Keep on Tracking

Understanding the long term use of personal informatics systems

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Abstract

Personal Informatics (PI) systems common trending theme is fitness, which in turn is a trending theme in human-computer interaction. These systems have been the focus of a handful of studies. So far, the research that has been conducted merely focuses on the technical details of such services and few investigate the longitudinal use of PI systems. Even though fitness is a popular area, still personal informatics systems designed for this purpose suffer from short-term use. Therefore, there is a need to design systems that encourages users for prolong use. The prolonged use of digital artifacts is an issue of sustainable interaction design. The purpose of this thesis is to explore the design space of personal informatics fitness systems through the lens of sustainable interaction design. This thesis aims at investigating motives and intentions behind the longitudinal use of personal informatics fitness systems. This thesis argues that by adopting the lens of sustainable interaction design we can find ways of designing PI systems with prolonged use for the users. Based on the findings the thesis ends by suggesting a guideline for designing personal informatics fitness systems which will hopefully help interaction designers and researchers alike.

Keywords: Personal informatics, Sustainable Interaction Design, Fitness Systems

1. Introduction

1.1 Background

Ancient Greeks were the first that brought up the importance of “Gnothi seauton” or “Know thyself”. People obtain self-knowledge by collecting and reflecting on information about their behavior, their habits or thoughts. Today, with technological advancements, Personal Informatics (PI) systems constitute an interesting area of study in Human-Computer Interaction that deal with self-knowledge and reflection (Li, Dei & Forlizzi, 2010). Li et al. (2010) defined personal informatics systems as those that “help people collect personally relevant information for the purpose of self-reflection and self-knowledge” (p.558). People can understand better their behavior and participate in the collection, exploration, and understanding of the information. Other names of Personal Informatics are: “Living by Numbers”, “quantified self”, “self-surveillance”, “personal analytics”, and “self-tracking” (Wolf, 2009; Yau & Schneider, 2009). People collect and reflect on a wide variety of information, where the most interesting and relevant are journaling, finance, general health, and exercise. An example of such communities can be found through the website www.quantifiedself.com.

Looking at popular personal informatics services today, we can see that one of the most common fields in personal informatics relates to fitness. There have also been reports on medical and clinical advantages of such systems (Higgins, 2016). Nowadays, there is an
increasing amount of wearable fitness tracking services and applications in the market such as Fitbit, Nike+, Runkeeper and more. The applications employ among others accelerometers, Global Positioning System, microphone, speaker, and camera to track users’ activities, including exercise, steps, calories burned, heart rate and sleep throughout the day (Lane, Miluzzo, Lu, Peebles, Chadhury & Campbell, 2010). The services collect, analyze and summarize those data providing additional motivation, frequent feedback, and personalized coaching. Research conducted in 2012 showed that one in five smartphone owners use, at least, one application of this kind (Fox & Duggan, 2012). Additionally, a survey conducted in 2013 revealed that one in ten U.S consumers over the age of 18 own a wearable activity tracker (Ledger & McCaffrey, 2014). However, the same survey indicated that more than half of the self-trackers no longer used those wearable services and a third of those discarded the system within six months of receiving it (Ledger & McCaffrey, 2014). In order to make personal informatics systems more effective, there have been several studies analyzing them. One of those studies is a five stage- based model of personal informatics introduced by Li et al. (2010). Although this model is successful in describing such personal informatics systems, those systems suffer from short term use. The model is technology-centric and focuses only on the collection of necessary personal information for reflection. However, designing meaningful, joyful and engaging artifacts still stays at the center of focus. (Odom, Pierce, Stolterman & Blevis, 2009).

Therefore, it is crucial to understand the durability of personal informatics systems. Durability is an issue of sustainable interaction design in HCI and is defined as a way to stimulate the longitudinal use of digital artifacts. Blevis (2007a) introduced the notion of “Sustainable Interaction Design (SID)” and the perspective that sustainability should be the central focus within HCI. As a starting point for a view of sustainability, design is defined, inspired by several authors, as “an act of choosing among or informing choices of future ways” (Blevis, 2007a, p.503).

Having personal relation with information systems is not limited to utilizing PI systems. Our personal interactions are bounded up with technological artifacts that affect our lives and comprise part of it. In the book “Things we do”, the design theorist Verbeek (2005) introduced the “philosophy of artifacts” and developed a comprehensive framework in order to understand the aesthetics in design. Most digital artifacts are thrown away before they are used for prolong period of time and there is a need to create artifacts that invite people to become attached to them. Odom and others (2009) based on the modern and design-oriented approach of the design theorist Verbeek, tried to analyze the relations between people and artifacts for understanding durability.

The purpose of this thesis is to explore the design space of digital artifacts and more specific the space of personal informatics fitness systems. The design principles suggested by Odom et al. (2009) will be further explored in the context of personal informatics fitness services. In this thesis, we have defined Personal informatics systems as any hardware or software that follows the stage- based model as suggested by Li et al. (2010). As stated by Odom et al. (2009), common digital products that are embedded with recording or data collection capabilities are largely an unexplored space. This, together with the raising
popularity of personal informatics fitness systems, makes it relevant to conduct research in the field of personal informatics.

1.2 Research question
The purpose of this thesis is to find out how we can describe the use of personal informatics fitness systems through the lens of sustainable interaction design, and subsequently how we can through that lens design personal informatics systems for longitudinal use. Why is this important?

- Fitness is a popular theme in personal informatics services. However, few studies have been made on the subject focused only on the software of the systems.

- There are no previous studies to this date that have examined personal informatics systems from a sustainable interaction design perspective.

This thesis argues that for a better understanding of how to design for longitudinal use of personal informatics fitness systems, more research should be conducted. By answering the research questions, this research will hopefully help researchers in interaction design better understand how to design personal informatics fitness systems for sustainable use. Also, Human-Computer Interaction researchers will find this research helpful for them to create better personal informatics fitness services for long-term use. The results that come out of this research will be useful for other personal informatics areas as well, even though this thesis is focused on personal informatics within the field of fitness. This thesis also contributes to the field of sustainable interaction design by exploring systems with data collection capabilities. In order to provide answers to these questions, we shall start by examining the related research that has been made so far in the context of personal informatics systems for encouraging exercises.

2. Related research
Research in personal informatics, in general, reveals different motives behind collecting and reflecting personal data. Li et al. (2010) mentioned that people start collecting information because of discovery of new tools, interest in data, natural curiosity, trigger events and suggestion from another person. Another research indicated that the three initial motivations for tracking were instrumenting for rewards or social engagement, the desire for change, and curiosity regarding data and habits (Eipstein, Ping, Fogarty & Munson, 20015).

In order to understand PI systems, researchers have conducted different studies. For this mean, some of them have designed their own PI system. In the following paragraphs, the researchers are listed one by one in chronological order. For each research, the most important achievement or outcome is highlighted.

Houston (Consolvo, Everitt, Smith & Landay, 2006) is a mobile fitness application that uses pedometers to encourage users to increase their daily steps and share their steps with
friends toward achieving a daily goal. Self-monitoring is encouraged by prompts on the phone and simple rewards are provided when a goal is completed. A three-week long in situ pilot study revealed that the simple rewards for achieving goals could motivate the participants and would increase their awareness of their activity levels. Since pedometers were not accurate with another kind of activities, participants suggested that all compatible physical activities should be included. Consolvo et al. (2006) for encouraging physical activity classified four key design requirements. These four requirements are as follows: giving users proper credit for activities, providing personal awareness of activity level, supporting social influence, and finally considering the practical constraints of users’ lifestyles.

Fish’n’steps is a game which with the use of pedometers, links a player’s foot step count to the activity and growth of an animated virtual character, a fish in a tank (Lin, Mamykina, Lindtner, Delajoux & Strub, 2006). An environment of both cooperation and competition was created for providing further engagement by including players’ fish tanks with other players’ fish. In a fourteen-week study, participants were encouraged by the game to foster long-term behavioral change. The desired change can be obtained by offering achievable and challenging goals.

Shakra is a mobile application that based on the understanding of related theories, employed features of the Houston project and is designed for long-term use of achieving greater public health (Anderson et al., 2007). The system provides awareness, encouragement among friends, and, in some cases, competition. The results of the study indicated that participants’ awareness encouraged reflection on the data and increased motivation for daily activity.

Ubifit is a system that encourages individuals to be physically active by using on-body sensing, activity inference, and a mobile display (Consolvo et al., 2008a). A mobile display represents a garden and flowers that grow through the user’s activity. The system draws features from several of the projects that discussed above. The user is prompted to engage with the system, an aesthetic representation of a garden is used providing trending information and positive reinforcement is given rather than punishment. Additionally, the system provides frequent opportunities for self-reflection and integrating use into everyday life. One important outcome of the study is that the usefulness and credibility of such systems are improved by allowing users to manipulate and add to inferred data. An additional study with Ubifit showed that an awareness glanceable display was able to maintain the physical activity lever of participants over time (Consolvo et al., 2008b).

IMPACT1 and IMPACT2 were two different versions of the same prototype used in a mobile phone and website system for encouraging physical activity. The purpose of the prototypes was to understand how the contextual information could make users become aware of factors that affect behavior. The study suggested that there was a tradeoff between manual and automated data collection in the amount of data that can be collected and the amount of awareness the user gained from using the system. There are advantages from the ability of automated data collection to collect more data than manual data collection. Systems with automated data collection can overcome the lack of engagement by encouraging users to reflect on their data more often (daily or weekly). Furthermore, the system automatically collected four types of information without considering the usefulness of those by the users.
These two problems with the system could have been avoided if the system was analyzed earlier in the development by using the stage-based model of personal informatics (Li, 2011).

2.1 Personal Informatics Model: What does it mean

The stage-based model and its properties provide the most commonly used framework for describing, comparing and evaluating personal informatics systems. The model has since been expanded and analyzed, dividing and combining stages but remains the central focus for designing personal informatics systems (Eipstein et al., 2015). According to Li et al. (2010), every personal informatics system has two core aspects: collection and reflection. For the design and development of effective personal informatics, it is important to be aware of the problems people are experiencing while using such systems (Li et al., 2010). The model consists of five stages: preparation, collection, integration, reflection and action. The stages of personal informatics and possible barriers in the different stages are described in the following section.

2.1.1 Preparation stage

The preparation stage absorbs people’s motivation to collect personal information by deciding the kind of information they will collect. According to Li et al. (2010) barriers in this stage can occur if the tracking tool does not meet the users’ needs. The selection of the appropriate tool that satisfies people’s information needs is crucial; otherwise, they switch to another tool that has negative consequences. The consequences can be that previously collected data must be abandoned because most systems do not support exportation of the data, and even if the system does, data formats between applications may differ. To avoid a gap in the data, one solution to the problem is better preparation when selecting which collection tool to use.

2.1.2 Collection stage

In the collection stage, people collect information about them and observe different personal information, such as their behavior, their thoughts, their interactions with people, and their environment (Li et al., 2010). The frequency of data collection differs between peoples' needs. The barriers in the collection stage can be related to the tool used for collecting information,
with the user or can be data-related. For example, the user may not have access the tracking tool used for collection when an event occurs. Problems related to users include the lack of time and the lack of motivation. Sometimes collecting information takes both time and requires effort, so it is difficult to keep up the motivation. Data-related problems include difficulty in finding the data, data may rely on subjective estimations or on subjective ratings with no standard for entering the data.

2.1.3 Integration stage
The collected data need to be prepared, combined and transformed for reflection before the user can reflect on those data. This stage is called the integration stage and it can be seen as the distance between the collection and reflection stages (Li et al., 2010). For the reason above, the integration stage can be long or short. A long integration stage means that the user has to put much effort into preparing the data for collection. For example, the user may need to transcribe manually the data that are collected on paper into a graphic tool. A short integration stage means that the user has little responsibility in preparing the information. Some systems automate the integration process such as Fitbit, which automatically synchronizes runs between a watch and the Fitbit application. The barriers that people encountered are collected data come from multiple inputs, and reflection of data happens in multiple outputs (Li et al., 2010).

2.1.4 Reflection stage
The reflection stage is important where users get meaningful insights about themselves by looking at the list of collected personal information or interacting with information visualizations. The reflections can be short-term or long-term. Reflections on the information immediately after collecting the data are considered as short-term reflections. The user can gain valuable information with this type of reflection and makes him or her aware of the current status. For example, pedometers continuously update the total amount of steps and offer a short-term reflection. Reflection on the information days or weeks after the data collection is considered as long-term reflection. Long-term reflection reveals trends, patterns and allows comparison of the personal information that is selected between different time periods. Barriers in the reflection stage are sparse data, difficulties in interpretation and lack of time. As a result, users are not able to explore and understand information about them.

2.1.5 Action stage
After the reflection on the collected information, the user decides what to do with the information. Some people have specific goals and are using tracking as a method to see progress towards the goals (Li et al., 2010). These people might change their behavior to match their goals. Most systems do not provide suggestions to the users on what to do with the information, which can be a barrier when it comes to applying the gained knowledge about oneself (Li et al., 2010). There are examples of systems which motivate to take action, for example through different rewards (Li et al., 2010).

Li et al. (2010) suggest that a holistic approach is important for designing personal informatics systems and propose four properties of the stages. The first property is the
barriers cascade which means that problems in earlier stages of the model affect the later stages. The stages are iterative and personal informatics systems should be flexible within a system and between systems to support users’ changing information needs. Each stage can use a user-driven, a system-driven approach or a combination of those. This classification refers to the users' responsibility for the activity in every stage. The user-driven approach leaves control in the hands of the user. The collection systems using this approach can motivate the user to collect the information if the demand is not too much. The system-driven approach enhances the experience and reduces the requirements on users. Depending on the facets of life, a system can be uni-faceted or multi-faceted. For example, Fitbit for physical activity where the data collection represents only one facet of life is uni-faceted.

### 2.2 Theoretical framework

Odom et al. (2009) provide design implications for designers of interactive technologies who want to construct digital artifacts and inspires a high strength of attachment. There are three factors that affect durability: function, symbolism, and material qualities. The factor of material qualities is emphasized more than the others. The emphasis on the material qualities is considered as a prediction and explanation of high strength of attachment between user and system. Those factors describe the strength of attachment of the user to the system, how easily the user would discard the particular system or how much the particular user cares about the durability of the system. Many aspects of other notions that describe a system like form, color, meaning, mediation, affordance, effect and other, are captured in the three notions mentioned above. A high strength of attachment to a system is often a result of mutual interrelations between those three factors. Furthermore, for a high strength of attachment, material qualities that are tied to useful functionality or meaningful symbolic representations seem to play an important role in the relationship between the user and the system. Artifacts with a high strength of attachment are classified as *ensouled* and artifacts with a low strength of attachment as *unensouled* things (Blevis et al., 2007b). The relationship between a system, a person and that person’s attachment to a system is complex. There are four relationship properties between user and system. Those relationship properties are engagement, histories, augmentation and perceived durability. We are going to examine the factors that affect durability and the relationship properties of a system and its user that can inspire a high strength of attachment and longitudinal use as a consequence.

#### 2.2.1 Strength of attachment between user and system

**Function**

The function refers to the purpose of the design of a specific digital artifact and its practical use. The durability between a single purpose-functional object and the user can be achieved if the user is engaged with the system or the system relates to personal history. Additionally, it is more likely to achieve longitudinal use if it can be used in a new way.

**Symbolism**

The symbolism relates to the meaning or sign-value of an object and the expression of a lifestyle that gives to users. The users choose products that reflect their interests, lifestyle or
values. People use a product to express the lifestyle to which they belong and use particular product styles and not others. A high strength of attachment through symbolism derives from augmentation or from personal history as a consequence of use over time.

**Material qualities**
The material qualities refer to the materials that an object is made of and the interaction of users with them. A high strength of attachment arises from the perceived quality of materials of an object. Digital artifacts and aspects of those that are not physical in nature may be able to preserve memories. Memories can enhance the enduring qualities that other material qualities add to an object. Material qualities include both the material of the object that the system is embedded in and qualities of the system itself.

### 2.2.2 Relationship properties between user and system

**Engagement**
Engagement refers to a person's involvement in using an object for a function and the extent to which physical engagement can be promoted by a system with the user during the use.

**Histories**
Histories refer to the personal histories or other memories that an object sustains. Apart from the appearance of a digital artifact, histories of use can enrich the strength of attachment of an object with the user. The data associated with a history of personal use can hold nostalgic value.

**Augmentation**
Augmentation refers to objects that have been reused, renewed, modified and altered. The object apart from its original use can be part of something augmented and can become a symbol of creative expression of the user and his resourcefulness. The design of the physical components of digital artifacts needs to be more modular, reconfigurable and adaptable.

**Perceived durability**
Perceived durability refers to how a user of an object considers the object as long lasting in terms of longitudinal use or in terms of function or both. For digital objects, the casing material construction of much higher quality materials is needed, even if the insides of such objects change frequently.

### 3. Method

To find out the answers for the research questions, we need to examine the relationship between users and personal informatics fitness systems for understanding durability in digital artifacts. This is the reason for conducting qualitative semi-structured interviews to understand the users of personal informatics fitness systems and the relationship between the users and systems. Understanding issues in depth and detail are promoted by qualitative methods (Patton, 2002). Interviews are conducted for finding out participants’ perceptions and experiences (Blandford, 2013). Semi-structured interviews are planned ahead the time,
although unexpected and interesting issues can emerge through the answers of interviewees (Blandford, 2013).

The interviews were conducted at the participants’ own home or in places that it was convenient for them. It was crucial that the participant felt comfortable during the interview. The questions were designed beforehand, and an interview script was made for keeping the structure of the interviews. An LG G2 was used as a voice recorder and sound check tests were done before each interview. All the interviews were transcribed in word documents.

In total, six interviews were conducted. Initially, the goal of this thesis was to interview users who had experience of prolonged use of PI systems (more than six months). However, later on in the process, for further understanding the long-term use of such systems and gaining more insights, I decided to interview users that have discarded their PI devices in less than six months. Due to time limitation, only two interviewees had the experience of using PI systems for less than six months. The questions were formulated in order to get answers for the research question and additionally, for bringing the feeling of convenience to the participants. In the first questions set, general information regarding their interests towards technology and health was gathered. Those questions were asked in order to understand the relation of participants with the technology and physical condition and exercise. The rest of the questions examined the strength of attachment and the relationship properties between the participant and the system. For better illustration, a basic script with the questions is provided in Appendix 2.

There are six important stages in the interview process that was followed in this study and helped in building the relationship between a researcher and an interviewer. Those stages are: arrival, introducing the research, starting the interview, the interview itself, the interview closure and after the interview (Ritchie, Lewis, Nicholls & Ormston, 2003).

The data gathered from different participants with different systems added a rich dimension in the analysis of data. The analysis of the data is based on thematic analysis (Blandford, 2013). Through repeating reading of the transcribed interviews in a 25 page long document, a set of themes were identified which brought clearer pictures of participants opinions. Furthermore, the paper of Odom at al. (2009) about durability used as a framework and analyzed based on the three factors that affect durability: function, symbolism, and material qualities. There are interrelations between those factors that provoke a high or low strength of attachment between the owner of the service and the service itself (see Figure 2). Finally, based on the framework, the results were connected to the relationship properties between user and system.
Figure 2: Factors that affect durability

3.1 Method criticism
Each method has its own pitfalls when it comes to interviews. The interviewees might answer the questions in a way that they think will bring satisfaction. The challenge of people answering the questions in order to satisfy the researcher could be a minor issue if the sample was bigger. The intention was to conduct a comparative study with prolonged users and short-term users, but due to the limitation of time, the final sample ended up with six participants. Only two of them had discarded the systems in less than six months. This could affect the results of the study. In order to understand the relation between the participants and the systems they are using, some of the questions were personal and people might have not be comfortable with them. For ethical purposes, the participants were informed that the study was going to be only used as an academic study. They had the right to withdraw at any time, even though none of the participants did. Additionally, they had the right not to answer any of the questions that they were not comfortable with. Permission from participants for recording the interviews were asked and they got informed about the confidentiality and anonymity of their personal information. According to Blandford (2013) these are the main ethical considerations for conducting any interview.

4. Interview Results
Section 4 starts by showing the participants usage of personal informatics fitness systems. The section follows with the results of the interviews based on the framework. More information about the participants’ relation with exercise and health can be found in Appendix 1. Additionally, a screen shot of the systems that the interviewees have used when the interviews were conducted is available in Appendix 3.
4.1 The participants usage of PI fitness systems

Motives behind the collection and reflection on personal data for most of the participants were the curiosity regarding data and habits in combination with suggestion from another person for the system that they use. Only one participant started using a personal informatics fitness system because it derived from a sentimental value (as a gift).

Participant 1 has been using the system for two years and is interested in tracking mostly activities of walking, running, and cycling. He is not interested in other functions of the service, like food intake or tracking other activities. Also, participant 1 is interested in seeing the differences in tracking between those activities. He reflects at the data unconsciously every time he unlocks his phone, or sometimes consciously during the exercise and he long-term reflect on those twice per week. Participant 1 conveyed strong attachment to the system due to function, symbolism and material qualities of it.

Participant 2 has been using a system for one year and is interested in tracking only the activity of running and the calories sometimes. The data that he is interested in are the duration, the distance and the elevation of each run. He has also set a specific goal that he wants to achieve every time he is running. He reflects on the data every time he finishes his running and he rarely long-term reflect on those because the numbers are more or less the same. Also, he does not use the system often during the winter because he goes to the gym and the machines provide the same information to him. Participant 2 conveyed high attachment to the system due to both function and symbolism.

Participant 3 has been using a wearable system for six months that is connected with an application in her mobile phone. She is interested in tracking mostly steps, heart pulses and sleep. She reflects on the data everyday, almost all day and interprets with those deeper every night. Participant 3 conveyed the strongest attachment to the system among the others due to function, symbolism and material qualities of it.

Participant 4 has been using an application for the activities of walking and cycling for four years, and he owns a runners watch for the activity of running for one year. He reflects on the data every time he is exercising, almost every day and he long-term reflect on those couple of times per month. He is interested to see the variation in training and the pulses when he uses the watch. He has also set a specific goal that he wants to achieve every time he is running. Participant 4 conveyed high attachment to the system due to function, symbolism, and material qualities.

Participant 5 used a system for tracking her walking activity for almost five months. She was interested to see the distance and the elevation in her walking. She was looking at the data after every activity. Participant 5 conveyed low strength of attachment to the system due to the symbolism and material qualities of it.

Participant 6 has used a system for tracking the activity of biking for five and half months. He still owns the system on his phone but he does not use it. He used the system for tracking his biking because he wanted to share and compare his routes with other friends. He was interested in looking at the route and the duration of each activity. He was reflecting on the data after the end of every activity. Participant 6 conveyed low strength of attachment to the system due to the function, symbolism and especially the material qualities of it.
4.2 Strength of attachment between user and system

Participants who are using personal informatics fitness systems for a long period of time conveyed a strong strength of attachment with the systems they are using and those systems are ensouled in their lives. The strong strength of attachment is due to function, symbolism and material qualities of the systems. Those factors are interwoven and as more characteristics belong to those factors, higher the attachment are. Low strength of attachment to the system can be related to one, two or all of those factors that affect durability. Figure 3 represents the strength of attachment between user and system that affects durability.

![Sustainable Interaction diagram](image)

**Figure 3: Strength of attachment and sustainability**

4.2.1 Function

The high strength of attachment that participants have due to function is related to the reliability and accuracy in the collection of the data for self-knowledge and self-reflection in the activities that they are interested in tracking. That means even if the system does not provide reliability and accuracy in tracking of other aspects, participants do not feel annoyed by that. Participant 3 have an even higher attachment to the system due to the function. Apart from the main purpose of the wearable, which is tracking, she is using the watch as an alarm clock and as a tool that helps her stay in contact with her husband. Person 3 stated:

> The good thing is that if someone calls me on the phone, my Fitbit vibrates and I can see who is calling me. I can have the phone in a drawer, especially in my work where it’s not allowed to care the mobile phone with me (...) if I see that my husband is calling, I am going to pick it up but if I see that someone else is calling, I do not do anything.”

4.2.2 Symbolism

The high strength of attachment was related to the symbolism. Symbolism in those systems for all participants is described as a way of confirmation and realization of themselves. Participant 1 stated: “I was away for three hours and you feel you have been walking all the time and then you check and you realize that you were doing something else for another three hours rather than walking”. Additionally, Participant 3 stated: “I am not exercising that time but I am doing steps and I am not sitting in a chair. I realized that only with the device. Basically, I learned stuff about myself and my habits”. Symbolism for all participants who are
using the systems for a long term is described by the long history of use. For Participant 1 the reflection on the data offers satisfaction. Participant 1 stated: “Initially was curiosity and now is satisfaction for myself to see, I walked this much, it is satisfying for yourself”. For Participant 3 rewards offer satisfaction. Also, symbolism for four participants is described as a way to improve and motivate themselves. Participant 2 stated: “When I start running in the summer I can see that my data are not so good, so I am trying a lot during the summer to improve them and then I can see my pick point. It is about the health and the body if I can lose fat.” Furthermore, Participant 4 stated: “It keeps me inspired more. That is the main thing it does”.

For one participant the meaning associated with the system added a sentimental value. Participant 3 stated: “My husband took it as a gift to me. To take care of my health.” For the same participant, the system is seen as a tool directly connected to her health. Participant 3 stated:

One guy in my husband’s job that did spinning fainted for 20minutes and the ambulance came and they did not know what happened to him, he was unconscious for 20 minutes and they took his Fitbit. They looked at the heart rate that he had before, (...) that helped doctors to understand stuff about his health condition. If something will happen to me, it could be possible to see the data about my health.

4.2.3 Material qualities

The material qualities of the systems differ because of the diversity of the systems in this thesis. Material qualities of the systems that offer high strength of attachment for all the participants is the data visualization that those systems offer and as consequence reflection on the data. Data visualization can be through charts, maps, and graphs. Furthermore, participants who are tracking more than one kind of activity have memories connected with the system that adds to the material quality of the systems, symbolic value to the participants and holds a nostalgic value to them. For Participant 1 the social element of physical sharing affords the enduring qualities of the system and preserve memories that add to the qualities of the system. Person 1 stated about the memories with the system:

There are a few in the top of my head. Recently, when I walked with my girlfriend around the lake, before that when I walked for Easter when I was in Vienna and I did some stuff with my family and there was cool to see as well, oh we spent two hours together (...) So, it pops up when you do activities and actually it pops up when you do activities with other people or on a very tight schedule for me at least. Especially, the first time, I noticed oh it shows everything, I showed my dad and he was not I am not using that and now he is using it too (laugh).

Participant 5 has also memories of sharing her routes with her boyfriend. Although, the lack of memory capacity in a new mobile phone forced her to discard the system and choose
among other communication systems that were essential for her. For Participant 3 the system
works as a mediator in the relationship between the participant and her husband and the
rewards also added a symbolic value cause are connected with memories. Person 3 stated:

\[
\text{I blame my husband that he wakes me up when I am sleeping because I can see}
\]
\[
\text{that I am restless and I wake up the time that he comes home. (laugh) I can}
\]
\[
\text{blame him with clues. I have also the rewards here (mobile phone).}
\]

Furthermore, the memories related to the significance and satisfaction with the system is
connected to other aspects of her life as well. Person 3 stated:

\[
\text{It made good at me because in my work every year I have a discussion with my}
\]
\[
\text{boss and when he asked me what I do with my physical condition, I talked also}
\]
\[
\text{for Fitbit, that I use it for my health. I told also about a fact that provokes me}
\]
\[
\text{agitation in my job, I told that Fitbit counted my pulses and I had 98 pulses}
\]
\[
\text{when this happened (...) and I could prove it!}
\]

Low material qualities can also provoke bad memories to the users. Participant 6 has both
good and bad memories of using the system. The bad memories enhanced the low strength of
attachment with the system

\[
\text{The memories. Both good and bad ones. I think it was interesting to see, for}
\]
\[
\text{example, now I had no clue that I was biking so fast, it was nice to get it done.}
\]
\[
\text{The only bad memories are when it dies or something or when it does not save}
\]
\[
\text{the data in the right way, I do not know how often that happened but especially}
\]
\[
\text{when you are done and it dies you don t know if the data will be saved or not. I}
\]
\[
\text{used it only when I was running or biking outside and I don t bike a lot on the}
\]
\[
\text{winter. I think I will use Strava now again because I want to keep track of it, see}
\]
\[
\text{how fast I go and the way. I will have one external battery that I will use when I}
\]
\[
\text{will bike maybe.}
\]

The participant who is tracking one kind of activity (running) has no memories with the
device. The low material qualities of the systems differ between the participants. Low
material qualities include the bad durability of the battery using those systems in the mobile
phones and the internet or Bluetooth connection needed in some of those systems that cause
problems. The problems are related to the function of the system during the use or even in
one case for the transmission of the data from the wearable to the mobile phone. Although, in
one case dissatisfaction provoked because the system tracks even if the phone is closed.
Furthermore, for the participants that are tracking the activity of running, the size of the
mobile phone constitutes a drawback. That’s why Participant 2 uses during the activity a
headband case for the mobile phone and Participant 4 runners watch. Other low material
qualities include the lack of memory capacity in a mobile phone that forced a participant to
discard the system when she needed to change phone and also bad memories of another
participant as mentioned above that enhanced the low strength of attachment with the system.

Two of the participants are using wearable services for tracking activities. One of them is using a watch only for the activity of running and the other is using a watch for tracking many aspects of her physical activity all day. The participant who uses the watch only for the activity of running was interested only in the functions of the watch. In contradiction, the participant that is using the watch for tracking many aspects of her life referred to the low material qualities of the watch. Low material qualities include the unrealistic feeling of wearing it because two lamps on the bottom can cause skin burn and she needs to charge it like a mobile phone. Participant 3 stated: “I need to take it off when I need to charge it and it is obvious that I cannot wear it for enough time until is fully charged.” Thus, she needs to clean the watch; otherwise, the results will be biased. Furthermore, she talked about the appearance of the watch. Participant 3 considers the watch as an accessory and indicates that the material is not glossy and there are not many color options for the watch. Furthermore, the watch biters her only when she wear tight clothes.

Even though most of the participants are high attached with the systems they are using, drawbacks encountered with the systems provided during the interviews. Participants who are using the systems for tracking of many activities avoid functions with non-automatically input of data. Functions that demand effort from the users are food or water intake. Five out of six participants wants customization in the interface of the systems. Customization can include the selection of the information for the data collection and representation and options to customize the data visualization of those systems. Another issue for most of the participants was the feeling of surveillance of the data collected. Some of the participants consider that they do not have the feeling of control of the system. For this reason, three of the participants avoid the location service and two of those avoid providing personal data. In this study, the privacy of personal data is an issue that provokes the full functional use of personal informatics fitness systems for some participants. An additional issue that came up from this study is the similarity on the data. Three participants are experiencing similarity on the data. One of the participants that had not a specific goal during the activity considered the system as not essential when the reflection on the data was the same. It is important to take in consideration those outcomes for the longitudinal design of personal informatics fitness systems.

In personal informatics fitness-related research, cooperation and competition between people using the systems are used as a way to motivate and increase the longitudinal use of those systems. In this study four participants are uninterested in the social sharing aspects of such systems. Instead, they consider social element the directly physical sharing with friends and people they are with during the data reflection.

4.2.4 Interwoven Factors and strength of attachment
As mentioned before the three factors that affect durability and described above are interwoven. In order to better understand the strength of attachment between users and the systems they are using is necessary to understand the importance of service for each
participant. The strong strength of attachment between participants and the systems they are using for a long period of time described during the interviews with emotions.

For Participant 1 the strong strength of attachment is described and when rarely the service does not work. Person 1 stated: “Sometimes it happens that it does not record part of the walk and I feel annoyed. I do not know if it affects my training but it affects my mood. It is mainly about that, is not it? "Moreover, the richly recorded histories acquired symbolic value over time. Person 1 stated: “My favorite thing about the system is just to know. To really understand things about myself. For example, every time when I log in on my phone I see it there. It is not like I am actively looking at it, but it is there, I know it is there, so that is probably my favorite thing,” Person 1 stated for the importance of the service:

> It depends on how used are you to that. Since I am used to it now; definitely it would be annoying not to have it. It would not change so much in my lifestyle I think, at least not for now. (...) Day to day life now, it would be really annoying to miss it but not so mental. If you use to know those things and especially if they brought you good and funny moments and be able to share and have those memories, so that is cool. Slightly emotional attachment, it is not emotional attachment to the data; it is emotional attachment I guess related to the application at a certain time. If you know something, and you do not know about that anymore, that is definitely annoying.

Participant 2 who track one kind of activity stated for the importance of the service:

> It is important, I use it because it helps me but I can run without it of course (laugh). I do not want to delete the app and I use it every time that I go running but it is not so important. If you have to search a lot to find extra information that the app can offer, I will not do it. Maybe there are other people that do it more professionally and for them are more important. I do not check during the exercise, I check the data after the training. (...) I think that more or less all the app like that one provides the same information. I do not want to delete it because it helps me, so I want to keep it. (...) It is important to know how much time I needed to do each km outside. I can understand if I run more time the same distance, that I am tired or that I ate a lot. I have data that I could not know about with another way. It is part of the process of running because even if I do not check during the running, I know that it tracks and I will check the data later.

Participant's 3 experience of use was characterized not only by strongly engaging with the device but also as a deeper understanding of how this system could be integrated into her life in unique and rewarding ways. Person 3 stated for the importance of the service:

> When it becomes a way of living to see that for example today I walked that much, I would miss it from my life. It is a habit anymore that I imposed that to myself. If I never had it, I would not care, but now that I am used to looking statistics, it would be difficult to wean off that. From the moment that I own it, my eyes are looking at it. It is the same with smoking. Of course, you can wean
from that as with all the other things in life but I never thought to stop using it and additionally if something happens to that one I will buy a new one that says more information. I would buy one that is more appealing.

For Participant 4 the system constitutes an integral part of his life. The strong attachment with the system is described in other ways during the interview. Person 4 stated:

For example, if I have done running and I see that Runkeeper, the GPS does not work and you get no results, always feels like a wasted training. It maybe sounds silly but for me, it feels like that. That happens one or two times per year because of the bad connection with the satellite.

Person 4 also stated for the importance of the service:

It is pretty important. I would for sure exercise anyway but it would not be so fun and it would be easy to be lazy but when I have this and I look at the history I see oh five days without exercise, what happened there? It keeps me motivated to go out. (...) I never thought to stop using the application. For some, when you train football you have the team and you have that to keep you go, or some runners in a runners club but for me, it is Runkeeper that pushes me to do next running. I will feel lazy without that application. I did not know how Fitbit or watches like that works and for Runkeeper then I used the phone just from the start. I have 11000 activities until now.

Participant 5 and 6 have low strength of attachment with the systems; they discarded them and did not mention any importance of the system. For Participant 5 even though, the system functioned well and symbolized realization for herself, the similarity in the data lead her to stop checking them after some months of use and the material qualities of a new phone averted a high strength of attachment to the system. Furthermore, the unavailability of the service would not affect her training. For Participant 6 even though, the system that tracked his biking routes function well and symbolized realization for himself, the low material qualities of the phone averted a high strength of attachment to the system.

4.2.5 Relationship properties
The relation properties of engagement, histories, augmentation and perceived durability have examined separately in the study of Odom at al. (2009). Although, in this thesis results shows that participants with high strength of attachment to the systems relate to more than one property mentioned above. The systems endure due to engagement, histories, and perceived durability. The material qualities of the systems offer perceived durability and the ability to hold up to use. Thus, participants who are using personal informatics fitness systems for tracking a variety of activities feel engaged with the system. Memories connected with the systems offer unique histories to each participant and enhance the strength of attachment. Results from this thesis show that what is needed for augmentation is a more modular design
of the physical components of the devices that participants are using. Thus, what is needed is customization on the interface of personal informatics systems.

5. Discussion

Based on the foregoing interviews, this section answers the two fundamental research question of this thesis. The purpose of this thesis was to find out how we can describe the use of personal informatics fitness systems through the lens of sustainable interaction design, and subsequently how we can through that lens design personal informatics systems for longitudinal use.

The results of the interviews were analyzed through the lens of sustainable interaction design to figure out motives and intentions for prolong use of those systems. More specifically, we examined the durability by analyzing the strength of attachment between the participants and the systems they were using. The examination of durability was something more related to a life story rather than examining the personal informatics fitness systems that participants had. Tracking was explained in terms of function, symbolism and material qualities of the systems; the three factors that provoke high strength of attachment and as a consequence longitudinal use with personal informatics fitness systems. Those factors were furthered linked to the relationship properties between users and systems.

There have been various participants involved in this thesis with distinct differences in personality and interests. No one was using an application or wearable service for achieving a behavior change, but they were using personal informatics systems often to support long-term interests. This thesis does not undermine the research of personal informatics fitness systems; rather, it brings a different perspective to the field. By answering the first question of this thesis we can understand that participants are not acting only in the reflection of the data. Describing the use of personal informatics fitness systems through the lens of sustainable interaction design, we can see the tied relation of systems with participant’s lives and the emotionality of activity tracking. Participants that are tracking a variety of activities in this study, are doing something intensely sentimental tied with their lives and do not crave to do disconnected data analysis about themselves. However, one participant who is tracking one kind of activity is caring for the functionality of the system. We could argue that there are two types of users that are using personal informatics fitness systems; either they are emotionally attached or they care for the functionality. The material qualities and the memories connected to the system seem to play an important role in the emotionality and longitudinal use of personal informatics fitness systems. The question is whether those systems can better work by increasing the functionality for a small group of people or by increasing the emotionality, and as a consequence increase the durability of such systems. In the field of Human-Computer Interaction what we can do is to create design for emotionality.

Based on the findings of the interviews from sustainable interaction perspective we suggest the following guideline for design of personal informatics fitness systems for prolong use:
• Allowing the user to the able to customize the service before the data collection and during the data representation and reflection can make the system more engaging.

• Accuracy and reliability in the data collection for self-knowledge and self-reflection are needed to invite people to become attached to the systems. Due to different personal needs for data collection, accuracy should be provided in every aspect of tracking that a system offers.

• The data cannot be meaningful for users with specific goals when there is similarity on those. For example, two of the participants are interested in tracking the pace during running and have a specific time goal for achieving the activity. Although, one participant did not set goals for the use of the service. For that participant, the data was unessential when she became familiar with them.

• Functions with non-automatically input of data are not useful for the users. For example, four of the participants are not using functions that demand effort for input of data like food or water intake.

• Pay attention to the material qualities of mobile phones. Low material qualities of mobile phones can affect the function of the systems during the use. The internet or Bluetooth connection needed for those systems consume battery. The durability of battery on the mobile phones should be considered. Thus, the strength of attachment is affected by the size and the lack of memory capacity of mobile phones.

• Pay attention to the material qualities of wearable services. For wearable services, the material qualities of them should be improved. For example, one participant who uses a watch for tracking many activities considers drawback the charging of it on a computer. Thus, this participant stated that the material quality of the watch itself needs to change.

• Consider the feeling of surveillance that personal informatics fitness systems provoke. The users need somehow to be informed about the privacy of their personal data. Thus, users need to be allowed to customize the amount of personal data that they provide.

• The principal driver for users of personal informatics fitness systems is to realize information for themselves through reflection on the data visualization. Instead of supporting data sharing among users for cooperation and competition, support the directly physical sharing with friends. In this study, four out of six participants are uninterested in the social tracking and competition among others.
The evaluation of personal informatics fitness systems should consider the emotionality that people have with those systems and the engagement during use. The important factor is not measuring increment in activities.

6. Conclusion

In this thesis, I have made an empirical study with the aid of several qualitative interviews to find out how we can describe the use of personal informatics fitness systems through the lens of sustainable interaction design. By looking at the personal informatics fitness systems from a sustainable interaction design perspective, we are able to supply grounded insights about how such systems can provide continued benefits. For longitudinal use of personal informatics systems, the issue of durability in the sustainable interaction design is of great importance to be taken into account. Li et al. (2010) stage-based model is a technology-centric model and refers to the technical problems that users may experience with personal informatics systems. However, from the results of this study, it can be concluded that the participants who are using personal informatics fitness systems for a long period of time are attached with the systems, and the technical problems can only draw one viewpoint for designing effective systems. By examining the use of personal informatics systems through the lens of sustainable interaction design, we can get some insight on how to design personal informatics fitness systems for longitudinal use.

6.1 Future research

This thesis investigated the relationship of users with personal informatics fitness systems from a sustainable interaction design perspective and brought to light insightful outcomes. The findings in this thesis show that the guideline for design does not cover all the areas of personal informatics systems. The guideline should not be seen as a final statement about personal informatics fitness systems; rather, it can be considered as a stepping stone for more research on this subject. This thesis can be further extended in several possible different ways in the further. A future study could examine prolonged users that are tracking a variety of activities comparing with users that have discarded the systems. All of the participants have different interest and none of them is doing fitness at a professional level. It would be interesting to use the same framework for understanding other user types and see how more active persons use personal informatics systems in their exercises. In this thesis, we have defined personal informatics systems as any hardware or software that follows the stage-based model as defined by Li et al. (2010). It would be interesting to make a distinction between mobile phones and wearable trackers and examine different hardware systems and the relationship of those with the users. Conducting similar studies in relation to other contexts of PI systems could help designers get even more meaningful insights for the design of personal informatics fitness systems.

The research in personal informatics fitness systems through the lens of sustainable interaction design should be spanned out to reach other areas as well, where sustainability should remain the central focus of Human-Computer Interaction. As pointed out earlier, only a few studies have been made in this area focusing on the software of such systems.
Hopefully, the results from this research could act as food for thought when doing research in this field, and help interaction designers create more durable personal informatics systems for long term use.

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References


Appendix 1: Participants

Participants

Participant 1
Male
Age: 22
Service: Google Fit application
Use of service: 2 years

Is quite interested in technology, and tries to find out new stuff all the time. He is interested in his health and he is trying to eat as healthy food as possible. He avoids microwave food and he has full meals with fresh stuff. He considers himself quite enthusiastic for his physical condition and he always did a lot of sports. He used to go to the gym but because of the lack of time, now he plays football and he goes for walking, running and bicycling.

Participant 2
Male
Age: 30
Service: Runtastic application
Use of service: 1 year

He is very interested in new technologies and he using them in his daily life. He is trying to eat healthy by avoiding carbs, pasta every day and he focuses on food that contains protein and vegetables. He eats fast food once per week. He is interested in his physical condition and this is the reason that he stopped smoking. He is training 4 or 5 times per week. He does beach volley, volley and running.

Participant 3
Female
Age: 34
Service: Fitbit wearable service and application
Use of service: 6 months

She is not so interested in new technologies but she is not indifferent. She is interested in technologies that make her life easier and are useful. She chooses devices for the appearance and the ease of use. Considers healthy the food that she cooks in her home and she follows a balanced nutrition that contains everything. She is not so interested in her physical condition but she feels guilty if she is not exercising. She used to go to the gym 3-4 times per week but because of an injury and lack of time, she is going less now. She likes walking and biking.
Appendix 1: Participants

Participant 4
Male
Age: 43
Service: Runkeeper application, Runners watch
Use of service: Runkeeper: 4 years, Runners watch: 1 year

Is interested in new technologies and tries to keep up and updated at new computers and phones. He is trying to eat healthily and he rates himself with 7.5 in a scale of 1 to 10. Considers himself pretty much interested in his physical condition and he exercises almost every day. He goes to the gym and he also goes for running, walking and biking.

Participant 5
Female
Age: 30
Service: MyTracks application
Use of service: 5 months (does not use it since last summer)

She is not interested in new technologies and she uses new technologies that help her life. Considers herself as a person that keeps balance and eat both healthy and unhealthy food. She is not obsessed with her physical condition and appearance but she tries to keep balance and remain healthy. She wants to be healthy and she exercises for that reason. She hates the gym and she does outdoor activities that include hiking, swimming, and running. Also, she is doing yoga and aerobic at home. Depending on the weather conditions, she is doing one of those exercises 5 times per week.

Participant 6
Male
Age: 27
Service: Strava application
Use of service: Strava: 5 ½ months in 2012 (does not use it anymore)

Is interested in new technologies and tries to keep up. He downloads a lot of applications very often just to try them. He is interested in his nutrition and he rarely eats fast food. He avoids food that affects his blood sugar and he is trying to eat as much protein as possible when he exercises. He tries to exercise as much as possible and he avoids it when he is stressed. He exercises 5 times per week. He goes to the gym and also goes for walking, running and biking.
Appendix 2: Interview script

Interview script

This is a very basic interview script that focuses on the most vital questions. There are other questions that come up during the interview.

- How interested are you in new technologies, and, if so, what was the newest digital device that you purchased?
- How interested are you for your physical condition?
- How interested are you in eating healthy food?

- Do you use any applications that collect your personal information?
- What type of health related applications you use?
- Are any of these systems tracking movement, and physical activity?
- How did you find about those?

- What are the reasons for using them?
- How often do you use or did use the system?
- When did you start using the system?
- What kind of data are you interested in collecting?
- How the data are collected?
- How often are the data collected?
- How reliable do you think the data are?
- How easy is to find the data?
- How the data are presented to you?
- What do you like about the data representation?
- What you do not like about that?
- Is there anything that could be better?
- How often do you look at the data analysis?

- How important is the data analysis for you with that device?
- What the data analysis help you for?
- How important is to reach your goals?
- How does it affect your training if you do not reach your goals?
- If the service does not work, how does that affect your training and use of service?
- Does the system alert you to take actions?
- How does the social sharing (aspects) affect your use?
- What are the memories you have by using the device?
- What is your favorite thing about the system?
Appendix 3: Figures of Personal Informatics Fitness Systems

Figure 4: Various screens of Runkeeper mobile application

Figure 5: Various screens of Runtastic mobile application
Appendix 3: Figures of Personal Informatics Fitness Systems

Figure 5: Various screens of Fitbit mobile application and Charge model of wearable tracker
Source: Fitbit
(https://www.fitbit.com/se)

Figure 6: Various screens of Runkeeper mobile application and TomTom runners watch
Source: Android market and TomTom
(https://www.tomtom.com/sv_se/)
Appendix 3: Figures of Personal Informatics Fitness Systems

Figure 7: Various screens of MyTracks mobile application
Source: Android market

Figure 8: Various screens of Strava mobile application