



Aalto University
School of Business

Quantified-self technology in promoting well-being

The digitalization of holistic well-being
models

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Abstract

Objectives

The main objectives of this thesis were to examine the current consumer quantified-self technology in use today, how the technology can be used for well-being purposes, and the different factors in play when building the future well-being models. The research was conducted as an examination of literature.

Summary

The main applications of quantified-self technology are activity trackers, sleep trackers, and habit trackers. EEG (electroencephalogram) sensors are also used, but less popular. There are several initiatives such as Google Fit and Neosmart Health that use this technology with AI (artificial intelligence) and ML (machine learning) to create constantly developing well-being models. The technology is developing, but science is still yet to prove that using quantified-self technology works to improve users' health. Furthermore, the applications are data heavy and issues with data ethics need to be sort out before wide commercial health applications can be assembled.

Conclusions

Quantified-self technology is still in its beginning phases. The potential of the technology with health care applications is notable in theory, but studies in randomized settings need to be conducted to prove the health benefits of using such technology. A working model for data ownership and privacy also is required for revolutionary health care applications. Until there is enough science and regulation behind quantified-self technology, industry pioneers will continue building new iterations of the technology and pushing it to be the future of health care.

Keywords quantified-self, well-being, healthcare technology

Table of Contents

Abstract

List of figures

1	Introduction	2
1.1	Research objectives and research questions	3
1.2	Scope of research.....	3
1.3	Structure and methodology of research	4
2	Quantified-self technology in use today	4
2.1	Activity trackers.....	5
2.2	Sleep trackers	6
2.3	Habit trackers.....	7
2.4	EEG sensors	9
3	Using gathered data to draw up well-being models	10
3.1	The ultimate fitness app.....	10
3.2	Digging deeper than self-tracking.....	11
4	What are the most important factors when creating future well-being models?.....	13
4.1	Data ethics.....	14
4.2	Does self-tracking really work?	14
4.3	Preventive medicine	15
5	Discussion and conclusions	16
5.1	Implications to research.....	16
5.2	Implications to practice.....	17
5.3	Limitations and future research.....	17
	References.....	18

List of figures

Figure 1. The Apple Watch activity tracker dashboard. (Apple, 2019)6

Figure 2. The Oura ring dashboard (Oura, 2019)7

Figure 3. The Sleep cycle dashboard. (Sleep cycle, 2019)7

Figure 4. Habit Bull Android app (Habit Bull, 2019)8

Figure 5. Commercial application of the EEG sensor (Imotion, 2019)9

Figure 6. Google Fit Journal (Google, 2019)11

Figure 7. Neosmart Health Methodology (Neosmart Health, 2019)13

1 Introduction

In an increasingly digitized and inter-connected world no industry is left untouched by technology. The rapid transformation began with making simple, but laborious tasks more effective and automated. Initially information systems moved quickly from instrumentality to more varied tasks and have moved on to affect the human in unforeseen ways. (Hassan et al. 2019)

Healthy living has been identified as one of the eight major megatrends in going towards 2030 by Euromonitor International (Boumphrey & Brehmer, 2017) and this has sparked a significant amount of new technological innovations and products. Especially, there has been a move by companies to create products and services that enable humans to gather data about themselves in a quantified way to encourage and allow healthy living. This is called the “Quantified Self” movement (Swan, 2013). Before these innovations, users have had to observe themselves qualitatively and make conclusions based on these observations. The latest technology has allowed for them to pick up the same information in a very rapid and accurate way into their smartphone or computer.

The similarly increasing amount of scientific research into personal well-being has further catalysed general interest on the matter. The movement has not only produced us with sleep scientists, happiness coaches, plenty of yogi, and wellness officers, but a significant amount of wellness apps, wearable devices, and habit trackers. The technology was created to provide users with both the access to the information they produce while living, and an insight into the scientific theory behind the actions taken. “Objectives may range from general tracking to pathology resolution to physical and mental performance enhancement.” (Swan, 2013)

The quantified-self has gathered a vast movement around it. Followers are strongly in the belief that this technology can significantly improve people’s energy levels and well-being. The narrative claims that a user of quantified-self products is more able to focus on things of actual importance from both a personal and a professional point of view. The people that self-track produce more for their employer, cost less in terms of healthcare, pay more taxes, have a more positive effect on their surroundings, and are not as prone to

mental health disorders. All these factors are extremely valuable for the society, if this really is the case (Balapour et al. 2019).

The possibility of self-tracking is so immense that individuals, companies, and other organizations have begun tackling one narrow problem at a time. Efforts to piece different applications together into a comprehensive, digitized well-being model have been limited, but is to be further expected in the future. The future well-being models will use the science of well-being together with helpful technology to achieve healthier humans.

1.1 Research objectives and research questions

The purpose of this thesis is to contribute to the research linking technology to well-being. I will begin this thesis by explaining the technology behind measuring the human body and what are some examples of such technology in our society today. Then I will continue by explaining how this gathered data can be used for well-being purposes and highlight some current players in the market. In the fourth chapter, I will focus on the most important factors of a future well-being model. The following three research questions are addressed consecutively in chapters 2-4 that follow:

RQ1: What is the consumer technology used today for measuring the quantified human?

RQ2: How can quantified-self technology be used for well-being purposes?

RQ3: What are the most important factors when creating future well-being models?

1.2 Scope of research

In this research I will focus on the technology-side of the digitized well-being model. This thesis will not be addressing definitions of well-being or the topic in further detail that is necessary. Instead, the aim is to highlight different aspects of self-tracking that are currently measured as guidance for what a fully digitized well-being system could look like if created.

Thus, my research will assess different technologies already available, emerging technologies, and literature both supporting and criticizing the development of the technology.

1.3 Structure and methodology of research

The rest of this thesis will be structured according to the three research questions and concluding remarks.

Chapter two of this thesis will outline what functions of the body can be measured nowadays, chapter three will discuss what can and is being done with this data, and chapter four will examine the phenomenon when looking at the future and some implications of the advancement. The final chapter will conclude and summarize the key findings of the thesis. Critique about the sources and findings are brought forward where applicable.

Literature is reviewed for each chapter, except the discussion and conclusions section. The literature used is mostly found from recent journal articles discussing the latest technology and the science behind the developments. The Scopus and Web of Science databases are used to find academic publications on the topics. The searches are conducted by using relevant key phrases, such as “quantified self”. Some company sources are also used to balance the information from the journals with real-life examples. Figures are from first-hand company sources.

2 Quantified-self technology in use today

Quantified-self technology has seen a steep increase in popularity in the past few years. There are several different ways to self-track the different functions of the human body. Companies have produced different applications and products to address the growing popularity. The technology is quickly improving to track more of the functions while being more efficient and precise. Many of the products are beginning to have analysis methods for self-development purposes, such as tips for better recovery or a better workout. In this chapter, I will review activity, sleep, and habit trackers as well as EEG sensors

2.1 Activity trackers

Activity trackers represent by far the largest portion of the current well-being technology market. An online survey conducted by GFK Statista (2016) claims that a third of all people track their health using a quantified-self tool. More than half of these were activity trackers. “In terms of physical activity behaviours for instance, the devices can track multiple aspects including steps completed, distance covered, duration of sedentary and active behaviours and calories burned.” (Alharbi et al. 2017) Additionally, the trackers can be used for health motivation and self-improvement purposes.

The significance of activity trackers lies in their ease of use, cheap cost, and easily understandable metrics. They are essentially one of the easiest ways to begin self-tracking. This is reflected in the growing number of brands that produce their own tracker (Apple, Fitbit, Garmin, Samsung, Xiaomi, etc). Figure 1 illustrates the Apple Watch tracker.

Activity trackers tend to focus purely on the tracking side, and rarely include significant analysis into the gathered data. This is mostly because usually activity trackers are not able to produce a full enough picture to make significant analysis on (Shin et al. 2019).



Figure 1. The Apple Watch activity tracker dashboard (Apple, 2019).

2.2 Sleep trackers

There are two types of sleep trackers easily available: wearable sleep trackers, such as Oura, and sleep tracking apps, such as Sleep Cycle.

Sleep trackers are used to provide insight into the unconscious part of our daily cycle, and more importantly to the different cycles we enter during our sleep. Sleep trackers can use various tools to measure sleep. The Oura ring uses the data gathered from our pulse, an accelerometer, and our body temperature to construct a holistic profile of our sleep. The company uses the data to make suggestions related to recovery and energy levels. For example after a short night of sleep, the Oura app might suggest “taking it easy.” (Oura 2019). Figure 2 is a screenshot from the Oura app.

Sleep Cycle on the other hand uses only the user’s phone to conduct a profile on their sleep. More specifically, the system relies on the accelerometer and microphone for data gathering (Sleep Cycle 2019). Figure 3 shows the Sleep cycle profile.

Sleep trackers are becoming more popular amongst quantified-self users, because they can track a significant part of our daily cycle that remains a mystery to many. By getting better information about the amount and quality of our sleep, users can draw better conclusions about their energy levels after a certain night of sleep and act accordingly. “These applications allow individuals to monitor their general health. They could also potentially be used to reinforce patient empowerment during treatment for sleep disorders.” (Gruwez et al. 2019).

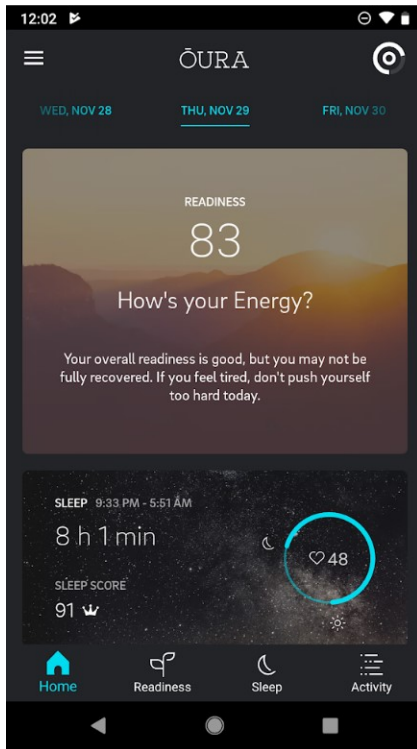


Figure 2. The Oura ring dashboard (Oura, 2019).



Figure 3. Sleep cycle dashboard (Sleep Cycle, 2019).

2.3 Habit trackers

Where both activity and sleep tracking are automated ways of quantitatively measuring events, habit tracking relies on qualitative measuring. Habit tracking is based on the notion that habits are beneficial for humans both from biological and psychological standpoints. Habit tracking exists to motivate behavioural change. “Existing theory and empirical findings from observational studies showed that behavior change occurs in 2 distinct action phases—a motivational phase, which results in the formation of a behavioral goal or intention, and a volitional phase, which results in the enactment of behavior once a goal or intention is formed” (Ellingson et al. 2019).

Furthermore, habit trackers use persuasive systems to their benefit, Persuasive systems persuade users to choose a certain course of action and have been designed with the purpose of serving a good purpose. Persuasive systems motivate desirable behavior by

using different persuasive techniques to increase user engagement and commitment. These features help the users achieve their goals. (Benbasat 2010)

There are not many studies available that specifically study the effect of habit tracking on behavioural change, but since several apps have risen into popularity amongst smartphone users, studies will be conducted on the matter sooner or later. Habit tracking could also hold a significant role in the future of well-being management.

Current habit tracking apps hold millions of downloads. The most popular on the Google Play Store are Habit Bull, Loop, Goal Meter, and HabitHub (Google Play Store 2019). Figure 4 shows the Habit Bull activity dashboard. In the Habit Bull app, users are able to track their habits. The example below shows the user's successful days using filled circles and unsuccessful days with unfilled circles. The purpose of the app is to provide transparency into how well the user of the app acts according to a desired or undesired habit.



Figure 4. Habit Bull Android app (Habit Bull, 2019).

2.4 EEG sensors

EEG (electroencephalogram) sensors gather data on the electric signals coming from your brain. EEG trackers are not at all common to be used casually, as they are mostly used to diagnose conditions such as epilepsy. However, they can be technically used casually to learn how your brain reacts to different situations in everyday life. There are a few notable quantified-self enthusiasts that practice this human experiment casually with their own bodies, such as Professor of Computer Science and Neuroscience Nathan Intrator from Tel Aviv University through his extensive research into neuroscience (Castellani et al. 2019). With this data the user can get extremely close to measuring data points that have to do with their emotions and perception. This is not possible with the trackers mentioned earlier in Sections 2.1-2.3, which is why it is extremely attractive for companies and other entities to create better methods to track more sides of the human body.

Studies related to EEG mostly have to do with very specific areas of the possibilities of the technology. Only a handful of the studies studied the effects of using the sensor in everyday life, but still mostly unrelated to improving the well-being of humans. Jiang et al. (2019) created in their study a system to log significant events in a user's life, such as times of high alertness or stress. Similar technology could be used in the future to supplement the holistic well-being model.



Figure 5. Commercial application of the EEG sensor (Imotions, 2019).

3 Using gathered data to draw up well-being models

Little by little we are able to start measuring increasing amounts of data points about our body, both observable and invisible to the outside. Most applications developed by companies and other entities focus on a very narrow aspect of our body, but the next step is to aggregate the data into patterns and easy-to-interpret analyses. There is no application out there that attempts to “do it all”, but some applications are getting close. The non-technical equivalent would essentially be a professional personal coach, but better and cheaper. There are a few initiatives out there that have taken different approaches to this possibility.

3.1 The ultimate fitness app

When imagining the ultimate fitness app, attention is immediately given to the largest tech giants in the world. Google, arguably one of the largest data possessors in the world, has taken a leap forward with their vision of the ultimate fitness app- Google Fit.

Google has been able to receive increasing amounts of data about us in exchange for increased convenience. We use Google Docs to draft our important documents, Drive to store them, Gmail to send them, and Android to handle our mobile digital life as a whole. Google has developed a quickly evolving Fit-application that is able to accurately track walks, bike rides, runs, and other forms of activity automatically. This is significant because the user is now able to bring the otherwise separated pieces of data together into a “big picture” of their health. Furthermore, the product seamlessly integrates with most popular fitness trackers and apps (Google Fit 2019).

Google Fit lets you input workouts not tracked by your phone, your weight, and your blood pressure. With this infrastructure all Google needs to do is to expand their realm of integrations into measuring habits, energy levels, sleep, and nourishment and it would be able to learn about the users in a manner that could give accurate comments, predictions, and proposals about their observable actions (Nobakht et al. 2018).

Google, given their expertise in AI (artificial intelligence) and big data, could provide self-trackers with a product that could pull these different pieces of data about us into a well-being model (Dasoriya et al. 2018). Google has such a strong grasp of our digital

self that this well-being model could be used in conjunction with other Google applications. For example, this system could plan out your day in a way in your calendar that leaves time for a much-needed lunch break or nap. Figure 6 shows the automatically generated digital journal of Google Fit's user's activities. The activity in the middle has been generated by another app, but Google is able to import the data into the Google Fit app.

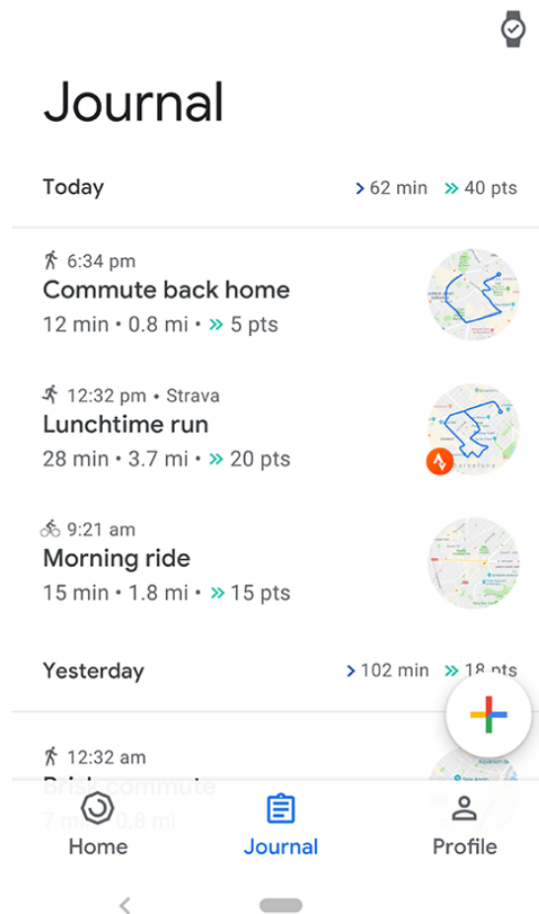


Figure 6. Google Fit Journal (Google Fit, 2019).

3.2 Digging deeper than self-tracking

Where all the applications mentioned before have focused on more observable and self-trackable sides of our body, Neosmart Health- a recently founded Helsinki start-up, has begun working on the less observable sides of the human body. The company measures

a vast array of different functions such as gut health, nutrition, genomics, hormones, metabolism, immunity, body composition, and minerals to construct a very holistic view of a patient's health. They even go to the extent of analysing the effect of third party-issues such as environment to make the model even more effective (Neosmart 2019).

The company's thorough examination has been partially automated, but costs almost a thousand euros to conduct at first and a few hundred per month to monitor. The company's vision is to be able to provide the examinations for free in the future using technology and previously gathered data. Neosmart Health's current expert-based system is set to move towards an almost automated AI-based system that would be extremely accessible- as opposed to the fully booked schedules of their doctors they have now (Neosmart 2019).

Neosmart's method is an early iteration of the extent technology can reach regarding the digitization of a well-being model. A working method could be set to revolutionize medicine to a more personalized and preventive direction- as opposed to being prescriptive and general that it is today. "ML (Machine Learning) for personalized medicine is a growing area of interest. The ability to draw on large data sets and predictive models allows for clinicians to more confidently diagnose, predict and treat their patients" (Handelman et al. 2018).

Figure 7 shows the different elements of a patient's health according to the Neosmart Health methodology. The methodology is eye-opening in the scope of this research, because the "quantified self" technology only applies to the first two elements: "Health & Wellness" and "Health Behaviour". The 7 new elements mentioned in the methodology bring several new dimensions into the health and open new possibilities for further integration of technology into well-being.

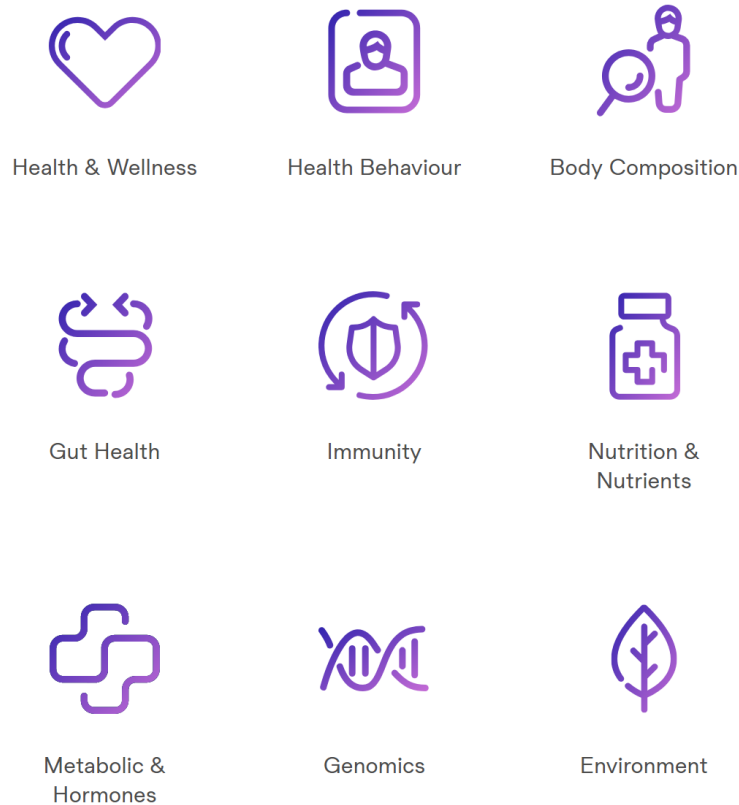


Figure 7. The Neosmart Health Methodology (Neosmart Health, 2019).

4 What are the most important factors when creating future well-being models?

When creating the future well-being models, individuals, companies, governments, and organizations need to be educated about the different sides of the development. An uncontrolled, rapid growth of the technology can have serious implications for society. Ethics regarding data gathering and processing need to be seriously considered for sustainable development of the technology. The technology needs to be proven and accepted by the scientific community for continuing support from science. The technology's possibilities with preventive medicine, and risks regarding privacy and other issues need to be weighed accordingly.

4.1 Data ethics

The major questions to consider when addressing the quantified self and well-being models have to do with the same issues that other AI applications and data-controlling companies battle with. The questions are by no means easy to answer and it is certain that government legislation is needed to address the questions locally and more generally. Here are just a few questions raised in Koll's (2019) recent research: "How was a set of data collected or obtained? Were the data collected directly from customers, or was the dataset purchased from a third party? Is use of the data restricted by a privacy policy or contractual requirements? Do any data protection or other laws apply, and from which jurisdictions? Can these data be combined with other data safely and legally? Are these answers the same for all customers, or do customers in different countries require different policies?"

The users of such technology are also faced with ever-so-difficult micro-questions. Do they want to be a part of a system where increasing amounts of data about them are controlled digitally? Many sceptical researches are already making claims that systems like these would lead us to outsource our decision making little by little to machines that admittedly know more about us than we do ourselves- and in some respects many of us are comfortable with it (Skulimowski 2017).

EU's attempt at protecting data and controlling companies handling data in the form of General Data Protection Regulation (GDPR) is a significant step in a direction to bring much needed regulation to the industry (Kędzior 2019). In Finland, a separate act has been laid down in 2019 concerning the secondary use of health and social data. The act aims to maintain an individual's personal rights and freedoms with their data, while ensuring efficient and secure use of the data for both personal and research purposes (The Finnish Ministry of Social Affairs and Health, 2019).

4.2 Does self-tracking really work?

Another important question to consider, when creating the future well-being models, is to follow science on what aspects of self-tracking really work. Currently there is a lack of scientific evidence about the actual benefits of self-tracking devices (Stiglbauer et al.

2019). A sustainable model can not base itself on only placebo and promises. All the different technologies introduced in this thesis need to be based on science- specifically what happens to a user if quantified-self technology is used- if true benefits are to be proven.

It is also a noteworthy issue whether the different technologies work not only on their own, but also together in a holistic model. The scientific backing for the use of quantified-self technology becomes especially important when implementing the technology to preventive medicine and health insurance.

Developers of the future well-being models need to be aware of psychological factors in play when using self-tracking devices. Stiglbauer (2019), for example, defines several theoretical explanations on psychological phenomena that can affect the usage of quantified-self technology. These include self-regulation, self-evaluation, reactivity, and intrinsic motivation. Each of these phenomena in relation to self-tracking devices deserves full scientific attention to survey their significance.

4.3 Preventive medicine

Preventive medicine, also known as lifestyle medicine, emphasizes proper nutrition, physical activity, behaviour changes, healthy sleep, responsible alcohol consumption, and emotional well-being. This type of medicine provides evidence-based treatment for preventable diseases that account for more than half of all disease-related deaths e.g. in the US (Trilk et al. 2019). In the future, both diagnosing and treating diseases early on can be easier with quantified-self technology. Because of the irrationality of the human and the sheer amount of data our bodies produce, trackers are much more able to pick out and report abnormal body behaviour than the human itself.

When creating the future well-being models, the world of medicine and technology need to be better merged. Diseases cannot be treated primarily with prescriptions, but through constant audits of the body and effective lifestyle changes. “In other words, instead of asking a patient to change his or her lifestyle to adhere to specific recommendations, health care providers can help patients find ways to fit recommendations into their lifestyle” (Arlinghaus & Johnston 2019).

There are some companies in the health insurance business that have recognized this potential. Insurers are betting that investing in the well-being of their customers early-on will cut back on treatment costs in the future (Japsen 2016).

5 Discussion and conclusions

The quantified-self technology sector is still in its beginning phases. Activity trackers, sleep trackers, habit trackers, and different sensors are developing quickly to track the user's body better and more efficiently. The evidence discussed in this thesis provides a strong backbone for the further development of these applications and products, as well as their use in well-being models and methods. Initiatives such as Google Fit, and Neosmart Health are important pioneers for these models and are likely to continue incorporating rapidly developing quantified-self technology into their models.

The sector still needs further research to get better scientific reasoning for whether self-tracking actually works, and in what ways the technology can be used to battle real problems with human health. The sector also needs discussion between the public and private sectors about the implications of the technology on human privacy and ethical use of data. This discussion followed by regulation will pave the way for the technology towards the desired direction. Scenarios need to be assessed realistically and with science-backed reasoning to achieve the best possible result.

The research questions were answered in chapters two, three, and four accordingly. This thesis presented the current state of the technology, some initiatives for data-backed well-being models, and suggestions for topics to keep in mind for further development of the models.

5.1 Implications to research

The findings in this thesis imply that “quantified-self” technology is in a decisive point of its lifecycle. As previous research suggests, the area has not been researched enough to make conclusions about the implications of the technology on the health of individuals, but it is safe to assume that this will be a topic for research in the coming years.

So far, there has been only little interest shown by the scientific community towards the development of integrated well-being models. As controlled experiments increase in the area, it is important to assess and continue developing these methods. This shows that the sector is still in its infant-stage. Scientists conducting research on the subject need to be especially educated about the psychological effects in play when using self-tracking devices.

5.2 Implications to practice

The results presented in this thesis should be taken both with excitement and caution by development companies, insurers, governments, and individuals. On one hand, there are a lot of possibilities in the sector for innovative solutions, but the issues are extremely important and sensitive to every human, so the developments need to be done ethically and with necessary precaution to the human health.

There are a lot of possibilities for cooperation in the field. Everything needs to work seamlessly together for the systems to work in a holistic manner. Current and future actors in the field should keep this in mind in their operations. Integrations between different systems allow for proper movement of data in a way that can benefit everyone.

5.3 Limitations and future research

This thesis was at the outset limited by the length restrictions of a bachelor's thesis. Furthermore, the topic is still extremely under-studied for the purpose of a literature review. There are several studies that survey the usage of self-tracking technology, but not many actually analyse the real benefits of using such technology on health. Additionally, the lack of studies in the analysis and well-being model sides of the thesis limited the examination of many of the interesting topics around the topic. These issues influenced the nature of the thesis from the originally planned.

Future research needs to focus not only on the usage of the technology, but on the implied health benefits in controlled, randomized settings. From here, research can move towards piecing the individual products into a holistic model where the effect of lifestyle medicine can be explicitly stated with concrete data.

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