations at two international congresses and three technological fairs to learn how technology promoters communicate the utility of fertility tracking apps; additionally, I had informal conversations and lead in-depth interviews with promoters during my fieldwork (see Table 1 for detail). These sites served as a 'strategically constructed' field (Karasti and Blomberg 2018) and were part of my doctoral research, conducted between 2016 and 2021.[3] I accessed the sites by registering online or replying to invitations from company representatives I met when conducting the larger study.

[1] See also Danesi et al. (2020).

[2] For art interventions as a means to disrupt too narrow biopedagogical frames and enable more diverse forms of self-representation, see Rice et al. (2016).

[3] This paper constitutes a chapter of my forthcoming Ph.D. dissertation, '*Technosciences, and the Contested Quest for Temporary Infertility*,' in which I investigate how specific fertility tracking biosensors are promoted, used, regulated and contested across different spaces and times. The dissertation draws on heterogeneous empirical data including promotional material of 'fertility computers' produced in the 1980s, biomedical literature, ethnographic accounts of design practices, users' interviews, and regulatory documents.

On the field, I introduced myself as a social scientist studying digital fertility tracking technologies, and promoters were eager to share their perspectives.

For this research, I use a broad definition of *promoter* to describe anyone advocating for the development of menstrual apps. Such a definition is an attempt to counter the 'figuration' of the autonomous professional designer, to acknowledge the blurred boundaries between 'designer' and 'user' (Suchman 2002, 94) and the observation that many actors besides technology developers intervene in the configuration of self-tracking technologies, including 'policymakers, designers, producers, marketers, journalists, and test users' (Oudshoorn, Rommes, and Stienstra 2004, 37). In the field, many promoters also defined themselves as 'users' of a menstrual cycle tracking app, and some had been directly involved in the app's design. The promoters I encountered include medical doctors, gynecologists, endocrinologists, physicists, and entrepreneurs.

Promoters' narratives are clearly shaped by the context in which they are performed. The discourses directed toward a crowd of skeptical gynecologists at a medical conference sponsored by a large pharmaceutical corporation differ dramatically from those aimed at natural family planning (NFP) advocates or venture capitalists. Analysis of promoters' discourses sheds light on two themes: (1) promoters' efforts to demonstrate comparability between apps and contraceptive methods; and (2) their attempts to differentiate the fertility tracking app they are advocating for from those of their competitors. These issues are contentious among promoters. As I will argue in the following sections, the core debate is the extent to which they (a) configure users' bodies as pedagogical sites, and (b) position users as valuable subjects of (useful) knowledge.

I paid particular attention to 'the situated practice of comparison' (Deville, Guggenheim, and Hrdličková 2016, 20) undertaken by promoters across sites. Rather than considering comparisons as an epistemic practice by which researchers classify social phenomena, this approach 'treat[s] comparisons as objects of analysis' (19), what Deville, Guggenheim and Hrdličková encourage as a 'creative' dimension of comparison (27). Focusing on 'how comparability and comparable phenomena are co-produced' – or 'emic comparisons' (Sørensen, Marlin, and Niewöhner 2018, 161) – renders visible the characteristics, criteria, values and entities mobilized by promoters while they justify their app's relevance and configure its use in practice.

Using this approach to interpretive analysis, I recorded and analyzed the comparisons made by promoters. This led to the construction of the *Body Tracking Configurations Matrix*, which would allow me to attune to the multiple ontologies of the body in fertility self-tracking apps. To create the matrix, I read the fieldnotes several times, annotated them, and grouped emerging themes. Focusing especially on promoters' comparative processes, I first created a table with the main emerging themes as vertical entries and each promoter's discourses on horizontal entries. After several iterations, I distilled a table summarizing the main configurations that emerged in my data and their key attributes, mapping them according to FSTS and EdTech concepts. This process resulted in an analytical matrix or heuristic tool to examine the different ways promoters configure the relations between bodies, learning and

agency through the materiality of their technology. By studying how comparisons are made in practice and foregrounding the multiplicity of sociotechnical configurations, it seeks to problematize 'the female fertile body' as a category that might otherwise be left unquestioned.

[Table 1]
[Table 2]

The body tracking configurations matrix

As seen in Table 2, I identified not one, but four ideal-typical configurations of technology and users' bodies imagined and materialized in promoters' discourses of fertility tracking apps: (1) 'the tracked', (2) 'the trained', (3) 'the tweaked', and (4) 'the threatened'.[4] These configurations do not represent the full range of fertility tracking apps, nor do they exhaustively describe variation in the sample. Promoters' perspectives sometimes overlapped with more than one ideal-type. Thus, the comparability of the matrix presented here (see Table 2) aims to make visible the diversity of the assemblages I observed in the development of fertility tracking technology. I present selected illustrations of each configuration below.

Configuration 1: the tracked body – valuing productivity

> 'Women's health has been undercapitalized, it's time for a change!'; 'Women don't buy healthcare like they buy shoes ... they need trust'. (CEO of a digital health company, Dec 3, 2019, Boston [MA])

On a snowy December day in 2019, I find myself on the 15th floor of a hotel in Boston city-center at the Women's Health Innovation Summit (WHI) listening to promoters of self-tracking apps pitch their technologies to an audience of venture capitalists. Discussions thrive around Femtech – understood as data-driven women's healthcare – which is presented as a lucrative and promising market opportunity. Women are referenced mainly in biological terms or gendered consumption behaviors.

In the tracked body configuration, users of self-tracking apps are imagined as objects for whom the app (as the main 'agential object' [Suchman 2007, 271]) automatically interprets and predicts personal fertility status. In addition, the tracked body is produced in relation to a biosensor that usually takes the form of a connected thermometer. Promoters describe the tracking method as 'simple' compared to traditional methods of fertility awareness, presented as 'complex'. Simplification comes from the automated interpretation by the device of reduced bodily parameters such as menstruation and basal body temperature. An algorithm translates users' calculated fertility states into simplified and behaviorally actionable information items, usually coded in a binary mode: 'fertile' versus 'not fertile' (and

[4] The names of these categories, inspired by emic terminologies, emerged as a result of 'Strathernian comparison,' which is a relational process through which the analytical category and phenomenon emerge together rather than separately (Sørensen, Marlin, and Niewöhner 2018, 153).

occasionally, 'unknown'). When fertile, users are expected to take contraceptive measures if they are at risk of becoming pregnant. The promise of empowerment is located in users' liberation from the learning as will be described in the next configuration, seen as a burdensome activity. Empowerment is understood as a delegation of a tedious task, enabled by the automated interpretative algorithm.

Although the *learning* process is entirely delegated to the algorithm, a software which is supposed to 'learn' from users' regular inputs, promoters usually do not reveal its underlying logic, as one explained:

> Total transparency is not always achievable from a business perspective. [...] We invented the algorithm of the app, and it will be constantly upgraded based on increasing big data. Accordingly, our operation mode or business model is different from other NFP [natural family planning] courses.

The secrecy associated with the corporate production and use of algorithms in this configuration embeds knowledge in what I've called elsewhere a 'soft(a)wareness': an incentive 'to know one's body's internal logic (via objectifying software) while being prevented from access to the inner workings of the software itself (which is black-boxed)'[5] (Della Bianca 2021, 10). This contrasts highly with the 'trained body' configuration that will be shown in the next section.

In this instance, users in this tracked body configuration are often described as having a double deficit. They are portrayed as lacking either the ability or time to engage in more complex methods of fertility awareness; sometimes both. Based on this imagined perception, the technology is presented as a means to reduce the burden of learning, allowing the user to allocate time for other (more productive) activities.

Promoters in the tracked body configuration usually emphasize the accuracy and relevance of traditional methods of fertility awareness (where users need to draw charts and calculate their fertility statuses) but acknowledge that, based on their observations or personal experiences, these tasks are too burdensome. Therefore, this is precisely where they situate their market opportunity: in the translation of a 'complex' educational method into an 'easy-to-use' and marketable tracker.

Configuration 2: the trained body – valuing autonomy

> How can natural family planning be implemented in an algorithm? How far can it go in the delegation to the software? (Gynecologist, April 27, 2018, Cologne)

These questions about the role of algorithmic technology in natural family planning (NFP) are presented by a speaker at a congress held in Cologne in April 2018 entitled 'Family planning today and tomorrow – They say it's love'. Under this intriguing title, the congress gathers members of the 'Arbeitsgruppe NFP', a working group created in 1981 and dedicated to the evaluation and promotion of NFP methods (NFP Online 2021). The speaker concludes:

[5] See also Lynch (2015, 176–199).

> Apps are the future in natural family planning, but the method will still require self-observation. [...] Apps cannot take 100% of the work from the woman. They will need to be well-fed, and we'll need prospective effectiveness studies.

As this gynecologist does, promoters in the trained body configuration describe self-tracking for pregnancy prevention as 'more than just technology'. They present the apps as the medium through which learning can be facilitated, but not replaced. In particular, they present self-tracking apps as a means for facilitating decisions about when to have sex, and recommend not to have unprotected intercourse when fertile to avoid conception.

The expected performativity of apps in the trained body configuration is conceived to enable interpretation *with* the user, but not to do 'the work' *for* the user (contrary to apps in the tracked body configuration). In fact, promoters in this configuration mobilize physiological facts assessing that no technology can actually *predict* ovulation. As one promoter states, 'Such an event can only be identified by the woman retrospectively, when all the parameters align'. The multiple parameters include menstruation dates, temperature, and self-observation of cervical mucus and secondary symptoms such as breast tenderness or cervix position. In this configuration, the substances tracked play a key role, as the apps rely not only on tracked temperature objectified by a thermometer, but also on users' self-observation of their body, that they enter into the app; based on these datafied substances and specific 'rules', the apps define in/fertile phases.

Promoters typically emphasize the importance of learning and the transmission of expertise from human instructors to learners who, once trained, become experts on their body and potential teachers themselves. Interpretation is encouraged in its collective dimension, i.e., with the help of teachers, practitioners, or partners.

As in the tracked body configuration, the apps function here as a translation on a digital format of the 'pen and paper' symptothermal method for NFP. But in the trained body configuration, users are 'figured' as able to become interpretative agents in the assessment of their fertility status (Suchman 2007, 281). They learn to recognize different body parameters, systematize their observations and transfer them on their digital charts to assess fertile and infertile days. Thus, this configuration materializes a 'science of perceptible knowledge' (Baumgarten, as quoted in Jimenez 2016, 207) where knowledge is produced through trained intuition and sensory experiences. Users themselves need to become the authoritative and autonomous figure of expertise. In this configuration, users are imagined to become empowered by learning about and from their bodies.

Configurations 3 & 4: the tweaked & the threatened body

Whereas most of my observations fit within either the tracked or trained configurations, two additional configurations, though less frequent, emerged from my field observations: the 'tweaked' and the 'threatened body'. As the analytical matrix is intended as a tool to articulate differences, I discuss them next to illustrate additional variations of ontologies of the self-tracking menstruating body.

The tweaked body[6] – valuing convenience

During the Natural Family Planning (NFP) Congress in Cologne, a session is dedicated to the 'practical experience' of NFP promoters from different countries around the world such as Gambia, Belgium, China, Sweden, the United States, to name a few. A promoter from the United States, a trained anthropologist working in the field of Obstetrics and Gynecology, presents a prospective study based on her team's newly developed fertility tracking app.

The promoter raises two problems related to existing menstrual cycle tracking apps for pregnancy prevention. The first one is related to a lack of rigor surrounding such apps, as she states:

> Fertility apps is a very crowded space. It seems that almost anybody can put an app on the App Store and just call it whatever they like. This is a bit of a problem and requires us to think very hard about how we can move this field forward in a positive way. Because almost none of these apps are based on very rigorous research.

She cites two reports concluding that apps predicting ovulation are generally inaccurate, insufficiently founded on scientific evidence, and, therefore, unreliable (cf. Setton, Tierney, and Tsai 2016; Duane et al. 2016). These reports show such apps might not be sufficient for pregnancy prevention, if users don't receive additional training or counseling from health practitioners. The second problem comes with the fact that such additional training or counseling are not accessible for many women lacking appropriate resources (financial, material, educational or infrastructural).

To address these problems, the promoter's research team developed an app in which complex methods for fertility tracking are simplified thanks to big data analytics, and therefore don't require additional user training. In parallel, the team launched a prospective efficacy study of (and through) their app to assess its accuracy. The simplification takes the form of minimal tracking requirements, using menstruation dates as the single parameter. This contrasts with the tracked body configuration, in which users are supposed to track both their menstruation dates and their temperature, or with the trained body configuration where users track multiple parameters such as menstruation dates, temperature, cervical mucus, cervix or breast tenderness.

The tweaked body configuration also differs in how promoters situate users and 'non-users' culturally (Oudshoorn and Pinch 2003). Its promoters emphasize differences between women (and changing perspectives in individuals) when it comes to contraception needs and preferences:

> It's not like either somebody wants to get pregnant or they don't. It's very nuanced, and we need to recognize that, I think in our teaching and in our studies and in the way we assess advocacy.

[6] I am referring to the Merriam-Webster's definition of 'tweak' as 'to make usually small adjustments in or to' something.

In the tweaked body configuration, promoters attempts to address biosociotechnical complexities. They acknowledge the utility and accuracy of the methods from the tracked and trained body configurations, but argue that those technologically mediated practices are not accessible for all women. Therefore, they aim for maximum convenience, rather than maximum productivity or autonomy. Instead of providing users with a techno-determined binary fertility status (such as in the tracked body configuration) or requiring them to triangulate and assess multiple body parameters (such as in the trained body configuration), they provide them with a simple and usable estimation, and let them act upon it.

The threatened body – valuing control

This configuration contrasts strongly with the previous ones, as actors in this configuration act as *dissuaders* of fertility tracking for pregnancy prevention. At different field sites, promoters frequently expressed skepticism about one or another conception of users, or how a particular configuration could be actualized. They raised criticism towards misleading or poorly backed-up research, and the general lack of transparency about how the algorithms were built. While they would at times challenge the relevance of specific fertility tracking technologies and/or create controversies, they would nevertheless agree on the possibility and desirability of using self-tracked data to assess fertility. By contrast, promoters in the threatened body configuration reject fertility tracking for pregnancy prevention in all its forms.

One striking example of such opposing perspectives occurred at the 15th Congress of the European Society of Contraception and Reproductive Health, held in Budapest in May 2018. After hearing a presentation from an advocate of 'Natural methods for birth control' – who happened to be the same speaker I had heard in Cologne –, I attended a talk on the 'Contraceptive Paradox' by a gynecologist from Austria. In his talk, he invalidates self-tracking for pregnancy prevention and states:

> It's either a woman controls her fertility, or her fertility controls her – only the romantic refuse hormones. Even the words 'natural' in 'natural contraception' is misleading. Chemical hormones are the language of the body. They really are the only way women can have full control over their reproductive bodies.

The gynecologist presents a conception of fertility different from the ones seen above. To him, hormones are nothing to fight against, as they represent the 'language of the body'; whether they are manufactured medication or human does not make a difference in his narrative. Therefore, he rejects the claims from advocates of 'natural methods' (as seen in the tracked, trained, and tweaked body configurations), for whom nature is associated with a subject whose body is not altered by synthetical hormones.

While previous configurations require users not to use hormonal medication that would render tracking inaccurate or meaningless, in the threatened body configuration, it is the reliance on tracking that is presented as inaccurate and meaningless. While the tracked and trained configurations often associate potential danger with the contraceptive pill, on the contrary, the threatened body configuration associates danger with not being in control of a

– chaotic – woman's body: empowerment results from external control over disclaimed 'natural fertility', rather than learning about or with the body. The body constructed in these oppositional relations is configured as a body at risk of misleading claims for accuracy. It is configured as vulnerable and in need of protection; a protection that should be offered by science and scientific experts.

Discussion

Contrasting the configurations

The typology that emerged from field observations and typified in the *Body Tracking Configurations Matrix* foregrounds not one, but multiple 'learning regimes' (Decuypere 2019, 4) embedded within fertility tracking apps for pregnancy prevention. As a tool for comparison, the analytical matrix make visible several distinct ontologies of the body that were configured by promoters of fertility apps.

For instance, promoters disagree on whether and how the body should or could become a pedagogical site through menstrual cycle self-tracking apps. The configurations range from emphasizing the biosensor as single authoritative actor in the pedagogical assemblage (cf. the tracked body), to the multiple actors involved and required in the process of learning and teaching (cf. the trained body), to the app's algorithm as the key learning component (cf. the tweaked body). Dissuaders, on the contrary, opt for the replacement of learning with external control over the body (cf. the threatened body).

Secondly, promoters mobilize different epistemologies (i.e., data-driven, sensory-based, and evidence-based) when framing the purpose of fertility tracking. Toggling between imaginings of more active users with 'low tech' (cf. the trained body) and more passive users with 'high tech' (cf. the tracked body, the tweaked body), promoters nevertheless agree on the potential validity of menstrual cycle tracking for pregnancy prevention. Their views contrast with imaginings of tracking as unreliable (cf. the threatened body).

Thirdly, promoters rely on and enact multiple 'ontologies' of the body (Mol 2002), configured as data provider (cf. the tracked body), instrument (cf. the trained body), social entity (cf. the tweaked body), or, for dissuaders, entity at risk (cf. the threatened body). In line with feminist science and technology studies approaches, it reminds us that – gendered – bodies are always constituted in practices (McNeil and Roberts 2011).

Thus, the matrix is not only a typology, it is an analytical framework for revealing how different technology promoters configure the relationships between agency, learning, and bodies. It helps make visible to what degree agency is being delegated to which actors (apps, biosensors, users, partners, teachers, medical doctors, etc.); at the same time, it helps make visible the degree to which learning is deemed necessary for the practice to 'work'.

Contesting some configurations

Within the social sciences, the ideal-type of the tracked body is the most commonly found configuration. Scholars studying apps related to this configuration have shown how users'

bodies and 'metrified fertility' are positioned by many promoters as lucrative business opportunities (Roberts and Waldby 2021, 17) and have highlighted, amongst other issues, the ways this configuration often fails to acknowledge for the diversity and 'messiness of menstruators' experiences (Pichon et al. 2021). Some social scientists accounts align with dimensions of the threatened body configuration, in which users' are 'at risk' of the unintended consequences of such tracking technologies. However, in their accounts, the risk is situated in potential threats to subjecthood and intensification of gendered reproductive imperatives rather than in ineffective contraception (Fox and Epstein 2020; Healy 2020; Lupton 2016a; Novotny and Hutchinson 2019), or in risks related to data reliability, security and transparency (Hendl, Jansky, and Wild 2019). Additionally, a growing number of studies of users' experiences ask *why* and *how* some individuals turn to such apps to track their menstrual cycles (for a scoping review of available research until April 2019; see Earle et al. [2021]).

In contrast to the tracked body, which has been critically theorized only very recently, the trained body configuration is most commonly found in sociological literature from the 1980s and 1990s. Feminist scholars were particularly critical of the marketing of any clinical instrument for ovulation prediction and detection. For example, DeNora (1996, 371) feared that the new technologies would exert power over the female tracking subject for male observers such as doctors or partners. Mobilizing 'ethno-technologies' and their body 'as an instrument in its own right' rather than objectifying technologies – such as dipsticks for ovulation detection – women 'once trained, [become] the 'real experts' on their own bodies (DeNora 1996, 370). Technological artefacts of 'quantitative measurements' for birth control were deemed 'unnecessary and likely ineffective' compared to women embodied knowledge (Bell et al. 1980, 30). Training women to know their own bodies was considered key for the method to work. However feminists from self-help groups in the United States were highly critical of the Catholic Church teachings of that time, and especially the recommendation to use 'abstinence', and insisted that training should also be led by 'non-Catholic teachers' (Bell et al. 1980, 31).

The tweaked body configuration that I observed has not yet, to my knowledge, been discussed in social sciences. To some extent, it is similar to the tracked body configuration in its reliance on data-driven analytics as a promise of accuracy for the detection of ovulation. However, it differs from the tracked body configuration in its inclusion of more-than-biological dimensions: by highlighting the socially situated positions of users, it can be said to foster a more co-constructivist approach of technology and users. It also aligns with design recommendations from the field of personal informatics suggesting representing fertility status as probabilities rather than dichotomic indications such as fertile versus not-fertile (Epstein et al. 2017, 7). Occurrences of the threatened body configuration as a rejection of fertility tracking apps for pregnancy prevention are most commonly found in the field of reproductive sciences, in which researchers tend to oppose the categorization of such apps as contraceptives, and valorize instead methods with higher clinical effectiveness, such as

'injectable and oral contraceptives, sterilization, and long-acting reversible contraceptives' (Austad et al. 2016, 342).

Imagining different configurations

Scholars have shown that promoters' expectations of imagined users often do not match users' ambivalent and complex experiences with data (Lupton 2020; Wilkinson, Roberts, and Mort 2015), resulting in 'disjunctures' (Fors and Pink 2017, 2). To address such concerns, activists and interdisciplinary research teams have suggested design interventions for shaping more emancipatory fertility tracking technologies, assuming that a change in the design will change their effects in society. Among these, some initiatives encourage the inclusion of users' feedback in the design of these technologies in order to better configure and represent users' specific needs and values (for example, Fox and Epstein 2020; Hendl, Jansky, and Wild 2019; Novotny and Hutchinson 2019; Pichon et al. 2021). Indeed, they echo the argument by Hayhurst, Giles, and Wright's (2016) to develop participatory research – or, in healthcare, 'experience-based co-design' (Fucile et al. 2017) – as an approach that serves to reorient reductionist market-oriented biopedagogies to the needs of the people they address.

Here, I also want to point to perspectives that do not locate the possibilities for intervention solely in the design process of such technologies but also in the interactions between technologies and users. Studying fetal ultrasound, feminist scholars Frost and Haas (2017, 92) invite 'everyday women' to be 'decolonial bricoleurs' in their approaches to technologies. By that, the authors mean to develop, with 'communities and allies' (103), critical means of looking at and interacting with technologies in ways that go beyond configurations in which subjects' agency over their bodies is undermined (97). Frost and Haas' recommendations echo what Jasanoff (2007, 33) calls 'technologies of humility', i.e., 'disciplined methods' that 'compel us to reflect on the sources of ambiguity, indeterminacy and complexity' inherent to technoscientific knowledge. Rather than aiming for a resolution of ambivalences in 'human-machines interactions' (Suchman 2007, 259) with a perfectly-designed artefact – a 'technological fix' (Rosner 2004) –, a more pragmatic attempt to deal with these innovations, as these approaches suggest, might be to engage in reflexive practices about the ambiguity and multiplicities of self-tracking apps.

As a heuristic device to better understand technologically mediated practices, the matrix can help actors engage in both kinds of strategies described above. Allowing to *zoom into* the specificities of each configuration, the matrix can help actors engage in reflexive activities by comparing, contrasting, and opting for the configuration(s) most fitting with their values. At the same time, as the matrix offers to '*zoom out* to a wider view' (Suchman 2007, 283, emphasis added), it can also help actors improve existing configurations, as well as map changes in self-tracking apps ecologies.

Conclusion

In this article, I have demonstrated how the configurations of bodies, learning, and technologies are not unidirectionally and uniformly determined by a supposedly monolithic

power (such as the ideology of healthism). Following FSTS perspectives to understand complex body-tracking assemblages, I rather suggest that biopedagogy is a concept that implicitly contains a dualistic mode of thinking – between designer/user, and valuable/invaluable knowledge – that could be too reductive to account for the diversity of practices from which body-tracking technologies emerge and in which they are embedded and transformed. Acknowledging that sociotechnical configurations are 'multiple' rather than fixed and determined, means that they can be appropriated differently (Mol 2002) or 'reconfigured' (Suchman 2013, 49).

With this matrix, I've started to formulate a more nuanced analysis of the different configurations of the self-tracking body as a pedagogical site in fertility tracking apps; the matrix leaves room for adaptation, exploration, redefinition. Further research could dive deeper into promoters' profiles, motivations, backgrounds, as well as the material resources and infrastructures beyond their work. Additional analyses in this line could investigate which body ontologies emerge from users' experiences and contrast them with the ideal-types presented here or expand the analytical matrix by adding an intersectional feminist lens.

Useful avenues for intervention, such as participatory research, critical reflexivity and humble engagement with technoscientific artefacts, offer promising opportunities to carve out the third space needed to widen the scope of the aforementioned empowerment vs. discipline debate. Such perspectives, rather than promoting a simple 'de-technologization' (Stanković 2017, 7), or over-technologization, incite us to consider technologies in the multiple contexts of their enactements that extend beyond the expectation of a singular technology adequately fitting the full-range of users' needs. Unpacking and expanding our understandings of the ways menstrual cycle tracking apps *are* and *can be* part of multiple biosocial assemblages can open up new and creative ways to live in our increasingly technoscientific environments.

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Table 1. Data sources

Method	Date	Location	Description
Field observations			
International Congresses			
NFP Congress	27–28 Apr. 2018	Germany	International Congress on Natural Family Planning, field notes
Medical Congress	8–12 May 2018	Hungary	15th Congress of the European Society for Contraception and Reproductive Health, field notes, and transcripts from audio files
Technological fairs			
Alternative Medicine Fair	31 Jan. 2019	France	Salon Bien Être et Médecine Douce, field notes, and transcripts from audio file
Innovators and Venture Capitalists Summit	3–4 Dec. 2019	United States	Women's Health Innovation Summit, field notes, and transcripts from audio files
Consumer Show	7–10 Jan. 2020	United States	Consumer Electronics Show 2020, field notes, and transcripts from audio files
Explorative and follow-up interviews			
Open interviews	16 Oct. 2017, 15 Dec. 2017, 6 Nov. 2019	Switzerland, Germany, United States	Transcripts from three face-to-face interviews with technology promoters
Open e-interviews	Nov. 2018 – Mar. 2020	Online	Emails exchanged between the author and three technology promoters, based in Switzerland, and in China

Table 1: The 'Body Tracking Configurations Matrix' applied to fertility-tracking apps promotion (and dissuasion*)

Ideal-typical configurations	**The Tracked Body**	**The Trained Body**	**The Tweaked Body**	**The Threatened Body***
A. Expected performativity of the tracking device	Predicting ovulation *for* the user	Interpreting fertility *with* the user	Estimating fertility *for* the user	Misleading the user
B. Authoritative actor(s)	Technology	Technology, users and related human actors (teachers practitioners, partners)	Technology and users	Scientific experts
C. Instruments; parameters tracked;	App & biosensor; reduced parameters	App & biosensor(s) and body; multi-parameters	App; single-parameter	Hormonal contraception; no parameter tracked
D. Learning regimes	Empowerment in the liberation from learning	Empowerment by learning	Empowerment in the liberation from learning	Not mentioned
E. Ontologies of the Body	Body as data provider	Body as instrument	Body as social entity	Body as entity at risk
F. Central value	Productivity	Autonomy	Convenience	Control