Reflections on Self-tracking Routines: Conducting Maintenance of Digital Data

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Abstract: Self-tracking technology is considered a critical learning and motivational resource that at best helps people self-reflect, thereby promoting attempts to make changes to lifestyle routines. This study examines how people incorporate this technology into their daily practices and the routines that self-tracking technology produces. The study is based on an in-depth empirical analysis of a sample of interviews of volunteer participants of a pilot study aiming to promote health and wellness. The interviews took place in two phases: first, after three months of self-tracking (in total 27 interviewees) and second, at the end of the pilot study after ten months of self-tracking (in total 21 interviewees). The analysis focused on the participants' reflections on their user experiences of a self-tracking device, the data that this produced and the resulting routines. The results suggest that people's self-tracking routines are often related to the maintenance of a visible and continuous data flow in self-tracking applications. Routines for wearing, tending to and communicating with self-tracking devices play an important role. These routines are either only remotely related or not necessarily at all related to making changes to lifestyle routines that affect health and wellness. The development of routines through novel artefacts involve much invisible work and can even lead to unintended consequences. During self-tracking, the focus may remain on the technology alone and on attempts to develop routines for maintaining a continuous, accurate flow of data, rather than on actually making lifestyle changes.

Keywords: routines; artefacts; health and wellness promotion; pilot study; self-tracking.

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1. Introduction

Health care settings are hoping for an overall shift in emphasis from routines of reactive treatment to routines of the proactive prevention of diseases and the maximization of people's wellness. These hopes are materialized in, for instance, emerging P4 medicine, which stresses the role of individuals' health data as predictive, preventive, personalized and participatory (Hood and Friend 2011). P4 medicine aims for behavioural changes to lifestyles that at best result in routines that add to health and wellness. People today are encouraged to actively collect their personal data because these are considered the "best (yet often 'untapped') resource for information" on themselves in general, and their own states of health and illness in particular (Wyatt et al. 2013, 132). Here, self-tracking devices that enable real-time tracking are considered important artefacts that support monitoring, documenting and analysing various aspects of daily life, such as activity and sleep, which affect health and wellness (e.g. Swan 2012). Self-tracking devices thus allow datafication, that is, the transformation of social action into online quantified data (Mayer-Schönberger 2013). The resulting personal data can act as a critical learning and motivational resource that at best may help people self-reflect and thereby improve their attempts to make changes to their lifestyle routines, in turn contributing to better health and wellness.

This study recognizes routines as patterns of action and refers to Feldman and Pentland (2003), who note that in addition to the routine in principle, i.e. the generalized idea of a routine, there is the routine in practice, i.e. the enactment that brings the routine to life. The role of artefacts is considered essential in the production and reproduction of routines (D'Adderio 2011). This is because they are seen to offer an 'invitation' for action simply by being there and being available (Callon and Muniesa 2005). At the same time, artefacts may act as important mediators or intermediaries in routines while organizing or even transforming the knowledge, skills and capabilities of their users (Latour 2005). As D'Adderio (2011, 210) points out, "the actor's knowledge, skills, and competences *depend on* – and are at the same time *configured by* – the tools and artefacts they encounter or involve into their routine performances". This does not mean that artefacts completely determine actions; instead, artefacts may act as an enabling or constraining source, making it easy and possible to do some things or difficult and impossible to do others, including the creation of particular routines (e.g. Orlikowski 1992).

The deployment of novel artefacts that support particular routines or even routine change is not, however, easy. The designers and promoters of behaviour change technologies face challenging questions not only regarding usability (can the users use the technology?) and user engagement (does the technology meet the users' needs?) but also on the long-term effects of the technology (Stawarz and Cox 2015). Thus, one of the key questions in terms of routines is whether the technology supports the de-

sired routines or routine change, in other words does the technology actually work for its user?

The existing literature has noted that self-tracking technology provides an infrastructure that "allows for both reflexivity and a creation of flexible routines" in a personalized manner (Lomborg and Frandsen 2016, 1019). At the same time, recent studies have acknowledged a lack of understanding of how people generate and interpret their self-tracking data, as well as of how they incorporate it into their daily routines (Pink et al. 2017; Lupton et al. 2018). Moreover, it is important to recognize that digital data may well be broken (Pink et al. 2018). This means that incomplete, inaccurate, contingent, fractured, or dispersed self-tracking data may affect the type of routines that self-tracking technology produces.

This study aims to contribute to the discussion on self-tracking routines through an empirical investigation of how the users of self-tracking devices reflect on their routines related to this technology. The context of the study is a large pilot initiative aiming to promote health and wellness. In the pilot initiative, the advancement of individuals' lifestyle changes played an important role, and to support the volunteers' attempts to record and potentially change their health- and wellness-related routines, in particular activity and sleep, they received an activity wristwatch, the Withings Activité Pop, which is a self-tracking device with a connected smartphone application (Withings Health Mate). This study is based on an in-depth analysis of a sample of interviews of the pilot study participants. The analysis focused on the participants' reflections on their user experiences of the self-tracking device, the data that it produced and the resulting routines. To obtain an understanding of how the participants incorporated this technology into their daily practices and the routines that the self-tracking technology produced, the interviews had two phases; first after three months of self-tracking, and second at the end of the pilot study after ten months of self-tracking. The interviewees consisted of three different types of pilot participants: those with no previous experience of self-tracking, those with extensive prior experience, and those who were extreme in their self-tracking.

The results show how in the interviews, the pilot study participants mainly reflected on the self-tracking routines that were related to maintaining a visible, continuous data flow in their smartphone applications. Some participants were also concerned about the accuracy of their data and tried to invent ways in which to gain more reliable data. The routines for wearing, tending to and communicating with their self-tracking devices played an important role in the participants' reflections. Interestingly, these routines were either only remotely related or not necessarily at all related to the original aims of the application of the self-tracking device in the pilot initiative, i.e. the improvement of activity and sleep routines contributing to health and wellness. The results thus suggest that developing routines through novel artefacts involves much invisible work and can

even lead to unintended consequences. Instead of promoting lifestyle changes, the focus may remain on the technology alone and the aim may be the development of routines for maintaining a continuous, accurate flow of data.

2. Self-tracking Routines

There are several disciple-specific literatures on routines. This study addresses the literature developed in organization theory, which recognizes routines as patterns of action. Feldman and Pentland (2003) have emphasized three interrelated and important aspects of routines; the ostensive and performative aspects of routines and the related artefacts. They define (2003, 101) the ostensive aspect of a routine as "the abstract, generalized idea of the routine, or the routine in principle". These can be taken-for-granted norms, normative goals, or may exist as codifications in various forms of artefacts consisting of guidelines, rules or templates for behaviour. Importantly, however, they remind us that such codifications are not unified objects; instead, people always have their own subjective interpretations and understandings of the ostensive aspect of a routine. Health and wellness promoters, for example, may consider self-tracking devices artefacts that contain a template for data collection routines that allows self-reflection and thereby potentially also the improvement of changes to lifestyle routines (see Lupton 2014). The subjective interpretations of device users, however, can vary from seeing self-tracking devices not only as a tutor helping in the formation of routines, but also as a tool to build statistical records, for instance, or simply a toy that is fun to play with (Lyall and Robards 2018).

The performative aspect of a routine, defined by Feldman and Pentland (2003, 101) "consists of specific actions, by specific people, in specific places and times. It is the routine in practice". They note that the performative aspect of a routine is inherently improvisational, as it can be adjusted to changing contexts. People may choose to use self-tracking devices in different ways in different situations. Studies show that people use self-tracking devices for various purposes; for example, to document their activities, to reach various goals ranging from behaviour change to effective training, to gain support for self-reflection and self-care, or to detect patterns and causal relationships in various health-related matters (e.g. Li et al. 2011; Rooksby et al. 2014). Artefacts that only contain ostensive aspects of routines become meaningless if the routines have no performative aspect. If people are indifferent to self-tracking data and do not find the use of the device meaningful at all, they may even abandon the device completely (Ledger and McCaffrey 2014; Nafus 2014).

Importantly, routines also contain internal dynamics. Feldman et al. (2016) note that in routines, action is always situated. This means that routines are always enacted at specific times and in places in particular

sociomaterial contexts. Pink et al. (2017), for instance, have shown how people appropriate their self-tracking practices into their cycling routines. Feldman et al. (2016) stress, however, that situated action requires a great deal of effort, and people need to be knowledgeable and often also reflective while accomplishing routines. It is not easy to generate the same patterns of action time after time. Instead, there is a constant struggle to deal with simultaneous pressures of replication (to copy exactly) and innovation (to make variations or changes) (D'Adderio 2014). Thus, as Feldman et al. (2016, 508) point out, "stability in routines is both a matter of perspective and a matter of time". They emphasize that stability is always an accomplishment, and at best, routines can only be stable at a given time. Ledger and McCaffrey (2014) have noted that many users completely stop using devices for self-tracking routines after a few months, which means that the devices do not necessarily succeed to drive long-term routine engagement.

Intentional routine change has been at the centre of many practitioners' attempts and is also the interest of research (e.g. Dittrich et al. 2017; Glaser 2017; März et al. 2017). Guidelines for healthy living, which are seen as advice for managing our bodies and lifestyle changes, are plentiful, and people often falsely consider changing everyday routines to involve simply, straightforwardly and easily putting knowledge into practice (Lindsey 2010). Routines change as a result of "people doing things, reflecting on what they are doing, and doing different things (or doing the same thing differently) as a result of the reflection" (Feldman 2000, 625). Reflective talk has shown to support routine change through envisaging and evaluating alternative patterns of possible actions as well as alternative ways of enacting a routine (Dittrich et al. 2017). The role of artefacts has also proved important in intentional routine change (e.g. Iannacci 2014; Glaser 2017; März et al. 2017). As Pentland and Feldman (2008) have shown, however, shaping routines through the design or implementation of novel artefacts is not easy, nor necessarily successful. As they note, the risk of failure is particularly high when artefacts are developed by those who do not participate in the routines themselves, and when the perspectives of those who enact the routines are completely ignored. As an example, technological artefacts are often designed only for particular versions of the human body: the action options of the same technological artefacts can be quite different, for instance, for a disabled body (see Scarry 1985; Bloomfield et al. 2010). The adaptation and customization of technological artefacts for better support of routines or routine change can also be difficult due to the 'power of default' of such artefacts (Koch 1999; Pollock and Cornford 2004; D'Adderio 2011).

To develop self-tracking routines, it is essential that people gain data that are 'lively', something that they can reflect on and consider somehow meaningful in their daily lives (e.g. Lury 2012; Lupton 2016). It is important to note that users of self-tracking devices do not perceive their data as uniquely objective and true, and self-tracking can produce a varie-

ty of meanings and values of data for people, from mindfulness and resistance to digital storytelling (Sharon and Zandbergen 2017). Similarly, self-tracking devices do not necessarily operate in a straightforward manner in health and wellness promotion: they may serve as conversation facilitators through the production of situated data that become meaningful through people's reflection on them in the context of their everyday lives (Pantzar and Ruckenstein 2017).

While using self-tracking devices, both experienced and inexperienced users may, however, experience serious difficulties in their attempts to track and reflect their personal data (e.g. Rapp and Cena 2016; Yli-Kauhaluoma and Pantzar 2018). Data collection and recognition of behaviour patterns and trends can be burdensome and time consuming (Li et al. 2011). Data interpretation, i.e. extracting meaningful information from self-tracking data, is not necessarily easy and may require clear tracking strategies or even various material workarounds (Choe et al. 2014). The users of self-tracking devices may even encounter data that are broken, i.e. inaccurate, incomplete, or dispersed across different digital platforms (Pink et al. 2018). This means that self-tracking devices and the data that they produce may require continuous maintenance and even repair routines. As long as the artefacts work, however, maintenance and repair routines often remain invisible (e.g. Shapin 1989).

Jackson (2014, 221) has noted that we ought to "take erosion, breakdown, and decay, rather than novelty, growth, and progress, as our starting points in thinking through the nature, use, and effects" of the artefacts around us in everyday life. The artefacts around us can be fragile (Connolly 2013) and they usually collect traces of consumption (Gregson et al. 2009). Object maintenance requires care tasks that entail both constant watchfulness (Denis and Pontille 2015) and user competences (Gregson et al. 2009). When breakdowns and malfunctions occur, they are not necessarily easily fixed (Graham and Thrift 2007); repair often involves situated interaction between the social world and material possibilities, which need to be examined carefully (see Jarzabkowski and Pinch 2013; Mitrea 2015). The digitality of objects complicates things even further and undoes professional boundaries not only between making and using (Suchman 2014), but also between making, using and repairing (Denis et al. 2015). Tanweer et al. (2016) have shown that the maintenance and repair of digital data is ordinary work for those who are professionally involved with complex data sets. They show how working with digital data requires data manipulation, improvisation and even innovation for dealing with and repairing continuous data breakdowns.

3. A Study of Self-Trackers' Accounts of Routines in a Health and Wellness Pilot Initiative

The design and implementation of various types of health interventions in the form of pilot studies or trials (e.g. Hood et al. 2015; Lynch and Cohn 2015) has attracted great interest in recent years, to find solutions for increasing the levels of people's physical activity and to more generally promote healthy ways of living in modern society. At the same time, people are eager to learn more about themselves, their state of health and health risks, their connection to others, and even to contribute to research (e.g. Turrini and Prainsack, 2016). The empirical setting of this study is a health and wellness pilot initiative[1] in which the promotion of individuals' lifestyle changes played an important role. To obtain knowledge of the participants' state of health, various types of data, such as genomic, metabolomic, microbiome and comprehensive lifestyle monitoring data were collected in the pilot initiative from roughly one hundred healthy volunteer participants (see Neiman et al. 2019). The pilot organizer recruited the participants from the clientele of a private occupational health service provider. They were employees from four different large organizations. All the participants signed an informed and voluntary consent form for the study. The pilot initiative ran for sixteen months from October 2015 to January 2017.

To support the volunteers' attempts to record and potentially change their health- and wellness-related routines, particularly activity and sleep, the participants were 'pushed' into a self-tracking mode (see Lupton 2014). This means that self-tracking was taken up voluntarily but encouraged as part of the pilot initiative. The participants received an activity wristwatch, the Withings Activité Pop, which is a self-tracking device with a connected smartphone application (Withings Health Mate). According to the pilot organizers, the selected self-tracking device was chosen in the pilot initiative because it was considered relatively affordable, easy to use (according to the manual, it has an estimated battery life of up to eight months, which means the battery does not have to be charged often), and discreet (it resembles a wristwatch). Most importantly, however, the chosen device allowed participants to collect data on their everyday activity (mainly number of steps) and sleep (amount of sleep time), thus helping them record and make their daily activity and sleep routines visible, potentially helping them change these.

3.1 Key affordances and maintenance and repair of device

The installation and operating instruction manual of the chosen self-tracking device, Withings Activité Pop, emphasizes ease of use. The tracking of walking, running and swimming as well as sleep is said to be automatic, mainly only requiring the person to wear the device. As a result, the user can see their total number of steps taken during the day, the

percentage of their achieved daily step goal and the estimated calories burned during the day. After swimming, the user is informed of the length of the swim session and the calories burned. Regarding sleep, the user gains data on their total time spent sleeping and the duration of their light and deep sleep cycles as well as waking hours. The percentage of the daily sleep goal is also visible. The collected data are shown in the connected smartphone application (Withings Health Mate) in multiple ways: as graphs, numbers, and percentages and in different colours.

The manual has guidelines for both the maintenance of the device itself as well as the data flow it produces. For maintaining the functioning of the device, the manual tells the user what kind of materials to use for cleaning (e.g. lint-free cloth to clean the glass and casing) and how to clean the device (instructions for glass, casing and wristband). In addition, the manual has instructions for when and how to replace the batteries or the wristband of the device (when the hands have stopped moving and the watch no longer vibrates when the reset button is pressed).

The key issue of the production and maintenance of data flow is data synchronization. The installation and operating instruction manual promises that the synchronization of data continues in the background as long as the Bluetooth wireless technology is enabled. Automatic synchronization is triggered when the user has collected a certain number of steps, reached the daily steps objective, when enough time (over six hours) has passed since the last synchronization, or if the time zone changes or daylight saving begins (p. 29). However, the user also has the option of synchronizing their data manually: for this they must open the connected smartphone application and keep it close enough to the device itself. The importance of synchronizing data is emphasized in the following text, which is highlighted, bolded and marked with a warning sign: "Your Withings Activité™ Pop/Withings Activité™ can only store your data for 38 hours. Make sure you open the app regularly so that you do not lose any of your data" (p. 29). Updating the software of the device is considered an important part of its maintenance. The manual emphasizes the importance of data synchronization before updating the versions, as otherwise data might be lost.

The main advice regarding the repair of the device is that users should not try to repair or modify the device themselves and should leave this to a professional technician. If the user feels that the time displayed on the device is incorrect, the manual advises recalibrating the device. The manual provides no other instructions for the repair of data.

3.2 Methods

The participants received their activity wristwatches in February 2016. After approximately three months, they were asked about their experiences of using the self-tracking device and the data that it produced. The interviewees were selected on the basis of two criteria. First, whether they

had any previous experience of using a self-tracking device and second, whether they expected to learn to use the device easily or not. According to these two criteria, three different groups of participants were identified for this study. The inexperienced self-trackers had no previous experience of using any self-tracking devices, nor did they expect it to be easy to learn to use the device. The opposite applied to the experienced self-trackers. The extreme self-trackers were already using either two to three other self-tracking devices or had been using one device for at least two years and expected no difficulties in learning to use a new device. The underlying assumption regarding the identification and selection of the different types of participants was that the experiences of the inexperienced, experienced and extreme self-trackers would differ, and that the analysis would result in the identification of the different types of self-tracking routines that participants develop to improve their activity and sleep.

Twenty-seven out of approximately one hundred participants were interviewed in May and June 2016. Nine interviewees were inexperienced, nine experienced and nine extreme self-trackers (nine male, eighteen female). After roughly six to seven months, twenty-one of these agreed to the second interview at the end of the pilot study in December 2016 or January 2017 (eight male, thirteen female). The time period for both interview rounds was aligned with the schedule of the whole pilot initiative. The first round of interviews was held after three months of using the activity wristwatch, as the assumption was that by then the participants would have become acquainted with the device and that they would have developed some related self-tracking routines. It is important to note that the pilot participants were in principle committed to the use of the selected self-tracking device from when they received it to the end of the pilot study. As the second round of interviews took place at the end of the pilot study, it was possible to examine any changes in use routines.

All the interviewees were well educated. Eighteen had a university degree (from either a university or a university of applied sciences). One interviewee even had a doctoral degree. Seven interviewees had a vocational qualification and one interviewee had completed general upper secondary school. The age of the interviewees ranged from 28 to 57. All the participants gave their signed informed and voluntary consent for the pilot study. The shortest interview lasted 13 minutes in the first round and 9 minutes in the second round, whereas the longest was 80 minutes in the first round and 45 minutes in the second round. The interview questions had received ethical approval[2] and focused on the use of the self-tracking application (Withings Activité Pop) in the pilot initiative. More specifically, the participants were asked how they used the application, how they experienced the use of the application and whether they had any difficulties or problems when using it. They were also asked whether they used any other self-tracking devices, and if so, what their experiences of these applications were. All the interviews were recorded and later transcribed

verbatim, resulting in a total of approximately twenty-five hours of interview material. The anonymity of the interviewees was guaranteed throughout and after the interview process.

Careful reading and systematic coding (see Eriksson and Kovalainen 2008) of the interview material first revealed that not all, but many participants and all the types of self-trackers (inexperienced, experienced and extreme) had connectivity difficulties when encountering and trying to engage with their data. This means that some participants had problems with invisible or inaccurate data, which led to feelings of indifference. Therefore, the next step was to focus on how the participants attempted to deal with the difficulties they faced. This resulted in an analysis of the self-tracking routines that the participants talked about in their interviews. Their attempts to maintain the functioning of the self-tracking device and to produce a continuous, correct data flow were at the centre of their reflections.

4. Maintenance and Repair Routines in Self-tracking Context

The pilot study participants talked a great deal about their methods and attempts to follow their daily activity and sleep patterns through self-tracking. Interestingly, however, many of the self-tracking routines that the participants reflected upon in the interviews were related to the use of the self-tracking technology itself. They talked about the ways in which they tried to maintain and sometimes even fix the data flow showing either activity or sleep.

4.1 Wearing the device: rigid patterns and improvisations

The interviewed pilot participants were dedicated to self-tracking in the pilot initiative. The primary requirement for producing self-tracking data was wearing the device. The interviewees described how they wore their devices and checked the data that they produced on a regular basis. Many followed the number of steps they accumulated during the day and in the mornings checked their time spent sleeping as well as the duration of their light and deep sleep cycles at night. Many considered wearing the self-tracking device and the resulting data exciting and engaging, particularly at the beginning of the pilot initiative.

> Ten thousand [steps] is the goal. You can see at one glance where you are. If it starts to get late and it's about time to go to bed and I notice that I've not reached ten thousand [steps] it begins to worry me. Or, if I already know during the day that this is not a very active day, I may walk a longer route and take additional steps or something. It's become a positive incentive. (Female, 42, experienced self-tracker) (Interview: 1st round)

The excitement of the novel device did not necessarily last long. The routine wearing of the device was no longer motivating when the data stopped producing new learning insights or the device seemed to malfunction. The participant quoted above said in the second interview that after roughly six to eight months, wearing the activity wristwatch felt like having handcuffs. It was not easy to take it off.

> Before the battery change the watch kept time accurately. But it produced silly data as if I'd gone to bed at four, even though it was ten o'clock. Or it showed no data, even though I knew that I had run for seven kilometres.… This [malfunction] lasted roughly 1.5 months. I began to think I wouldn't be bothered if it couldn't be fixed. There was no novelty value for me anymore and as [the data] were a bit unreliable I started to think whether I should wear it at all. I would have liked to wear my own watch again. … I think that I gained the benefits of the device during the first six to eight months of use. I should perhaps try to better remember those insights and live accordingly even if I don't wear these handcuffs all the time. (Female, 42, experienced self-tracker) (Interview: 2nd round)

The same interviewee reflected on her dedication to wearing the self-tracking device in the course of the pilot project. She described her devotion to the routine wearing of the device as obsessive for a long time, even in situations when wearing it broke a dress code or it did not suit certain special festivities. She said that she no longer kept up the routine of wearing the device on all occasions.

> At the end of the summer, a friend of mine had a birthday party… As my hair and makeup were done, my hairdresser wondered whether I would wear the activity watch during the party. I told her that I collected data every day and that [people] won't notice the watch much under my lace gloves. Today, this would be out of the question. I would leave Withings lying on the table if I was invited [to a party like that]. (Female, 42, experienced self-tracker) (Interview: 2nd round)

Some of the participants who felt that the device did not register all the data that it should have were eager to experiment with different ways of wearing the device. These participants were particularly concerned about their activity data as they felt that the device seemed to register only some types of activity, particularly steps, and only when the circumstances for data registration were favourable, for example, when their hands were not still. The problem of lacking activity data mostly bothered the participants who were active cyclists, as the device did not register cycling at all, but also many participants who actively took part in different types of sports. Therefore, some of them tried to think of new ways of routinely wearing the device that would allow them to maintain a data flow of their activity that they considered more realistic.

> I've had the Withings from the beginning [of the pilot study] and I use it and follow [the data]… We were instructed to wear it in our wrists all the time. But, let's say you cycle on an exercise bike for two hours. This means that you hold on to the handlebars for two hours and [the device] thinks that you've being lying on the sofa for two hours… Well, I did some tests and put it on my foot… It worked to some extent. It did recognize some activities. I noticed that in many cases it was better that I had it on my foot instead of my wrist. But, this isn't really the idea. (Male, 43, extreme self-tracker) (Interview: 1st round)

The above-quoted participant's dissatisfaction with the functionality of the device made him experiment with wearing the device in a way that it measured the different kinds of sports that he took part in more accurately, in a more versatile way. The experiment soon turned into routine use. Instead of wearing the device on his wrist, the participant wore it on his ankle.

> Since the last meeting in the spring I've worn it as an ankle monitor. This is where it has least hindered my daily activities. But I quit using it as I didn't gain anything from it anymore… [This was] after the summer, sometime in the autumn. (Male, 43, extreme self-tracker) (Interview: 2nd round)

The participant quoted above felt that the device selected for the pilot participants was not designed for people like him who were active in sports. According to his experience, it did not recognize many of the activities that he conducted regularly, such as skiing. He also feared that it guided people to routinely do sports in an unbalanced way, as people wanted to demonstrate their activity through data, but the sensors measured only particular types of activities (mainly number of steps). The device was designed to be worn on the wrist, and although he felt that the device did not function properly when worn on the ankle, it collected data for him much more effectively than when he wore it on his wrist. Therefore, he kept the device on his ankle instead of his wrist until the watch strap of the device broke. This made him quit using the device completely, as he considered the data useless.

Another participant who was also extremely active in both sports and self-tracking tried to wear the pilot study device on her other wrist, as one wrist already held her own self-tracking device. This was because she feared potential connection disturbances between the devices. However, she felt that it did not help her collect accurate activity data.

> The intensity of my workout in the gym, well, I was completely dead. It was terrible. there was no way I could have done anything else… Well, it showed that I had burned 127 calories and that was it. No calories burned! While my own device showed the recovery time [needs] to be at least 12 hours… I didn't wear [the two different devices] on the same arm because I thought that they [may] connect with each other and there

> might even be interference or something. I wore the one on one hand and the other on the other hand. (Female, 52, extreme self-tracker) (Interview: 1st round)

The participant quoted above needed the self-tracking device most importantly to remind her of the importance of recovery time. Being motivated to be active and do sports was not a problem for her. Instead, she wanted the device to remind her that she also needed to remember to rest. The device used in the pilot study did not recognize all the sports activities that she did. This worried her and therefore, she tried to think of new ways to wear the device to help her collect data. She wore the device either on her ankle or on a different arm to her other self-tracking device. She was frustrated as she did not succeed in obtaining data that she could consider correct.

4.2 Tending to the device: automatic settings and manual tasks

Many participants mentioned that every day they routinely checked both the number of steps achieved during the day and the amount of sleep they got at night. Monitoring sleep seemed to be particularly interesting for most participants, many of whom were either in management or expert positions and suffering from high stress levels. Some participants mentioned having only four to five hours of sleep per night, which is well below the recommended eight hours of sleep. Obtaining and seeing the data required not only data collection but also regular data synchronization, either automatically or manually.

> I wear the device practically all the time… It's easy in the sense that you just turn it on once a day. And, the phone reminds you to turn it on to synchronize the day's data… I do check the number of steps every day… I don't think I could do more in a day. My job, hobbies, and the hobbies of my children make it a 16-hour day. An evening walk after all that, no way! (Male, 40, inexperienced self-tracker) (Interview: 1st round)

Despite their stressful lives, many participants kept collecting, synchronizing and monitoring their activity (number of steps) and sleep data. However, being constantly reminded of goals that are hard to reach was trying.

> I had it until around Christmas. But, I got bored somehow… I had a tough year. It didn't add to my well-being that the device told me I didn't sleep well. (Male, 40, inexperienced self-tracker) (Interview: 2nd round)

The participant quoted above held a high-level management position in a large organization. He used to do sport regularly but now found it difficult to find time for exercise. His heavy workload and stressful job left him sometimes only a couple of hours of sleep at night. The partici-

pant revealed that he had considered participation in the pilot study in order to slowly reactivate his sports routines. The result was, however, frustrating for him. He was only able to build up a routine of maintaining and monitoring a continuous data flow in his self-tracking device. He wore the device and synchronized the data devotedly every day. However, he claimed that seeing his constant failure to recreate the regular training routines he desired, or to increase his amount of daily sleep made him finally abandon the device completely.

Another participant compared the maintenance of the device to the care of a virtual pet, a Tamagotchi, which needs constant care and nurture. In the first interview round, the participant talked about her attempts to maintain a beautiful flower in the interface of her smartphone application. She emphasized the importance of caring for the four petals that represented her levels of activity, sleep, weight and blood pressure in proportion to the pre-defined optimal levels of these health and wellness areas.

> It has a visual incentive system containing all four different areas [activity, sleep, blood pressure and weight], so it's a bit like a Tamagotchi. You need to keep it happy… It turns into a beautiful flower when all these four areas are in balance. (Female, 39, experienced self-tracker) (Interview: 1st round)

Taking care of a pet, even if it is virtual, can be hard work that requires persistence. For the participant quoted above, taking care of her Tamagotchi meant not only taking enough steps or having enough sleep every day; she had also developed weight and pulse measurement routines, the results of which she needed to record manually.

> I'm clearly not as enthusiastic [as in the beginning]. I used to check [the number of] my steps every day, but now I haven't monitored them so actively. Instead, I've tracked my sleep every day. This is where I've had problems and therefore, it's been useful. It has increased my self-knowledge of my own sleep a lot. Monitoring sleep has clearly become a positive routine… My steps on the other hand, after my initial excitement I haven't walked as much [as in the beginning]. Then I've felt a bit bad, had a guilty conscience and been annoyed because I've cycled a lot but [the device] doesn't show cycling at all… I've [started] to think I might need a break from monitoring my steps, because there's no reason to feel guilty as I do exercise a lot. (Female, 39, experienced self-tracker) (Interview: 2nd round)

In the second interview, it became clear that keeping to the routines of caring for the Tamagotchi or maintaining the beautiful flower in the interface of the smartphone application had been too much work for the participant. She had given up measuring her weight and pulse as well as recording the resulting data of her device. She only followed her amount

of daily activity irregularly as cycling did not add to the numbers. Instead, she kept monitoring her sleep actively, as she had successfully overcome her sleep problems and had even been able to give up her sleep medication. The flawed numbers showing her activity, however, bothered her a great deal.

The users of the activity wristwatch were also able to share their data with others. Some participants in the pilot initiative who were colleagues at work teamed up to share their activity data (number of steps) and to compete in activity. Many of those who participated in this type of competition reported that it was motivating, fun or at least somehow stimulating.

> We can challenge each other. Now, [two of my co-workers] have challenged me. I can see their weekly [steps]. I happen to be in the lead now. For some reason, [the other co-worker] has not been able to update [her data]. That's why she has zero steps. I know she exercises a lot though. (Female, 48, inexperienced self-tracker) (1st interview)

The participant quoted above found the competition with her co-workers motivating. At the same time, she pondered the functionality of her own device and even that of her co-worker's device, as well as the visibility problems of the activity data. According to her, the problems with the functionality of her own device and the visibility of activity data continued and even increased in the course of the pilot initiative, which reduced her motivation to be more active in exercising.

> I'm not involved anymore because I always get so little steps. … Sometimes we talked during our coffee break about [who] had beat [the others]. I sometimes noticed that [a co-worker] had an evening walk around 11 pm and beat me. It was fun, but nobody talks about this anymore. … I wonder whether [one co-worker] has some problems too because I noticed a couple of weeks ago that that she only had 23 000 steps a week. In a whole week! She exercises outdoors a lot, goes hiking and does all kinds of things. How is it possible that she has only 23 000 steps? I don't believe it. Last week, zero steps. This week, zero steps. Most likely her device is acting up. At one point, she disappeared completely [from my screen]. I don't know what happened. She said that all her friends disappeared from her screen. (Female, 48, inexperienced self-tracker) (2nd interview)

The above-quoted participant quit the activity competition. She felt that some of her activity data remained unregistered and reflected on the possible causes of her device's functionality problems, such as the lack of memory space in her smartphone. She claimed that the problems continued despite switching her activity wristwatch for a new one and changing its batteries. It seems that the functionality of hers and her co-worker's device troubled her quite a lot and that she focused her attention on the technical issues of data recording.

4.3 Communicating with the device: Data synchronization and repair

Data synchronization was essential for the maintenance and visibility of continuous data flow in the connected smartphone application. Despite the operating instruction manual promising that the user "should never have to worry about syncing" (p. 29) their data, as this would take place in the background automatically as long as the Bluetooth wireless technology was enabled and when some specific milestones, such as a certain number of steps, were reached, some participants still had to synchronize their data manually. Data synchronization was thus not completely unproblematic for all the participants. Problems in data synchronization emerged when, for example, data were missing or data sets were broken. Some participants had developed peculiar routines for conducting manual data synchronization to ensure continuous data sets.

> I have a brand-new phone, but still, it doesn't always [synchronize the data]. You have to put the phone really close [to the activity wristwatch]… I don't know if it's because of the phone case or what… Sometimes there are days that show no activity, because I haven't remembered to put it right. Then you have to keep it [close to the activity wrist] for quite a long time before it starts importing [the data]… I usually try to do this once a day so that it begins to synchronize. Or, I put the watch on top [of my phone] and go and do something else… Otherwise it's easy to use, but if you don't always remember to hold your phone close enough to the [wrist] then it might not register [your data… It's all about routine, of course… but I don't always remember to do this in the morning. (Female, 49, experienced self-tracker) (Interview: 1st round)

The participant quoted above had a brand-new smartphone, but still felt that the phone did not always synchronize the data easily. Her attempt to solve the problem was to put the phone close enough to the activity wristwatch and let the synchronization take all the time that it needed. She had days that showed no activity (number of steps), and believed that this was because she had not remembered to position the activity wristwatch and the smartphone in the correct way for synchronization to take place. Although the operating instructions manual emphasized the importance of the activity wristwatch and the smartphone being close enough to each other while synchronizing data, the participant wondered whether the data synchronization problem may originate from her phone case. For her, data synchronization was burdensome. She stressed that remembering to synchronize the data required routines and thus tried to do it once a day in the morning. She did not always succeed, and sometimes forgot to do the manual synchronization, which resulted in missing data. As she felt that importing the data took a great deal of time, she sometimes just left the activity wristwatch on the top of her phone and

went to do something else. She left the self-tracking wristwatch to 'communicate' alone with the connected smartphone application.

It was important for the pilot participants that self-tracking produced continuous, visible data flows. This required them to ensure data synchronization and that the activity wristwatch 'communicated' correctly with the connected smartphone application. Some participants also brought up the issue of the reliability of data. For example, one of the pilot participants compared the data produced by the activity wristwatch with the data produced by a pedometer application, Moves, which could be uploaded for free onto his smartphone.

> Sometimes when I activate Moves, it shows some numbers. But, if I immediately restart Withings and then go back to Moves… it may add 1000-2000 steps. I don't know how it collects the data. From its own logs? Does it somehow spy on the logs in Withings? Is it a coincidence, depending on how I use it at specific times?… I haven't been able to figure out its logic. For example, why does it sometimes cut down my number of steps? Is it somehow connected to location information?… I don't know whether Withings works in the same way. Maybe it does, maybe it doesn't. I don't feel like synchronizing it so often because it's such a slow process. That's why I can't figure out if it works in the same way. (Male, 41, inexperienced self-tracker) (1st interview)

The participant quoted above said that he considered the activity data produced by the activity wristwatch more reliable than the data produced by the free pedometer application. At the same time, he felt that the data synchronization took too long in Withings and therefore, preferred to check the number of steps in Moves as it seemed to produce numbers in real time. He complained, however, that the free pedometer application sometimes either added or reduced his number of steps, which made him reflect on the possible causes for this. Uncertainty in the functioning of one piece of technology seemed to lead to concerns about the functioning of the activity wrist device.

Some participants in the pilot initiative felt that some of the data that the device registered were unreliable, even false, and tried to invent ways in which to guarantee accurate data that did not involve paying attention to wearing the activity wristwatch. Some participants were unsatisfied with the reliability of their activity data (number of steps), and others did not consider even the sleep data reliable.

> It annoys me that the device thinks I'm fast asleep even though I am 100% sure that I'm awake and watching television… Of course I don't move a lot when I watch television. I suppose if you don't move at all it considers that you're fast asleep… Every now and then I've tried to wave my hand like this in some direction so that it understands I'm awake. But, I don't feel like doing this all the time… It should be possible to correct [the data] myself. I could do this myself and [change the data] to show

> that this is not sleep. (Female, 47, experienced self-tracker) (Interview: 1st round)

Inaccurate data may annoy self-trackers so much that they are prepared to do a great deal of additional work and invent routines that may seem odd to others, such as waving their hands to show the device that its owner is awake. The participant quoted above was persistent in her several attempts to develop self-tacking routines that would result in reliable data.

> I wear it on my wrist all the time, but I'm extremely disappointed because the numbers are so flawed. It gives way too few steps and it thinks that I keep sleeping all the time even although I'm just still… I've not figured out [how to fix it] because when I watch television, I don't feel like moving all the time… But I do see the times here. I can make comparisons and then I save my real sleep times in my [other smartphone app]. I check that ok, this is when I went to bed. I know that I watched the television for an hour. It may look like I woke up in the middle of the night but I know that this is when I went to bed from the sofa… I have tried to calibrate [=the different devices]. (Female, 47, experienced self-tracker) (Interview: 2nd round)

The participant quoted above was annoyed that the device interpreted that she was fast asleep even though she knew she had been awake and watching television. The participant came to the conclusion that the problem could be that she stayed too still while watching television. The inaccurate data annoyed her so much that she would even have been ready to correct the data afterwards through changing them manually from asleep to awake. Although this was not possible in the application, she tried to fix the problem by communicating with the device through waving her hands while watching television to tell the device that she was indeed awake. Waving her hands routinely or remembering to change her position constantly while watching television was, however, frustrating. Therefore, her next effort to obtain accurate data was to start using another smartphone application. She collected her sleep data via both devices, compared the data with each other, and modified the data to reflect how she remembered her sleep and waking hours. She recorded the corrected data in her new self-tracking application and thereby tried to calibrate the devices. We can conclude that she was ready to do a considerable amount of additional work in exchange for accurate data flow. One reason could be that she did shift work and had several animals at home to take care of and therefore wanted to make sure that she gained enough sleep every day.

5. Discussion

Self-tracking devices are considered examples of technological artefacts that offer possibilities for promoting lifestyle changes. This is because they help people collect personal data and thus invite them to develop everyday routines for monitoring, documenting and analysing various aspects of daily life that affect health and wellness, such as activity and sleep (e.g. Swan 2012). At best, the knowledge produced by self-tracking devices may result in the development of daily routines that foster and maintain people's healthy living and thereby also support the overall shift in health care from treatment to the prevention of diseases. Self-tracking technology can be considered an infrastructure which, due to its communicative affordances, allows people to create personalized, flexible routines as well as reflect upon them (Lomborg and Frandsen 2016). So far, however, an understanding of how people generate and interpret their self-tracking data, and how they incorporate it into their daily routines, has been lacking (Pink et al. 2017; Lupton et al. 2018). This study contributes to this critical stream of research through the empirical examination of reflections on the self-tracking routines of pilot participants in a large health and wellness pilot initiative.

In the studied pilot initiative, the promotion of individuals' lifestyle changes played an important role. Different types of health and lifestyle data were collected and returned to the pilot participants, who also received an activity wristwatch to collect their activity (mainly number of steps) and sleep data themselves. The underlying normative goal or the ostensive aspect of self-tracking in the pilot initiative was that the self-tracking device would not only allow the participants to document their data but also possibly inspire them to change their activity and sleep routines and thereby affect their health and wellness.

The results of this study emphasize the subjective interpretations and understandings of self-tracking device usage. Many of the interviewed pilot participants developed routines for monitoring and documenting their everyday activity and sleep data. In the evening, many of them checked the number of their daily steps, and in the morning they looked at how they had slept in the night. Some were even attracted by the elements of gamification or the possibility to use the self-tracking device as a toy or a tool for competing with others. Other participants mentioned that self-tracking data indeed acted as motivation to change their activity or sleep patterns. However, when reflecting on the data, many of the participants in this study did not mainly focus on how to produce better activity or sleep data, i.e. how to change daily routines to gain data that show an increased amount of daily activity or sleep. Instead, they primarily reflected on the routines that were related to the use of the technology itself. One of the reasons for this could be connectivity problems (Yli-Kauhaluoma and Pantzar 2018), when the data remained broken and were thus inaccurate or incomplete (see Pink et al. 2018). Therefore, they described

their attempts to create routines that would help them collect reliable data and synchronize the data between different technologies, i.e. the activity wristwatch and the smartphone application. For example, they experimented with how to wear the device, on which wrist or even on their ankles. They applied elements of gamification while tending to the device. They communicated with the device by, for instance, waving their hands to tell the device they were not asleep. They organized time for data synchronization to allow the smartphone application to connect with the device itself. They even tried to calibrate the device with their other self-tracking applications. It seems that a close, even dialectical relationship developed between the users of the self-tracking device and the technology itself. Importantly, however, the practices that the participants developed did not necessarily have anything to do with the original aims of the use of the self-tracking device in the pilot, i.e. the development of routines that improve activity or sleep thus contributing to health and wellness. Instead, in practice these routines emphasized the maintenance of the digital flow of data.

The results of the study are based on a sample of pilot participant interviews in two phases. The first round was held after approximately three months of self-tracking (twenty-seven interviewees) and the second round after roughly ten months of self-tracking in the pilot study (twenty-one interviewees). Although the study protocol was strictly controlled and focused on the use of the self-tracking device and the related service application, the pilot participants gave rich descriptions of their technology use routines. The advancement of individuals' lifestyle changes played an important role in the studied pilot initiative. Therefore, it was surprising that many of the participants' reflections mainly emphasized their everyday tasks with the self-tracking technology instead of how the technology had supported their activity and sleep routines or more generally, their health and wellness. One reason could be that the interviews were not conducted by a health or wellness professional, nurse, physician or personal trainer. Nevertheless, during the interviews, many participants were eager to show their everyday activity (number of steps) and sleep data in great detail. The need to reflect on routines for wearing, tending to and communicating with the device might originate from frustration with the 'power of default' of technological artefacts, which makes their adaptation and customization for better support of routines or routine change difficult (see Koch 1999; Pollock and Cornford 2004; D'Adderio 2011). This means that the deployment of novel artefacts that support particular routines or even routine change is not easy.

The study shows that self-tracking requires users to do more than just wear a device, as claimed by user manuals. Accomplishing self-tracking routines calls for a great deal of effort (see Feldman et al. 2016) that involves not only maintenance but sometimes even repairing the digital data produced. This study shows that the maintenance and repair of digital data are everyday tasks, not only for professionals involved with complex

data sets (Tanweer et al. 2016), but also for the ordinary people involved with different artefacts or consumer technologies such as self-tracking devices. The study suggests that the stability of routines is related to the meanings that technologies or artefacts produce, as well as to the affects that they have on their users. Among the pilot participants, the routines for maintaining the digital data flow often ceased if the users no longer found self-tracking data meaningful in their lives or when they constantly faced feelings such as boredom or frustration when confronting their personal data. As Ledger and McCaffrey (2014) have noted, self-tracking devices do not necessarily succeed in encouraging the long-term routine engagement their users. The constant maintenance work effort is not rewarding if it results in data that remain invisible, inaccurate, self-evident or frustrating.

6. Concluding Remarks

The study shows that self-tracking devices and the data that they produce may require continuous maintenance and even repair routines. Here, the device users had to exercise persistence, creativity, improvisation and even care in their attempts to produce complete data. The study suggests that users of self-tracking devices may develop even peculiar routines in their communication with self-tracking devices and data synchronization. Such routines may result in a close relationship between the user of the self-tracking device and the technology itself. The analysis of everyday routines thus helps expand the literature on self-tracking by revealing patterns in the users' application of their devices at specific times and places in their lives. More research on these everyday routines is needed to gain a better understanding of the spectrum of the invisible work of users, as device maintenance is often considered straightforward, and data synchronization, for instance, is regularly assumed to take place automatically or without much effort. Future research would be particularly valuable in cases when self-tracking devices or other novel technologies are introduced into people's everyday lives with the aim of helping them make changes to lifestyle routines that affect their health and wellness. The results could eventually contribute to the better design of technologies and more understanding of the type of additional support that people need when using such technologies in their everyday lives.

The study also suggests a need for more longitudinal research on routines and the related artefacts in general, and self-tracking routines in particular. The obvious challenge and premise of this study was long-term routine engagement with interesting technological artefacts such as self-tracking devices. Even the relatively small sample of interviews in two phases at six- to seven-month intervals revealed changes in people's reflections on their routine practices and the related affectual atmospheres. A focus on how changing patterns of action relate to changing affectual

atmospheres in self-tracking offers an interesting avenue for future research.

One important practical implication of the study concerns health and wellness interventions that are organized in the form of, for instance, pilot studies and trials. The study suggests that participants of such interventions are deeply dedicated to data production and their contribution to research: in this case, through self-tracking. However, the committed use of technologies such as self-tracking devices in organized health and wellness projects may simultaneously have unintended consequences. Constant recognition of failure to reach the desired activity or sleep data may lead to frustration rather than motivation in attempts to make lifestyle changes. Therefore, the design of pilot initiatives that apply novel artefacts for routine change and consolidation should caution users about the possible negative or unintended consequences of following routines and offer participants strong technological and social support.

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[1] The Digital Health Revolution (DHR) health and wellness pilot initiative was organized by the Institute for Molecular Medicine Finland (FIMM), HiLIFE, University of Helsinki.

[2] The DHR Pilot Study was conducted according to the guidelines of the Declaration of Helsinki. The study protocol was approved by the Coordinating Ethics Committee of the HUS Hospital District (51/13/03/00/15).