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Perceived Well-being Effects During the Implementation of a Self-tracking Technology

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Abstract

In recent years, both individuals and the healthcare sector have become more interested to measure and improve health and well-being by using different self-tracking technologies. However, the number of studies concerning the experiences that people have with these technologies is still rather limited. This study investigates the expectations and perceived short-term effects of using self-tracking technologies on users' well-being. The focus is on the first weeks of usage i.e., the implementation phase. The study is qualitative in nature and based on thematic analysis of ten semi-structured interviews. The results reveal that the perceived well-being effects of using a self-tracking technology are relatively minor during the implementation phase and in line with the expectations. The increase in well-being is expected to occur in a longer time scale. Perceived psychological well-being is found to be affected the most during the implementation phase. The results also reveal interesting findings regarding the use of self-tracking technologies. The results are discussed and several important implications are drawn.

Keywords: Self-tracking, Activity Tracker, Mobile Application, Implementation, Well-being, Healthcare

1 Introduction

Technological development is revolutionizing several fields of society both in the work life and people's private lives with a variety of new kinds of products, applications, and services. It has also fostered the emergence of various new technologies and procedures that allow tracking, measuring, and evaluating one's own activities and bodily functions i.e., *self-tracking* or *self-measurement*. In recent years, both individuals and the healthcare sector have become increasingly interested to measure and improve health and well-being by using such self-tracking technologies. Physical measures, different biosignals, mood, nutrition, and sleep are all examples of the variables that can be self-measured with different technologies (cf., Quantified Self Guide to Self-Tracking Tools, 2015). Overall, different kinds of self-tracking technologies can be utilized by the individuals as well as by the health sector in disease prevention, treatment, and in promoting general well-being.

The popularity and significance of using self-tracking technologies in both individual level and in healthcare are rising. These technologies have also become a part of occupational healthcare. However, the number of studies concerning the experiences that people have with self-tracking technologies is still rather limited (Lupton, 2013). Therefore, it is important to start conducting more research regarding the topic. This kind of investigation can adduce several important implications for the development and utilization of these technologies. As the goal of self-tracking is often to examine and promote well-being, this research aims to find out whether these technologies influence the individuals' perceived well-being during the implementation phase. Examining the use experiences of the users of these technologies provides relevant information about how self-tracking affects the perceived well-being of users.

The adoption of some technologies is necessary to most people, but for the majority, starting to use self-tracking technologies is a voluntary choice, even if suggested by a healthcare professional. In this individual level adoption of a technology, the first few weeks are highly important: does the implemented technology provide sufficient value to the user or not? (Rogers, 2003). Thus, the implementation phase and the experiences during the implementation phase, for example, regarding the perceived well-being, can be crucial in the adoption process.

The main research questions of the paper are:

- 1) Do self-tracking technologies influence the users' perceived well-being during the implementation phase?
- 2) How the potential influence occurs?
- 3) What are the expected short-term well-being effects of using a self-tracking technology?

We use the term *technology* as an overall term for different technological devices, services, applications, and other products. The focus of the study is on the users' subjective experiences during the implementation phase of self-tracking technologies. The implementation phase is set to cover the first four weeks of use, as the study precisely focuses on the experiences and perceived well-being during the implementation phase, not on a long-term time scale. According to Rogers (2003), during the implementation phase the individual implements the innovation into use and determines its usefulness. We consider four weeks to be long enough for this, as Rogers (2003) also highlights the importance of first few weeks. The study is explorative in nature and follows a qualitative approach. More precisely, the study is based on thematic analysis of ten semi-structured interviews.

Our results can help the industry to develop and market more user-oriented technologies. In addition, our findings are of great value to the healthcare sector in employing self-tracking technologies as means of care to the patients.

This paper consists of the following sections. After this introductory section, the background is presented, followed by the sections for methodology, results, and the conclusion. Finally, the limitations and future research are presented.

2 Background

2.1 Self-tracking

Advancement of different wireless and wearable technologies has significantly improved the ability to track and measure one's own actions and to collect various data from everyday actions. Technological development also drives consumers to track and collect data about themselves (Wolf, 2010). There exists a growing number of various solutions that automatically collect data from different actions of everyday life and transform the otherwise meaningless numbers into something that the users can understand (Whitson, 2013). Instead of averages and generalisations, it is possible to get detailed information from specific actions. The information can include, for example, what has been done, when, where, how, and what has been the impact. This information, in turn, can potentially be used to improve, for example, related aspects of well-being.

The use of different self-tracking technologies has become a part of daily life for more and more people (McFedries, 2013). They are used, for example, as a tool to promote one's own health and well-being (Swan, 2013). Depending on the type of the technology, the use can also have a dual-purposed meaning. Previous studies have shown that the reasons behind the use can be utilitarian, hedonic, or both (e.g., Kari & Makkonen, 2014; Makkonen et al., 2012). Self-tracking has been applied to various areas of life, for example, social communications, travel, and the well-being and health context, "*where the expanded definition of health is embraced as applications address both medical issues and general wellness objectives*" (Swan, 2009, p. 509). The use of self-tracking has indeed increased in general healthcare (Paton et al., 2012; Swan, 2009), not just as means to support treatment and therapy, but also to cut the rapidly rising healthcare costs (Swan, 2013). In healthcare, there is also a growing trend that the role of the patient is shifting from a mere receiver to a more active self-tracker (Swan, 2009).

Different kinds of actions for quantified self-help and self-tracking can be placed under the *quantified self* umbrella. The term *Quantified Self*, coined in 2007 by two editors of the *Wired* magazine, Gary Wolf and Kevin Kelly (e.g., Combs & Barham, 2015; Strong, 2014) has evolved from its original meaning of collaboration of users and tool makers who share an interest in self knowledge through self-tracking. According to Swan (2013), quantified self refers to one's actions of monitoring any biological, physical, behavioural, or environmental factors regarding one's life. A fundamental part of the quantified self phenomenon and quantified self-help is increasing self-awareness through technology and measured data (Lupton, 2014) i.e., self-tracking.

According to the study by Fox and Duggan (2013), 69 % of U.S. adults track at least one health indicator such as exercise, weight, or diet. Out of them, 21 % do it with the help of some technology. For example, out of all the smartphone owners in the whole sample, 19 % had downloaded a health application. Out of the 69 % who were trackers, 46 % reported that tracking has changed their approach to managing personal health or the health of someone who they provide care to. 40 % reported that it has led them to consult doctors in new ways, and 34 % reported that self-tracking has affected how to treat a condition or illness. Generally, people who have a

chronic condition or a more serious health issue take their tracking more seriously. These results show that tracking can indeed affect person's overall approach to health and well-being and technology can be an important part of it (Fox & Duggan, 2013).

2.2 Well-being

Well-being, both as a concept and phenomenon, is multi-faceted and something that changes over time. It is closely related to the concept of health and covers several dimensions. There are numerous definitions and dimensions of health and well-being found in the existing literature. World Health Organization (WHO) (2003) defines health as "*A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*". According to the U.S. Centers for Disease Control and Prevention (CDC) (2013), well-being includes such dimensions as physical well-being, emotions and moods, positive functioning, and satisfaction with life. We adhere to these definitions. According to WHO (1997), quality of life is a fundamental part of measuring health and well-being, and the organization has developed the World Health Organization Quality of Life Instruments (WHOQOL-100).

The WHOQOL-100 instrument includes six broad domains: physical health, psychological, level of independence, social relationships, environment, and spirituality/religion/personal beliefs. In addition, the instrument includes a number of facets incorporated within these domains. By measuring these domains, the quality of life, including well-being of the individual, can be evaluated (WHO, 1997). We use the relevant and applicable domains and their facets together with the previously mentioned definitions for health and well-being in evaluating whether the implemented self-tracking technologies influenced the individuals' perceived well-being during the implementation phase. This fits the focus of our study, perceived well-being of an individual, well.

3 Methodology

To investigate individuals' perceived well-being during the implementation phase, we chose to follow a qualitative approach. The goal of qualitative research is to understand reality and discover new knowledge. The aim is to understand people and their sayings and actions in the social and cultural context they live in. One of the key benefits of qualitative research is that it enables the researcher to view and understand the underlying contexts in which actions happen and choices are made (Myers, 2013).

To collect the data, we chose to use qualitative interview as the method. "*The qualitative interview is the most common and one of the most important data gathering tools in qualitative research*" (Myers & Newman, 2007, p. 3). As we wanted to collect meaningful experiences related to the theme of the research, the type of interview we chose was semi-structured interview. It is the most used type of interview among qualitative research in information systems. A semi-structured interview typically has an incomplete script, but includes a pre-formed structure developed for the interview (Myers & Newman, 2007). This was the case also in this study. In planning and conducting the interviews, we followed relevant guidelines for semi-structured interviews (e.g., Guest, Bunce & Johnson, 2006; Myers, 2013; Myers & Newman, 2007). This helped us to avoid the potential problems and pitfalls such as artificiality of the interview, lack of trust, constructing knowledge, or ambiguity of language (Myers & Newman, 2007), and to gain maximal benefit from using semi-structured interview.

Our study included two interviews for each interviewee, one before and one after the implementation. For these, we developed an interview script. Following Myers and Newman (2007), the script included the opening, the introduction, key questions

related to certain themes, and the closing. We also presented questions regarding other aspects than well-being for the purpose of another study. The questions for the other study did not influence the well-being part of the script. The well-being part of the script is presented in Appendix A. The themes of the script were developed based on the research questions, previous literature, and determinants of well-being. The actual questions regarding well-being were adapted and modified from the WHOQOL-100 instrument (WHO, 1997) for the relevant and applicable parts.

As suggested by McCracken (1988), to maximize the depth and richness of the data, we aimed for fairly homogenous sample that share similarities regarding the research question. In selecting the interviewees, a certain criterion was also used. The person was deemed as a suitable candidate for interview if he or she: 1) had interest toward self-tracking technologies, 2) had the possibility to use and was about to implement one or more of these technologies, 3) was motivated to take part in the research. To obtain the interviewees, we used a snowball sampling approach (Patton, 2002). We first sought persons that met the set criterion and then suggested them with the possibility to participate in the study. Selected participants provided information on further possible participants and these again spread the word. All the interviewees stated that they would have implemented the technology at some point in the near future even without the suggestion of the researchers. As we were looking for authentic implementation situations, we did not require all the interviewees to implement the same technology, but allowed them to choose a technology that genuinely interested them. This was not in contradiction with the focus of the research, as the aim was not to examine one specific technology but rather self-tracking technologies on a general level.

The study was conducted with ten interviewees. Out of the ten interviewees, six implemented an activity tracker and seven implemented a mobile application for self-tracking. The total number of implemented technologies was higher than ten, as four of the interviewees simultaneously implemented an additional mobile application. All of the implemented technologies also supported some kind of social features such as sharing or web-based community.

In total, we conducted ten interviews before the implementation and ten interviews after the implementation. The first interview focused on the expected well-being effects and the second on the perceived well-being effects. The second interview was held approximately a month after the first one. The interviews were conducted during late 2014 by one of the authors. The interviews were held face-to-face with the interviewee. On average, the interviews lasted 30 minutes. The interviews were recorded and transcribed (in the interviewees' native language). Based on the transcriptions and notes made during the interviews, the analysis began.

To analyse the data, we used thematic analysis, which is the most widely used method of analysis in qualitative research (Guest, MacQueen & Namey, 2012). Thematic analysis is a method for "*identifying, analysing and reporting patterns (themes) within data*" (Braun & Clarke, 2006, p. 79). It allows to organize and describe the data set in rich detail and to interpret various aspects of the research topic (Braun & Clarke, 2006). In doing our analysis, we applied the guidelines for thematic analysis by Braun and Clarke (2006) and Patton (2002). As suggested (Braun & Clarke, 2006; Patton, 2002), we applied the guidelines flexibly to fit the research question and data. We began the analysis by familiarizing ourselves with the data and marking all the interesting features of it. We continued by first searching for recurring themes, which we then reviewed in relation to the data. We also defined and named them. Finally, we produced the report. As suggested by the followed guidelines, the analysis process was more a recursive one than a linear phase-to-phase process, as we moved back and forth between the different phases of the analysis. This is typical to thematic analysis

and allows checking if the identified themes work in relation to the data set and the extracts from the data being analyzed (Braun & Clarke, 2006).

4 Results

The interviewed sample consisted of ten Finnish interviewees, out of which two were males and eight females. The age range was between 21 to 27 years with the average of 24,1 years. The interviewees were people interested in self-tracking technologies and generally had little or some previous experience of these technologies. Table 1 describes the characteristics of the sample and shows which type of technologies the interviewees implemented. Four of the interviewees implemented two different technologies, leading to a total of 14 implemented technologies.

	Gender	Age	Employment status	Implemented technology*
Participant 1	Male	27	Employee	AT + MA
Participant 2	Female	24	Employee	AT
Participant 3	Female	24	Unemployed	MA
Participant 4	Female	21	Student	AT
Participant 5	Female	24	Student	2x MA
Participant 6	Female	24	Employee	AT
Participant 7	Female	24	Employee	AT + MA
Participant 8	Male	25	Student	AT + MA
Participant 9	Female	24	Student	MA
Participant 10	Female	24	Employee	MA
*MA = Mobile application for self-tracking; AT = Activity tracker				

Table 1: Description of the Sample

4.1 Expected Well-being

The expected well-being effects before the implementation of a self-tracking technology were quite similar in general. The general expectation was that if the use would have positive effects on well-being, the technology would also provide positive information about this to the user. Receiving this kind of positive information was expected to cause pleasure, support the made choices, and foster the perceptions of increased well-being. Interestingly, would the received information be negative, for example, certain actions being insufficient, it was not expected to influence one's own mood or perceptions of well-being. It was, however, expected that negative information could influence the behaviour or help to see what kind of things are negative in the first place. Regarding the usability of received information, it was expected that the technology would provide reliable information that is clearly presented, relevant, and easy-to-understand.

When comparing the expectations between activity trackers and mobile applications for self-tracking, some differences arose. Activity trackers were expected to be more potential than different mobile applications in increasing the amount of physical activity, and this way, in influencing both physical and psychological well-being. However, if a mobile application would be designed for a specific purpose, it was expected to be more potential in improving that particular area.

The well-being effects during the implementation phase were expected to be relatively small and unrecognizable, and they were not seen as the primary goal of use for either type of technology on a short-term. Rather, the general expectation was that during the implementation phase, these technologies would mainly operate as an interesting supplement, and improving own activities and well-being would possibly take place in a more distant future. Regarding this, an interesting finding was that the potential increase in well-being was expected to originate from doing the activity itself and the pleasure caused by doing it rather than directly through using the technology. In other words, it was expected that a mere use of a self-tracking technology would not increase well-being, but rather the increase in well-being would derive from different actions that are supported or monitored by these technologies.

4.2 Perceived Well-being

The actual perceived well-being effects of using a self-tracking technology were relatively minor during the implementation phase. Perceived *psychological* effects mostly arose from those positive experiences where the technology verified or showed the user's successful performance, which caused pleasure and assurance to the user. Negative experiences were not perceived to affect well-being as they were mainly connected to the technology itself instead of own actions or failure. If the user perceived increase in psychological well-being, it increased the likeliness of the user continuing the use after the implementation phase.

Effects to *physical* well-being were perceived as minimal. Even when the use of technology supported and boosted, for example, exercise sessions, the physical well-being was perceived to grow because of the physical activity itself, not because of the use of technology. In other words, the interviewees did not experience that the technology itself would have improved the physical well-being.

Perceived effects to *social* well-being were related to the possibility of sharing and discussing meaningful use experiences, both positive and negative, among friends. In a way, this offered a sort of peer-support. Still, the overall perceived increase in social well-being was small. We also found that the shared personal use experiences served as positive or negative recommendations concerning the technology. Compared to sharing use experiences, the interviewees were more reluctant to share their personal data with others, because it was seen as more personal or uninteresting to friends. This is logical in the context of self-tracking technologies, as their main purpose is often to collect data from oneself and to increase self-awareness.

In addition, we found that the technology can influence the behaviour in unexpected and negative ways that do not improve performances, but instead hamper the daily activities. Some interviewees described how they had purposely changed their behaviour in order to receive better feedback from the technology, for example, by carrying bags in different hand than normally to avoid absence of hand movement that is detected by the tracker; or by having to plan when and how to charge their mobile phones due to the increased battery consumption caused by the self-tracking application. These kinds of negative changes in behaviour were seen to lower certain elements of well-being, namely, the *level of independence*. Thus, these technologies can even have a negative effect on some aspects of perceived well-being.

These findings regarding the relatively small actual perceived well-being effects during the implementation phase were in line with the pre-implementation expectations. There are two possible explanations for the minor perceived well-being effects. If the user did not have a clear felt need or a problem in mind when implementing the technology, then well-being was not perhaps seen as a subject of development and the user did not try to improve it during the implementation phase. Of course, the minor perceived effects on well-being could also have been caused by the relatively short

usage period that was restricted to the implementation phase, preventing the perceptions of any longer-term benefits. In any case, this lack of perceived improvement in well-being was one of the reasons behind the fact that out of the 14 implemented technologies, the use of eight discontinued during or after the implementation phase. Other reasons for discontinued use included, for example, bad usability or functionality of the technology and the received information not being valid and reliable.

5 Conclusion

This study examined whether self-tracking technologies influence the individuals' perceived well-being during the implementation phase. In addition, the study also investigated what are the expected short-term well-being effects of using a self-tracking technology. The main research questions of the study were: 1) Do self-tracking technologies influence the users' perceived well-being during the implementation phase? 2) How the potential influence occurs?, and 3) What are the expected short-term well-being effects of using a self-tracking technology?

The short-term well-being effects before the implementation of a self-tracking technology were expected to be relatively small and unrecognizable, and they were not seen as the primary goal of use on a short-term. Rather, in general it was expected that during the implementation phase, these technologies would mainly operate as providers of interesting information, and improving own activities and well-being would take place on a longer time scale.

The actual perceived well-being effects of using a self-tracking technology were relatively minor during the implementation phase. Psychological well-being was perceived to grow with those positive experiences where the technology verified or showed the user's successful performance, subsequently causing pleasure and assurance for the user. With physical and social well-being the perceived effects were small. There are two possible explanations that could explain the relatively minor perceived well-being effects during the implementation phase. One, the user not having a clear felt need or a problem in mind when implementing the technology, and two, the relatively short usage period that was restricted to the implementation phase and prevented the perceptions of any longer-term benefits. These findings imply that the industry should take the well-being aspect into account even more when designing and marketing these technologies. As our results suggest, the lack of increase in perceived well-being was one of the reasons behind discontinued use. Thus, it would be valuable for the adoption, continued use, and success of the technology if it would be able to provide the users with perceived increased well-being effects already during the early stages of use.

To promote the diffusion of self-tracking technologies and increase their success in healthcare, new users and patients will need proper understanding and guidance on how to make the use of these technologies more goal-oriented, not just something to wear. This could be achieved if improving well-being would be a clearer and a more concrete target for usage. As our results show, the users want clear, relevant, and easy-to-understand information, so providing this could also advance the goal-oriented use of self-tracking technologies and subsequently increase perceived well-being. This would be valuable to acknowledge both in the industry and healthcare. The lack of increase in perceived well-being on a short-term is also something that the healthcare sector should acknowledge. It indicates that using self-tracking technologies will most probably be more successful in improving health and well-being if prescribed to the patient for a longer-term use. Also, when deploying these technologies for patients, the professionals should provide them with clear guidance and goals for use. The same applies for occupational healthcare and employees.

In addition, our study shows that acting or living on the terms of a self-tracking technology can have a negative influence on the daily activities and life of the user and thus even have a negative effect on some aspects of perceived well-being. This is important for the designers in the industry to take into account when designing these products.

In conclusion, the study provides valuable new insights regarding the experiences that people have with self-tracking technologies. We believe that the healthcare sector can use our findings and implications in employing self-tracking related means of care to the patients and subsequently in improving general health and well-being. We also believe that the different industry parties working among self-tracking technologies can utilize our findings in the development of self-tracking technologies and in providing products that are better welcomed by the users and gain success in the market.

6 Limitations and Future Research

We consider there to be three main limitations in the study. The first limitation concerns the general limitations of qualitative interview. However, in planning and conducting the interviews, we followed relevant guidelines for semi-structured interviews (e.g., Braun & Clarke, 2006; Guest et al. 2006; Myers, 2013; Myers & Newman, 2007) to gain maximal value and to avoid the potential problems and pitfalls of using the method. The identified themes in the thematic analysis are always based on the interpretations of the researchers (Guest et al., 2012). Therefore, we also applied relevant guidelines in doing the analysis. Typical to qualitative research, making generalizations from the sample to a larger population can be problematic (Myers, 2013) and should be done with caution. Second limitation concerns the focus being on the implementation phase, meaning the target group consisted of people just about to implement a self-tracking technology. Thus, the target group was rather small and to obtain the interviewees, we had to suggest the possibility to participate in the study. All interviewees could, however, choose the technology to implement themselves and reported that they would have started using the technology in the near future even without the suggestion of the researchers. Thus, the implementation was a natural situation based on own interests. We also followed previous guidelines (McCracken, 1988) in selecting the interviewees. Third limitation concerns the sample. Although providing a great amount of information, the number of interviewees could have been higher. However, we believe that an adequate number of interviews were conducted, as we continued to conduct interviews till we had recognized that their marginal benefit was significantly reduced. Regarding the gender distribution, it could have been more balanced. Also, the age difference among the sample is rather small, but as proposed by McCracken (1988), a fairly homogenous sample that shares similarities regarding the research question helps to maximize the depth and richness of the data.

Also, when examining well-being effects, it should be noted that well-being in itself is a multifaceted and abstract concept that may mean different things to different people. Hence, it can be challenging for the users to highlight concrete factors that affect their perceived well-being, especially from the implementation phase, as it is a relatively short period of time to recognise the effects. Future research can build on this notion: it could be valuable to study perceived well-being effects with longer periods of use and prolonged study duration. The findings of the study also provide other potential paths for future research. First, this study examined different self-tracking technologies, but it would also be interesting to investigate one specific technology. By investigating a specific technology, it would be possible to identify technology-specific characteristics in more detail. Second, the target group could be limited to a certain kind of users who have similar well-being goals, for example, weight loss, better sleep,

or other specific area. The target group could also cover some different demographic such as elderly people.

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Appendix A Interview Script and Examples of Questions

Opening		
Introduction		
Themes of the key questions		
1. Background	1.1 Demographics	1.2 Socioeconomic characteristics
2. Well-being aspect		
2.1 Physical health (energy and fatigue) e.g. “Do you feel that the use of the technology has affected your physical well-being?”	2.2 Psychological (feelings, self-esteem, cognitive functions) e.g. “Do you feel that the use of the technology has affected your mental well-being?”	2.3 Level of independence (work capacity, activity) e.g. “Do you feel that the use of the technology has changed your activities of daily living?”
2.4 Social relationships (social support, sexuality) e.g. “Have you received support or negative reactions regarding the use of the technology from your social circle?”	2.5 Environment (finance, health and social care, opportunities for acquiring new information, physical environment) e.g. “How have the environmental factors supported the use of the technology?”	2.6 Personal beliefs (religion, spirituality) e.g. “Do you feel that your personal beliefs have affected the use of the technology?”
Closing		

More detailed descriptions of the key questions are available from the authors by request.