From Quantified Self to Qualified Self

the benefit for DM2* patients

*Diabetes mellitus type 2

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Abstract

The list of things that can be measured about ourselves feels endless. Amongst others, our heart rate, the number of steps, our stress-levels, respiration, hours of sleep, or even the number of sneezes and coughs during the day can be measured. These measurements can be tracked with smart and wearable self-tracking devices such as fitbits and smartwatches. Those devices are part of the Quantified Self. The Quantified Self is self-tracking tools. Besides the devices, there is also an international community of users and makers of those tools who share an interest in “self-knowledge through numbers” (quantifiedself.com). But only looking at numbers does not give enough meaning to the findings. Therefore, the Quantified Self must become a Qualified self. “Data generated by body tracking in all forms are not merely a passive material for interpretation, they do not merely lie around in databases until something from the outside makes meaning out of them.” (Belliger & Krieger, 2016).

In this research, the Quantified Self is applied to newly diagnosed Diabetes Mellitus Type 2 patients. Through literature research, State-Of-The-Art, interviews with professionals and prototype testing research has been done on what the benefit of the Quantified Self and the Qualified Self can be for newly diagnosed Diabetes Mellitus Type 2 patients. A prototype of an application is developed and tested with five participants. From research it can be concluded that patients can benefit from an application where the Qualified Self extends to the Qualified Self as long as there is enough motivation from the patient to keep tracking themself.

Acknowledgements

To begin, I would like to thank my supervisors A. Schaafstal and R. Klaassen. While the Covid-19 crisis has a great impact on everyone, both A. Schaafstal and R. Klaassen made sure the meetings, support and guidance could continue virtually. I want to express my gratitude for the feedback, inspiration, experience and knowledge that they shared.

Next to this, I would like to thank all the people that supported this graduation project in any way. I want to thank the participants of the concept testing for putting in the effort of self-tracking and answering surveys. And I want to thank G. van den Burg and C. Hendriks - Volmeijer for giving insight and sharing expertise. Lastly, I would like to thank D. Reidsma for arranging meetings to share knowledge and help the students with HMI related projects.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

This Chapter introduces the terminology ‘Quantified Self’ and ‘Qualified Self’, as they lay the foundation for this report. After which, the challenges concerning the benefits from self-tracking for DM2 patients are enlightened. To overcome these challenges, research questions are set. These questions are answered throughout the report, of which the structure is described at the end of this Chapter.

1.1 Quantified Self

The Quantified Self is a movement of self-knowledge through numbers. This means tracking yourself for any reason and with any goal. Even though the concept of the Quantified Self might not be known, everybody knows about self-tracking. Whether it is tracking your runs, sleep time or even your weight on a simple scale, self-tracking technology is very common. Quantitating yourself in numbers has been done for ages, but got a new meaning to it with the rise of technology. This tracking of the self can be done using, for instance, a tracking device such as a smartwatch or by using an app on your phone. Via the Quantified Self people can learn from their own data. An example of a Quantified Self visualisation is the visualization by Lauren Manning and shown in figure 1 (Swan, 2013). The Quantified Self movement led to the Quantified Self community, originating from San Francisco, started by G. Wolf and K. Kelly in 2007.

Figure 1: One year of french fries consumption, visualized by Lauren Manning (Swan, 2013).

1.2 Diabetes patients and technology

This report links Diabetes type 2 patients with quantitative data. There are multiple reasons why it is important for DM2 patients to self-track. For starters, they need to keep track of their glucose levels to stay healthy. Using a smart device or app is an easy way to track for instance physical activities and sleep. This way the patient does not have to think about writing down everything about their day, as the tool does it for them. Not only physical activities and sleep need to be tracked. A few factors that affect glucose levels are food, activity, medication, not being active, illness, tiredness and alcohol (Global Diabetes Community, 2019).

Since there are so many factors to take into account, Diabetes is looked at as data-intensive. For Diabetes patients, collecting data is necessary to stay healthy. “Unlike other areas like weight loss or fitness in which the collection of quantitative data is a matter of personal choice and self-improvement goals, for diabetic patients proper and timely data collection is a necessity of vital importance.” (Konstantina V, 2017).

There are a lot of people living with this chronic disease, and the number is expected to grow. There is a high need for DM2 patients to use self-tracking, and the number of patients is big. The World Health Organisation WHO has estimated the figure to be over 422 million adults worldwide who have Diabetes. This makes it very important to have properly quantified data for Diabetes patients. This report focuses on people who have Diabetes type 2 because there is a big range of people using insulin and people who are not using insulin but rather adjust their diet and lifestyle. This range makes that there are a lot of things that need to have the possibility to be tracked for DM2 patients (Osborn, 2017). Therefore type 2 Diabetes is chosen to focus on in this research, as it is more linked to self-tracking than type 1 Diabetes.

“Diabetes technology is the term used to describe the hardware, devices, and software that people with Diabetes use to help manage blood glucose levels, stave off Diabetes complications, reduce the burden of living with Diabetes, and improve quality of life.” (American Diabetes Association, 2019) “ More recently, Diabetes technology has expanded to include hybrid devices that both monitor glucose and deliver insulin, some automatically, as well as software that serves as a medical device, providing Diabetes self-management support. Diabetes technology, when applied appropriately, can improve the lives and health of people with Diabetes; however, the complexity and rapid change of the Diabetes technology landscape can also be a barrier to patient and provider implementation.”.

1.3 Diabetes patients and the Qualified Self

The Qualified Self comes from the Quantified Self when it is interpreted. It must be integrated into networks of identity, society, and meaning. The Quantified Self must become a Qualified Self if body tracking is to have any impact on our lives and society. Knowledge of the self requires a self that is properly qualified and not just properly quantified (Belliger & Krieger, 2016). Qualifying the Self results in a deeper layer to the data, giving it value and meaning. It is important that the Qualified Self gives proper feedback to the user such that they can gain self-knowledge from it. Only Quantifying the Self is not enough. “The quantified self provides individuals with means for qualifying themselves, through which some level of performance may be attained or exceeded. This is one way in which quantified self leads to the qualified self.” (Swan, 2019).

For DM2 patients, Qualifying the Self would mean gaining more from personal tracking. When the trackable data is improved with extra information, the patient can learn from their own data. The tracking of physical activities could, if combined with sleep pattern and mental well-being, give more insight into when insulin needs to be taken and how a DM2 patient can live insulin-free.

1.4 Challenges

There are numerous factors that affect the glucose level of a DM2 patient. A few of those factors that can be self-tracked are physical activities, sleep, food, medication, not being active, illness, tiredness and alcohol (Global Diabetes Community, 2019). A DM2 patient can track this information, and see how they perform in the separate factors. To gain self-knowledge from the data, there should be shown how the factors influence the insulin intake. This leads to self-knowledge through the Quantified Self.

To extend the knowledge and gain more insight into the numbers, this Qualified Self needs to become a Qualified self. The trackable information needs to be extended with extra information for the patient to be able to learn more about the Self.

The challenge in this research is to find what is trackable and how to give extra information to this data. This way, the Qualified Self gives added value for DM2 patients to help control their disease and live, if possible and wanted, insulin-free.

1.5 Goal and Research Questions

The goal of this research is to extend the trackable data of DM2 patients with extra information. This way people with DM2 can gain self-knowledge through self-tracking. Self-tracking information will be combined with the personal situation to give extra meaning to the data. Therefore, the main research question is:

How can data from the Quantified Self be extended such that a DM2 patient benefits from the Qualified Self?

To help define and explore this field, three sub-questions are formed. These help form the information that is needed to answer the main question. The sub-questions are:

a. What can a DM2 patient track about themself?
b. How can DM2 patients benefit from self-tracking technology?
c. How can data about the self be given deeper meaning?

1.6 Structure of the report

In Chapter Two, the conducted background research is discussed. Then, the State-Of-The-Art of Qualified Self applications will be compared and analyzed. After this, a conclusion is drawn from the literature research. In Chapter Three, the ideation phase is conducted, based on literature research. The product specification phase is stated in Chapter four, after which the realization is discussed and described in Chapter five. Chapter six contains the evaluation, which is followed by the conclusion, discussion and recommendations in Chapter seven. Finally, the references and appendices are attached.

Chapter 2: State-Of-The-Art

This Chapter displays the background research done on the subject. Research will be discussed, covering the benefits of Quantified Self as well as the specifics about Diabetes. In addition to this, expert interviews are conducted. In the second part of Chapter two, the State-Of-The-Art of Qualified Self-tracking for DM2 patients will be reviewed and analyzed. Finally a conclusion is drawn.

2.1 Background research

Before existing applications are reviewed in the State-Of-The-Art, a literature review is done in the field of self-tracking for DM2 patients. As part of the background research, expert interviews are conducted.

2.1.1 Benefits of Quantified Self

A lot of benefits resulting from using the Quantified Self to gain self-knowledge. These benefits have resulted in a big Quantified Self community of enthusiastic self-trackers. Quantified Self helps keep an eye on diseases, health indicators and the effectiveness of care. Health tracking has been used by doctors for a long time, but now that you can do it on your own you have more control over the data (Klosowski, 2013). For instance, keeping a food log makes you more conscious of what you eat, just because you are paying attention (Henry, 2013).

To find benefits form Quantifying the Self, over 250,000 measurements were taken daily for 43 individuals in a study. Multiple benefits were found from the Quantified Self in this study. For instance, there was found that airline flights resulted in a significant drop in blood oxygen levels. Wearables were useful in identification of early signs of Lyme disease and inflammatory responses. And in addition to this, wearable sensors can reveal physiological differences between insulin-sensitive and insulin-resistant individuals, raising the possibility that these sensors could help detect risk for type 2 Diabetes (Li, 2017).

A negative side of the Quantified Self, is the lack of meaning in the results. Some self-trackers are put off by the cold, emotionless number-driven nature of the Quantified Self. When the Quantified Self becomes a way of life, self-trackers may tend to equate their

self-worth to the various numbers they are computing each day. This turns the emotionless numbers into a positive way of learning about the self from the Qualified Self (Opfer, 2020).

2.1.2 Benefits of Qualified Self

The Quantified Self concerns with counting surface data, but the Qualified Self digs deeper. The Qualified Self aims to understand the quality of human experience. Advances in AI, machine learning and Natural Language Processing are enabling qualitative data to be interpreted by computers, creating the new potential for Qualified Self digital tools for self-knowledge. The Qualified Self adds human insights to create more value for the user (Lynden, 2018).

The meaning that is added to the data is important. For instance, a user is trying to lose weight but has their birthday coming up. This is on Friday, but the app they use to track their weight loss has the cheat day planned on Saturday. If the app lacks a human-component of adapting to the personal needs of the user, it would mark the birthday as over-eating while the user might have swapped the cheat days to suit their personal needs. This is no set-back in the weight loss journey. Self-Qualification shapes the Self-Quantification and brings the numbers to become an identity (Pages, 2013).

Another example of how the Qualified Self improves Self-Tracking is by showing FitBit sleep data. In this specific example, the average sleep time of the subject per night is roughly 7 hours and 7 minutes, but an important additional data point is added: on October 1st a second child was added to the family. This is a data point which is not recorded by FitBit, but when included helps gives the data better meaning. The sleep rhythm gets worse once the child is born, but ideally, the watch will not say to sleep more but rather adapt to the new situation (Design Mind, 2015).

2.1.3 Diabetes Mellitus

Diabetes mellitus is a term for several conditions involving how your body turns food into energy. Your body turns carbohydrates into glucose and sends it into your bloodstream. To be able to use this glucose as energy, your pancreas releases insulin to help move the glucose from your blood into your cells. A Diabetes patient does not use insulin the way it should. There is no cure for Diabetes, but it can be treated with medication and lifestyle changes. Diabetes comes in different forms, depending on the cause.

PreDiabetes is when your blood sugar is higher than it should be, but not high enough for a doctor to diagnose Diabetes. PreDiabetes makes it more likely to get type 2 Diabetes and heart disease. These risks can be lowered by losing extra weight and doing exercise.

Type 1 Diabetes is also called ‘insulin-dependent Diabetes. It is an autoimmune condition. The pancreas is damaged and does not make insulin. Type 1 Diabetes patients need to make changes in their life in order to stay healthy. They need to do frequent blood sugar level testing, plan meals carefully and exercise daily. In addition to that, they have to take insulin and other medications as needed.

Type 2 Diabetes is often milder than type 1, but can still cause major health complications. Type 2 Diabetes has become more common in children and teens over the past 20 years, largely because more young people are overweight or obese. About 90% of the people who have Diabetes, have type 2. Treatment involves keeping a healthy weight, eating right and exercising. Some people need medication as well (Taylor, 2008).

People who have Diabetes type 1 do not produce insulin. People with type 2 Diabetes do not respond to insulin as well as they should, or do not make enough insulin (Osborn, 2019). The research in this paper is based on Diabetes type 2. This is because Diabetes type 2 includes more patients and because type 2 Diabetes patients can benefit more from the Quantified Self. This is because they still could become insulin-independent. There is thus a big group of people using this form of self-tracking. In this paper, type 2 Diabetes is referred to as DM2.

2.1.4 The relation between DM2 patients and data

As DM2 patients need to keep a healthy weight, eat right, exercise and possibly take medication there is a lot to keep track of. Apps can track your physical activity, as well as devices such as smartwatches. This self-tracking can be placed into three categories: passive, minimally manual and professional tracking.

Passive tracking requires some setup or specific tools, but when it is working the actual tracking should be largely automatic. Minimally manual tracking involves some amount of user input to do the tracking, you have to take some step or action logging that particular data point. Often this can be done using your phone or a simple and relatively inexpensive device. Professionally manual tracking generally requires extra time, special equipment or even a visit to a professional. (Koester, 2017) (Academic Writing assignment, 2020)

Passive Tracking	**Minimally Manual Tracking**	**Professional Tracking**
Step counters	Manual time tracking	Blood tests
Computer time tracking	Food tracking	DNA tests
Electricity usage	Heart rate variability tracking	Fat measurements
House and room temperatures	Weight tracking	Gut tests
Audiobook listening time	Media consumption	Telomeres
Music listening	Blood pressure	Physical assessments
Heart rate monitors	Glucose monitors	Fitness assessments
Word count trackers	Fitness tracking	
Sleep trackers		

Table 1: Examples of different sorts of tracking, from (Koester, 2017)

For a DM2 patient, both passive and minimally active tracking are options. Glucose monitors, weight tracking, fitness- and food tracking are examples of minimally active forms of tracking that can be used by DM2 patients. Good passive tracking devices such as apps can also keep track of glucose levels.

“Apps allowed users to track blood glucose, insulin doses, carbohydrates, weight and physical activity and review their data in a variety of ways including raw numbers, graphs or summary values such as averages. The majority of tracking apps required the user to manually enter their health data into the app. Just a few apps could directly upload glucose levels to a mobile phone, such as the Glooko system, the iBGStar meter, or the Telcare meter.” (Årsand et al, 2015) (Academic Writing, 2020).

2.1.5 Psychology behind motivation

Diabetes is a chronic disease that requires a person with Diabetes to make a multitude of daily self-management decisions and to perform complex care activities (American Diabetes Association, 2016). In a study done to evaluate the effectiveness of a commercial mHealth app in improving clinical outcomes for adult patients in a Federally Qualified Health Center with uncontrolled Diabetes and/or hypertension there was found that the lack of integration with the electronic health record was a problem. This was a problem for both patients and staff, who said the app was just one more thing to attend to (Thies, Anderson et al, 2017).

Children tend to be critical to apps, as opposed to adults. They are less critical, but do need the right motivation to use the app. When an app is being recommended by a doctor, the acceptance to use the app is bigger (van den Burg, 2020). But the biggest difference lies in whether the Diabetes patient is newly diagnosed, or whether they have been diagnosed for years. Newly diagnosed patients still need to remind themselves to open the app and log their numbers. When a patient has been diagnosed for years, logging or writing down measurements has become a routine. An example of this is C. Hendriks - Volmeijer. She has been diagnosed for 29 years and does not think about logging values. She does not set any reminders to help her remember to write down values.

2.1.6 Conclusion

There has been found that, even though the Quantified Self brings great benefits, the Qualified Self teaches the user more when it is used for personal use. For instance, data is personalized to give the data identity. DM2 patients need different sorts of tracking. An app that needs to fill the needs of the patient, otherwise it is just one more thing to attend to. The app would preferably have an option to set a reminder for yourself, to keep the user motivated if needed.

2.2 State-of-the-art review

In the state-of-the-art review, multiple Quantified Self-tracking applications will be described and compared. Each of these applications will have Diabetes type 2 as the main focus. The following seven applications are a selection of the top-rated tracking-apps for DM2 patients in 2019 (Doyle, 2020). The selection is based on functionality, and the requirement that multiple aspects are tracked that would benefit the DM2 patient, as listed in 2.1.2.

2.2.1 Description of the system

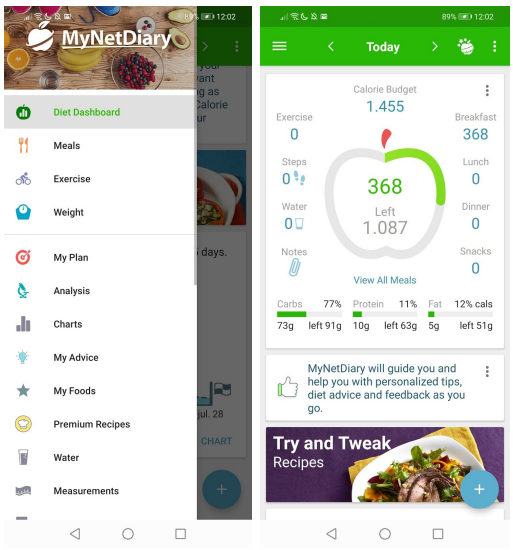
<table>
<tr><td colspan="2"> 

Figure 2: Two screenshots of My Net daily CalorieCounter PRO</td></tr>
<tr><td colspan="2">My Net daily CalorieCounter PRO: diary-app. The main focus of the app is losing weight. The dashboard of the app immediately shows feedback on the progress of the day. (1+ mil. Downloads, AppStore rating 4.7, PlayStore rating 4.6).</td></tr>
<tr><td>Measured variables</td><td>Categories: Meals, exercise, weight, Time

Variables:
<u>Meals</u>
Fat, Protein, Carbs, Water
<u>Exercise</u>
Steps, Walking, Running, Cycling, other exercises
<u>Time</u>
Breakfast, Lunch, Dinner, Snack</td></tr>
</table>

Data visualisation	The app visualizes the calorie intake over the day in the shape of an apple on the dashboard of the app. When the apple is filled, the maximum calorie intake of the day is reached. In addition to this, there is also a weight chart that the user can see when they move to the charts of the app. Here the weight target and progress is shown.
Evaluation	The app has a clear focus on weight-loss. Instructions and goals are clear, the app visualizes data to guide the user. It seems very effective, but is mainly adaptable for pre-Diabetes. This, because the exercise log is limited to three types of activity and there is no possibility to log medicine or insulin intake.

Table 2: description of My Net Daily CalorieCounter PRO

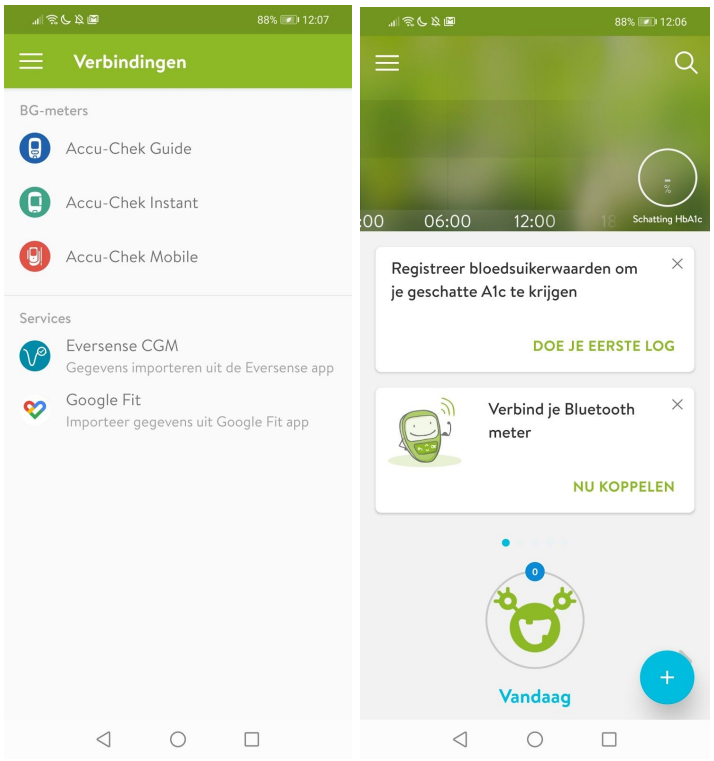


Figure 3: Two screenshots of MySugr

MySugr is a Diabetes app that allows the user to log carbs, connect a blood sugar tracker and estimate HbHbA1c. The app shows reports and gives feedback to the user (1+ mil. Downloads, AppStore rating 4.7, PlayStore rating 4.7).

Measured variables	**Categories:** Blood Sugar, Insulin, Carbs, Medicine, Feelings, Time, Picture, Activity, Weight, blood pressure, other **Variables:**

	Picture Picture Blood Sugar mmol/L Insulin Food, Correction (syringe, pump,..) Carbs Gram Medicine Pills Feelings hypo, hyper, happy, stressed, angry, excited, relaxed, sad, nervous, cleaning, work, party, binge-eating, hungover, holidays, eating out, shopping, sick, pain, allergies, headache, morning high, menstruation, special situation, on the road. Activity Hours:minutes, steps Weight kg Blood pressure mm/Hg Time Time, meal, before/after meal, snack, fasting, bedtime, night, after sport
Data visualisation	On the dashboard the app shows the HbA1c% at the moment. This can be done by linking a device (Accu-Check) with BlueTooth. Besides that, the app gives schemes in pdf, csv or excel which can be downloaded or sent to someone.
Evaluation	This app is an all-inclusive app meant for Diabetes patients. Everything can be logged, and Google Fit can be linked to log all exercises as well. Multiple devices can be linked to track values more accurately. The high rating and amount of downloads confirm that this app is widely used.

Table 3: description of MySugr

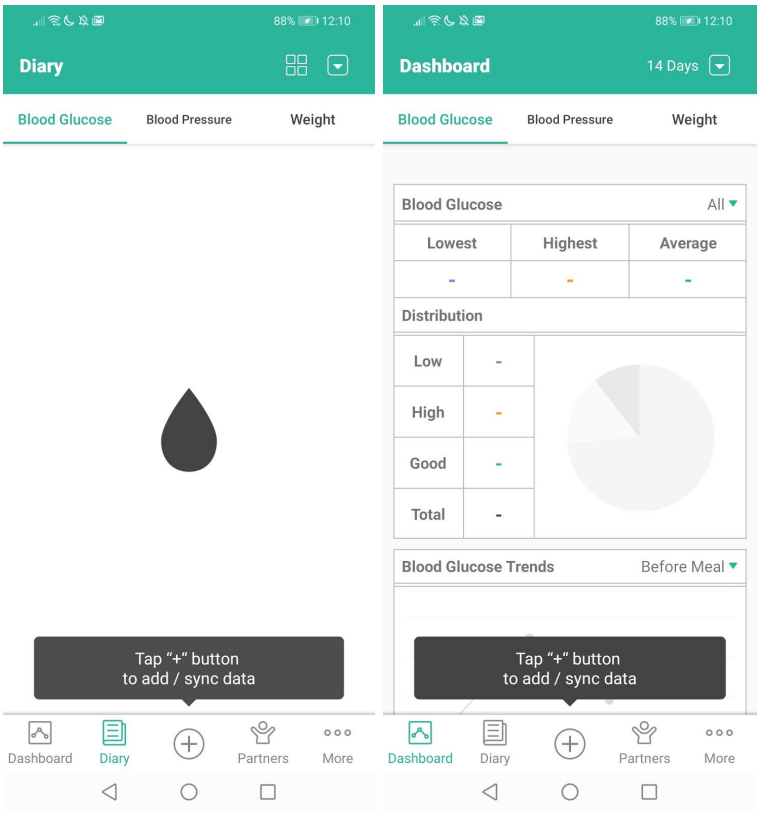


Figure 4: Two screenshots of Health2Sync

Health2Sync (500K+ downloads, AppStore rating 4.7, PlayStore rating 4.6)	
Measured variables	**Variables:** Diabetes Type, Medication, Weight, Body Fat, Blood Glucose, Blood Pressure, Weight
Data visualisation	The data is visualized on the dashboard of the app. It shows your lowest, highest and current weight as well as the weight progress. Weight trends are shown in a graph. The same goes for Body fat. Blood Pressure and Blood Glucose are shown in pie charts as well as trend lines and bar charts to compare before and after meals or exercise.
Evaluation	Health2Sync can be synchronized with Google Fit and Fitbit. The app then shows what the relation is between exercise and blood glucose, -pressure and weight. This gives the app all features to help a DM2 patient track their measurements.

Table 4: description of Health2Sync

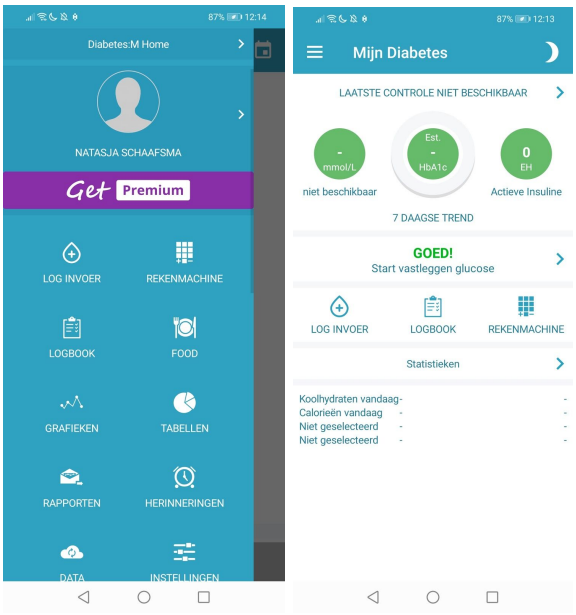


Figure 5: Two screenshots of Diabetes:M

Diabetes:M (500K+ downloads, AppStore rating 4.6, PlayStore rating 4.5)	
Measured variables	**Categories:** Diabetes Type, Medication, Weight, Glucose, Carbs, Insulin, Time, Blood pressure, Activity, Laboratory tests **Variables:** <u>Insulin</u> Several types of quick working and slow working insulin <u>Blood pressure</u> Systolic Diastolic Heartbeat <u>Activity</u> A sport or activity can be chosen out of a long list. <u>Laboratory tests</u> HbHbA1c Total Cholesterol LDL HDL Triglycerides Microalbumine Creatinine clearance eGRF Cystatine C Albumine Creatinine Calcium Total proteïne

	Natrium Kalium Bicarbonaat Chloride ALP
Data visualisation	Diabetes:M has no data visualisation on the dashboard. Instead, here data can be logged. In the menu, there are several options to view your data. First, there is the option to view a graph of glucose infuse speed (mg/kg/min) which shows hypo and hyper values as well as the goal value of the patient. Next to that, it tells the patient when their value is too high or too low. In addition to that, there is a 'charts' option on the menu. Here the division per day in these infuse speed values is shown over time, as well at specific moments of the day. These moments are for instance before/after breakfast or sports. Besides this the charts also show an ambulatory glucose profile, glucose week projection, metabolic control, glucose history and several more graphs. Even injection spots and glucose test locations can be displayed here. Extra options this app gives are to make a report of your data, send reminders during the day or to link devices. Data can also be imported or exported from/to other sources.
Evaluation	Diabetes:M is a very complete app and is clearly aimed to contain every option a Diabetes patient could possibly need. The app is aimed at making the user work towards their goals. The app has 500K+ downloads and a very high rating, with reviews saying: 'I'm really impressed with the amount and quality of the data provided by this app.' This shows clearly that the amount of data collected by the app is appreciated by the users.

Table 5: Description of Diabetes:M

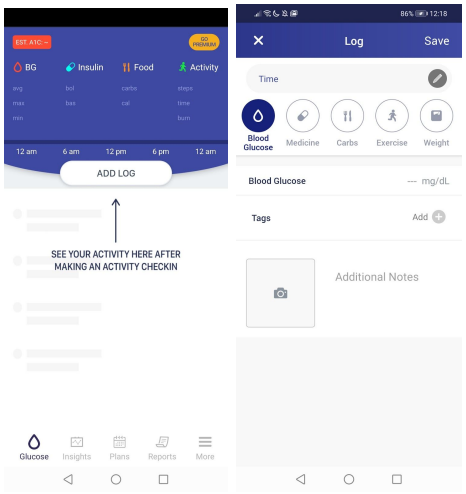


Figure 6: Two screenshots of Glucose Buddy

Glucose Buddy (100K+ downloads, AppStore rating 4.8, PlayStore rating 4.0)	
Measured variables	**Categories:** Diabetes Type, Food, Insulin, Blood Glucose, Medicine, Carbs, Exercise **Variables:** <u>Exercise</u> Multiple sports (in-app) Several Activities (in-app) Google Fit (extern)
Data visualisation	On the dashboard, the Blood Glucose, Insulin intake, Food intake and Activity of the day are shown. In the ‘insights’ tab on the menu, the Blood Sugar is displayed in a graph. Blood Sugar at several times of the day over a month is shown. There are 4 trendlines; Before Meal, After Meal, Other and Average of the week. Next to this, a report can be generated over a prefered period of time with all data available.
Evaluation	Glucose Buddy is a compact app with a lot of downloads and a high rating. The app has a simple design and is easy in use. It does not show many graphs or charts but it does show the information clearly.

Table 6: Description of Glucose Buddy

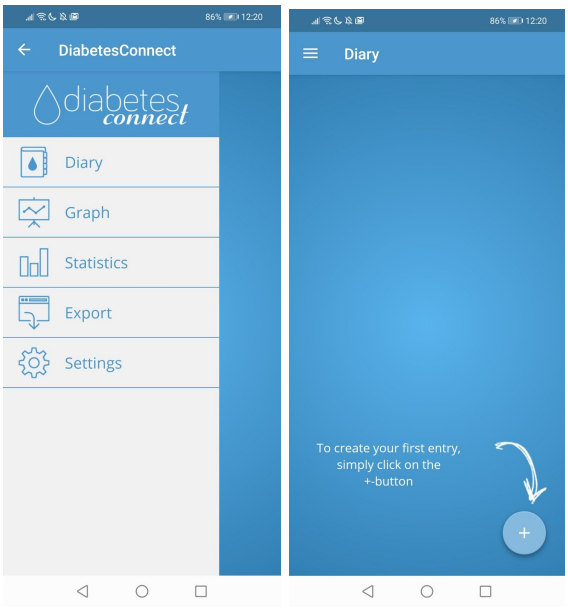


Figure 7: Two screenshots of Diabetes Connect

Diabetes Connect (100K+ downloads, AppStore rating 4.6, PlayStore rating 4.4)	
Measured variables	**Categories:** Diabetes Type, Blood Sugar, Meal, Basal Rate, Blood Pressure, Pulse, Weight, Sports, Reminder **Variables:** Sports Several types of exercise
Data visualisation	This app has two options to see data: graphs and statistics. The app has two graphs. Both show the current day starting at 06h in the morning until the next day 06h in the morning. The graphs show the Blood Sugar profile, which can be switched to a pie chart in the settings. Next to this, the statistics show Blood Sugar Statistics, Meal Statistics, Insulin Statistics, Weight Statistics and Blood Pressure Statistics. Statistics can be exported as a report.
Evaluation	Diabetes Connect is a simple app with clear directions. It does not show much feedback but does contain the main feedback a DM2 patient needs. The reviews and downloads of this app are high.

Table 7: Description of Diabetes Connect

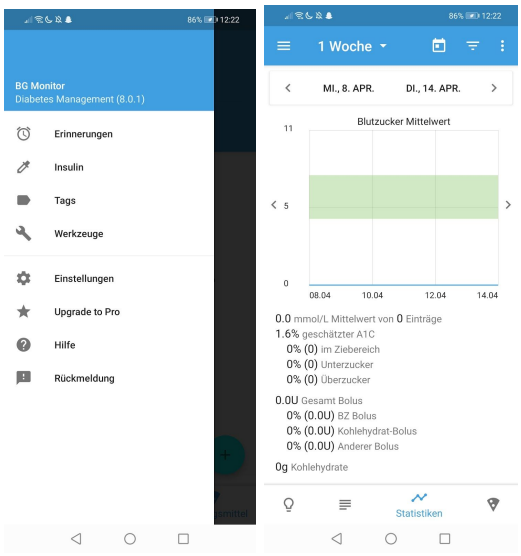


Figure 8: Two screenshots of BG Monitor Diabetes

BG Monitor Diabetes (50K+ downloads, AppStore rating -, PlayStore rating 4.5)	
Measured variables	**Categories:** Blood Glucose, Food, Insulin, Exercise **Variables:** Food Carbs Calories Fat Cholesterol Natrium Protein
Data visualisation	Blood Sugar is shown in a graph, including the specific numbers.
Evaluation	The app is complex, it has a lot of functions but it is hard to find them. But the positive thing about this app is that reminders can be set and the graphs show detailed numbers. The downside of this app is that the language can not be set. The standard language is German/English. All titles and names are in German, while the instructions are in English. This is very confusing.

Table 8: Description of BG Monitor Diabetes

2.3 State-of-the-art Discussion and Conclusion

In the state-of-the-art seven apps were discussed. Multiple things were found, for instance, that all apps include a diet. It differs how much these apps track about food. All apps include feedback in the form of graphs or pie charts. Some apps even show reports which can be sent to the doctor.

G. van den Burg mentions that type 2 Diabetes patients have a high percentage of older patients as well as a group of people who do not have much experience with apps. Besides this, needing a paid subscription on an app also restricts a group of people to download this.

An app should make the life of a Diabetes patient easier. Logging measurements has to be an easy task, it should not take up a big part of the day. Therefore an easy and clear system is preferred. C. Hendriks-Volmeijer, a Diabetes type 1 patient, noticed that measuring your values becomes routine when you have done it for years. So for her, no reminder from the app itself would be needed. What she would like to see is a clear overview of the exercise, diet and Blood Glucose level such that the user can make their own conclusions from it. For a recently diagnosed Diabetes patient, the opposite is true. They would need more reminders to help them make the measurements a habit, and need more help making sense of the data.

Thus, it can be concluded that an app for Diabetes needs to have a simple design, simple in use, display the Blood Glucose levels as well as what influences these levels and should preferably not have a paid subscription. My Net daily CalorieCounter PRO is a dietary app, and even though this is part of the DM2 treatment the app is not complete enough. Concluding from the interview with G. van den Burg HbA1c needs to be tracked by the app. The apps that do not track this are thus not compatible. Besides this, ideally loads of different activities need to be able to be tracked while the app has a simple design.

Chapter 3: Ideation Phase

This Chapter contains the ideation phase of this graduation project. Five concepts were formed based on the first two Chapters of this report. The concepts are based on findings in literature or interviews. The titles of the five concepts were: easing the newly diagnosed patients into self-tracking with reminders, adding data points, simple design, automatic versus human input and integrating health records.

For each of these concepts, multiple sketches were made on paper covering several sides of the subject. After making the sketches, some ideas are combined and other ideas are further explored. There is found that the concepts ‘Adding Data Points’ and ‘Automatic versus Human Input’ are linked closely together. Combining these two concepts makes the sub-concepts stronger, as the sub-concepts are equal and enhance each other when combined. Thus there is decided to combine these two concepts into one concept: ‘Having Control over the Data’. After having made four concepts and subconcepts, three ways of showing progress to the patient were thought out. These ideas can be found in concept 5, called: ‘Achievements’.

From all sketches three sub-concepts are selected, explored and digitized. These final concepts are shown in table 9, including the titles of the ideas. All ideas are smartphone-based.

	Sub-concept 1	**Sub-concept 2**	**Sub-concept 3**
Concept 1 Easing newly diagnosed into self-tracking	Setting reminders	Continuous reminder	Family motivation
Concept 2 Having control over the data	Adding data points	Automatic v.s. Human input	Telling the data
Concept 3 Personalisation and tailoring	Switching options off	Repeating input	Icon instead of words
Concept 4 Integrating health records	Expert input	Logging personal health	Keeping a diary
Concept 5 Achievements	Weekly summary	Improvement charts	Daily motivation

Table 9, A summation of all concepts and sub-concept of the ideation phase

3.1 Concept 1: Easing newly diagnosed into self-tracking

Newly diagnosed patients are not yet used to tracking and logging their disease. To help them ease into self-tracking several ideas were explored. As G. van den Burg mentions during the interview, an app can get annoying when it bothers the user too often with meaningless prompts. In contrast, however, he states that the app can bother the user to motivate them to put in their measurements. This does not bother the user, it helps them remember their tasks. The interview with G. van den Burg was the main inspiration for this concept. The statement is mostly implemented in the first sub-concept to allow the user to set their own reminders. The second sub-concept concerns having a continuous reminder on the home screen of a phone and the third sub-concept uses family to motivate the patient.

3.1.1 Setting reminders

The first idea is for the user to be able to set their own reminders. To make sure the user is not restricted to only using the reminders for one thing such as medicine, the text can be adapted. The user sets how often they want to be reminded, at what times and what the reminder should say. This way the reminder can completely be adjusted to the user's needs and preferences.

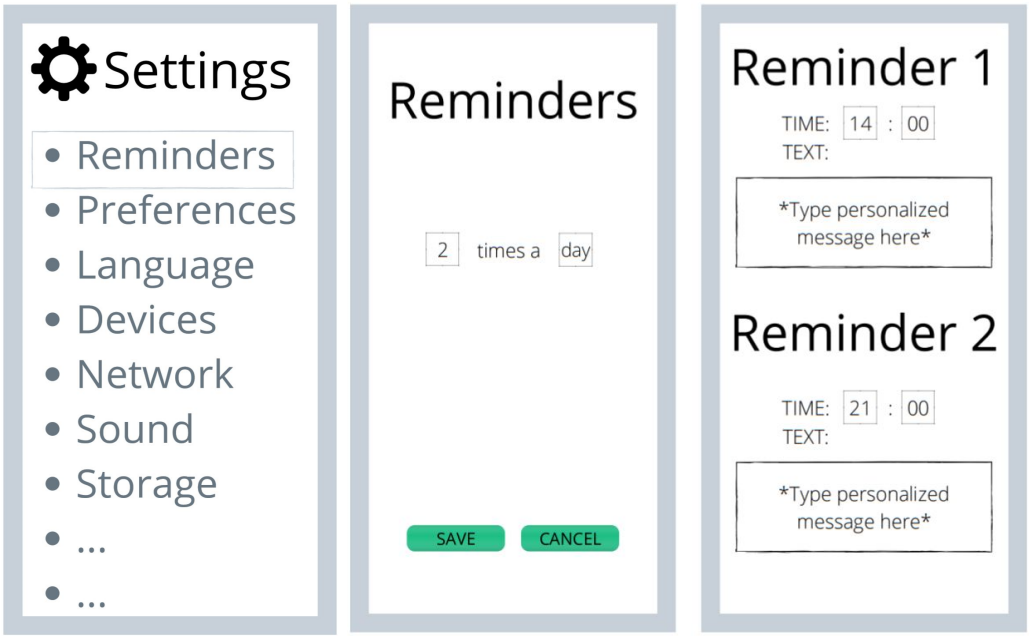


Figure 9: Setting reminder concept explanation

After the user has set the reminder, it will show up at the times set. This is shown in figure 10 for example, where the reminder is shown at 14:00. The reminder will show up at the top of the screen, such that it will pop up over any app or display. This concept makes use of a prompt.

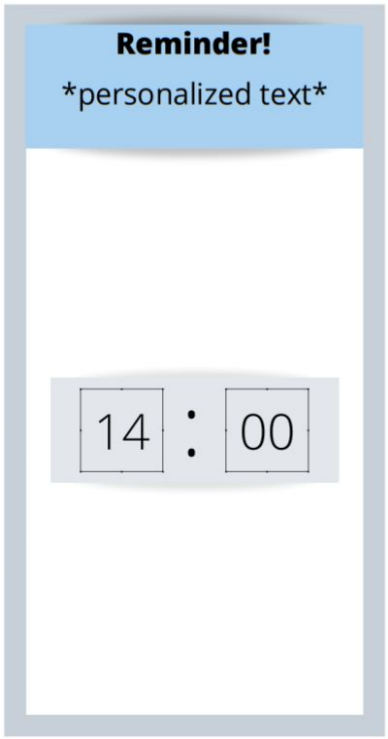


Figure 10: Reminder prompt concept

3.1.2 Continuous reminder

The second idea to help ease a newly diagnosed patient into creating new habits is to give them an option to set a continuous reminder. This is very different from the previous concept, where the reminder would pop up at a given time as a prompt. The continuous reminder is added to the home screen of a phone. The user can set a text that will be displayed. For instance, they could make a list of things they need to do during that day. They could also place a motivational text or anything else. This can be seen in figure 11, in the settings a personal text can be set. This text will be continuously shown on the home screen, any time of the day.

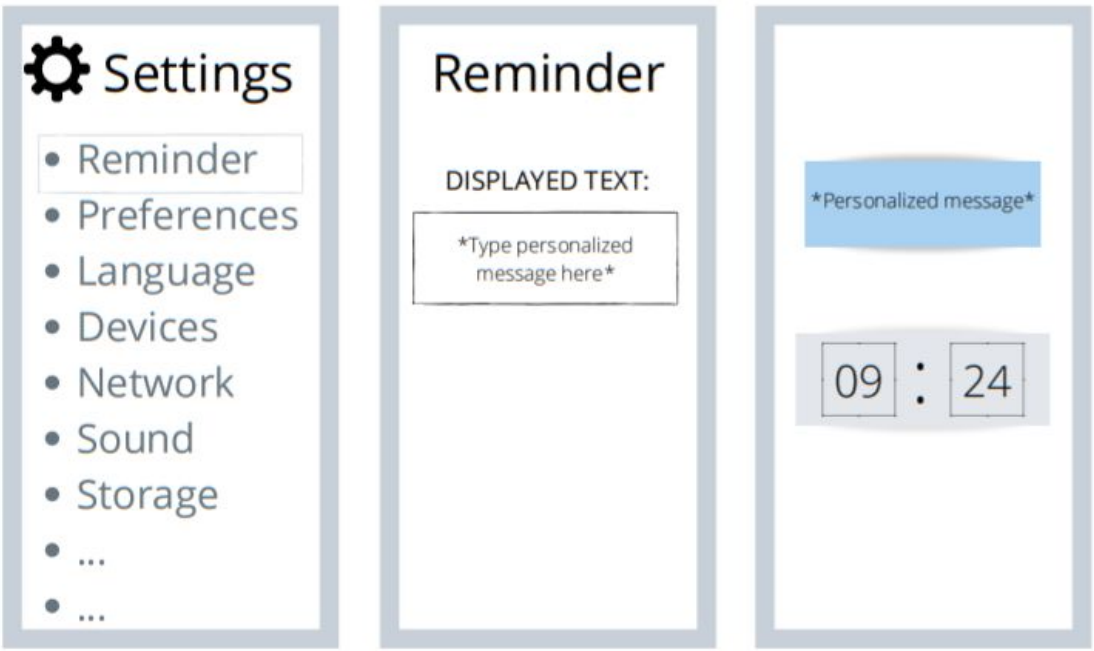


Figure 11: Explanatory sketches for the continuous reminder concept

3.1.3 Family motivation

For some people, it is harder to find motivation. Especially in this case, the third concept is created. This concept combines self-motivation with motivation from family members. The patient can set up a schedule and colour events green when they execute these plans. However, when a plan is not executed it stays red. Their family members get a notification to leave you a video message or call. In the example seen in figure 12, where a sad family member calls because the user did not do their sport exercises. In this example, negative motivation is used. It would be up to the family to either give positive or negative motivation. Positive motivation is highly encouraged, as external motivation has proven to be helpful to learn. Students who are multidimensionally motivated enjoy learning more and are more welcome and communicative in classes (R. Schmidt et al, 1996). External motivation from family members or friends could potentially be a big step for a recently diagnosed DM2 patient to start to better their life, as this is essentially a big learning process.

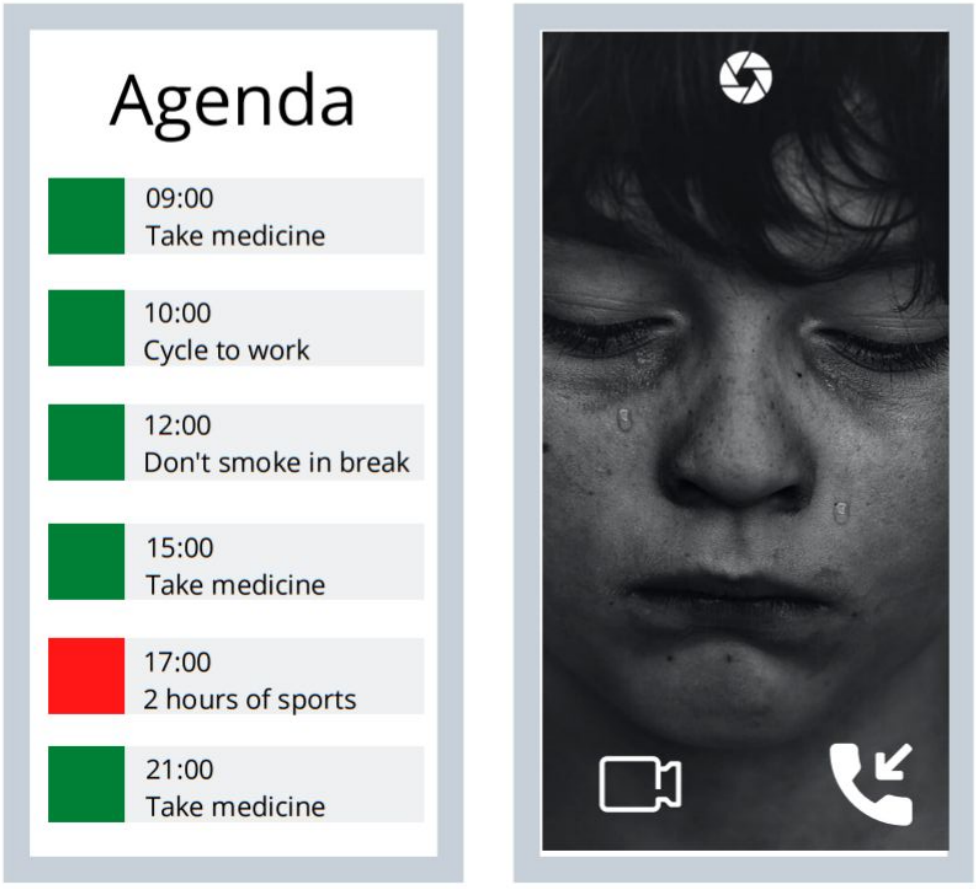


Figure 12, Using family response to motivate the patient

3.2 Concept 2: Having control over the data

As the patient will start Quantifying the Self, it is important that they stay on top of the data. This concept is based on the journals of (Pages, 2013) and (Anderson et al, 2017) which are discussed in Chapter 2. They state it is important to have control over the data. Besides this, it was discussed that it is important to be able to have more control over the data without getting the doctor involved (Klowski, 2013). They need to have control over it to make sure the numbers have a meaning for the user. Three concepts were made to support this idea. The first concept discusses adding data points, the second idea focuses on what should be automatic self-tracking and what should be human input and the last idea shines a different light on the idea and looks at voice recordings.

3.2.1 Adding data points

The first idea that aims at the user getting more control over their data discusses adding data points. This idea is inspired by the storyline of Chapter 2.1.2, where a man tracks his sleep. His sleeping rhythm changes when he has a child, but since the tracking device does not know that the man had a child it assumes their sleeping rhythm is terrible. This concept allows the user to add data points.

This is illustrated in figure 13, where the user tracks their calorie intake. As can be seen the calorie intake on Wednesday is very low, which might be very alarming. But as can be read on the footnote the patient added, they went on a night out and the menu did not state the calories. They still have to log this.

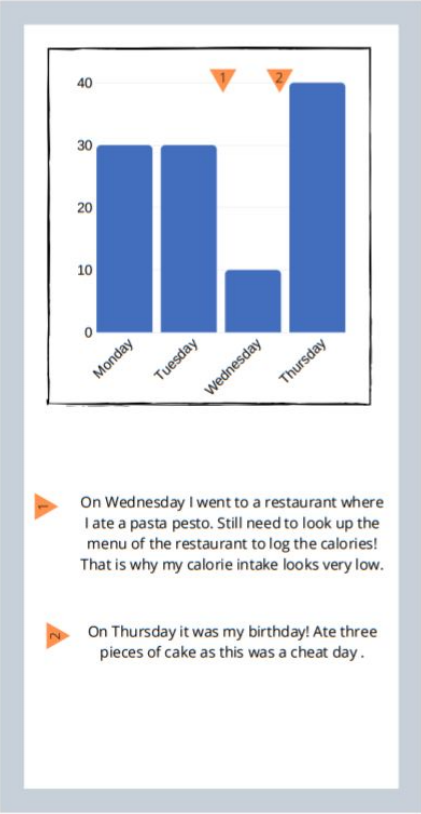


Figure 13: Logging calorie intake with footnotes

3.2.2 Automatic v.s. Human input

When using self-tracking equipment, it is easy to just let the device do its work and work with the numbers that come out of this. However, this might not always be completely accurate. Take for example someone who tracks their steps and draws health conclusions out of this. They might not always have their phone on them, so not all steps they take during a day will be tracked by their phone. For instance when they go on a swim or on a canoe trip. There is still a lot of walking involved in these activities, but if their phone is not waterproof and they have no Fitbit or smart watch they will have no tracking device on them.

Even the little things will not be tracked. When working upstairs the user might climb down the stairs to grab a drink and go back up while leaving their phone on the desk. This example alone shows how automatic self-tracking is not ideal, there should be some human input involved. In figure 14 there is shown how a possibility for the user to edit the steps taken could improve the validity of this number.

There are several blogs, forums and articles concerning this topic. For instance, TMetric blog writes about the pro's and con's for time-tracking by their employees. Manual time tracking is considered cheap, simple, independent from technology and easy to maintain. Meanwhile it lacks accuracy, consumes too much time entering data and prevents integration with other business components. Automatic tracking is seen as precise, eliminating the human error, reducing time on attendance management and collecting valuable data for performance tracking and analysis. However, disadvantages are that the cost effectiveness might be difficult to predict, trackers might feel overwhelming for users and there is dependency on the network coverage (A. Chernets, 2019).

Considering all negatives and positives, both automatic and human input are not ideal. In an ideal situation, both automatic and human input will be combined to a balanced union. This sub-concept tries to find a fitting combination. This idea allows the user to adapt the numbers. A downside of this is that the user needs to be honest when logging these numbers since this option gives them the opportunity to sit on the couch all day and still log 10.000 steps. In addition to this, human editing step count could also lead to an overestimation of the number of steps taken.

Figure 14: Human input on step count

3.2.3 Telling the data

Another way of having control over the data is to give the user an opportunity to do self-reporting. This concept is inspired by the voice-memos on a phone. The user would be given the opportunity to record anything they want and make a sound diary. This way, the user could look back if they had the problem they are facing in the past and listen to old recordings about it.

This idea makes self-reporting more inclusive, as text requires a larger vocabulary than speech (I. Nation, 2006). Patients with a lower IQ, from a lower-class, patients with dyslexia or patients who have trouble with spelling or grammar are able to reflect better on themselves than they would with text.

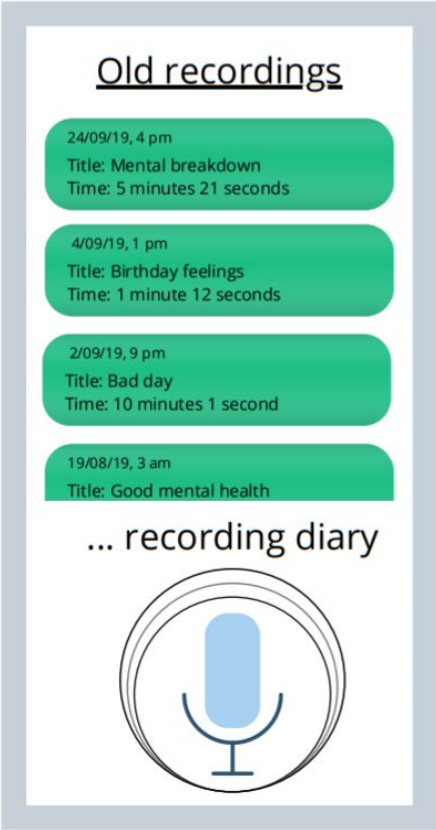


Figure 15: record a diary

3.3 Concept 3: Personalisation and tailoring

The third concept is based on the interview with C. Hendriks - Volmeijer. Hendriks - Volmeijer states that it is very important that self-tracking takes up as little of the day as possible. Besides that, it should be very easy to find options and make sure it is easy in use. This, combined with the statement of G. van den Burgt that a lot of older people and people from all sides of society will make use of it resulted in making this concept an important part of the ideation. The first idea focuses on switching options off to make logging exercise easier, the second concept allows the patient to repeat input and the last concept takes on using icons instead of words.

3.3.1 Switching options off

A lot of Diabetes apps as discussed in the State-Of-The-Art include loads of sports when tracking exercise. This is, of course, very nice as the app becomes more personalized because of this. Every user can find their sport or activity type in the long lists. However, it will become very tiring and take up a lot of time if the user has to scroll through this long list every day while there are probably a lot of sports in this list which the user never performs. This concept works on the idea that the user can find this long list in the settings and set their preferences as shown in figure 16. When they now want to log a sport, see figure 16, they will only have their own shortlist appearing and there is no need to scroll through the long list.

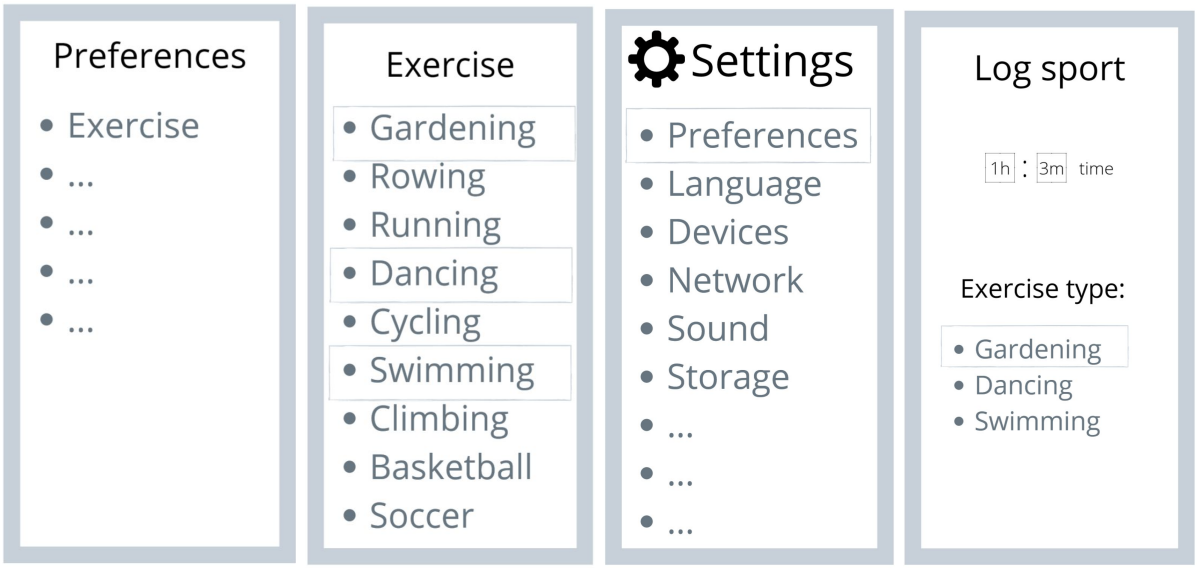


Figure 16, Setting and logging exercise preferences

3.3.2 Repeating input

As newly diagnosed patients start exercising more, it is likely that they join a sports group or make a schedule. Go to the gym for an hour every Monday, join soccer classes on Tuesday or row every Thursday. When tracking this kind of exercise, they will have to enter the exercise every week. It would be much more convenient if they could repeat last week's input. The weekly rower then saves a lot of time by repeating last week's input. This is illustrated in figure 17, where the user instead of logging exercise repeats input.

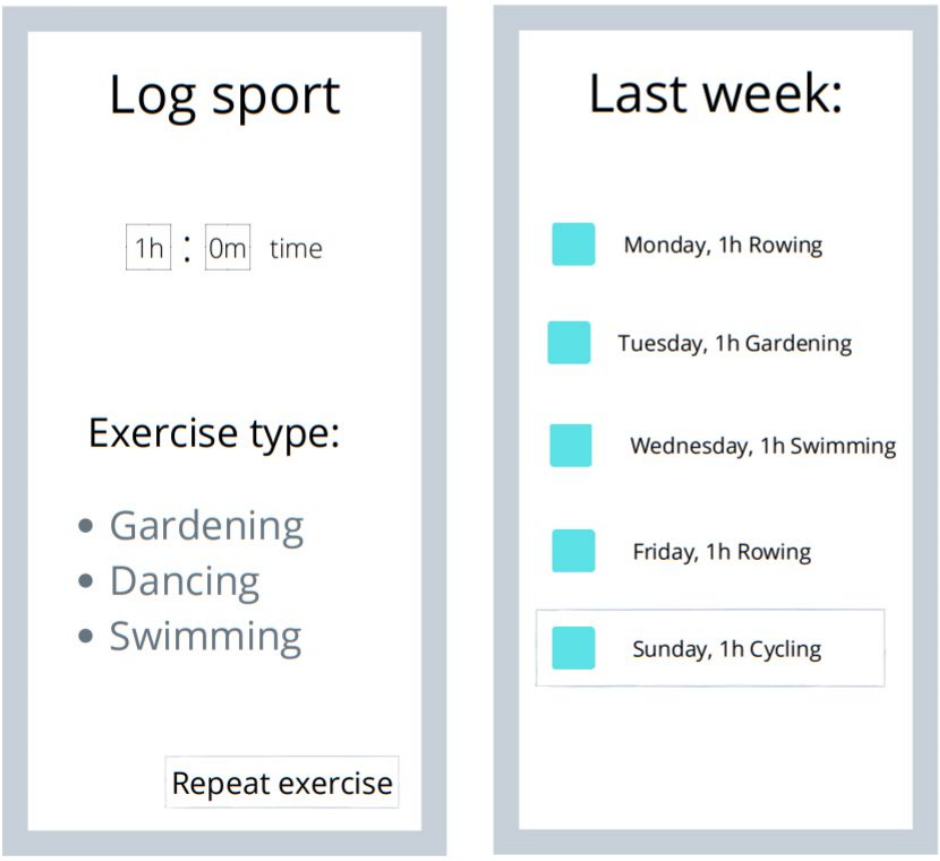


Figure 17, Repeating sport input

3.3.3 Icons instead of words

This sub-concept is created to make self-tracking easier for any user. A lot of DM2 patients are older, and some patients might not have had a great deal of education. Therefore it makes self-tracking accessible for everyone if the words are replaced by icons. Any patient from any country will understand the icons directly, making it faster for them to navigate.

The motivations for using icons in command menus is because they can be visually more distinctive from one another than a set of words can, and consequently, it is easier to spot a graphic symbol among other symbols than it is to pick out one word among words (K. Hemenway, 1982).

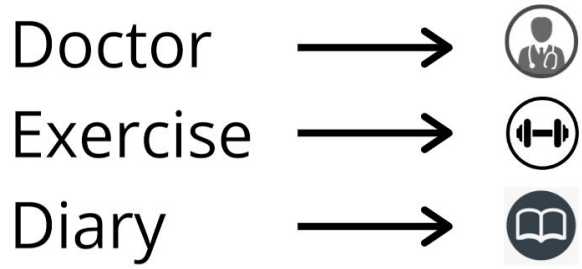


Figure 18, Examples of icon menu buttons.

3.4 Concept 4: Integrating health records

In Chapter 2, there is discussed that it is important to integrate health records to make sure the Quantified Self transitions into a Qualified Self (Thies, Anderson et al, 2017). It is important to integrate health records, thus three sub-concepts are made. The first idea is about including expert input, the second idea allows the user to log health records and the last idea gives the user the opportunity to keep a diary.

3.4.1 Expert input

To help the user integrate their health records, this sub-concept is based on adding an option to see anything the doctor said to the patient. Three options are explored: seeing records, sharing progress and reading advice. These options can be found in figure 19, where the menu is shown.

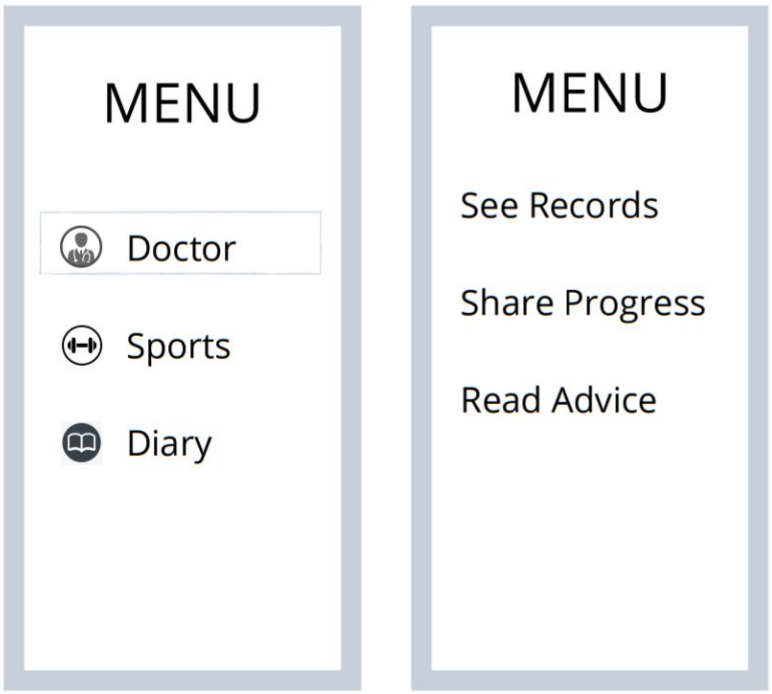


Figure 19, The menu of the expert input sub-concept

The doctor can send in advice for the patient at any time. This advice is then listed so the patient has an overview. Every time the patient goes to a doctor, the doctor or caregiver can enter a diagnosis, advice or both to the records. In addition to this, the patient can share everything they tracked about themself with their doctor. This way the patient can get feedback and work with advice from their doctor. An example of this can be found in figure 21.

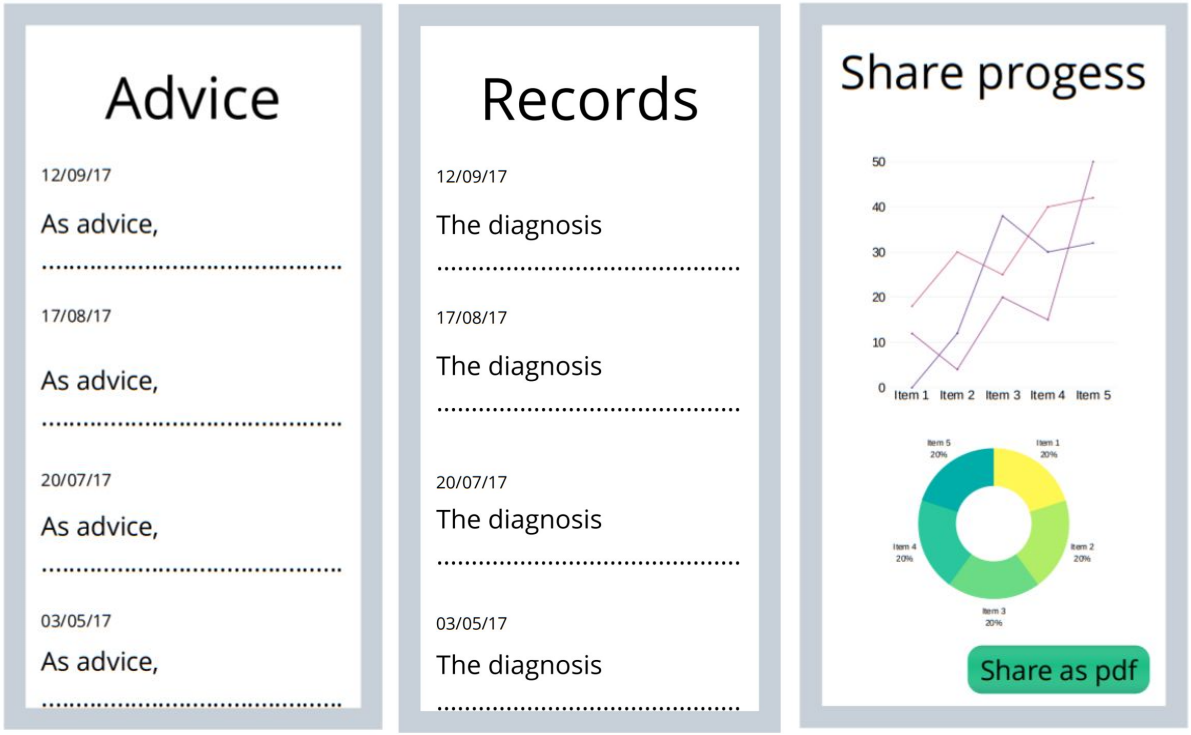


Figure 21, Sharing with and receiving expert input

3.4.2 Logging personal health

Next to the appointments at the doctor, there might be more personal health records that a patient may want to log. Take for example small wounds, feelings or even menstruation. A simple and convenient way to show this is to make the user log them. This is an idea in between 3.4.1 and 3.4.3, as the user tracks their health and appointments without getting a doctor or caregiver involved. An example of this is given in figure 21. This is not a diary, as it is purely aimed at tracking health-related issues. Thus this in-between option is a good solution for patients who have a doctor that does not know or does not like working with self-tracking devices or apps.

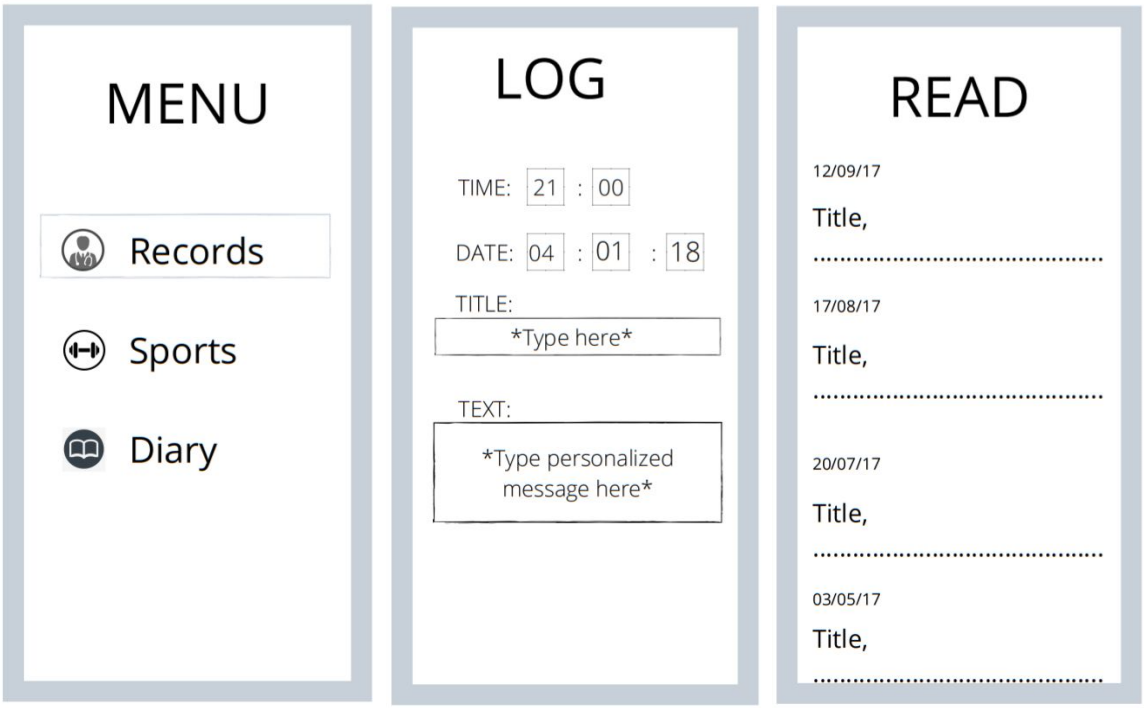


Figure 21, Logging health records

3.4.3 Keeping a diary

As a last sub-concept, the diary is presented. This idea allows the user to self-record anything they want to. They can write down everything, from health-related issues to what they did during the day. The diary-concept gives the patient the option to be free in what they write down. In figure 22, this idea is shown as an in-app diary.

Figure 22, In-app diary

3.5 Concept 5: Achievements

To summarize all ideas, there should be an option for the patient to view their results. As a way to inform the patient of their achievements, multiple ideas are explored. The first idea concerns a weekly summary, where the patient gets a summary of all facts in numbers. The second idea introduces improvement charts. On those charts the patient sees where they are, and how they improved in charts. The third idea does not send numbers or charts, it sends updates in words on how the patient is doing.

3.5.1 Weekly summary

In the weekly summary, the patient would get a list with numbers and facts. The patient would have to draw their own conclusions from these results. An example of this is shown in figure 23.

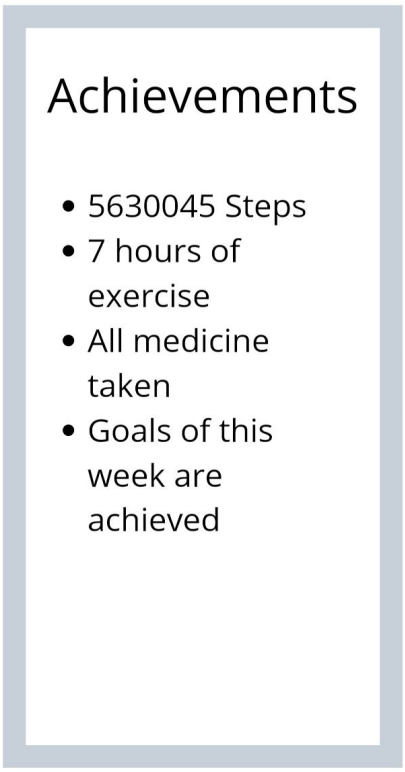


Figure 23: Weekly summary of achievements

3.5.2 Improvement charts

This concept ensures that the user can see their progress anytime. They can access the charts to see how they are doing, if they are improving and how their body responds to certain activities, foods or medicine. An example of these charts can be found in figure 25 below.

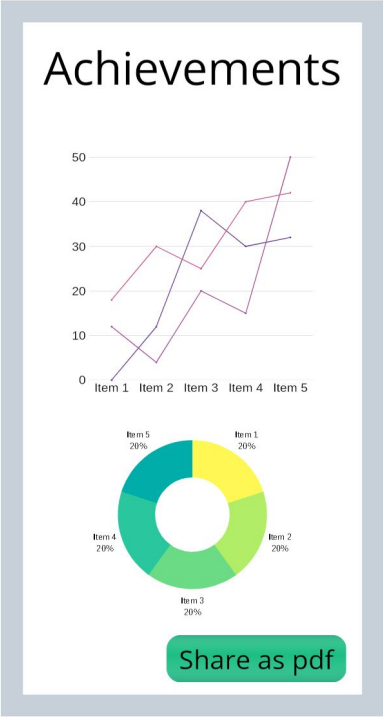


Figure 25: Improvement charts illustration

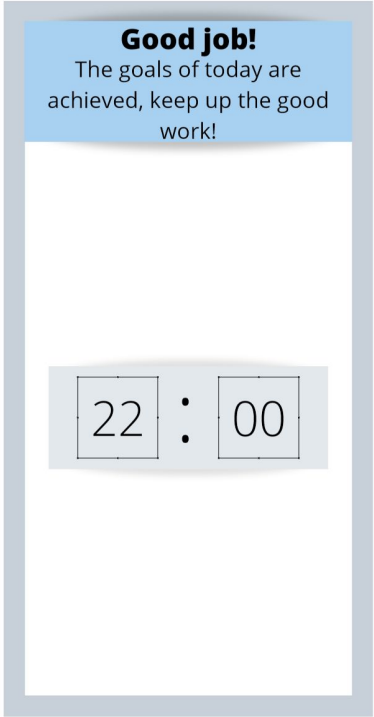


Figure 26: Daily motivation prompts

3.5.3 Daily motivation

In the third sub-concept, a different approach is taken on reflecting to the user. In this concept, the patient gets no direct feedback on numbers or progress. The user would set goals and enter their exercise, medicine and other factors. Based on the numbers that the patient entered, the motivation prompts will either be motivating such as: ‘Good job, keep going!’ or empowering such as: ‘Make sure next week is even better!’. In figure 26 above, an example of such a prompt is shown.

3.6 Conclusion

In this section of the ideation chapter, the conclusion is drawn. In the conclusion all sub-concepts are reviewed. After this, a final idea will be formed. This idea is formed with all concepts combined. The final idea from the ideation Chapter as found in the conclusion is a start towards the next Chapter, the Specification phase.

3.6.1 Discussion

Every concept is built on an objective set in the introduction in section 3.1. All concepts have the potential to support the transition from Quantified Self to Qualified Self for DM2 patients. Each concept could potentially be a solution to the objectives. However, some sub-concepts fit the objectives better than others. To draw a conclusion which sub-concept suits the research best, every concept is reviewed separately.

Concept 1 covers the reminders for newly diagnosed patients. The three sub-concepts are: setting own reminders, having a continuous reminder and getting family motivation. The first sub-concept seems more convenient than the second, as the first can be personalized more and will remind the patient at the time they want to be reminded. When the reminder is on the screen continuously they will start getting used to it and will not look at it anymore at some point. The prompts will always be noticed as they pop up on the screen and have to be acted on. The third idea seems really effective but a bit too much. When the patient forgets exercise often, the family might not want to send videos anymore as they feel it is no use. On the other hand, it could be too effective as the patient is confronted very often with what they are doing wrong. This is a lot of negative feedback. Sub-concept 1 thus seems the most fitting.

Concept 2 makes sure the user has control over the data. The three sub-concepts made differ very much from each other. The first focuses on adding data points, the second on human input and the third on telling data. As these ideas are all focusing on another part of data-control, the best option would be to combine all three ideas. The patient would then be able to Quantify their data in several ways.

Concept 3 focuses on keeping the design simple. As this concept covers three different parts of the field, there can be concluded that the best option would be to combine all of the ideas. The first sub-concept is to allow the user to switch options off, the second to repeat input and the third concept replaces words to pictures. The ideal combination would use more

pictures to make surfing through all options easier, and allow the user to switch options off as well as repeat input.

Concept 4 involves the user in integrating health records. The first sub-concept allows an expert (doctor or caregiver) to help the patient, the second sub-concept allows the patient to log their health and the third sub-concept involves self-reporting with a diary. Ideally, the patient would have a doctor who is involved in the patients self-tracking and will read their self-tracking reports as well as give advice. However, not all doctors are like this so it is good to have the second sub-concept to have the patient reflect on themselves. The third concept seems too much when the patient has already got access to logging their health. Thus the best option is to combine the first and the second sub-concept.

Concept 5 is the last concept that was explored. This concept finds ways to combine previous concepts to ensure the patient can learn from their input. Three sub-concepts were made: the weekly summary, improvement charts and daily motivation. As every patient has different goals and needs different insight, improvement charts seem most fitting to help each patient reflect on themselves easily. Daily motivation is a good way to reflect on the user, but G. van den Burgt stated that useless prompts only annoy the patient and make them stop using self-tracking. Since the prompts are also used in concept 1, using both would result in having too many prompts. A combination of a summary and improvement charts seems possible. The combination makes it possible to see pure numbers as well as charts that help with giving insights.

3.6.2 Conclusion

The first choice is for set reminders, continuous reminders or family motivation. Multidimensional motivation has proven to have a positive result, as stated in Chapter 3.1.3 (R. Schmidt et al, 1996). Research has been done before where video messages are used as means for improving A1C levels of Diabetes patients. In this research Diabetes nurse practitioners sent video messages to the patients. This did prove helpful, but there were people who simply did not watch the videos (A. M.Bell et al, 2012). This journal researches something completely different from family motivation, but it does show that video messages are helpful if used. Prompts are effective, but having to respond to multiple prompts results in ignoring them (Downs, S. M., Uner, H. 2002). Concluded is that in the final idea the patient will get the option

to choose between getting prompts or a continuous reminder. Family motivation seems effective, but asks for a lot of dedication from the patients to watch the videos to get results.

The second choice regards having control over the data and is about the ideas of adding data points, automatic vs human input and telling data. Adding data points and human input will be combined. At the end of the day, the patient can write down everything that could not be tracked. This includes the data points as described in Chapter 3.2.1 as well as how many more steps they think they have taken. Data telling will not be used, as there will be no test subjects who would benefit from this because they have not got a large enough vocabulary.

Third, there will be an option to log only personal types of exercise. The idea of repeating input will be discarded, as the testing will not last for multiple weeks and thus it is of no use to repeat for instance all monday rowing sessions. As it is researched that icons are easier to spot than words, icons will be used in all menus (K. Hemenway, 1982).

To make a decision on which options to implement for the ‘integrating health records’ idea, the corona measurements taken at the University are taken in regard. People working in the medical care sector are not to be used in graduation projects as this puts even more pressure on them. Thus the idea of expert input is discarded. The ideas of logging personal health and keeping a diary are combined into one idea as this is more efficient.

The last decision made is on how to make sure the patient can learn from their data. The daily motivation option is discarded, as prompts are already used to set reminders and having too many prompts results in the patient ignoring them. Someone diagnosed years ago who can make their own conclusions, such as C. Hendriks - Volmeijer, would benefit from seeing numbers as well as charts to see the correlations between numbers and events to draw their own conclusions from. A newly diagnosed patient would need to be eased into this, and thus benefit more from having conclusions laid out for them in the form of graphs. The main use will thus be improvement charts, but in addition to this there will be an achievement list to see from which the user would benefit more.

	Sub-concept 1	Sub-concept 2	Sub-concept 3
Concept 1		✓	✓
Concept 2	✓	✓	
Concept 3	✓		✓
Concept 4		✓	
Concept 5	✓	✓	

Table 10: The final integrated ideas from the ideation phase

Thus, the final idea as can be seen in table 10 includes:

- A choice between reminder prompts or a continuous reminder.
- Data points and human input will be included.
- There will be made use of icons and logging personal types of exercise will be possible.
- The patient will be able to log their personal health.
- To learn from the data, patients will get improvement charts with an achievement list.

Chapter 4: Specification Phase

Chapter 4 describes the specification phase, where the proposed product is specified. The product as conceptualised in Chapter 3 will become a tangible product as requirements are defined and a user scenario is stated. The Chapter is concluded with a summary of the specifications of the final concept as defined in the ideation phase described in Chapter 3.

In this Chapter the product is specified. The requirements needed to specify the design of the product are defined at the end of this Chapter. First, the purpose and goal of the tool are illustrated through a user scenario. After this, the data that the tool must track is stated. To conclude the requirements are stated.

4.1 User Scenario

Raymond went to the doctor two months ago, where he got diagnosed with Diabetes mellitus type 2. He has been prescribed medicine and exercise. As a newly diagnosed DM2 patient, Raymond opens Google and starts looking for ways to handle his Diabetes. There are so many tips and different sorts of advice that he gets lost. Raymond started keeping up with everything he remembers from the doctor’s advice, but he often forgets to take medicine, do exercise or write down his progress.

He starts looking for a tool to help him keep track of his Diabetes. Raymond finds an app that helps him keep track of everything, and discovers that the app has a way to combine self-tracking with self-reporting. The first day he sets his preferences, makes sure the app sends reminders and enters his favorite sports. Since the reminders pop up for every doctor's appointment, exercise class and when Raymond needs to take his medicine he has not forgotten anything since using the app.

When Raymond gets overwhelmed with the process he now reads back the advice from his doctor or his medical history in the app instead of using Google for answers. This calms him down and together with the daily prompts keeps him motivated to work on himself. He realises handling his Diabetes is a full time job, but is very grateful for the app taking part of the workload away.

After having used the app for a week, Raymond uses the achievement section for the first time to see correlations between exercise and blood sugar levels. Seeing this helps

Raymond understand his disease and self-reflect. Over time Raymond keeps getting better at handling everything and turns the app into his new best friend.

Persona:	Master student
Photo:	 *Figure 26: Persona photo (Unsplash.com)*
Fictional name:	Raymond de Vries
Job title/major responsibilities:	Master student Business and Administration
Demographics:	● 25 years old ● Relationship ● Lives in a student house ● Sports occasionally
Goals and tasks:	He wants to get fitter as his health has not been great since he started studying. ● Takes medicine ● Tries to exercise more ● Watches his diet
Environment:	Has a girlfriend who likes to eat loads of snacks while watching a movie with him. He drinks a few beers each week at his dispuut and goes to his parents once every few months.
Quote:	“We should order another round of bitterballen to go with this beer.”

Table 11: Logic format persona

4.2 Factors related to the HbA1c level or blood sugar level

In the interview with G. van den Burg there was concluded that factors related to blood sugar and HbA1c values need to be tracked daily. To give the newly diagnosed patient more insight into what affects these values, multiple factors that have influence on the blood sugar level or HbA1c level will be tracked. In this Chapter, the factors related to the HbA1c level or the blood sugar level that can be tracked are summed up. Eventually, factors that will be tracked with the application are found. These factors are based on findings in the State-Of-The-Art and literature research. The factors found are factors that would ideally be in the final application made to help DM2 patients get insights about their blood sugar and HbA1c related factors.

In table 12, the factors related to blood sugar as were found in Chapter 1 from the Global Diabetes Community is shown. HbA1c gives a longer-term trend of how high blood sugar levels have been over a period of time. This can be seen as an average. Blood glucose level is the concentration of glucose in your blood at a single point in time (Global Diabetes Community, 2019). Blood sugar levels itself can be tracked with a blood glucose meter, which requires a drop of blood to see the blood sugar levels. (D. Pickering & J. Marsden, 2020)

As DM2 is lifestyle-aimed, it is important to include factors in the product that both influence the blood sugar level as well as the lifestyle of the patient. Eventually, when the patient makes changes in their lifestyle the blood sugar levels will change too. And hopefully, their Diabetes will stay stable, or even get better.

1. Physical activity - Physical activity can affect insulin sensitivity for up to 48 hours, which can lead to lower blood sugars over this time. - Sugar levels can initially rise following a short burst of activity. If you usually are active most days, not doing activity could lead to higher blood sugars than usual. - If you exercise a muscle near where you last injected, it could cause your insulin to be absorbed more quickly.
2. Food - Proteins affect sugar levels as well as carbohydrates, but to less of an extent and more slowly than carbs.
3. Alcohol - Alcohol can affect sugar levels for up to several hours after stopping drinking.
4. Illness - Can significantly affect sugar levels.
5. Stress - Can significantly affect sugar levels. - Includes sleep levels.
6. Medication - Other medications taken may affect your sugar levels. - Missing out on a medication dose or injecting at irregular times can also lead to fluctuating sugar levels.
7. Conditions - Conditions such as menstruation cycle, pregnancy or medical conditions such as gastroparesis.

Table 12: Factors that influence the Blood Sugar Level (Global Diabetes Community, 2019).

4.2.1 Automatic self-tracking

From the factors found in Chapter 4.1.3, some can be tracked by automatic self-tracking. A list of these factors is made:

- Physical activity
- Sleep
- Menstruation cycle phases

4.2.2 Self-reporting

From the factors found in Chapter 4.1.3, some can be tracked by self-reporting. A list of these factors is made:

- Medication
- Food intake
- Alcohol intake
- Illness
- Stress
- Vitamin intake

4.3 Choice of Data

To make a choice which data will be collected by the product, several things need to be taken into account. First, the circumstances need to be taken into account. Any data that needs face-to-face contact to be tracked, can not be tested in the prototype because of the ongoing pandemic. These data can thus not be implemented in the prototype and product. Next, tangible factors were chosen that can be tracked using self-reporting or self-tracking. Factors such as medicine intake and illness are hard to track. Those factors can be written down in the logbook if the user wishes so, but will not be tracked automatically or manually. Last, as the participant group will be a mix of males and females there will be no tracking of gender-related factors such as menstruation cycle and pregnancy.

The final factors chosen are exercise, steps, sleep, mood, food and alcohol. Below, those factors are divided in two groups. The self-tracking factors can be tracked using software. The other three factors can be tracked using self-reporting. To track food, the application should have an option to help the user track their food intake, as people who are recently diagnosed with DM2 are likely to have no experience with counting calories.

Self-tracking:

- Exercise
- Steps
- Sleep

Self-reporting

- Mood
- Food
- Alcohol

In table 13, the factors are shown per sub-concept as discussed in the Ideation Phase. The data is mainly used and displayed in the improvement charts. However, a few other sub-concepts make use of data. For instance, sub-concept 3.1 needs the exercise types to make the user choose their favorites. Sub-concept 2.1 and 4.2 do not make use of self-tracking but help the user reflect.

Sub-concept	Data
1.1 Setting reminders, 1.2 Continuous reminders	-
2.1 Adding data points	- Self-Reporting
2.2 automatic v.s. Human input	-
3.1 switching options off	- Exercise
4.2 Logging personal health	- Self-Reporting
5.2 Improvement charts	- Exercise - Steps - Sleep - Mood - Food

Table 13: Final data choice per sub-concept

4.4 Native application

In the State-Of-The-Art several existing ways of collecting data for Diabetes type 2 patients are explored. Ideally, the final idea would be turned into a native app. In this app, the patient can track factors about his/herself to get more insight in what influences their blood sugar levels.In the application the user can track their exercise, step count and sleep. In addition to that, the app will guide the user in reporting on their mood, food and glasses of alcohol. All those values are combined in the report so the user can reflect on their own values and see how their actions influenced blood sugar and bA1C levels.

4.5 Requirements

To conclude the Specification Phase, a list of requirements for the final product is made. The user requirements following from the user scenario, literature study and interviews.

4.5.1 User requirements

1. The user has Diabetes Mellitus Type 2.
2. The user has recently been diagnosed for DM2.
3. The user has a smartphone.
4. The user wants to learn how to control their DM2.
5. The user is interested in learning from their data.

4.5.2 Use requirements

1. The user needs the opportunity to learn from their data.
2. Data can be entered in less than 2 minutes.
3. The tool should not bother the user with more prompts than the amount the user sets.
4. The tool is aimed to ease newly diagnosed type 2 Diabetes patients into self-tracking.

4.5.3 Functional requirements

1. The system needs to track daily amounts of steps.
2. The system needs to track various types of exercise.
3. The user should be able to set their preferred types of exercise.
6. The user should be able to keep a logbook.
7. The user should be able to track their calorie count.
8. The application should teach the user how to track calories.
9. The system should show weekly progression in clear graphs, including weekly progress numbers such as calorie count.
10. The user should be able to choose between a continuous reminder or daily reminder. If the user wishes to choose for a daily reminder, they should be able to set the number of reminders they wish to get.

Chapter 5: Realization

In this Chapter, the realization phase of the concept is described. In Chapter 4, an ideal version of the application is described. In this Chapter, the concept test is addressed. The prototype testing will take place using the concept version of the native application. In this Chapter first, there is explained how data is gathered. After this the surveys are discussed. Finally, there is explained how the data will be visualised.

5.1 Dataset

The dataset of the concept will include both data gathered using the automated tracking application Google Fit data and data collected from surveys. The surveys allow the participant to track their mood, food and alcohol intake while Google Fit tracks step count, exercise (in calories and minutes) and sleep data automatically. How the surveys are conducted is described in section 5.2. These values are all closely connected to the blood sugar levels as is explained in Chapter 4. Blood sugar levels itself will not be a factor measured in this prototype, as it requires the patient to have a blood sugar meter and to draw a drop of blood from themselves.

As Google Fit requires a Google account to use the application, for each participant an anonymous Google account will be created to be linked to the Google Fit app. Physical activity data will be measured through step count and exercise logs. Sleep activity will be tracked through the Google Fit app in hours. The participants will log their calorie intake, mood and alcohol intake through surveys. Calories will be counted by the participant, by writing down their food intake and converting this into calories. The manually tracked data and how this data is gathered is further explained in the section below. Help on how to track and count calories is given, this is described in the section about manually tracked data. The data gathered from these six factors will be gathered and eventually visualized using visualization software Tableau. This will be described further in section 5.3. In figure 27 the flow of data is pictured.

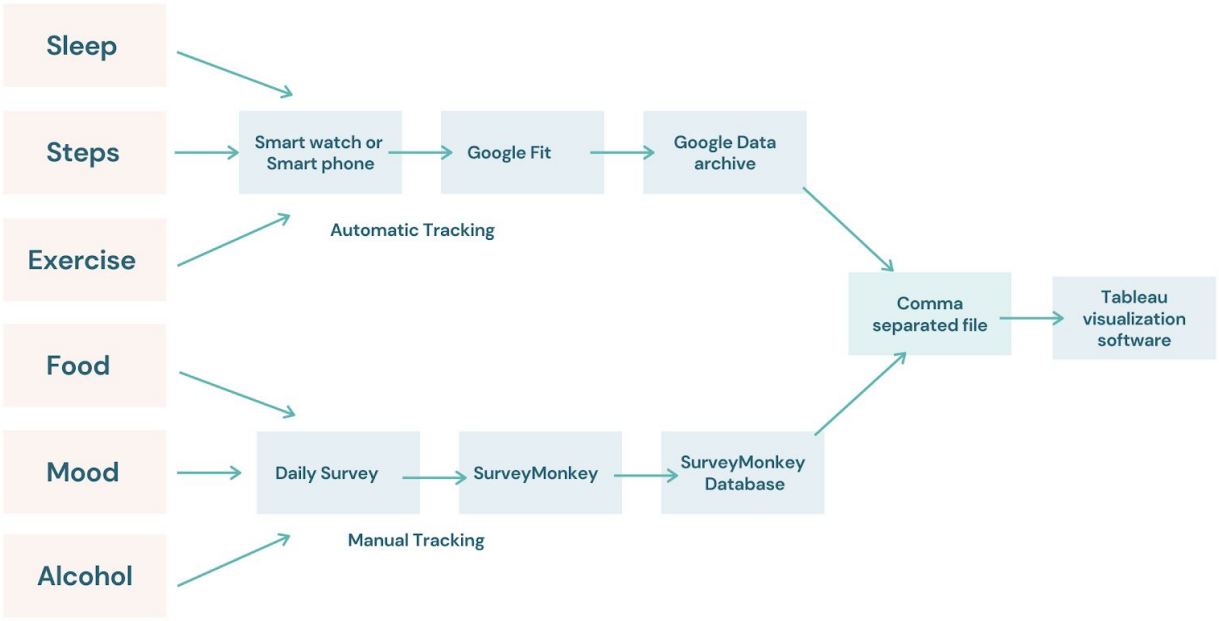


Figure 27: Dataflow

5.1.1 Automatically tracked data

The three factors that are tracked automatically through Google Fit are step count, exercise and sleep. Steps are recorded automatically by the application. Exercise is tracked by the application when the user clicks the button to track a certain type of exercise. Sleep is logged in the Google Fit application by the participant. Google Fit is linked to an anonymous Google account made by the researcher.

How values can be logged in Google Fit and where this can be found is shown in the explanation manual that will be handed out to the participants. How Google Fit works according to the explanation manual can be found in Appendix B.VI. As Google Fit is linked to a disposable Google account, the information gathered from the participants does not violate privacy or anonymity by not having access to the private Google account of the participant.

5.1.2 Manually tracked data

The three factors that are tracked through SurveyMonkey are alcohol intake, mood and calorie intake. Alcohol intake is tracked counting the number of glasses of alcohol drunk during a day, calorie intake is tracked by writing down calories in food eaten during the day. To help the participant track the amount of calories a setup of a logbook was shared, as can be seen in figure 28.

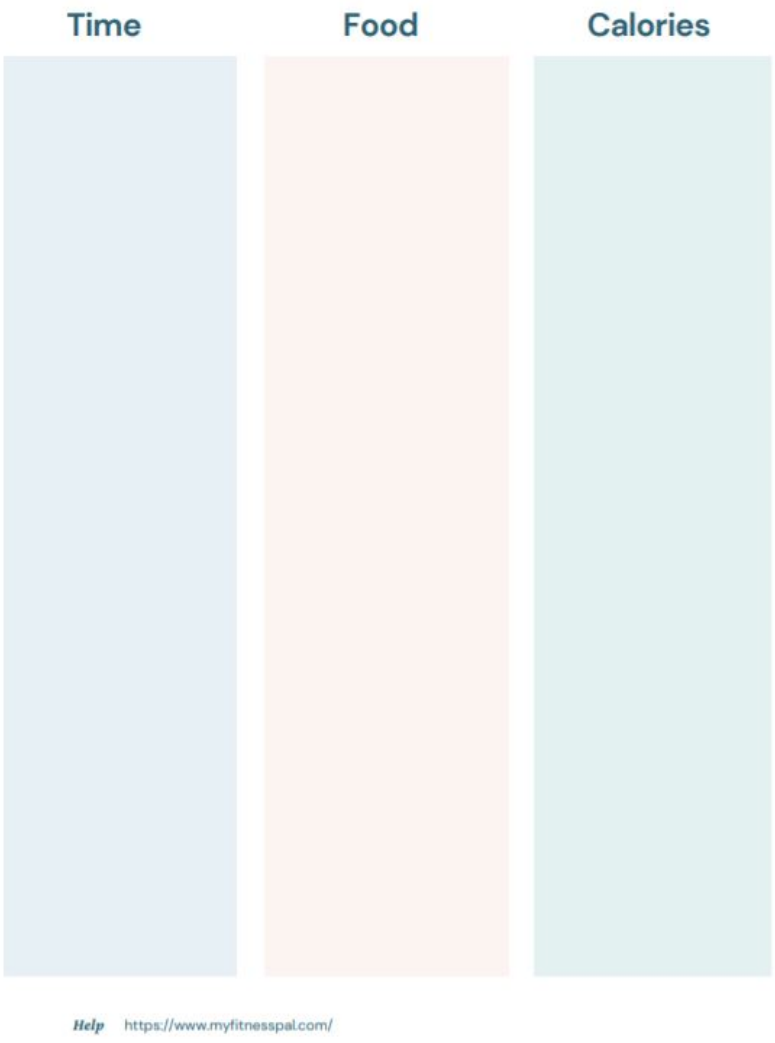


Figure 28: Logbook setup to help participants track their calorie intake.

This way of tracking calories is advised by Michele Dolan (M. Dolan, 2019). In addition to this, My Fitness Pal calorie tracker is shared as an option to find the amount of calories in food. This advice is shared, as My Fitness Pal is easy to use, free and accurate (D. Rebedew,). A side note is that participants will need to be good at determining how big the portion was. Guessing how big a portion is can be hard. The advice to use this calorie tracker is for participants who have no experience with calorie tracking and need help to get started. Mood is tracked through the pick-a-mood instrument for reporting and expressing moods. The manual from Delft University of Technology is used to make sure the instrument is used properly (Desmet et al, 2016). In the survey, each of the eight moods is clickable for the participant. They can click on the mood they felt during the day. The eight moods are shown in figure 29.

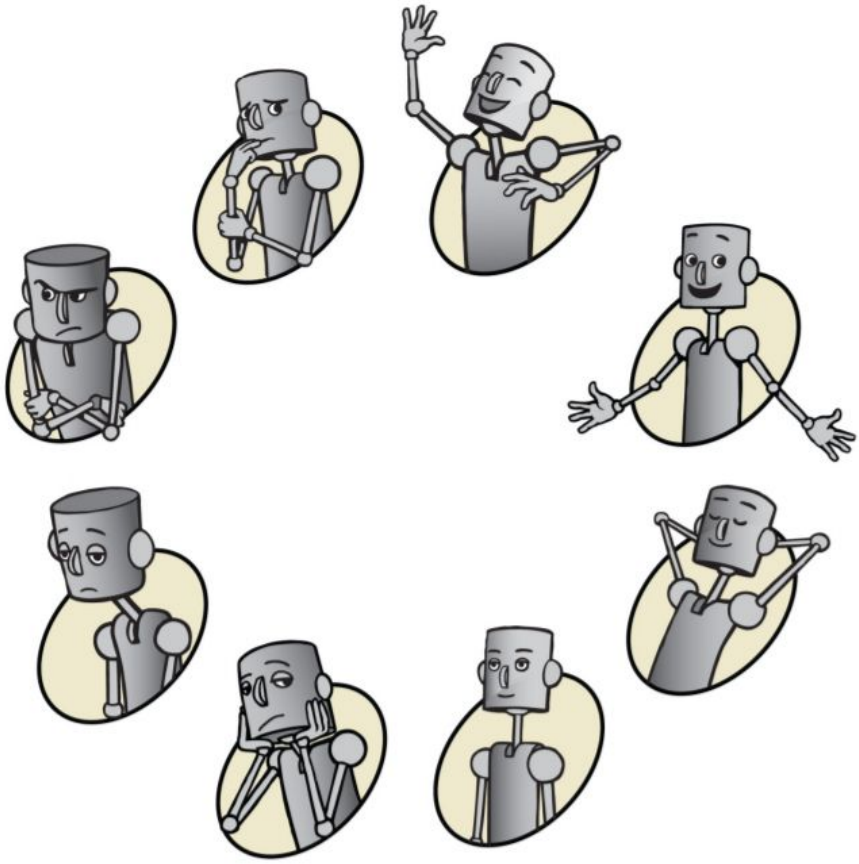


Figure 29: Pick a mood robot character by Desmet et.al. (2012)

Pick a mood has three different characters to choose from; male, female and robot. Since the participant group is a mix between males and females the robot character is chosen as all participants will relate to the character equally. If, for example, the female character would be chosen then the three male participants will relate less to the character than the two females. In the visualization, mood will be integrated as well. Since it is hard to integrate pictures in a visualization, the pictures will be transformed into numbers. A figure of the pick a mood characters with their numbers will be shared with the participants so they know what mood they filled in when they see the number. This way the number will feel more natural and personal. This is pictured in figure 30.

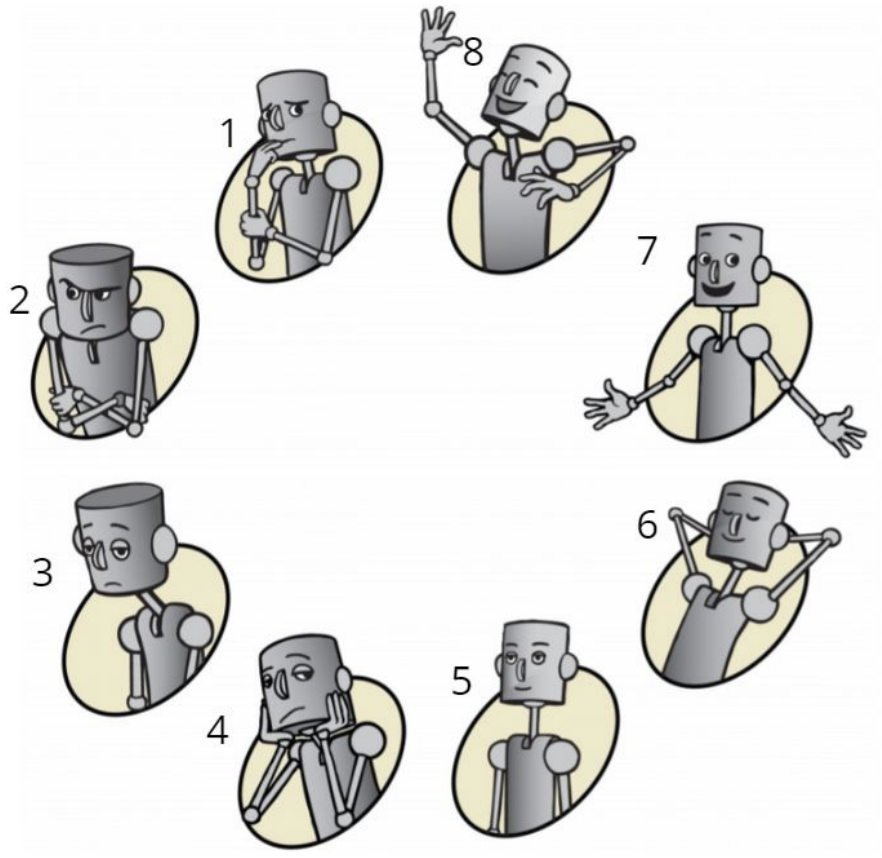


Figure 30: Pick a mood character with numbers as included with the final visualization, as *edited from Desmet et.al. (2012)*

5.2 Surveys

In order to gather the manually tracked data, also referred to as self-reporting, a survey made with surveyMonkey will be sent to the anonymous Gmail accounts. These surveys will be filled in each day. Depending on the amount of reminders set, the survey is either sent out at 19h or via a daily accessible link at the beginning of the week. The participants are asked to fill in the surveys at the end of the day right before going to bed, so all data is tracked. A setup of these forms is shown below. To ensure the personalization options of reminders are integrated, another form will be sent before starting the tracking week.

To complete the research, multiple surveys are sent out to participants of the concept test. There are three different surveys. The first type of survey is sent before the evaluation study starts to collect the demographic data and set preferences. The second type is the survey which gathers the manually tracked data as well as the logbook. The last type is the exit interview, which includes reflective questions about the self-tracking as well as the data visualization. The exit interview has questions set up like a survey, but will be answered through a Skype conversation.

The first survey collects demographic information about the participant and asks them how many and what kind of reminder they want to receive. The daily survey gathers the manually tracked data from the participant and allows them to change their step count if they wish to. In addition to this they can fill in a logbook and add data points. The last survey is the exit interview. This interview allows the participant to reflect back on the self-tracking week and give feedback on the prototype. All questions posed can be found in Chapter 6.2.

5.3 Visualization software

All the data that is gathered needs to be visualized in order for the participant to be able to possibly find correlations in their data.

The data gathered from the surveys and Google Fit is transferred to an Excel file. This file is imported in the Tableau Desktop software. Tableau has a lot of possibilities to make interactive visualizations where the user can hover over the visualization to see details or click on a part of the visualization to highlight this. For this research, a dummy Excel file is made to make a first visualization. This file will eventually be replaced with a file filled with truely tracked data during the testing week. In figure 31, the example input is shown. The six factors that are tracked are put in an excel file. Exercise is put in as sport in minutes and sport in calories, as Google Fit tracks sport. Mood is made numerical so it can be plotted in a graph, in figure 30 from the previous section the numbers linked to the moods are shown. Here there is also explained why the numbers are connected to the figures in this manner.

Tableau offers the possibility to see data next to each other. It does not only show numbers, but also includes text. The data explanation as discovered in the ideation Chapter will be displayed in this way. In addition to this, Tableau offers the option to click on a bar, line, dot or other form of visualizing data to highlight this part. That is why using the Tableau software is a fit to this research.

Date	Sport (minutes)	Sport (calories)	Food (calories)	Alcohol (glasses)	Sleep (hours)	Step count	Mood	Text
06/08/2020	3	1356	24624	0	7	6000	5	It was a good day. I was very enthusiastic about doing sports.
06/09/2020	0	0	23456	4	3	564	2	I ws so tired that I did not do any exercise.
06/10/2020	5	23465	26423	0	6	7345	6	Had a day off so I had loads of time to do exercise.
06/11/2020	0	0	24655	0	10	645	3	I ate very little, as I forgot to have lunch.
06/12/2020	1	587	76355	0	8	1231	7	I ate a lot because it was my birthday.
06/13/2020	3	3465	76523	0	8	2643	4	I ate a lot because it was my fathers birthday.
06/14/2020	1	685	62540	4	7	123	1	I ate a lot because I had cravings.

Figure 31: Example of Tableau input from Excel.

5.4 Visualization

The visualization for the final concept will contain four visualizations. Each visualization focusses on a different part of the collected data. This is partially because all data combined is expected to look chaotic, and partially because it might be easier to navigate through the data and see the theme the user is interested in. For instance, the user can look only at the exercise results if they are only interested in this part of the visualization. The four themed visualizations as from the results of a participant can be found in figure 32-figure 35.

The first visualization in figure 32 plots calories eaten, calories burned and the mood in numbers. In grey, the calories burned cover the calories eaten so the participant can easily see what the ratio between them is. Mood is plotted in every graph because this links closely to the blood sugar levels. When the participant hovers over the bars, their data explanation is shown as the ‘data points’ part of the ideation Chapter describes.

The second visualization in figure 33 plots the exercise of the participant, or as Google Fit calls it: ‘sports’. In the top graph the steps are shown, and below the sport in minutes and mood are plotted against each other. Mood is plotted in every graph because this links closely to the blood sugar levels. When the participant hovers over the bars, their data explanation is shown as the ‘data points’ part of the ideation Chapter describes.

In the third visualization in figure 34, sleep in hours and alcohol intake in glasses are displayed together with mood. In this visualization a correlation between sleep and alcohol intake might be discovered. Mood is plotted in every graph because this links closely to the blood sugar levels. When the participant hovers over the bars, their data explanation is shown as the ‘data points’ part of the ideation Chapter describes.

The fourth and last visualization in figure 35 displays all the tracked data in lines, so the participant can see all data in perspective. In this graph can be seen how all values (possibly) have an effect on eachother.

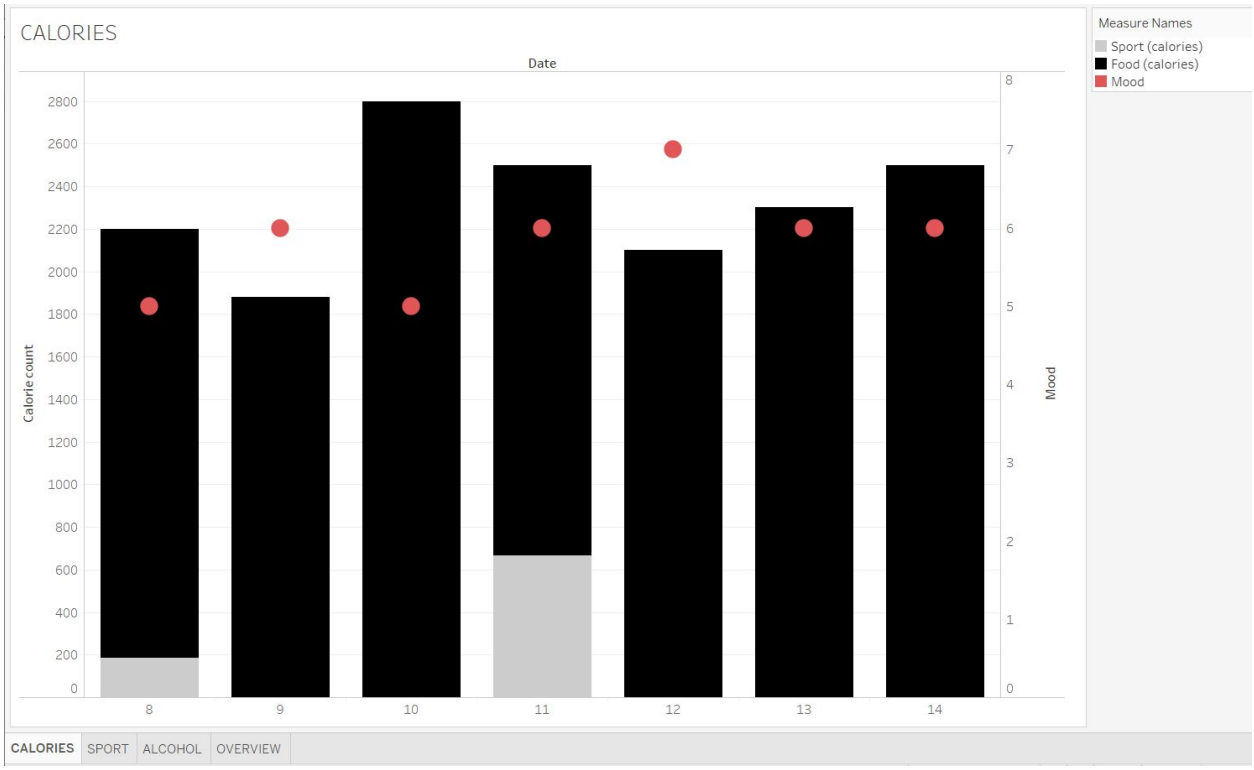


Figure 32: Participants results of calorie intake, mood and calories burned by doing exercise

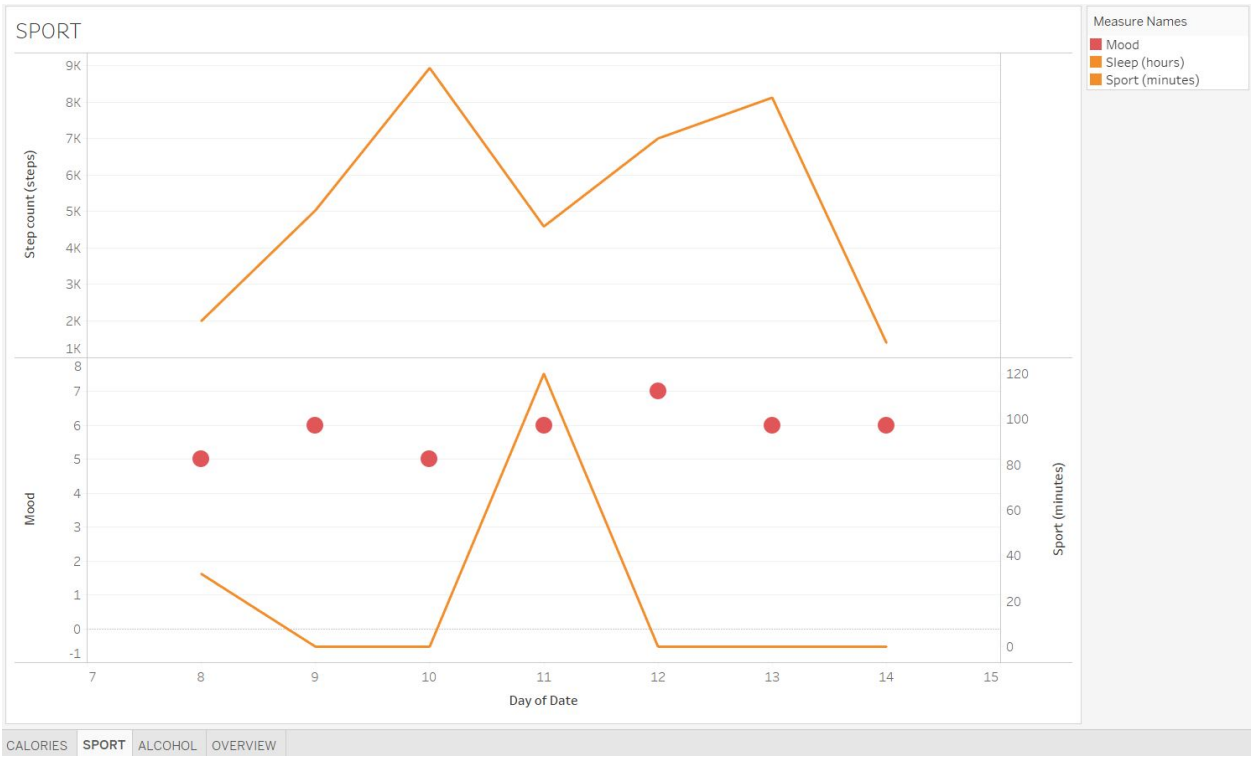


Figure 33: Participant result of steps, mood and exercise in minutes

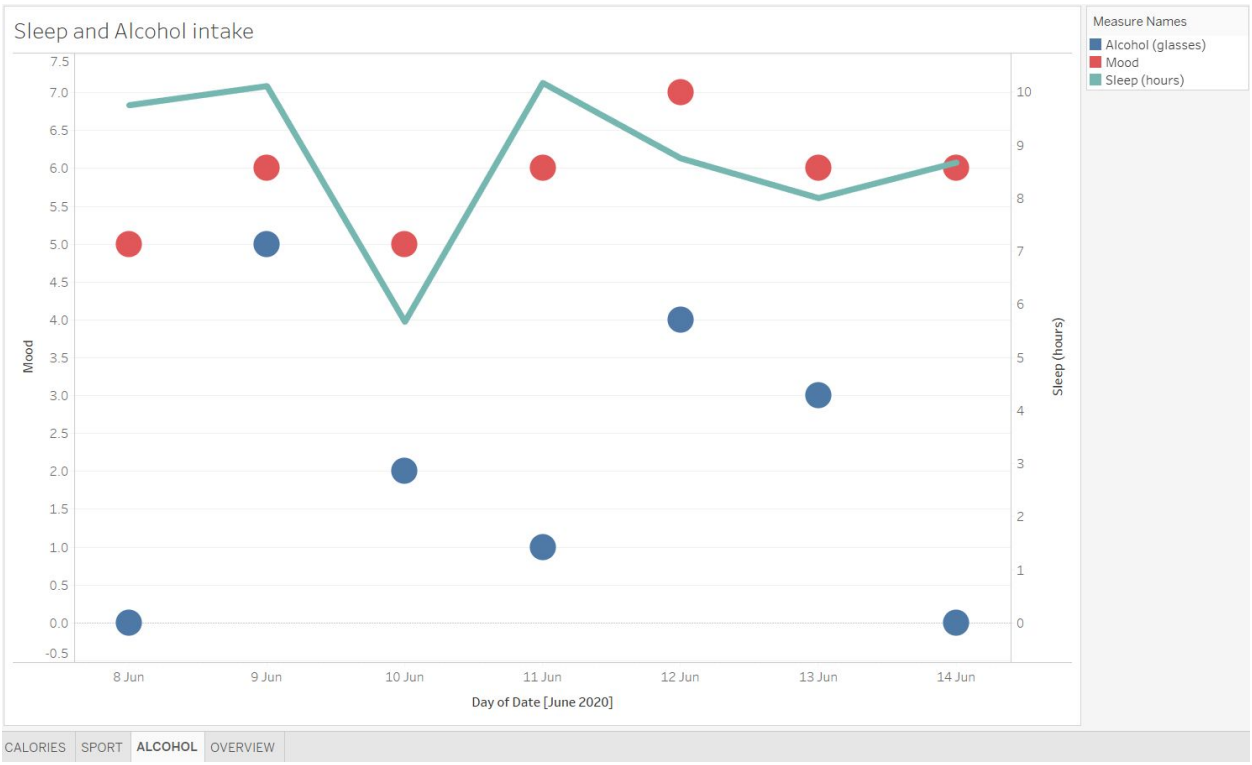


Figure 34: Participant result of alcohol intake, mood and sleep

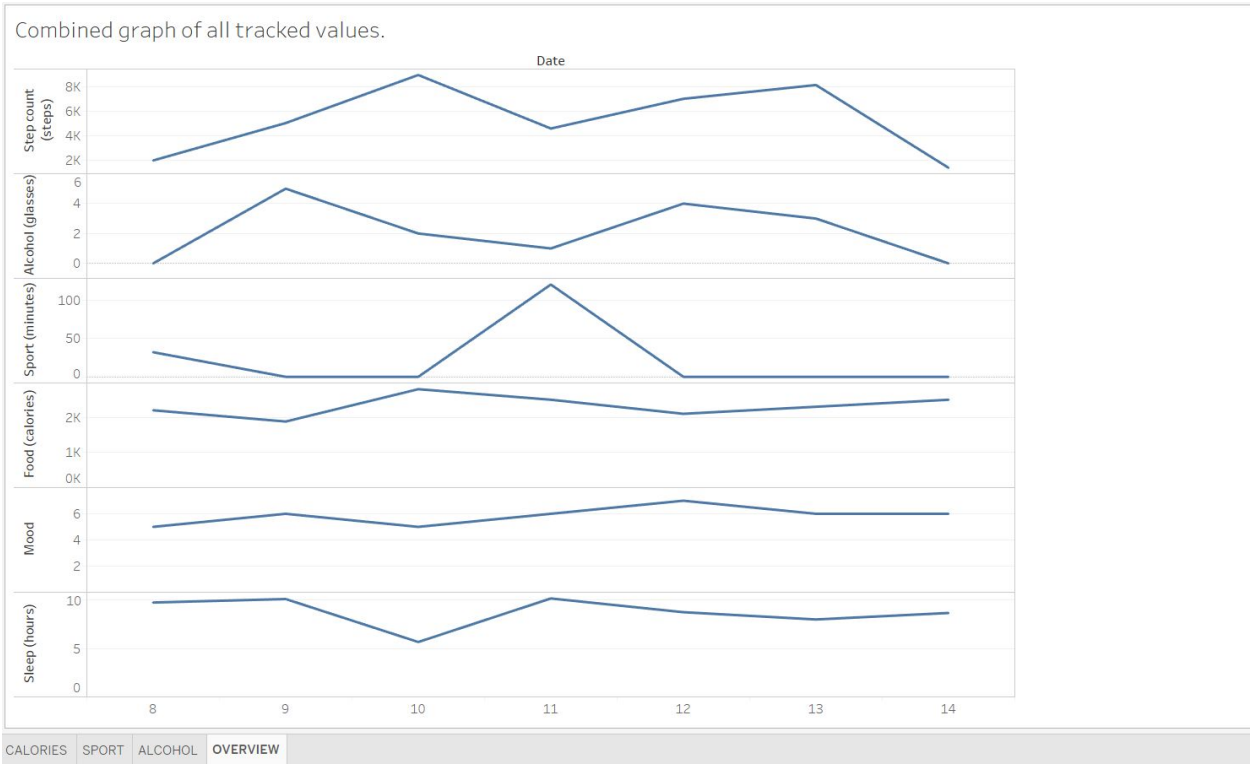


Figure 35: Overview of all of the tracking results from a participant

Chapter 6: Evaluation

In Chapter 6, the concept as designed in Chapter 5 is tested. The evaluation tests whether the concept as designed to help DM2 patients has reached the goals of the research. It also tests whether the participants have learned from their data, and if this concept helps the participants reflect more on their activities.

6.1 Usability test

The usability test is conducted with five participants, who will use the prototype for a week. After this week, an exit interview is conducted. During the exit interview the participants will give feedback on the prototype. The participant group is a diverse group of people ranging in ages from 19 to 57 years old. Three male participants and two female participants are joining in the usability testing.

6.1.1 Setup

Item	Explanation
Participants	5
Demographics	The age of the participants ranges from 19 to 57 and the research includes three males and two females. There is a huge diversity of participants in age. All participants have some previous experience with tracking applications, but it varies a lot how much experience they have. All participants have a form of Diabetes.
Goals	● Test the relevance of the selected factors from the Quantified Self to the Qualified Self ● Test whether the prototype reached the following goals: ○ Helps the user reflect on their unhealthy habits ○ User learns more/new information about themself in relation to DM2 ○ Helps the user learn about how their habits affect their Diabetes ○ Helps the user improve on their health ● Find flaws and possible improvements to the above mentioned points
Privacy and Ethics	This research has been qualified as standard HMI research and approved by the ethics committee EEMCS. It has been complied with the General Data Protection Regulation (GDPR), the participants have read the information

	brochure and signed the informed consent form. In addition to this, a distance explanation form has been sent to the participant including all details of the research. For instance how to download the applications needed and how to fill in the survey. All the forms sent can be found in the Appendix.
Collection of Data	The pre-tracking survey will be sent once before the tracking week starts. During the week, the daily survey as can be found in Appendix C.II will be sent out to the participants. Depending on what the participant set as a reminder amount the survey will be sent out as a continuous reminder or a set amount of daily reminders.
Preparation of the data visualisation	Before the data collection starts, a test visualization in the Tableau software is made with random values. This way, when the data is collected, the random values can be replaced by the collected data and the visualization is ready to show to the participant.
Presentation	After the week of data collection and self-tracking is completed, an exit interview is conducted. As part of this interview the visualizations are presented. First, the user is shown the visualizations and is asked to test out all possibilities and tell what they see. After, each visualization is looked at separately and questions about the visualizations are asked.
Exit interview	The exit interview will take approximately 50 minutes and discusses the surveys and the personalized visualizations as a result from the data collection. The questions asked and the results of the interviews can be found in section 6.1.2.

Table 14: Prototype testing procedure information

In the Ideation Chapter, there was decided to allow the user to choose their amount of reminders. In the entry survey, the participants were asked to choose between a continuous reminder, or daily reminders. Only participant number 2 chose to have a continuous reminder. The text of the reminder that was displayed in this continuous reminder can be found in table 15. Participant 1,3 and 5 chose to have one daily reminder. This reminder was sent out at 19:00 every day. Participant number 4 chose to have four daily reminders. The text that was sent out in these reminders can be found in table 16, as well as to which participant the reminder was sent to. All reminders were sent to the anonymous Gmail accounts of the participants.

Date	Participant	Reminder title	Reminder text
This reminder was sent on Sunday afternoon, the day before the prototype testing started.	This was sent once to participant 2.	Continuous reminder	Don't forget to track your exercise and sleep with Google Fit! Calories, mood and alcohol intake need to be filled in each night in the survey: https://www.surveymonkey.com/r/Q7Z7DZM

Table 15: Text of continuous reminder

Time	Participant	Reminder title	Reminder text
10:00	Sent to pp4.	Reminder to track your exercise today	This is a reminder: Don't forget to log the time you woke up, and track your exercise today with the Google Fit app!
14:00	Sent to pp4.	Reminder to track your exercise today	This is a reminder: Don't forget to track your exercise and write down the food you ate!
19:00	Sent to pp1, pp3, pp4, pp5.	Reminder to fill in the survey	This is a reminder: Don't forget to fill in the survey tonight! Stay motivated to track your sleep, food and exercise today! Link to the survey: https://www.surveymonkey.com/r/Q7Z7DZM
21:00	Sent to pp4.	Reminder to fill in the survey and track sleep	This is a reminder: Don't forget to fill in the survey and track your sleep! Link to the survey: https://www.surveymonkey.com/r/Q7Z7DZM

Table 16: Text of daily reminder(s)

6.1.2 Participants

In table 17 below, the participant demographics are shown. This table contains information about the participants as was collected in the entry survey before the prototype testing took place.

Participant	Age	Gender	Diabetes type	Previous experience with tracking applications	Motivation for previous tracking tools	Motivation to participate study
1	21	Female	Type 2	Has some experience	Out of curiosity	I am just diagnosed with diabetes and wanted to help out a classmate.
2	19	Male	Type 1	Yes	Tracking blood sugar levels is part of the treatment, some of the apps automatically import your exercise so I started with self-tracking without being aware of it.	I am curious about the results and like to help.
3	57	Male	Type 1	Yes, Freestyle Libre	Since I have type 1 diabetes, I need to know my blood glucose levels.	Helping a student.
4	53	Male	Type 1	Yes, Garmin vivoactive 4 sportwatch.	Better tracking of my diabetes	My son arranged this because he knows that I always want to help with studies.
5	24	Female	Type 1	Yes	To lose weight and have a healthier lifestyle.	I am already self-tracking but wanted to help with this research.

Table 17: Participant demographics

6.2 Methods

To conclude the week of self-tracking and data collection, an exit interview is conducted. For each participant four visualizations are created. After reflecting on the self-tracking week, the visualizations are shown to the participants. The interviews are conducted the day after the week of data collection has finished, so the participants still remember the week clearly. Each interview took 30-45 minutes. The interview questions were not only answered, they also resulted in a reflective conversation with each participant.

This interview is a semi-structured interview. The questions are set-up beforehand, but the interview is held conversation-wise. For each participant, the answers to the questions are written out fully. These answers can be found in Appendix D. After all of the answers were fully written out, the themes of the answers were found. For each participant on each question the theme was written down, after which the answers of all participants were combined. The questions are here used as main codes, where the answers are categorized using emergent coding.

After the answers are combined, the themes are counted. Thus the answers are written as: (2/5) participants (….). Which means, two out of the five participants had this opinion or answered this to the question. For a few questions, the themes are not grouped. These are the experience questions, as experiences are hard to group and are important to fully address. In section 6.3.1 the exit summary can be found.

6.3 Results

The results of the exit interview can be found in this section. The exit interviews are processed as described in the last section, 6.2. Exit interviews are conducted via Skype, and questions are posed through a conversation.

6.3.1 Exit Interview Summary

Reflective Questions	
How did you experience this self-tracking week?	(2/5) Participants found it hard to track calories. (1/5) Participants said tracking everything took time some days. (1/5) Participants found it very educational to learn about themself and would like it to last longer (1/5) Participants said it was like a normal week because they self-track often. Everyone had a positive experience.
Did the research meet your expectations? In what way?	pp1- Did not have set expectations except that it would not ask for too much input pp2- Yes it did. I just did not understand why I had to track my calories. pp3- Yes, it was well thought out and prepared. Would have preferred using my own email account instead of the anonymous. pp4- No expectations, did not know Google Fit and had doubts about it but everything worked out fine. pp5-Yes, I expected sending in values. Did not expect there to be a logbook.
What was your overall impression of the week of data collection?	pp1- Doable. Got annoyed of tracking calories pp2- I've done this before to control my blood sugar levels, besides that not being the goal it was as I expected. I would not be able to do this for longer than a week, tracking calories got annoying. pp3- The less you have to manually do the better. pp4- I did not think that much data was necessary pp5- I am a fan of self-tracking because it makes you more aware of your choices.
How did you experience the surveys?	pp1- Relevant questions, easy to answer pp2- I did not know how I felt so picking a mood was

	hard, the rest went very well. pp3- Did not take too long to enter, which was nice. pp4- Clear, did not see a reason to change steps. pp5- Guessing steps was hard, the logbook and data explanation looked the same but the rest was clear.
Which questions were superfluous or lacking?	(5/5) Participants did not think any questions were superfluous or lacking.
What would you have changed (added/removed) about the daily questionnaire?	pp1- Removing the logbook. Alcohol is not relevant for me as I don't drink. pp2- Maybe the opportunity to write how you feel instead of a picture. pp3- Making entering calories more user friendly. (no suggestion given) pp4- I did not understand why the steps were asked but now I understand this is to see its effect on blood sugar levels. I thought a deviation would be calculated between all participants, I would have made this more clear before the testing week started. pp5- I would combine the logbook and data explanation.
Did the logbook section add any value to you?	(1/5) No added value, already logs their own data explanation in a written logbook. (1/5) Did not see the option to fill in the logbook. (3/5) Did add value.
What was your experience with tracking yourself via Google Fit?	(4/5) Participants are positive about Google Fit and said it was easy in use. (1/5) Participants found entering sleep complicated but were positive about the app.
You had the option to set a continuous or daily reminder. What did you choose, why, and how did you experience this?	(3/5) Chose to have 1 daily reminder and thought this was sufficient and convenient. (1/5) Chose to have a continuous reminder and was happy with this decision but did forget to fill in the survey in time multiple times. (1/5) Chose to have 4 daily reminders and got very annoyed with the amount. They said 1 daily reminder would be sufficient.
Visualisation Questions	
Open the Tableau visualizations. Please look at all of them and explain to me what you see.	None discovered the hovering option, everyone started looking for correlations directly and clicked through all four visualizations. Everyone found the legend and topics of the visualizations.

Vis 1: What is your first impression of the results?	pp1- It looks like I eat a lot because the visualization scales automatically. I directly see a correct relation between mood and food. pp2- That there is a huge difference in the amount of calories I ate per day. pp3- Clear graph, sad that I did not do any sports. pp4- On June 13th I ate a lot. pp5- My calorie count is higher than I'd like it to be. I directly see how happy food makes me, which is my problem.
Vis 1: Can you understand anything that can be seen on this graph?	pp1- Yes, it is a clear graph. pp2- Yes pp3- Yes pp4- Yes, I do miss a line through the calories. pp5- Yes, sadly Google Fit did not add my sport calories.
Vis 1: Which correlations do you see?	(2/5) Participants saw the correlation that their mood goes up when they eat more. (3/5) Did not see a correlation.
Vis 1: Did you learn anything from this data visualization? If so, what did you learn?	(1/5) Did not learn anything from this visualization (4/5) Learned something from this visualization: - The relation between mood and food intake - That their calorie intake fluctuates a lot - The their mood is not linked to their calorie intake - That their mood is linked to their food intake
Vis 1: Is this new information to you, or is this something you are already familiar with?	(3/5) This is new information (1/5) This confirmed something they already knew. (1/5) Not relevant. Did not learn anything from the visualization.
Vis 2: What is your first impression of the results?	pp1-Correlation between steps and mood pp2- The difference in steps per day pp3- That I did not do any sports and because I'm always tired I feel the same every day. pp4- These graphs don't say anything to me. pp5- The difference in steps per day
Vis 2: Can you understand everything that can be seen on this graph?	(3/5) Said it was clear (1/5) Said it was clear, but found it weird the sports axis was a straight line on 0 in the middle of the Y-axis because they did not do any sports. (1/5) Said having an orange line in both graphs is

	confusing.
Vis 2: Which correlations do you see?	(3/5) Did not see any correlations (2/5) Did see a correlation. - When I move more (steps) my mood lifts up. - Sports do not make me happy.
Vis 2: Did you learn anything from this data visualization? If so, what did you learn?	(3/5) Did not learn anything from this data visualization. (2/5) Learned something from this visualization: - Learned that sports do not make them happy. - Learned that walking makes them happy.
Vis 2: Is this new information to you, or is this something you are already familiar with?	(3/5) Not relevant. Did not learn anything from the visualization. (1/5) New information - Knew exercise made them happy, but did not know small movements like steps have a big influence as well. (1/5) Said this information is not new.
Vis 3: What is your first impression of the results?	pp1- I don't drink alcohol and my sleep is consistent so this is not interesting for me. pp2- That there's a lot of dots but it's very clear. pp3- It is hard to interpret it directly because the dots make it hard. They are not easy to directly see the value from. Maybe alcohol should be bars. pp4- I would have switched the Y-axises and it's hard to see three different things in this graph. pp5- My best mood is the day I drank the most alcohol. I think this is because of the social factor. And I sleep less when I drink alcohol because I come home late.
Vis 3: Can you understand anything that can be seen on this graph?	(4/5) Said everything was clear to understand, next to the statements they had made in the previous question. (pp3 about bars instead of dots, pp4 about switching Y-axises) (1/5) Had the same mood number (5) as the amount of alcoholic beverages drank on that day. This resulted in the mood not being visible as this was displayed in the background. The rest was clear.
Vis 3: Which correlations do you see?	(3/5) Does not see any correlations. (2/5) Sees they get happy when they drink alcohol. They both say this is more because of the social factor of drinking with friends. (1/5) Says they sleep less on days they drink, because they got home late from their friends.

Vis 3: Did you learn anything from this data visualization? If so, what did you learn?	(4/5) Learned nothing (1/5)Learned that little sleep is bad for their mood, and alcohol (social events) lift their mood.
Vis 3: Is this new information to you, or is this something you are already familiar with?	(4/5) Not relevant. Did not learn anything from the visualization. (1/5) Knew this already, but actively tracking makes it very clear.
Vis 4: What is your first impression of the results?	pp1- It is very interesting to see how multiple factors influence each other. pp2- It looks like mood and food are steady while the rest fluctuates. pp3- That all factors are lines but not everything is lineair (e.g. sleep for instance is nog a linear value). But the lines make everything clearer than anything else would, because you can see how things relate to each other. pp4- It is a bit unclear to me because everything is displayed below each other. pp5- My data is quite constant except for the amount of steps a day.
Vis 4: Can you understand anything that can be seen on this graph?	(4/5) Yes (1/5) Yes, but notices the title of the X-axis is missing. (Due to automatic axises of Tableau, each graph stated the title of the X-axis, except for this graph. This needs to be manually added and should be there in a.)
Vis 4: Which correlations do you see?	(2/5) Do not notice any correlations. (3/5) Do see a correlation. - Calories burned, food and mood correlate together. - I eat more when I move because I have to keep my blood sugar up. - That you burn very little calories with sports while eating a lot.
Vis 4: Did you learn anything from this data visualization? If so, what did you learn?	(4/5) Learned nothing, or already learned this at a previous visualization. (1/5) Learned that their daily steps are really low and only go up when they actively look for exercise and movement.
Vis 4: Is this new information to you, or is this something you are already familiar with?	(3/5) Not relevant. Did not learn anything from the visualization. (2/5) This is new information.

When filling in the surveys, there was a data explanation option. Did you notice this option? Did you use it? Did the answers to this question as displayed in the graph add anything to your self-reflection?	Every participant said this option adds a lot of value to the visualization, even the participant that did not use the option. Every participant says it helps explain the data when you've forgotten what the day was like. The other arguments why this is a good options are: - It makes the data logical. - It helps you get more insight. - You get a better feeling about yourself because you can explain why values are high or low.
Questions after showing the visualization	
Would you consider using an application like this in the future?	pp1- Yes, when I'm working on my food intake and movement. But then I'd like a monthly visualization instead of weekly. pp2- Yes it would be convenient, if it matches with my treatment. pp3- No, because I know all my correlations already. This is because I already had a lot of treatment. pp4- Yes, I already do this with my watch. pp5- If it would combine everything that this research did, yes. I track things myself but have to use a lot of separate apps.
What requirements would an application like this have to fulfil for you to use it?	pp1- No requirements, but a nice addition would be a huge database of food and calories. Also it needs the option to link other apps. pp2- A good combination with my diabetes treatment pp3- Add blood glucose levels. pp4- As anonymous as possible. I liked the proposals from Google Fit 'We detected movement, were you cycling?' pp5- It needs to be easy to enter things. Maybe you should choose what you want to track, alcohol is not interesting for me for example as my alcohol intake will stay the same since I am a student.
Would you be motivated to continue tracking yourself? What would you track and what wouldn't you track?	ppp1- Currently I'm happy with my weight and health. In the future I will start tracking myself when this is not true. pp2- Yes, knowing how much you exercise is an important part of your blood sugar levels pp3- Yes, all things from this research are meaningful to track. The mood system works really well. pp4- Sleep is difficult and hard to enter. Entering minutes and hours is hard. I would not track mood and

	steps but the rest is relevant for me. pp5- Steps and alcohol are not interesting to me but the rest is. Food especially since I am trying to lose weight.
Did you find relevance in tracking your body functions?	(4/5) Found tracking their body functions relevant. (1/5) Did not find it relevant, but did find it interesting.
Did you feel more pressure to eat healthy because you were tracking your calories and showing them to the researcher for this research? Did this make you eat healthier than normal or is this week representative?	(3/5) Did not feel pressure to eat healthy. (2/5) Did feel pressure to eat healthy. For all participants, even though some felt more pressure to eat healthy, they ate as they would in a normal week.
You had the option to keep a logbook. After the week of tracking, you were shown a summary of your logbook input. Do you like having this option? Does it add anything for you?	(3/5) Would rather not have this option. - Does not see extra value, no need to write words when you've already tracked it in numbers. - Has a logbook themselves on paper. Would prefer adding labels, such as '+sports, +birthday'. - Only interesting if you can discuss it with a professional. (2/5) Liked to have this option. - Nice to have the possibility to write something down. - It is always convenient to have the possibility to write something down.
Which visualization was the easiest to understand?	pp1- The overview pp2- Calories pp3- Sport pp4- Calories pp5- Calories (3/5) Said the calories visualization was easiest to understand. (1/5) Said the sports visualization was easiest to understand. (1/5) Said the overview was easiest to understand.
Which visualization was the most relevant to you? Rank them 1-4. Why this order?	pp1- Overview, sport, calories, alcohol pp2- Alcohol, calories, sport, overview pp3- Overview, sport, calories, alcohol pp4- Calories, sport, alcohol, overview pp5- Calories, overview, sport, alcohol

	For each visualization the average rank has been calculated: Calories: 2 Sport: 2,4 Alcohol: 3,2 Overview: 2,4
Did the visualization make you see correlations that you would not have made without the visualization?	pp1-Yes, the relation between steps and mood I would not have figured out myself. I didn't even notice it while tracking the data during this week! pp2- Yes, some things you realize while tracking and other things you know but are not aware. The visualization confronts you with it. pp3- No, I already knew my correlations before the research started. pp4- Yes, the correlation between sport and calories. That you burn very little calories on a day. pp5- Yes, that sport really has no effect on my mood at all. I always thought this might be true but that nothing concrete to base this feeling on. It also surprises me to see sleep does not change my mood as I used to think this was a big deal.

The visualization, combined with the tracking options are a concept version for an application. This application would allow newly diagnosed Type 2 Diabetes patients to get started in regulating their Diabetes. Do you think newly diagnosed Type 2 Diabetes patients could benefit from self-tracking? If so, how.	(5/5) Yes. The arguments from the participants why this is beneficial are: ● It gives the user extra control over their daily actions. ● It motivates the user to keep doing well between hospital visits. ● Food and exercise determine whether your DM2 gets worse, stays the same or gets better. It is good to have an overview of how this is progressing. ● It might take over a part of the function a dietician or doctor would have. ● By seeing the visualizations you will be more conscious about what you eat. ● The graphs confront the user in a good way, and make them take action. ● Mood relates closely to blood sugar levels, so the effect on this is clear to see. ● By having such an app, you are more motivated to get your values checked regularly. ● It helps patients see the effects of what they do. ● They would learn about the factors that influence their diabetes. ● Someone recently diagnosed can learn a lot from their own data and visualizations, especially if they look at it together with a nurse. One participant said adding blood sugar would be even better. One participant said they would like to have carbs and proteins included in the food tracking.

Table 18: Exit interview results

6.4 Usertest Conclusion & Discussion

The goals for the user testing were:

- Test the relevance of the selected factors from the Quantified Self to the Qualified Self
- Test whether the prototype reached the following goals:
    - Helps the user reflect on their unhealthy habits
    - User learns more/new information about themself in relation to DM2
    - Helps the user learn about how their habits affect their Diabetes
    - Helps the user improve on their health
- Find flaws and possible improvements to the above mentioned points

This section will be divided in four subsections based on the goals to check if the goals are achieved. The subsections are relevance, reflection, education and health.

6.4.1 Relevance

In this section there is taken a look at the relevance of the factors used in the prototype as well as the relevance of the visualizations. 4/5 participants found tracking their body functions relevant, the last participant did not find it relevant because he has been doing self-tracking for a long time and already knows a lot about himself. He does find self-tracking interesting. From the research it is shown that two participants are not interested in tracking steps, and two participants are not interested in tracking alcohol. However, when asked about the benefit for DM2 patients all participants agree that all the six factors tracked in this research are very relevant to newly diagnosed DM2 patients. As an improvement, there is mentioned that there should be an option to track the blood glucose level as well.

In addition to the relevance of the factors, the relevance of the visualizations is of importance. The participants were asked to put the visualizations in order of relevance. The alcohol visualization is ranked last three times and has an average rank of 3.4. The mean is thus 3.4 for alcohol, where the mean of the population is 2.5 with a standard deviation of 0.4. This means the alcohol visualization including sleep hours, alcohol intake and mood is ranked the least relevant on average. However, since two participants still ranked alcohol very high, alcohol is not found completely irrelevant for every participant. The other visualizations are all ranked almost equally relevant, with exception of the visualization including calorie intake, calories burned and mood. This visualization is ranked the most relevant. The reason for this seems, next to those values being relevant to the participant, that the graph is really clear and easy to read. The overview is ranked first multiple times, for the reason that it is easy to spot correlations when all factors are displayed in the same way. Some critique rises here, as values are displayed linear while those are not linear values. However, the participants that state this also say the lines make the correlations more clear and easier to see. They all say that they prefer to have lines, even though the values might nog be linear.

6.4.2 Reflection

The participants have reflected on the week of testing the prototype in the exit interview. In this interview the participants had to reflect on themselves. In this section, there is summed up what options helped the participants to reflect back on themselves and what did not. To three participants the logbook added value, but the data explanation is preferred. Most participants

would rather not have the logbook option and the two participants that do like to have a logbook say it is nice to have the option but it is not a necessity. All participants directly see how the data explanation helps them reflect on their values. (4/5) Participants learned something new from these visualizations, and two participants shared that the visualizations are confronting and make the participant want to improve their health. The combination of data visualization and data explanation helped the user reflect on their habits and health.

6.4.3 Education

In this section, the exit interviews are examined to see whether the participants were encouraged to learn something new from the visualizations and prototype overall. As mentioned in the reflection section, (4/5) participants learned something new from the visualizations. The last participant who did not learn anything did not do any sports, entered the same mood every day and the same guess of calories eaten. They did this, because they have already tracked their body functions for ages because of their DM1. They thought making an elaborated guess would be good enough as they have got the knowledge of tracking several things as they did this before. From this can be concluded that it is important that if the user wants to learn something from the application they really have to actively track their values. This is also mentioned by multiple participants, as they said self-tracking only allows you to learn something valuable from it when you track everything actively. A suggestion from one of the participants is to have monthly visualization instead of a weekly visualization so more patterns and correlations can be discovered.

6.4.4 Health

As this prototype is aimed at newly diagnosed Diabetes type 2 patients, the most important part of the prototype testing it to discover whether the prototype will benefit DM2 patients. Besides the patients seeing benefit for themselves from the visualizations, they could also see the benefit for newly diagnosed DM2 patients.The visualization should keep the patient motivated to keep doing well between hospital visits, become more conscious of what they eat, learn the factors that influence their diabetes and the patient will be able to see from the tracked values whether their diabetes gets worse, stays the same or is getting better.

Chapter 7: Conclusion, Discussion & Recommendations

In this Chapter, the research will be rounded up. The research question as posed in Chapter 1 will be answered, and from this a conclusion will be drawn. After the conclusion, there will be a discussion. The research will be concluded with future research recommendations.

7.1 Conclusion

In this section a conclusion will be given. The conclusion answers the research question as posed in Chapter 1, together with the sub questions. The research question and sub questions are:

How can data from the Quantified Self be extended such that a DM2 patient benefits from the Qualified Self?

a. What can a DM2 patient track about themself?
b. How can DM2 patients benefit from self-tracking technology?
c. How can data about the self be given deeper meaning?

In the State-Of-The-Art, there has extensively been looked into the possibilities DM2 patients already have. Seven mobile applications were reviewed, positive and negative sides about the applications were noted. These applications were all mobile applications. From the State-Of-The-Art was concluded that all applications contain food tracking options as well as feedback in the form of graphs or pie charts.

In this research there was chosen not to display the Blood Glucose levels, but only the factors that influence these levels. The factors chosen to track in this research were: food intake in calories, exercise in calories burned and active minutes, sleep in hours, step count, mood as defined in Pick a Mood and alcohol intake in glasses. More factors were found that affect the blood sugar levels, such as stress, illness and medication. Not all factors that affect the Blood Sugar levels can be tracked automatically. Some factors have to be self-reported in a logbook as they are not numerical such as illness. In this research these factors could be written down through a logbook or data explanation. The data explanation seemed most effective, as all participants liked reading back the specifics of their day when they hovered over their values

and the data explanation popped up. From the factors that were tracked in the research, the visualization that pictures glasses of alcohol and sleep was found the least relevant. However, there was a huge variation between participants as one participant found this the most relevant visualization. All factors tracked thus had meaning for the participants, even the factors that were deemed least relevant still meant a lot to two participants. There is a variation in what is found the most relevant by different participants.

Concluded from the interview with C. Hendriks-Volmeijer was that no reminder from an application is needed when measuring values becomes routine. G. van den Burg mentioned in his interview that there should be a balance between effectiveness and irritation in the number of reminders. Sending too many reminders would annoy the user and eventually make them delete the application. This could be concluded from this research as well. The participants were given the option to choose the number of reminders a day. More than 1 reminder a day was found to be annoying, and a continuous reminder only worked when the participant made the survey part of their daily routine. One reminder a day showed to be effective.

There was looked at in what ways the prototype as designed would be beneficial to newly diagnosed DM2 patients. All of the participants of the research agree the application as designed would benefit newly diagnosed Type 2 Diabetes patients. There were multiple arguments why this application would be beneficial, the arguments summed up are quotes from what the participants said:

- It gives the user extra control over their daily actions.
- It motivates the user to keep doing well between hospital visits.
- Food and exercise determine whether your DM2 gets worse, stays the same or gets better. It is good to have an overview of how this is progressing.
- It might take over a part of the function a dietician or doctor would have.
- By seeing the visualizations you will be more conscious about what you eat.
- The graphs confront the user in a good way, and make them take action.
- Mood relates closely to blood sugar levels, so the effect on this is clear to see.
- By having such an app, you are more motivated to get your values checked regularly.
- It helps patients see the effects of what they do.
- They would learn about the factors that influence their diabetes.
- Someone recently diagnosed can learn a lot from their own data and visualizations, especially if they look at it together with a nurse.

To (4/5) participants the visualizations brought them new information. The combination of being confronted with the progression, patterns and correlations of their own data and seeing the explanation for the highs and lows in peaks resulted in a self-reflection tool. Nobody saw the numbers as abstract data, the numbers started having meaning and personality. Participants even mentioned that they could learn things from the visualizations that they did not discover while tracking the values. This added extra meaning to the Quantified Self.

In this week there was enough time to see how the correlations between factors are spotted by participants and that this way of visualizing the data adds meaning to the Quantified Self. A participant suggested that tracking for a month would allow the participant to reflect even further on their data. This week, however, was enough time for the research to see the effect the tracked values have on each other.

Through literature research, interviews with professionals in the field and prototype testing it has become clear that the prototype can offer a newly diagnosed DM2 patient an environment to help them recognise which factors determine whether their Diabetes will get better or get worse. Using the application the patient is offered visualizations that can help the patient recognise what they have to improve in themselves to get healthier. From the research can be concluded that the right amount of reminders helps the patient to stay motivated and remember to enter their tracked values. However, the patient needs to have a motivation to use the tracking application in order to fully gain all the positive benefits the application has to offer.

Finally, there can be concluded that this research surpasses the Quantified Self. The participants could find correlations and new information from the visualizations, which they never knew before and did not see during the tracking process. They could only see this with the visualizations, even though the data was accessible to them during the whole week as they tracked it themselves. It is hard to say if the visualizations ensured a Qualified Self, it did lead to more consciousness about the data and to a deeper understanding of the self. But, it is hard to say whether the perfect Qualified Self is reached as the factors were limited and the research had a set time period of a week. However, the goal of the research is reached. There is found that recently diagnosed DM2 patients can certainly benefit from the extended Quantified Self, and eventually, Qualified Self.

7.2 Discussion

First, the limitations of the research should be stated. One big limitation for this research was having to cope with the Covid-19 situation. This included not having face-to-face contact and not sharing any materials as the virus can stay ‘alive’ on a surface for 24 hours. In addition to this, the care sector should not be bothered with this research as they need all their time to focus on the ongoing pandemic. Because of these constraints, it was hard to find DM2 patients as these could not be found through contacting the care sector. Thus, via my network several diabetes patients were found to participate in the research, but four of them are DM1 patients. This was not a huge problem, as DM1 patients know the needs, differences and similarities between DM1 and DM2 patients. However, the biggest difference that did have an effect on the results is that DM1 patients all have knowledge and experience with self-tracking as they need to do this to keep track of their health. This could be seen in the results, as for instance participant 3 did not find it interesting to track a lot during this week as they already know their correlations. They made a guess about their daily calorie intake as they did not see use to track it exactly as they are quite ok at guessing the numbers. This gave interesting insights, as this user also did not do any exercise during the week, and has a constant mood. Thus there were so little known values, that this participant could not see any correlations between their tracked values. This leads to the conclusion that a user needs to be motivated to keep track of all of their values, otherwise the results are not optimal or even false (for example, when you guess the calorie intake wrongly).

The first point of discussion is the age-group of DM2 patients. As G. van den Burg mentions in the interview, Type 2 Diabetes Patients have a high percentage of older patients as well as a group of people who do not have much experience with apps. Thus, it was concluded previously that the application should have an easy to navigate interface. From the concept testing it was made clear that both participants with ages above 50 years old had a hard time navigating through the sleep functions of the Google Fit application. According to them, the option to enter sleep hours was hard to find and the buttons to enter the time were hard to navigate. The interface of the application should thus be made easier to navigate if the older age groups of the Diabetes patients are to be included.

The second point of discussion is the addition of a new factor. It became clear from the prototype testing that the biggest effect alcohol had on other factors was not because of drinking

but because of the social factor attached to it. Two participants mentioned they could see a correlation between alcohol and mood. Their mood went up when they drank alcohol. Both of them suggested their mood did not go up because they drank alcohol, but because they were with a group of friends having fun while they also drank alcohol with those friends. These participants suggest that another factor should be added: being social. According to the participants, this has a huge impact on at least the mood. Especially now, during the Covid-19 pandemie, where there is little social contact.

Having the option to set an amount of reminders or choose to have a continuous reminder turned out to work really well. The only remark on this system is that the reminders had a set time. One of the participants suggested the participants could set a time themselves. This would be a good addition, as multiple participants mentioned that they did like the reminder but had a hard time finding the right time to fill in the survey. The survey, manually tracked data, had to be filled in right before going to sleep but the reminder is sent out at 19:00. There is still a few hours between the reminder and filling in the survey, in which the reminder can be forgotten.

Motivation seemed to be a huge part of the ability to benefit from the visualizations. Multiple users mentioned that they would not be motivated to track longer than a week or month. There can be seen from the results of participant 3 that when a participant makes an estimate of calories instead of manually tracking them, they can not see correlations in their calorie intake.

In the visualizations, there was chosen to use a line where some factors were not linear. Multiple participants have commented on this, that even though the numbers are not linear it is easier to see a correlation when the factors are displayed in lines. This is also why the last visualization, the overview, was ranked the most relevant by multiple participants. Still, this displays the information different from what is measured, as for instance sleep is displayed in a line but only during the night the participant sleeps. Now, even though none of the participants read the visualization in this way, it might look like the participant slept through the whole day because sleep is not displayed as a single value but as a continuous line. This is a point of discussion, as lines are found to be more effective for the participant to see correlations and learn from their data but on the other hand the values are not linear so they should not be displayed in a line.

There was decided not to track blood sugar levels, as it would require the participant to have a blood sugar meter and to draw blood to measure blood sugar levels. As a requirement

for the application to have newly diagnosed DM2 patients benefit from it, one of the participants mentioned blood sugar levels should be implemented. Not every user will need this option, and only one out of the five participants mentioned it to be needed in the application. It might be useful to have the option to track blood sugar levels, or to make it a part of the data explanation. This way the user can track their blood sugar levels if they wish to do so.

In the specification phase, several requirements for the application were set. From the user requirements every requirement has been met except for, as discussed previously, the fact that most participants did not have DM2. Thus, they also had no wish to learn how to control their DM2, with exception of one participant. The user requirements are met. Not all functional requirements are met. For instance, the user was not able to set their preferred type of exercise. And, the application itself did not teach the user how to track calories. Instead, a database and calorie logbook were handed out to give the user some explanation and help. The calorie logbook can be found in Appendix B.IV. From the research, at least 3 functional requirements can be added. All of these requirements were suggested by participants.

1. The user should be able to choose at what time the reminders show up.
2. The system should offer monthly progression in clear graphs, including monthly progress numbers such as calorie count.
3. There should be the option to track or log the blood sugar level measurements.

7.3 Recommendation for future work

Ultimately, the goal of finding the benefit of the transformation from Quantified Self to Qualified Self for recently diagnosed DM2 patients should lead to the patient leaning more about their disease to stay steady or even get healthier. To reach this goal, not only should a patient be able to see correlations between values linked to HbA1c and blood sugar levels but also progression over time. This research offers no space for big scale research into progression over time, as the prototype study lasts only a week. This week is suitable for finding correlations and seeing how habits affect health, but it offers no room for a long term research on the (positive) effects of such an application. It would be interesting to see what the long term effects are of using the application as specified in Chapter 4.

Additionally, there could be looked into the effects of visualization. During this research, there was found that multiple participants did not see any correlations between their data while tracking it. But, when it was visualized the data got meaning and the participant could see what the data meant. There could be more research done in when the Qualified Self becomes the Quantified Self. Is a visualization in itself enough to make a user lean more about the self? Is visualizing data the last step to self qualification, or can data be deepened even more? Personally, I think there is no end to the Qualified Self. I think it is bigger than we can imagine, and will only get bigger as technology advances. The visualizations certainly passed the Quantified Self, as the participants learned correlations between factors that they never saw before and did not realize while tracking the numbers either.

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Appendix A: Interviews

Appendix A.I: Information Brochure

Information Brochure 'From Quantified Self to Qualified Self aimed at Diabetes Mellitus Type 2'

This interview will take the form of a semi-structured interview, where open-ended questions will be asked, allowing for a discussion between the interviewer and interviewee.

The topics regarding this interview will be; Diabetes Mellitus Type 2, the Quantified Self and the Qualified Self, factors related to Diabetes Mellitus Type 2, self-tracking/self-reporting data of factors related to Diabetes Mellitus Type 2, existing solutions and interventions aimed at reducing academic procrastination, a strengths-based approach to reduce academic procrastination, and a Qualified Self approach to reduce academic procrastination.

The interview will take place online through the application Skype.

Figure 36, Information brochure expert interviews

Appendix A.II: Consent form

Informed Consent Form 'From Quantified Self to Qualified Self aimed at Diabetes Mellitus Type 2'

'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research as described in the aforementioned information brochure 'From Quantified Self to Qualified Self aimed at Diabetes Mellitus Type 2'. My questions have been answered to my satisfaction. I agree with my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. My personal data will not be disclosed to third parties without my express permission. If I request further information about the research, now or in the future, I may contact Natasja Schaafsma.

Please check the box if you agree with the following:

- ❑ I have read and understood the information brochure and the informed consent form, I have no further questions, and I wish to participate in the interview.
- ❑ I give permission to the interviewer to state my name in the report as a source.

OR

- ❑ I wish to participate in this interview anonymously.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, P.O. Box 217, 7500 AE Enschede (NL), email: ethics-comm-ewi@utwente.nl).

Signed in duplicate:

.....	.....
Name subject	Signature

I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.'

....Natasja Schaafsma....	.....
Name Researcher	Signature

Figure 37, Consent Form expert interviews

Appendix A.III Interview Gert-Jan van den Burg

G. van den Burg is a retired doctor specified in children with Diabetes Mellitus, where type 1 often occurs. Besides this, he has worked in the Pergamon project for Horizon 2020 and the PAL project. Here he worked with the Quantified Self, and how a virtual agent can motivate a patient.

What does a Diabetes patient need to track about themselves to stay healthy?

Daily, blood sugar levels need to be tracked. This is less urgent for DM2 than it is for DM1. This is because the fluctuations are less intense for type 2. Besides this, the HbA1c value needs to be tracked. This value is composed of the number of sugar particles sticking to the red blood cells. A high value means more particles. Type 1 Diabetes patients check their values more regularly than type 2 Diabetes patients, thus type 1 Diabetes patients know more often whether they are out of range for these values.

Type 2 Diabetes is very ‘lifestyle-aimed’ in treatment. The patients need to exercise, keep a healthy weight and make sure to use the right food supplements. This makes that DM2 needs a lot more monitoring and thus tracking than DM1. Besides this, it is hard and important for DM2 patients to stay motivated. This is because the provisions for DM1 patients are much better, and more of the costs are covered by insurance for DM1 patients. In addition to this most DM1 patients use an insulin pump, which already tracks a lot of values automatically.

(how) Does self-tracking add more than using a diary?

It adds ease and motivation. If you were to try to write down something in a logbook 4 times a day 14 days in a row, you would find it very hard. If you succeed, you are unique. It is not easy. Writing something down is too easy, self-tracking is precise. That is why the basis of the Quantified Self is of importance.

It is important that self-tracking is done in the background. A user should not be bothered by it unless they need to act on a notification a few times a day.

What does self-tracking add for your patients? Is it easier to draw conclusions about their health from the values the self-tracking gives?

Yes. Self-tracking is used a lot to draw conclusions from. Take for example the insulin pump with all its measurements. It differs per doctor whether they find the reports made by the apps useful. This depends on the treatment used. The question about those apps is often: ‘What kind of people start using it, and what kind of people keep using it?’ The apps need to be in line with the way of life with the user. I would like to see apps being used more in the future.

What is most used by your patients? (apps, watches, devices..) What do you recommend?

It differs a lot. What I did notice is that there is a difference in acceptance for the apps. Children are really critical about apps, this might be because they grew up with them. Adults are less critical, but the motivation needs to be right. The motivation and acceptance tends to be bigger when an app is recommended by a doctor than when it is just on the market.

Is self-tracking the ultimate solution, or does it lack some insight? What is missing?

Self-tracking is the basis. Coaching might be much more important. Being coached on what your body produces. Being more human might be better than sticking to the rules. Nuanced coaching is important to stay motivated and keep going to interpret the values and translate them to health-tips.

Do you think patients can benefit from the Quantified Self when it comes to Diabetes?

Yes. DM2 patients often have no insulin pump. One of the advantages is that monitoring shows an enormous improvement. Tracking the self should become a habit, just like brushing your teeth. The Quantified Self should be a meaningful interpretation and stimulation. MySugr is very elaborate, but to be able to use all functions the user needs to pay 3 euros a month. This is not a lot but it forms a boundary; poor people are not able to use it. Besides this, the Quantified Self systems need to be easily understandable as Type 2 Diabetes has a lot of older users. The app should not need much attention from the user but it needs to motivate them to improve themselves. Thus, patients can certainly benefit from the Quantified Self but it needs to be suited to them.

Appendix A.IV Interview Charlene Hendriks - Volmeijer

C. Hendriks - Colmeijer is a Diabetes Mellitus Type 1 patient. She was diagnosed 29 years ago and has been logging her values on a logbook ever since. C. Hendriks - Volmeijer used an app for a while but had to stop using it. She misses it and would love to have the freedom of a self-tracking app again.

What do you track about yourself?

Currently, nothing. I am of the old ways. I write blood sugar down in a logbook. The hospital is becoming more digital, so they use excel. I calculate everything myself and put it in excel every day. For a year, I have used Freestyle Libre. This was linked to a device I had glued to my arm. I could tap the device with my phone and all values would automatically be uploaded to the app. Sadly, I was allergic to the glue so I went back to using pen and paper. I do miss the app, now I have to calculate everything by hand. The app did this very quickly, that saved a lot of time.

Do you use insulin?
Yes, four times a day and with a pen. I have used a pump for 16 years but stopped using this in 2015. I do not set any timers or reminders on my phone and I never forget injecting the insulin. It is in my system, a habit.

(how) Does self-tracking add more than using a diary?

It absolutely adds more than using a diary. I have had the luxury to use it for a while, and it for sure adds a lot of ease. You do not have to continuously think about the carbs, calculations, diaries, etc. Everything is in the app, calculating it by hand costs a lot of time and the app takes care of this. I should calculate everything every day, but sometimes I don't have time for it. Then I just write down the values and do it later or not at all. With the app, this does not have to be taken care of.

I have Diabetes Type 1. For me, self-tracking is used to get insights into my data. Am I seeing certain trends? Should I adapt my insulin values? How much did my exercise influence this? Did I inject my insulin too early after eating pasta? I can think about those things myself but it could be way clearer in an app. DM2 patients could possibly 'get rid' of the disease by following rules closely. These patients can benefit greatly from self-tracking. For both DM1 and DM2 patients, it differs per person what values mean. An app should give fitting advice I have yet to find a fitting app for me.

Appendix B: Prototype testing

Appendix B.II Information Brochure

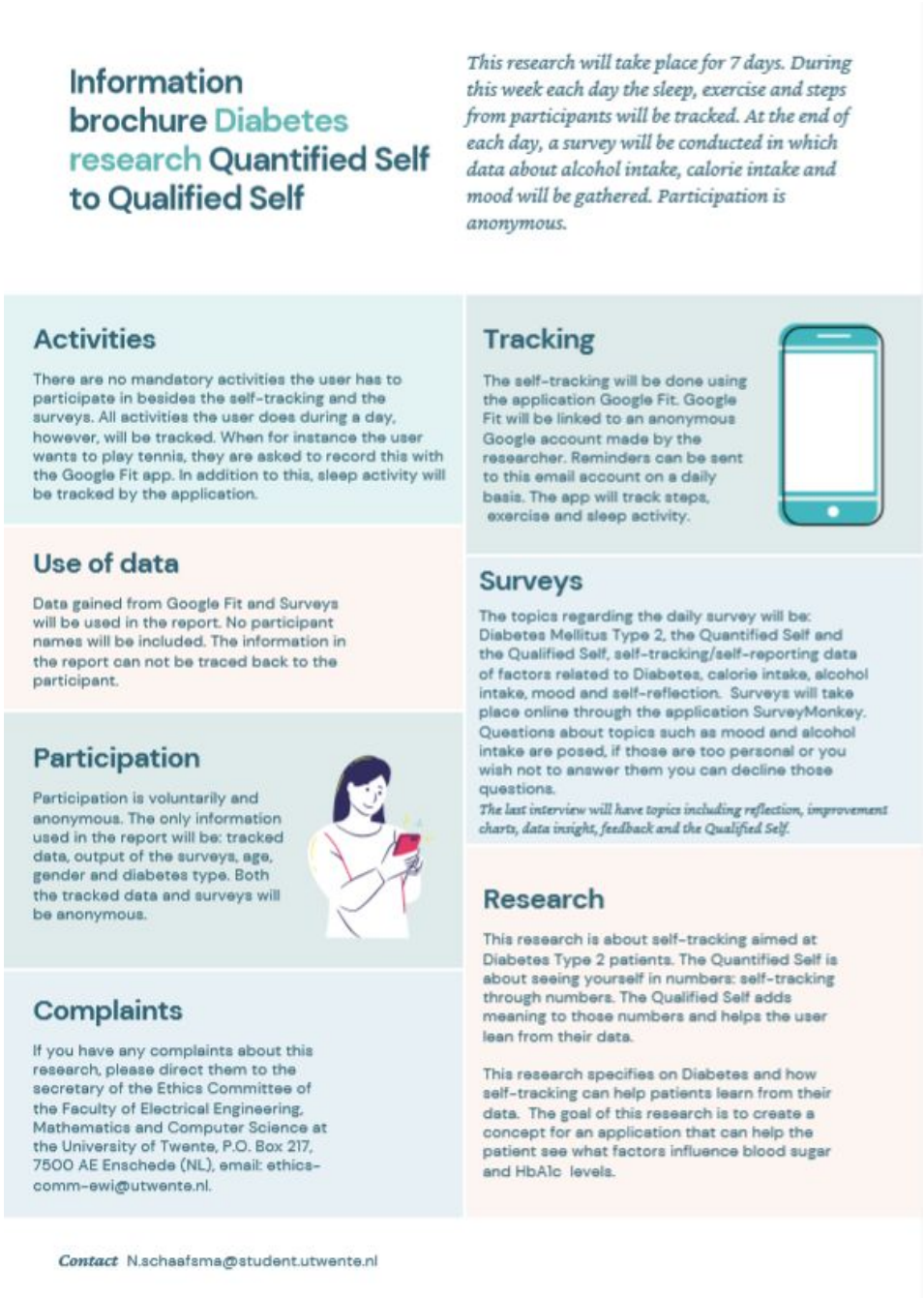


Figure 38, Information brochure prototype testing

Appendix B.III Informed Consent Form

Informed Consent Form 'From Quantified Self to Qualified Self aimed at Diabetes Mellitus Type 2'

'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research as described in the aforementioned information brochure 'From Quantified Self to Qualified Self aimed at Diabetes Mellitus Type 2'. My questions have been answered to my satisfaction. I agree with my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. My personal data will not be disclosed to third parties without my express permission. If I request further information about the research, now or in the future, I may contact Natasja Schaafsma. By doing this research Natasja Schaafsma confirms that she does not put extra pressure on the health care sector during the ongoing pandemic.

Please check the box if you agree with the following:

- ❑ I have read and understood the information brochure and the informed consent form, I have no further questions, and I wish to participate in the research.
- ❑ I understand that I can leave a question open if this question is too personal or if I wish not to answer it for other reasons.
- ❑ I give permission to the researcher to state my age, gender, diabetes type and recorded data from tracking and surveys as described in the brochure to be stated in the report.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, P.O. Box 217, 7500 AE Enschede (NL), email: ethics-comm-ewi@utwente.nl.

Signed in duplicate:

.....	.....
Name subject	Signature

I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.'

....Natasja Schaafsma....	.....
Name Researcher	Signature

Figure 39, Consent Form prototype testing

Appendix B.IV Food Calorie Self-Reporting Help

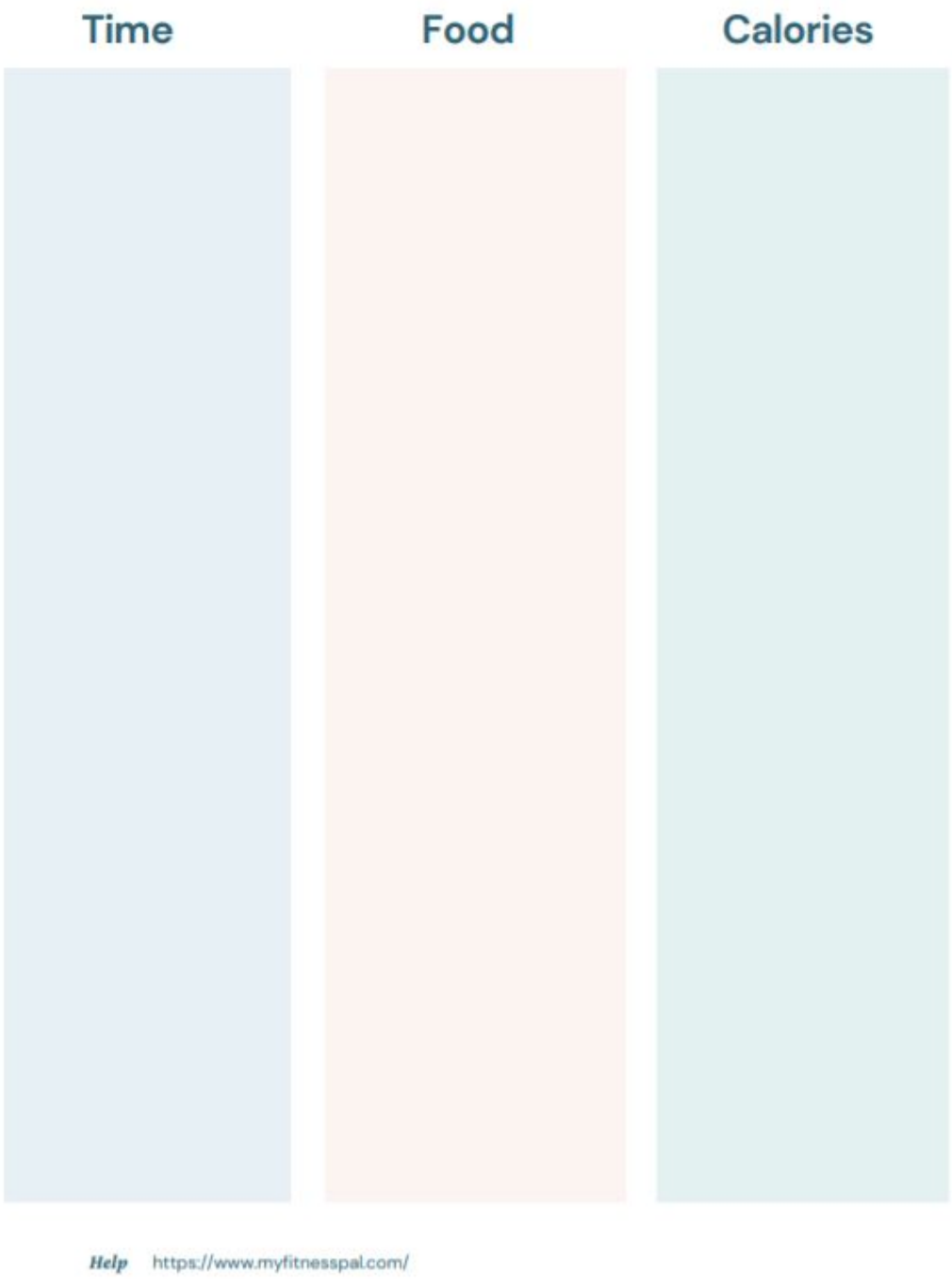


Figure 40: Food calorie self-reporting help

Appendix B.V Explanation and Research Clarification

Explanation and Research clarification

In this form, all steps about the testing week are explained. Normally this would have been done in person but due to Covid-19 it is hard to explain everything over email. This form is made to give detailed explanation on how the test week works from a distance. All Google Fit screenshots in this manual are in Dutch as this is the native language of the participants.

Self-tracking with Google Fit

During this week, you will use Google Fit to track your exercise, sleep and step count. On the next page there is explained how the app should be downloaded, connected and where options can be found.

- Each participant will get a Gmail account and password. This account will be deleted after the research. This Gmail account ensures privacy and anonymity.
- Starting on Sunday evening, you will need to track your sleep hours. This will be done with the Google Fit app by entering the time you went to bed and the time you woke up.
- To track exercise, each time you do a sports activity you should log this in the app. This is done by 'starting' the tracking when you start exercising.
- The last thing tracked by Google Fit is the step count. This will go automatically as long as you are carrying your phone when you walk around.
- Double check if Google Fit is linked to the anonymous Gmail account. This way your privacy is ensured.
- To make sure everything works, you are asked to download the app one day in advance and try to track sleep, exercise and steps. If something is unclear, you can send me an email. My email address is linked below.

Gmail account

You will get an email account and password. It would be nice if you could add this address as a mailbox on your phone so you can get notifications from it.

The mail addres will be linked to the Google Fit app as well as the Surveys.

Filling in Surveys

Each day the participant is expected to fill out a survey. These will be sent to the same anonymous Gmail account Google Fit is linked to at 19:00 each day. The survey does not have to be filled in exactly at 19h, but right before going to sleep. This way all steps, exercise and other factors measured are all executed.

- The first survey will be filled in on Sunday, before the tracking starts. This survey is to set preferences and ask details such as age, gender and diabetes type.
- The daily survey sent around 19h and to be filled in before going to sleep will ask questions about mood, food, alcohol intake and data gathered.
- After the testing week a reflection survey will be sent out. We will have a short Skype session while I ask you the questions and show your data 'results' in graphs. I will ask you questions about the graphs and the testing week.

Tracking Sleep

Make sure to track sleep the night before. For this research, the night of Sunday-Monday will be registered at Monday. This is because the effects of a good night sleep show on the day after not the day before. So the nights that need to be tracked are:

Sunday 7th of June - Monday 8th of June
Monday 8th of June - Tuesday 9th of June
Tuesday 9th of June - Wednesday 10th of June
Wednesday 10th of June - Thursday 11th of June
Thursday 11th of June - Friday 12th of June
Friday 12th of June - Saturday 13th of June
Saturday 13th of June - Sunday 14th of June

Contact n.schaafsma@student.utwente.nl, +31683896816

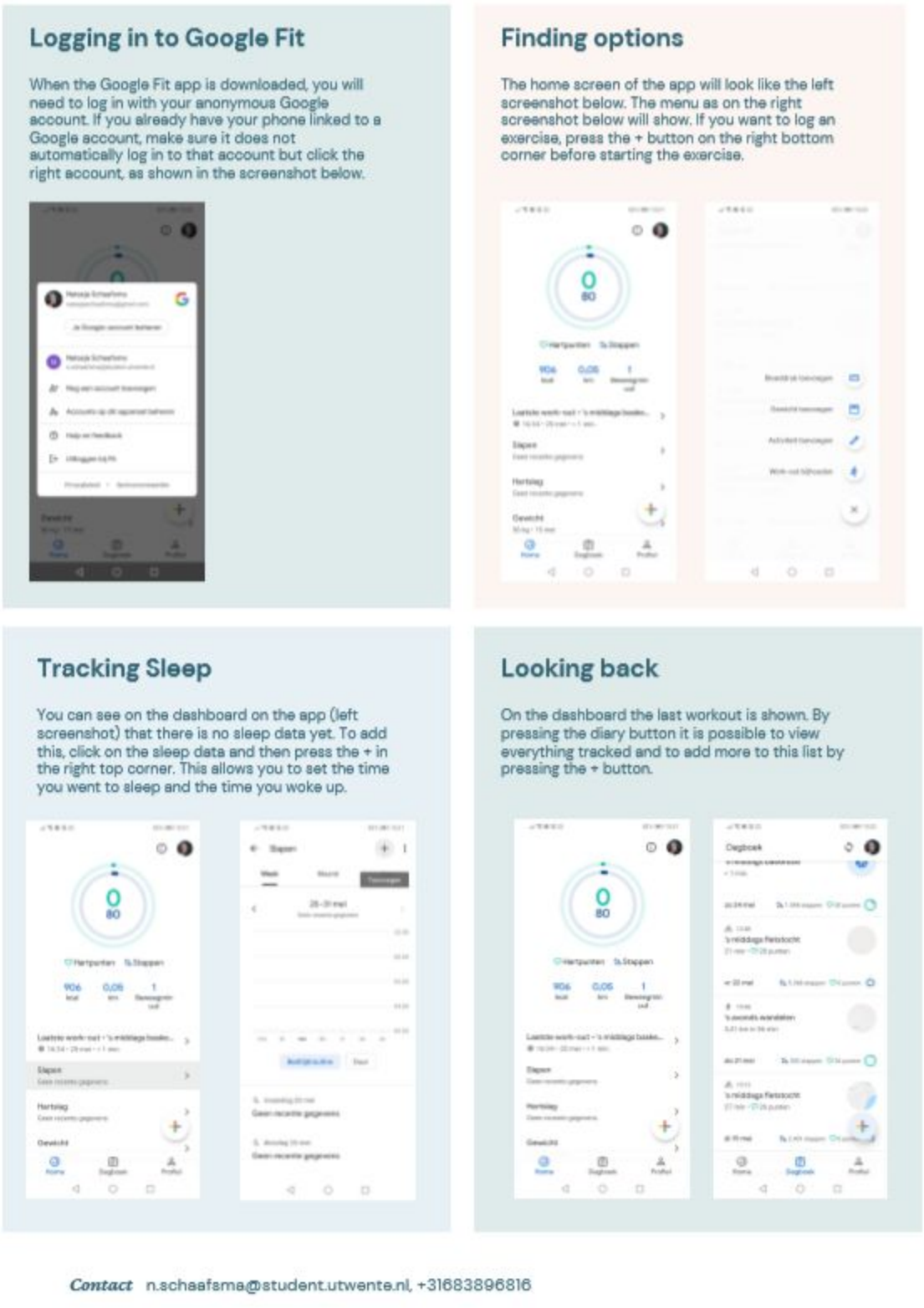


Figure 41, Explanation and research information prototype testing

Appendix C: Surveys

Appendix C.I Pre-tracking survey

Pre-Tracking Form - research Natasja Schaafsma

Pre-Tracking Form, Quantified Self to Qualified Self
'The Benefit for Diabetes Type 2 patients'

This Survey asks questions about the user as well as some preferences during the tracking week.

1. Over email, you were given a number to enter at the beginning of each survey. Please enter your number here.

2. During the test week, there is the option to get reminders to track exercise or fill in surveys. Would you like to get reminders? You can choose between a continuous reminder (get 1 email marked with a star at the beginning of the week so it always shows) or multiple reminders during the day.

- ◯ Continuous reminder
- ◯ No reminder at all

Daily reminder(s), please enter the amount of reminders during a day

3. What is your age?

4. What is your gender?

- ◯ Female
- ◯ Male
- ◯ Prefer not to say
- ◯ Other

5. What is your diabetes type?

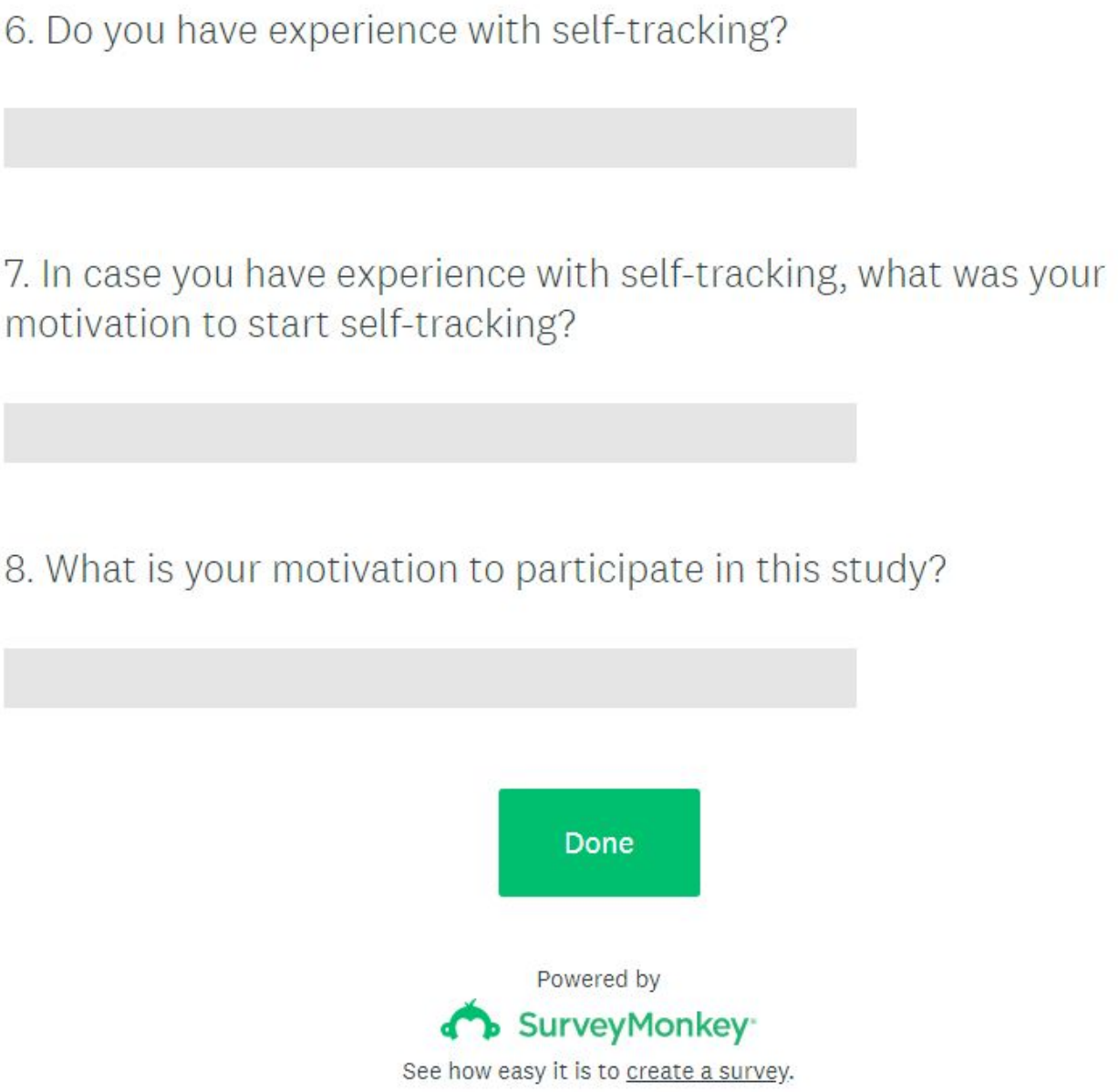


Figure 42, Pre-tracking survey

Appendix C.II Daily survey

Daily Self-Tracking Survey - Research Natasja Schaafsma

Daily Self-Tracking Survey, as part of the 'Quantified Self to Qualified Self' researched.

This survey tracks food, mood and alcohol intake as well as data accuracy and 'behind the data' explanation.

1. You were given a number over email. Please state your number here.

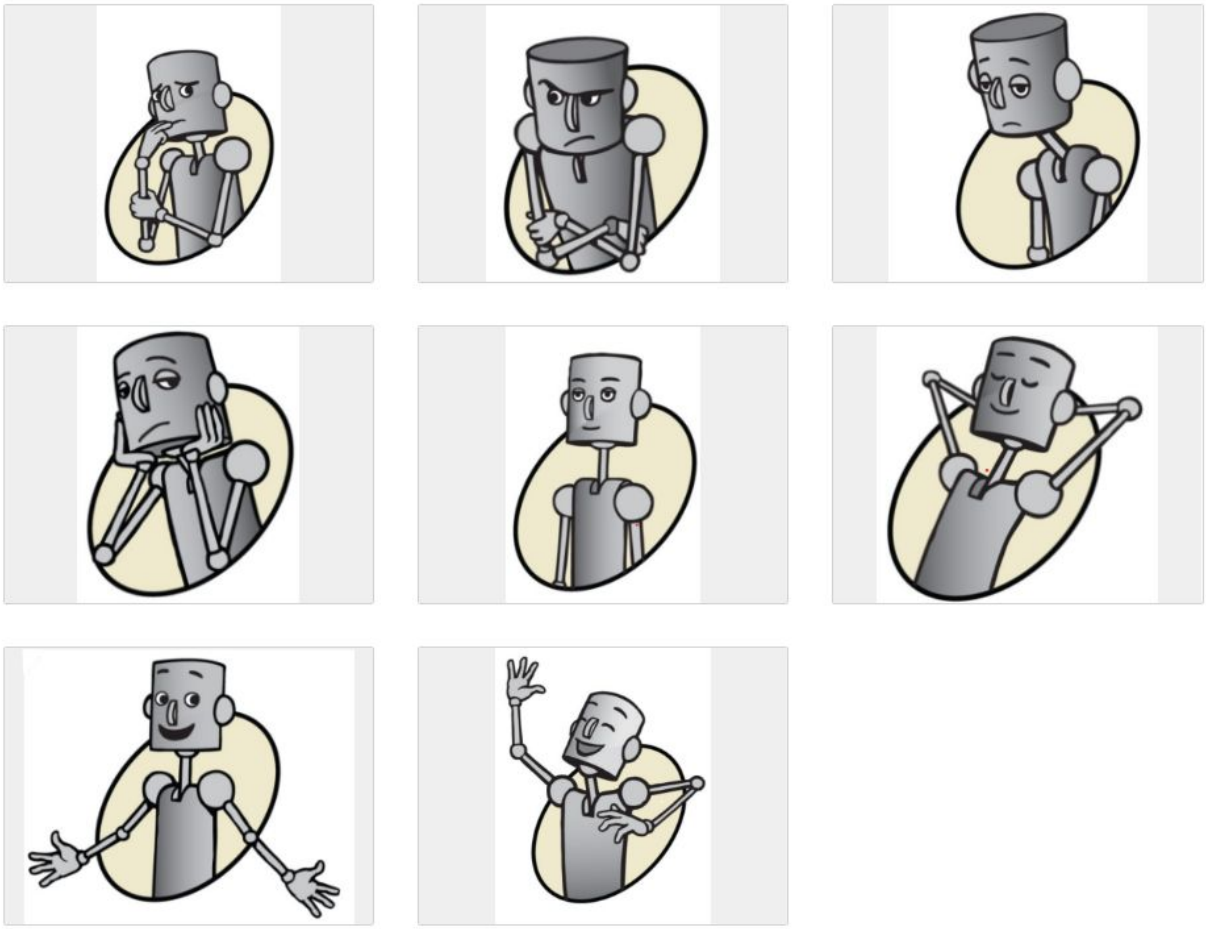
2. Your steps were measured by Google Fit today. Do you feel this number is accurate? Please describe why the Google Fit number is higher/lower than the reality. Make an estimated guess on what number of steps you think you made today.

3. Please enter how many calories you ate today in total.

4. How many glasses of alcohol did you drink today?

0 10

5. Please pick a picture that suits your mood today best.



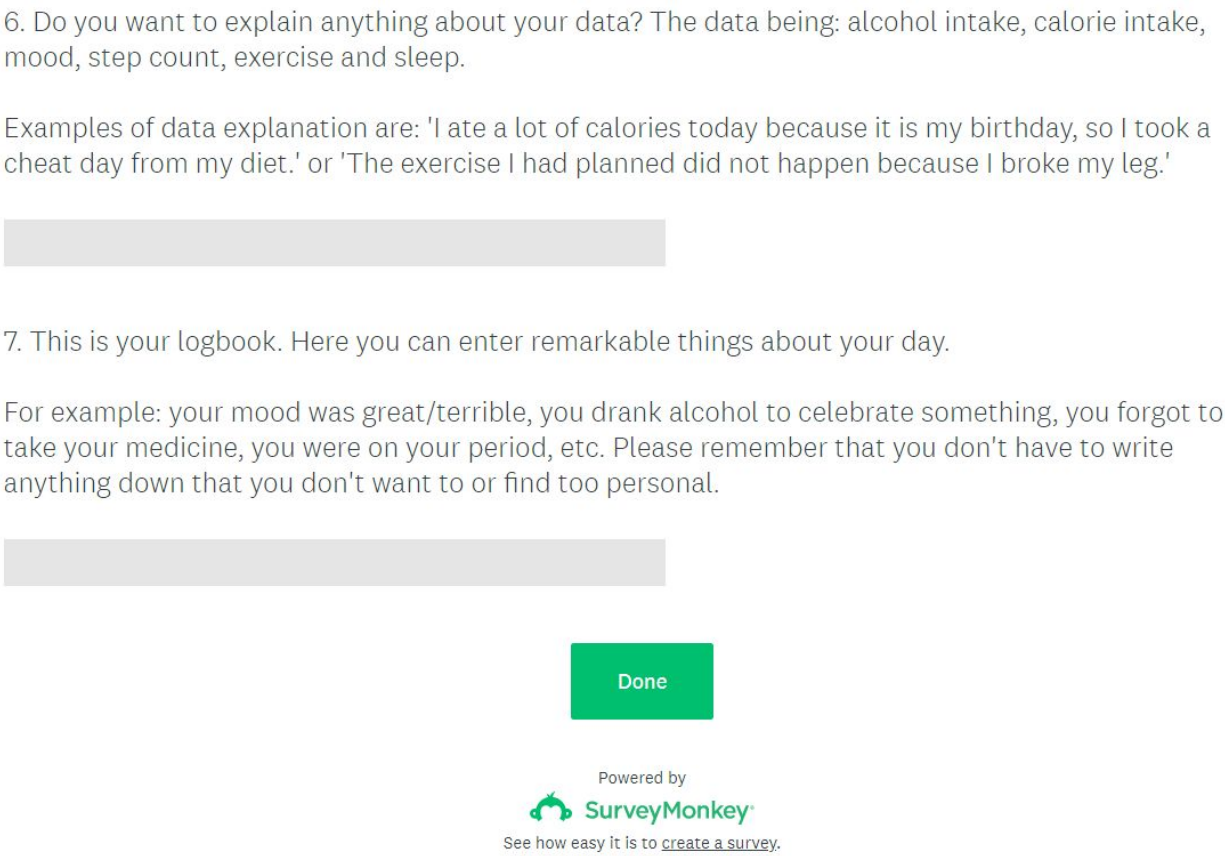


Figure 43, Daily self-tracking survey

Appendix D Reflection survey results

Appendix D.I Reflection survey participant 1

Reflective Questions	**Participant 1**
How did you experience this self-tracking week?	It went well. Towards the end of the week I got annoyed by having to count calories all of the time.
Did the research meet your expectations? In what way?	Yes. I did not have certain expectations. I did expect that I did not have to deliver too much input and that was true. I knew beforehand that tracking calories was going to be a pain as I've done it before.
What was your overall impression of the week of data collection?	Overall, it was very doable. Only the last two days I got annoyed with tracking calories. I would not want to do it longer than a week.
How did you experience the surveys?	Yes, the questions were relevant and easy to answer. There were no difficult questions.
Which questions were superfluous or lacking?	No, everything was clear to me.
What would you have changed (added/removed) about the daily questionnaire?	The logbook could be removed, for me this is the same as data explanation so it's double. Once is enough if you want to keep up. Besides this, tracking alcohol is not interesting for me as I never drink alcohol.
Did the logbook section add any value to you?	Not
What was your experience with tracking yourself via Google Fit?	everything neatly from the tracking system I use on my phone. I had to use a converter with a free 1 week trial but it worked perfectly.
What was your experience with answering the daily surveys?	It was quick to fill in the survey, mainly because you already know the answers. There's nothing to calculate it's just putting in the values or entering text if you want to.
When filling in the surveys, there was a logbook option. How did you experience answering this question?	Not relevant for me.

You had the option to set a continuous or daily reminder. What did you choose, why, and how did you experience this?	I chose to have 1 daily reminder. This was enough. Mainly because I fill in everything at the end of the day. I would prefer to be able to set the time of the reminder myself. Right before going to sleep I tend to forget what I still have to do so I'd prefer to have the minor around 22:00 at night.
Visualisation Questions	
Open the Tableau visualizations. Please look at all of them and explain to me what you see.	I can see all of the axises clearly, and notice that my sleeping rhythm is very consistent. On weekends I eat more. Steps differ a lot. Funny how the less I move the more terrible I feel. And I can also see that food clearly makes me happy.
Vis 1: What is your first impression of the results?	It looks like I eat a lot because the bars are high, but the scale just zooms automatically. I can directly see how my mood relates to the amount of movement even though I don't do a lot of exercise nowadays.
Vis 1: Can you understand anything that can be seen on this graph?	Yes, it is a clear graph.
Vis 1: Which correlations do you see?	My mood is related to the amount of food I eat. I can see that the more I eat the happier I get.
Vis 1: Did you learn anything from this data visualization? If so, what did you learn?	I'm surprised about the relation between food and mood, the correlation is very clear. I would have never thought this myself, I could have if I had thought about it but I did not realize how big the impact of food is.
Vis 1: Is this new information to you, or is this something you are already familiar with?	This is the first time I see this. I could have thought about it, but I never realized it. This really exposes it for me.
Vis 2: What is your first impression of the results?	The correlation between steps and mood.
Vis 2: Can you understand anything that can be seen on this graph?	Both of the graphs are orange, this is confusing to me.
Vis 2: Which correlations do you see?	There is a logical correlation that if my steps are higher my mood lifts up.
Vis 2: Did you learn anything from this data visualization? If	I did not know I was this vulnerable to movement. I am someone who loves doing sport and becomes happy when

so, what did you learn?	doing more exercise. But I did not know that this also counted for smaller movements, such as the steps on a day.
Vis 2: Is this new information to you, or is this something you are already familiar with?	I was aware that exercise makes me happy, but did not know this is true for steps as well!
Vis 3: What is your first impression of the results?	I don't drink alcohol and my sleep rhythm is very consistent so I don't see a correlation at all. My mood swings a lot but my sleep does not.
Vis 3: Can you understand anything that can be seen on this graph?	Yes it is clear.
Vis 3: Which correlations do you see?	None.
Vis 3: Did you learn anything from this data visualization? If so, what did you learn?	Not relevant
Vis 3: Is this new information to you, or is this something you are already familiar with?	Not relevant
Vis 4: What is your first impression of the results?	I think it is very interesting to see how calorie intake and movement have such a huge impact on me and my mood.
Vis 4: Can you understand anything that can be seen on this graph?	Yes
Vis 4: Which correlations do you see?	Calorie (sport), food and mood correlate together
Vis 4: Did you learn anything from this data visualization? If so, what did you learn?	Yes, but this is said before at the separate visualizations as well.
Vis 4: Is this new information to you, or is this something you are already familiar with?	This is new information.
When filling in the surveys, there was a data explanation option. Did you notice this option? Did you use it? Did the	I did not use it a lot myself. I can see how the explanations resulted in the data that can be seen. For example on the day I had a birthday my calorie intake is the highest of the week, and the day I forgot to wear my smartwatch to track

answers to this question as displayed in the graph add anything to your self-reflection?	my steps the amount of steps were very low.
Questions after showing the visualization concerning the visualization and overall concept	
Would you consider using an application like this in the future?	Yes, when I'm really consciously working on my food intake and movement I would like to have an app that combines those functions. But then I'd like a monthly visualization instead of weekly.
What requirements would an application like this have to fulfil for you to use it?	It would be a nice addition if there'd be a huge database of food and calories to choose from. And an option to link other apps to it.
Would you be motivated to continue tracking yourself? What would you track and what wouldn't you track?	Currently, I am happy where I am at with my weight and health. I try to watch it and track it once in a while but I don't consistently track anything and don't think I will in the near future. Maybe when I get older and my metabolism gets worse.
Did you find relevance in tracking your body functions?	I don't find it relevant in itself but it is interesting to have done it.
Did you feel more pressure to eat healthy because you were tracking your calories and showing them to the researcher for this research? Did this make you eat healthier than normal or is this week representative?	I ate as I would in a normal week, except that I weighed everything now to write down and calculate the calories.
You had the option to keep a logbook. After the week of tracking, you were shown a summary of your logbook input. Do you like having this option? Does it add anything for you?	Personally, I don't see any additional value to having a logbook. This is because entering all the values is to me a logbook in itself, writing words about it has no more value to me.
Which visualization was the easiest to understand?	The overview, because you can see everything together and see all correlations at once.

Which visualization was the most relevant to you? Rank them 1-4. Why this order?	Overview - sport - calories - alcohol Overview shows everything, both 2nd and 3rd spot are relevant to me as they show correlations. As my sleep is very steady and I don't drink alcohol that visualization is not relevant to me.
Did the visualization make you see correlations that you would not have made without the visualization?	To me that is the sport visualization. It really shows how step count and mood correlate. I would not figure this out myself, I didn't even notice it while writing down the data during this week so I am very surprised!
The visualization, combined with the tracking options are a concept version for an application. This application would allow newly diagnosed Type 2 Diabetes patients to get started in regulating their Diabetes. Do you think newly diagnosed Type 2 Diabetes patients could benefit from self-tracking? If so, how.	Yes. It is important to track how much you eat and how much you move because these factors determine whether your diabetes will get worse, stay the same or even gets better. Further I would say it is important to also show the carbs and proteins in the food that's eaten because carbs for instance trigger the insulin intake. I think it would certainly help as it might even take over some of the functions for the dietician or doctor by tracking it for a year and giving updates or tracking blood once in a while. IT would certainly be a good app to use for recently diagnosed type 2 Diabetes patients.

Table 19: Exit interview results participant 1

Appendix D.II Reflection survey participant 2

Reflective Questions	**Participant 2**
How did you experience this self-tracking week?	Yes, the tracking took some time some days but it was a good experience.
Did the research meet your expectations? In what way?	Yes it did. The only thing I did not understand is why I had to track my calories.
What was your overall impression of the week of data collection?	I've done a tracking week before because I had no control over my blood sugar levels. This time that was not the goal. It made me think about everything I eat and it makes you think about food. But I would not be able to do this for more than a week.
How did you experience the surveys?	I did now know how I felt so could not pick a mood very well. The rest went very well.
Which questions were superfluous or lacking?	None.
What would you have changed (added/removed) about the daily questionnaire?	Maybe have the opportunity to write more about how you feel. Not just a simple picture. But I'm not sure what the best way would be, just that a picture does not represent my feelings.
Did the logbook section add any value to you?	I wrote something once in a while, but only if my day was not average. This did add value.
What was your experience with tracking yourself via Google Fit?	It went well, I had no problems, and am very content with the step counter. The only thing is that you need to remember to register your sleep but it is a very good app!
What was your experience with answering the daily surveys?	----
When filling in the surveys, there was a data explanation option. How did you experience answering this question?	I did not use it a lot, it was kind of the same as a logbook to me.
You had the option to set a continuous or daily reminder. What did you choose, why, and	I chose to have a continuous reminder. This was perfect for me as I remember to track and fill in surveys myself very well. Sometimes I forgot to enter the survey but then I did it

how did you experience this?	in the morning after.
Visualisation Questions	
Open the Tableau visualizations. Please look at all of them and explain to me what you see.	I can see a calorie graph. There is a big difference between how many calories are eaten per day. Red is clearly my mood. If I look at it now I don't see a direct relation between mood and calories. In the sports graph I'm not sure what I need to see. The alcohol graph is very confronting. It is a bit chaotic, I don't see any relations.
Vis 1: What is your first impression of the results?	That there is a huge difference in the amount of calories I ate a day.
Vis 1: Can you understand anything that can be seen on this graph?	Grey is clearly the calories that I burned and black what I ate. The axises are clear, days below. Did not know you can hover with the mouse.
Vis 1: Which correlations do you see?	Nothing more than on day 9 and 12 I ate less calories and was happier. But I am not sure how those two things relate to each other.
Vis 1: Did you learn anything from this data visualization? If so, what did you learn?	Yes, that my calorie intake fluctuates a lot.
Vis 1: Is this new information to you, or is this something you are already familiar with?	This is new information to me. I've got the idea it's because of the quarantine. My life is a chaos at the moment.
Vis 2: What is your first impression of the results?	The mood does not seem to deviate a lot, even though it is the same as in the last graph. There is a lot of difference in how much I move in a day, but this seems normal to me.
Vis 2: Can you understand anything that can be seen on this graph?	Yes
Vis 2: Which correlations do you see?	No
Vis 2: Did you learn anything from this data visualization? If so, what did you learn?	-
Vis 2: Is this new information to	-

you, or is this something you are already familiar with?	
Vis 3: What is your first impression of the results?	There are a lot of dots. But once you know what they mean by looking at the legend it is very clear.
Vis 3: Can you understand anything that can be seen on this graph?	Yes
Vis 3: Which correlations do you see?	Yes. It looks like red and blue have the same pattern. I apparently get very happy when I drink alcohol. Often when you drink alcohol, you are not alone, so I think it relates to me being more social! Besides that seeing how much alcohol I drink is very confronting.
Vis 3: Did you learn anything from this data visualization? If so, what did you learn?	Yes, it surprises me that I entered that I felt great on June the 11th, as I know how much having little sleep irritates me. I think the fact that I filled in the survey in my bed being glad the day is over made me happy. From this visualization I can clearly see what sleep does to me.
Vis 3: Is this new information to you, or is this something you are already familiar with?	I did know already, but because it is tracked so actively now, making you think about it all the time it really makes it clear how my mood depends on this.
Vis 4: What is your first impression of the results?	Because of the graphs it looks like food and mood are very steady while the rest fluctuates.
Vis 4: Can you understand anything that can be seen on this graph?	Yes
Vis 4: Which correlations do you see?	No
Vis 4: Did you learn anything from this data visualization? If so, what did you learn?	-
Vis 4: Is this new information to you, or is this something you are already familiar with?	-
When filling in the surveys, there was a data explanation option. Did you notice this option? Did you use it? Did the	Yes, it really adds a lot to the visualization. For example, on June 12th it was warm weather, by reading that you think: ‘Ah right, the day it was so warm I did not do anything!’. You remember the day clearer and the values become logical.

answers to this question as displayed in the graph add anything to your self-reflection?	
Questions after showing the visualization concerning the visualization and overall concept	
Would you consider using an application like this in the future?	Good question. Yes it would be convenient, but then I'd want to know that it matches with my treatment. I would not do it for fun. The graphs and visualizations could be very helpful, if I knew how they could help with my Diabetes treatment.
What requirements would an application like this have to fulfil for you to use it?	A good combination with the treatment.
Would you be motivated to continue tracking yourself? What would you track and what wouldn't you track?	Yes. Your phone tracks a lot for you automatically without you realizing it. I think knowing how much you exercise is an important part of how much your body does to blood sugar. This is something that is convenient to track for me.
Did you find relevance in tracking your body functions?	Yes
Did you feel more pressure to eat healthy because you were tracking your calories and showing them to the researcher for this research? Did this make you eat healthier than normal or is this week representative?	Yes! A combination of being aware of myself and of someone else seeing the results. Not that I changed my pattern, but when eating a pizza I would think 'Shit this is 3000 calories!'. Normally I don't think about that, at the end of a day when counting calories I do realize now that some things contain a lot of calories.
You had the option to keep a logbook. After the week of tracking, you were shown a summary of your logbook input. Do you like having this option? Does it add anything for you?	Yes. I think it's always convenient to have the possibility to write something down. I did not do this every day this week but sometimes it is nice.
Which visualization was the easiest to understand?	The first (calories) because every part has their own 'figure'. Bar or dot. It seems logical.
Which visualization was the	Alcohol - Calories - Sport - overview

most relevant to you? Rank them 1-4. Why this order?	
Did the visualization make you see correlations that you would not have made without the visualization?	The fact that you track it makes you think about it already. It is very convenient to see everything in a graph. Sleep and alcohol in combination is something I normally don't think about. I can think about it myself but looking at this graph is way more confronting.
The visualization, combined with the tracking options are a concept version for an application. This application would allow newly diagnosed Type 2 Diabetes patients to get started in regulating their Diabetes. Do you think newly diagnosed Type 2 Diabetes patients could benefit from self-tracking? If so, how.	Yes, I do think so. I am not sure if it would work for Type 1 because they also need to know a lot about carbs. For Type 2 calories are a lot more important. By seeing this you will be more conscious about what you eat. For a lot of Type 2 diabetes patients their diabetes gets better when they lose weight. As a motivation for this the graphs confront you very well.

Table 20, Exit interview results participant 2

Appendix D.III Reflection survey participant 3

Reflective Questions	**Participant 3**
How did you experience this self-tracking week?	Well. Tracking should not cost extra effort. If you have to enter numbers by hand it does. And it makes you walk with your phone all the time. For some people that might not be a problem, but it is something extra to think about. I don't always have my phone with me. Google Fit is not user friendly. Further, the biggest problem is entering calories. I know how to guess my calories very accurately. Every day I entered a bandwidth of a guess of calories. I always relate it to carbs. The rest was fine.
Did the research meet your expectations? In what way?	Yes, it was very well thought out and prepared. It was very convenient to get a link to the survey every day, this way I did not forget to fill it in. The negative side would be that the emails went to another email account. It would be more user friendly if it went to my own email.
What was your overall impression of the week of data collection?	Overall impression, the less you have to do the better.
How did you experience the surveys?	It did not take too long to enter, which was very nice.
Which questions were superfluous or lacking?	None
What would you have changed (added/removed) about the daily questionnaire?	Yes well entering calories could be made more user friendly. Most people who eat a lot will probably think 200g is 100 g.
Did the logbook section add any value to you?	I have filled in something sometimes. Having the possibility of filling in a logbook is nice, some things are not measurable and in this way you can still state them.
What was your experience with tracking yourself via Google Fit?	I'm allergic to everything made by Google. I do use it sometimes. Google does not work for free, they will sell all your data. So I don't like free apps. Further it was technically well and the interface was really nice.
What was your experience with answering the daily surveys?	--

When filling in the surveys, there was a logbook option. How did you experience answering this question?	--
You had the option to set a continuous or daily reminder. What did you choose, why, and how did you experience this?	I had one daily reminder. This was sufficient and very convenient. I can imagine more reminders would be necessary if you need to enter more things manually. But not too much otherwise it would get annoying. I liked that I could set an amount of reminders myself. That was thought out very well, If I had thought this idea out myself I would have forgotten a lot of minor convenient things like that.
Visualisation Questions	
Open the Tableau visualizations. Please look at all of them and explain to me what you see.	Step count, data, alcohol. I would make bar graphs from some of the things that aren't interpolar. Sport.. I did not do any exercise this week, normally I would for 180 minutes but because of a birthday and rain I did not do any exercise. I don't like Tableau Reader and the Tableau software. Microsoft BI would be better.
Vis 1: What is your first impression of the results?	Clear graph, sadly I did not do any sports. I am guessing if I did do sports there would be a grey bar covering the black bar.
Vis 1: Can you understand anything that can be seen on this graph?	Yes, except that I found the legend really late. But that is because I opened it in full screen and the graph covers half of the screen, while the legend moves to the right top corner.
Vis 1: Which correlations do you see?	I did not do any sports, but if I did I'm sure there would be a correlation.
Vis 1: Did you learn anything from this data visualization? If so, what did you learn?	That there is no linear relation between calories and mood. But I did not learn anything.
Vis 1: Is this new information to you, or is this something you are already familiar with?	-
Vis 2: What is your first impression of the results?	That I did not do any sports. There is a clear relation between mood and movement in steps. But because I'm always tired my mood does not change. That is why my mood is the same every day. I know this is because of the amount of sleep I get, which is not shown in this graph so I have nothing to see here.

Vis 2: Can you understand anything that can be seen on this graph?	Because I did not do any sports one axis is set on 0. Weird but understandable.
Vis 2: Which correlations do you see?	None
Vis 2: Did you learn anything from this data visualization? If so, what did you learn?	-
Vis 2: Is this new information to you, or is this something you are already familiar with?	-
Vis 3: What is your first impression of the results?	Because of the dots it is hard to interpret it in the glance of an eye. I don't see a correlation directly. If there was only one type of dot I would because it would be more clear, maybe alcohol should be bars.
Vis 3: Can you understand anything that can be seen on this graph?	Yes
Vis 3: Which correlations do you see?	Not really
Vis 3: Did you learn anything from this data visualization? If so, what did you learn?	-
Vis 3: Is this new information to you, or is this something you are already familiar with?	-
Vis 4: What is your first impression of the results?	They are all lines but not everything is lineair. But it is really nice that they are all lines because dots and bars are confusing and now it's easy to see correlations and factors.
Vis 4: Can you understand anything that can be seen on this graph?	When I drink alcohol I walk more the day after. This is a coincidence. I also ate more when I moved.
Vis 4: Which correlations do you see?	I eat more when I move more because my blood sure goes down when I move so I have to keep eating. Furthermore I have a lot of constant values.
Vis 4: Did you learn anything	Nothing new.

from this data visualization? If so, what did you learn?	
Vis 4: Is this new information to you, or is this something you are already familiar with?	-
When filling in the surveys, there was a data explanation option. Did you notice this option? Did you use it? Did the answers to this question as displayed in the graph add anything to your self-reflection?	Yes, that is very convenient! When you look at the graph you can see everything about that day and know why there is a peak. I would love there to be a full date next to the text as well.
Questions after showing the visualization concerning the visualization and overall concept	
Would you consider using an application like this in the future?	Well to be honest I would not, but that is because I am stubborn and know all correlations already. If you want to discover correlations when you don't know them yet it would help, or if you want to change them. But I already know all the correlations. Also because I already have to know a part for my diabetes (type 1). For Type 2 patients this is a lot more necessary. For type 1 the values change very frequent and fast. Type one needs to track them and show a nurse.
What requirements would an application like this have to fulfil for you to use it?	Easy: It would need to contain blood glucose values as well.
Would you be motivated to continue tracking yourself? What would you track and what wouldn't you track?	Yes, I think all things that were measured during this research are meaningful. Mood is fun if you can find a relation but my mood does not change. I do really like the figures to pick a mood! I would not be able to give it a grade for example.
Did you find relevance in tracking your body functions?	Yes
Did you feel more pressure to eat healthy because you were tracking your calories and showing them to the researcher for this research? Did this make you eat healthier	No, this week was representative. Every day I made a guess about the calories. There were a lot of birthdays and I drank a lot of alcohol this week.

than normal or is this week representative?	
You had the option to keep a logbook. After the week of tracking, you were shown a summary of your logbook input. Do you like having this option? Does it add anything for you?	See above.
Which visualization was the easiest to understand?	Sport.
Which visualization was the most relevant to you? Rank them 1-4. Why this order?	Overview - sport - calories - alcohol I can't really handle the dots.
Did the visualization make you see correlations that you would not have made without the visualization?	No.
The visualization, combined with the tracking options are a concept version for an application. This application would allow newly diagnosed Type 2 Diabetes patients to get started in regulating their Diabetes. Do you think newly diagnosed Type 2 Diabetes patients could benefit from self-tracking? If so, how.	Yes, for sure. Especially by seeing the correlation between food intake, sport and blood sugar. Blood sugar is essential. Everything can be linked back to mood, especially because mood relates closely to blood sugar levels. A challenge will be getting all values, especially because for instance a device in your arm costs a lot of money. But having such an app, you are motivated to get your values checked more regularly. I think it will have a lot of value for the patients as it helps them directly see relations between everything.

Table 21, Exit interview results participant 3

Appendix D.IV Reflection survey participant 4

Reflective Questions	**Participant 4**
How did you experience this self-tracking week?	I experienced it as very educational, I liked doing it and for me it could have lasted longer.
Did the research meet your expectations? In what way?	I did not have any expectations, I did not know Google Fit and had my doubts but eventually it worked out fine.
What was your overall impression of the week of data collection?	I did not think that much data was necessary, but I also did not know much about it. I saw what Google Fit could track but next to carbs and sports that was it. Tracking with explanation would add more value, there is asked for mood but I think there are more factors.
How did you experience the surveys?	Clear, asking for steps was suggestive. I looked at the difference between my watch and google fit to answer this question.
Which questions were superfluous or lacking?	No
What would you have changed (added/removed) about the daily questionnaire?	I thought steps would not be asked every day, but that is because I did not see anything wrong with the numbers. I thought a deviation would be calculated between all participants.
Did the logbook section add any value to you?	I had not seen the option. I did write down my meals during the day so I could calculate everything.
What was your experience with tracking yourself via Google Fit?	I would not use it myself, I struggled entering sleep every day as it is not seen as an activity. And the entering sleep buttons are hard to find. It was interesting that my smartwatch was automatically linked because I logged in to the google account coupled to Google Fit on my watch. The reminders also popped up on my watch. I thought it would be complicated to start up Google Fit but it was not. Some things might be complicated for other people, such as opening Tableau.
What was your experience with answering the daily surveys?	I did not mind it. It was hard to find the right moment for it, the only convenient moment is right before going to sleep but I often answered it in the beginning of the night when I had not yet tracked everything as you often eat something

	later in the night.
When filling in the surveys, there was a logbook option. How did you experience answering this question?	---
You had the option to set a continuous or daily reminder. What did you choose, why, and how did you experience this?	I chose to have 4 daily reminders. I did not know how many I would need. It turned out I did not need any at all. It was too much, it got annoying.
Visualisation Questions	
Open the Tableau visualizations. Please look at all of them and explain to me what you see.	I can see the date, calorie intake and how many calories I burned. If I'd make it myself I would add more trendlines so it is easier to see everything. Where I ate a lot I apparently also did a lot of exercise. I can see steps and moods. From this I cannot see a lot except that on June 13th I moved and exercised a lot. What I noticed is that the amount of sleep and alcohol go up at the same time. I am aware of this, as I sleep and drink more on the weekend. The amount of glasses of alcohol should be a bar graph.
Vis 1: What is your first impression of the results?	Everything is quite the same except June 13th I ate a lot. Monday evening I thought: I'm at home and I've been at home the whole day and in the evening I'm home still. Because of this research I started moving every day. This is because the numbers have confronted me, and because questions are asked about it. I don't know if I would keep it up longer but in the beginning for sure I would try my best.
Vis 1: Can you understand anything that can be seen on this graph?	Yes. I do miss a line going through the calories so it is more clear. I felt great every day so my mood is the same every day. What annoys me is that mood is a circle in the graph and a square in the legend.
Vis 1: Which correlations do you see?	That everything is quite the same except on the 13th.
Vis 1: Did you learn anything from this data visualization? If so, what did you learn?	Yes, for example the days that I ate less I still felt the same. So my mood is not linked to my calorie intake.
Vis 1: Is this new information to you, or is this something you are already familiar with?	Yes, I did not know this before.

Vis 2: What is your first impression of the results?	That you can't make a line of mood, but furthermore these graphs don't say anything to me.
Vis 2: Can you understand anything that can be seen on this graph?	Yes
Vis 2: Which correlations do you see?	None
Vis 2: Did you learn anything from this data visualization? If so, what did you learn?	No
Vis 2: Is this new information to you, or is this something you are already familiar with?	No
Vis 3: What is your first impression of the results?	This is a bit weird. The blue is clearly alcohol and red is mood. I would have put sleep on the left Y-axis and Mood on the right side. I find it hard to see three different things in one graph. Maybe there are just no correlations for me that is why I don't see the relation.
Vis 3: Can you understand anything that can be seen on this graph?	Yes
Vis 3: Which correlations do you see?	No
Vis 3: Did you learn anything from this data visualization? If so, what did you learn?	No. Maybe if the average person's values would be displayed next to it I could see a correlation. Which is what I expected there to be.
Vis 3: Is this new information to you, or is this something you are already familiar with?	-
Vis 4: What is your first impression of the results?	It is a bit unclear to me because all graphs are displayed below each other. There should actually be a breakpoint on such a line where you can see what is happening at another line. Learned later that if you hover over with your mouse this is what happens.
Vis 4: Can you understand	I'm missing the date on the X-axis

anything that can be seen on this graph?	
Vis 4: Which correlations do you see?	I did see a lot of correlations while tracking myself, mainly that you burn very little calories while eating a lot.
Vis 4: Did you learn anything from this data visualization? If so, what did you learn?	That daily steps are normally really low so you have to look for exercise and movement yourself. Further I found mood interesting because it makes you think about the type of day it was.
Vis 4: Is this new information to you, or is this something you are already familiar with?	Yes this is new to me.
When filling in the surveys, there was a data explanation option. Did you notice this option? Did you use it? Did the answers to this question as displayed in the graph add anything to your self-reflection?	Yes, because after a day you don't remember the day before. This helps you get more insight.
Questions after showing the visualization concerning the visualization and overall concept	
Would you consider using an application like this in the future?	Yes, I already do this with my watch so I certainly would.
What requirements would an application like this have to fulfil for you to use it?	As anonymous as possible and easy in use. What I liked about Google Fit is the proposals: 'We detected movement, were you cycling?'. This makes tracking easier.
Would you be motivated to continue tracking yourself? What would you track and what wouldn't you track?	Sleep is difficult and hard to enter. Entering hours and minutes is hard. Everything that goes automatically is nice but the rest is complicated. I would not keep tracking mood and steps but the rest I would keep tracking.
Did you find relevance in tracking your body functions?	Yes I think it is important. This has to do with my health and diabetes..
Did you feel more pressure to eat healthy because you were tracking your calories and showing them to the	Not at all. I liked learning what the food I eat contains. I did start eating easier to calculate meals. Tracking sport did pressure me to do more exercise.

researcher for this research? Did this make you eat healthier than normal or is this week representative?	
You had the option to keep a logbook. After the week of tracking, you were shown a summary of your logbook input. Do you like having this option? Does it add anything for you?	No. I know this function from my blood glucose meter and pump. It is only interesting when you discuss it with a professional.
Which visualization was the easiest to understand?	Learning the mouse hovering, the calories visualization is the easiest to understand.
Which visualization was the most relevant to you? Rank them 1-4. Why this order?	Calorien - sport - alcohol - overview Sport is an interest of mine. Alcohol and overview are just given values to me.
Did the visualization make you see correlations that you would not have made without the visualization?	Yes that would be the correlation between sport and calories. And that you actually burn very little calories on a day.
The visualization, combined with the tracking options are a concept version for an application. This application would allow newly diagnosed Type 2 Diabetes patients to get started in regulating their Diabetes. Do you think newly diagnosed Type 2 Diabetes patients could benefit from self-tracking? If so, how.	They would learn about the factors that would influence their diabetes. What you would have to add is blood sugar to relate the factors to. For someone newly diagnosed they could learn a lot from this, especially if they look at it together with a nurse. I think it would be very relevant.

Table 22, Exit interview results participant 4

Appendix D.V Reflection survey participant 5

Reflective Questions	**Participant 5**
How did you experience this self-tracking week?	I do this more often so it was a very normal week for me. Sending in results is an extra checkpoint. For yourself it doesn't matter to send in the survey, which is nice on one hand but it can also be stressful.
Did the research meet your expectations? In what way?	Yes, I expected sending in measured values. I did not expect there would be the possibility to keep a logbook.
What was your overall impression of the week of data collection?	I am a fan of self-tracking because it makes you be more aware of your choices. It makes you more self-conscious.
How did you experience the surveys?	The question about steps was hard, because it is hard to guess steps. Logbook and data looked alike so that was confusing. The rest was clear.
Which questions were superfluous or lacking?	No, I don’t think so.
What would you have changed (added/removed) about the daily questionnaire?	I would combine the logbook and data explanation, or make them part of each other. I liked having the opportunity to enter how you feel.
Did the logbook section add any value to you?	Yes, in the sense that it makes you think about why you ate/drank more. It would probably have more effect if I would look at it way later than a week after tracking it.
What was your experience with tracking yourself via Google Fit?	I normally use this as well, I just had to switch Google accounts. It was easy in use.
What was your experience with answering the daily surveys?	---
When filling in the surveys, there was a logbook option. How did you experience answering this question?	----
You had the option to set a continuous or daily reminder. What did you choose, why, and	I chose 1 daily reminder. This was enough.

how did you experience this?	
Visualisation Questions	
Open the Tableau visualizations. Please look at all of them and explain to me what you see.	In the overview I can see a clear difference between how much I walk and how much I exercise. I eat about the same every day so that is good. I find mood hard to see with the line alone, I need to keep the figures next to it to make sense out of it. I clearly get happier when I eat more food. Does not discover the hovering option.
Vis 1: What is your first impression of the results?	My calorie count is a bit higher than I'd like it to be. When I see such a graph I directly see that I eat more than I want, and that I get happier when I eat more food. Which is also my problem.
Vis 1: Can you understand anything that can be seen on this graph?	Yes, sadly Google Fit did not add how many calories I burned but after an explanation how they would be displayed this sounds like a good way to show the values!
Vis 1: Which correlations do you see?	Mood goes up when I eat more.
Vis 1: Did you learn anything from this data visualization? If so, what did you learn?	It confirmed something I already knew.
Vis 1: Is this new information to you, or is this something you are already familiar with?	Knew this already.
Vis 2: What is your first impression of the results?	I can see that some days I move a lot and other days I go for a walk. This is because I don't walk unless I plan to do this.
Vis 2: Can you understand anything that can be seen on this graph?	Yes. I had to look at it for a bit longer because mood and sport are both in this graph.
Vis 2: Which correlations do you see?	That sports do not make me happy.
Vis 2: Did you learn anything from this data visualization? If so, what did you learn?	Yes, that sports and movement do not make me happy.
Vis 2: Is this new information to	This is not new to me.

you, or is this something you are already familiar with?	
Vis 3: What is your first impression of the results?	My highest mood is on the day that I drank the most alcohol. I think my mood is high not because of the alcohol, but because I was with friends while drinking this. The social factor made me happy. Next to this, I sleep less on days that I drank alcohol because I was home late.
Vis 3: Can you understand anything that can be seen on this graph?	Yes, everything is clear! The only thing is that it looks like I did not enter my mood on day 1. But I drank 5 glasses of alcohol ánd my mood is 5. So the circle representing mood disappears behind the alcohol circle.
Vis 3: Which correlations do you see?	No, the data deviates. Only that I sleep less on days that I drink alcohol, because I am home late.
Vis 3: Did you learn anything from this data visualization? If so, what did you learn?	No
Vis 3: Is this new information to you, or is this something you are already familiar with?	-
Vis 4: What is your first impression of the results?	That all my data is quite constant except for the amount of steps a day.
Vis 4: Can you understand anything that can be seen on this graph?	I have to look at it a bit longer to understand it but it is very clear to me.
Vis 4: Which correlations do you see?	No
Vis 4: Did you learn anything from this data visualization? If so, what did you learn?	-
Vis 4 : Is this new information to you, or is this something you are already familiar with?	-
When filling in the surveys, there was a data explanation option. Did you notice this option? Did you use it? Did the answers to this question as	Yes it adds something. It explains why a value is low or high. You get a better feeling about yourself because you can explain it.

displayed in the graph add anything to your self-reflection?	
Questions after showing the visualization concerning the visualization and overall concept	
Would you consider using an application like this in the future?	If it would combine everything that this research did, yes. I have multiple apps that I use to track things now but that tracks everything separately. Google Fit is only sports, other apps only track food. You can't see how those things relate to each other when they are all separated. So I'd use such an application!
What requirements would an application like this have to fulfil for you to use it?	It needs to be easy to enter things without having to look through thousands of pages before finding the thing you want to enter. Maybe you should be able to choose what to add and what not. Alcohol for instance is not interesting to me. I am a student so my alcohol intake would not change if I track it. Maybe it should be linked to other apps as well so everything automatically goes to Google Fit.
Would you be motivated to continue tracking yourself? What would you track and what wouldn't you track?	Steps and alcohol are not interesting to me. Food is especially interesting to me now because I am trying to lose weight. Steps are fun but don't tell me a lot. So food and exercise would be the most interesting.
Did you find relevance in tracking your body functions?	Yes
Did you feel more pressure to eat healthy because you were tracking your calories and showing them to the researcher for this research? Did this make you eat healthier than normal or is this week representative?	Yes it pressures me, that is why I normally use a calorie tracker as well when I notice I start snacking more. It gives you self-control. I don't start eating healthier but I do snack less.
You had the option to keep a logbook. After the week of tracking, you were shown a summary of your logbook input. Do you like having this option? Does it add anything for you?	I have a sort of logbook myself. What I would like is having buttons like '+ sports, + birthday', easy abels. That is easier than text and still tells the story behind the data.

Which visualization was the easiest to understand?	The calories, because it is very clear and easy to understand correlations.
Which visualization was the most relevant to you? Rank them 1-4. Why this order?	Calories - overview - sport - alcohol Right now I am watching my calories. The overview is nice because it shows everything at the same time. Mood and sports combined does not have my interest nor does alcohol.
Did the visualization make you see correlations that you would not have made without the visualization?	What is really interesting to me is that sport really has no effect on my mood at all. I always thought it was true but I had nothing concrete to base this on. And it also surprises me to see that sleep does not affect my mood, I used to think this was a big deal.
The visualization, combined with the tracking options are a concept version for an application. This application would allow newly diagnosed Type 2 Diabetes patients to get started in regulating their Diabetes. Do you think newly diagnosed Type 2 Diabetes patients could benefit from self-tracking? If so, how.	Yes I do think so, it gives an extra controle. I know what it is like to plan a hospital visit and wait on it for weeks. In those weeks, it is nice to see how well you are doing yourself by using such an app. If you keep up well it will work, you should not track only half of the time.

Table 23, Exit interview results participant 5

Appendix D Visualization results

Appendix D.I Visualization participant 1

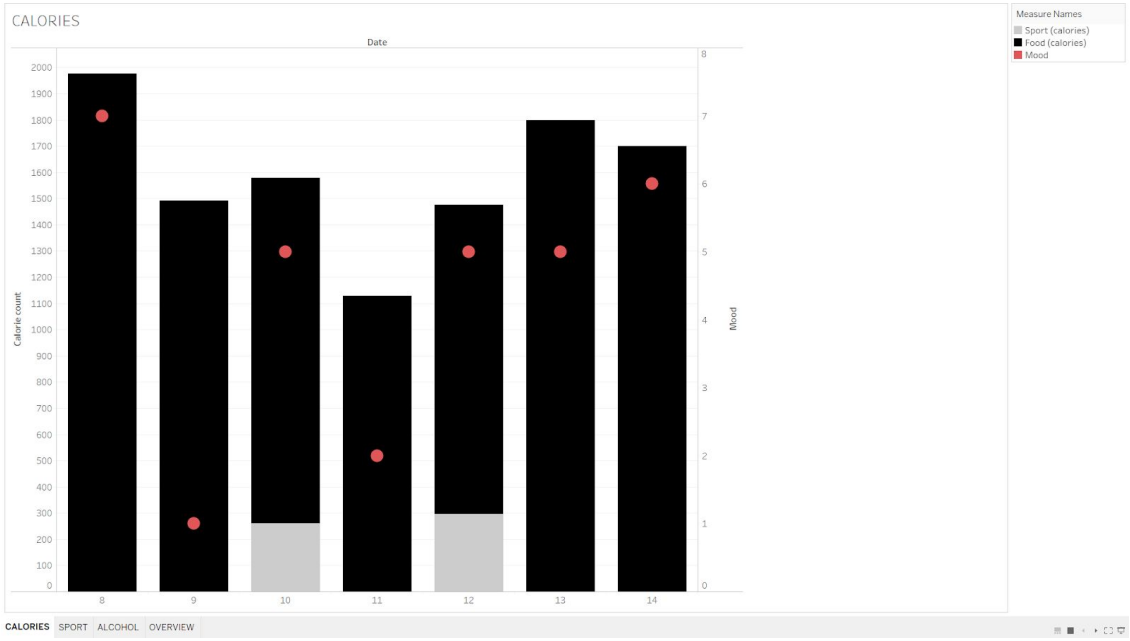


Figure 44, Calorie visualization participant 1

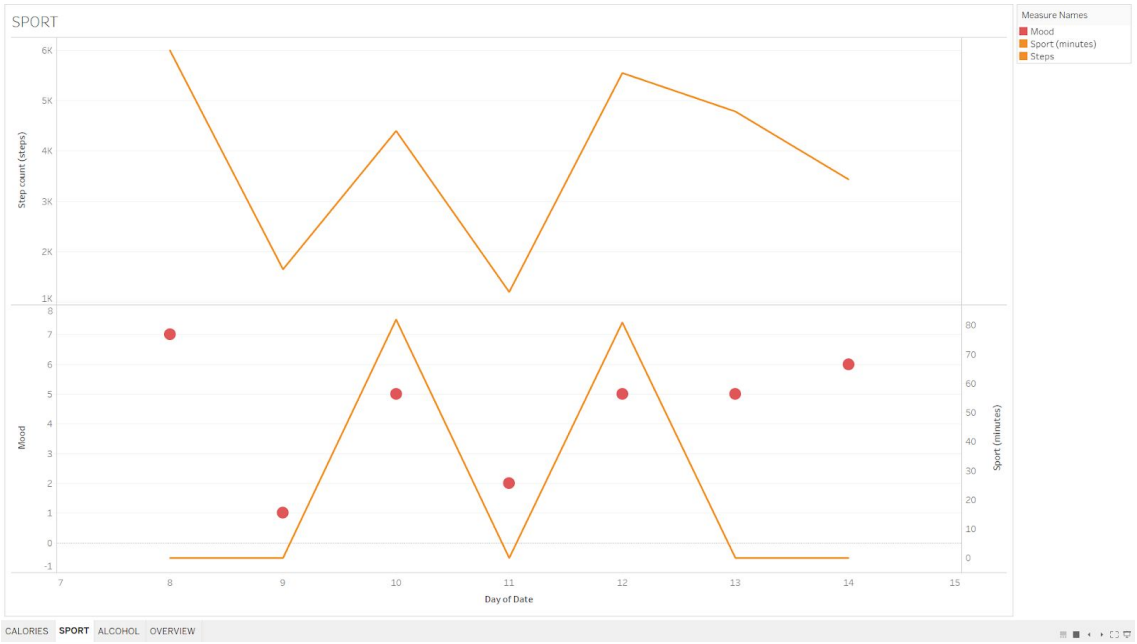


Figure 45: Sport visualization participant 1

Figure 46: Alcohol visualization participant 1

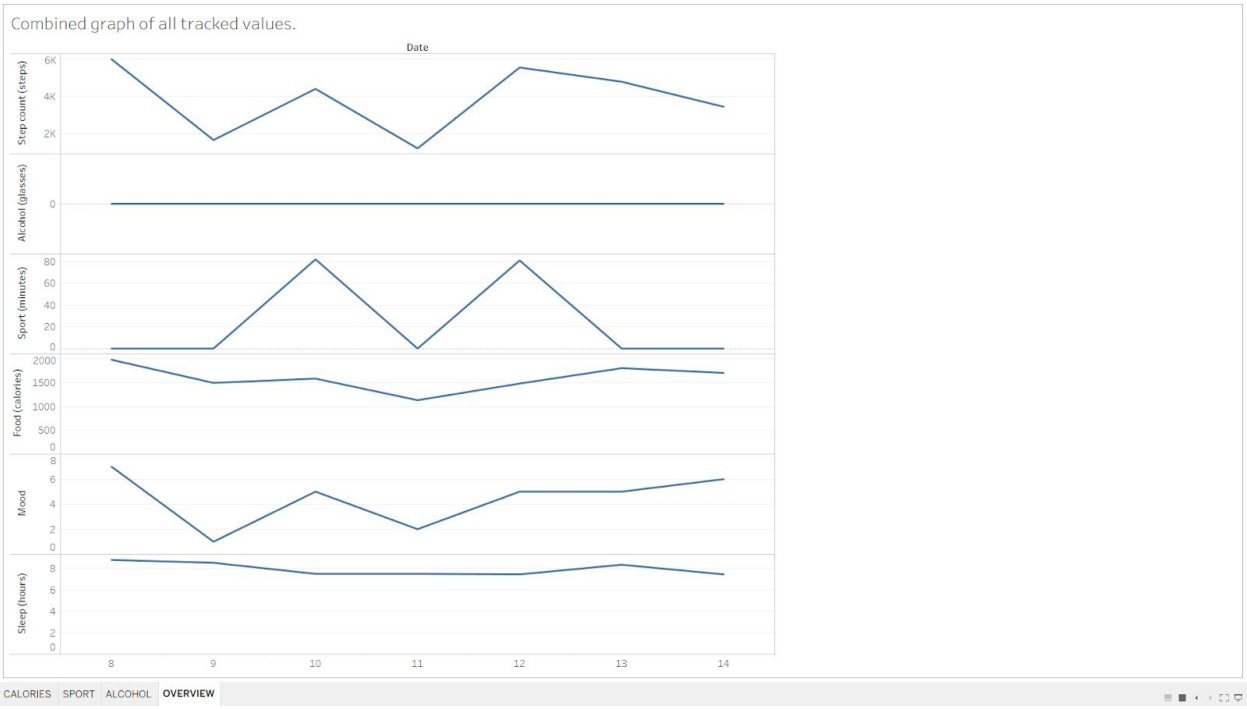


Figure 47, Overview visualization participant 1

Appendix D.II Visualization participant 2

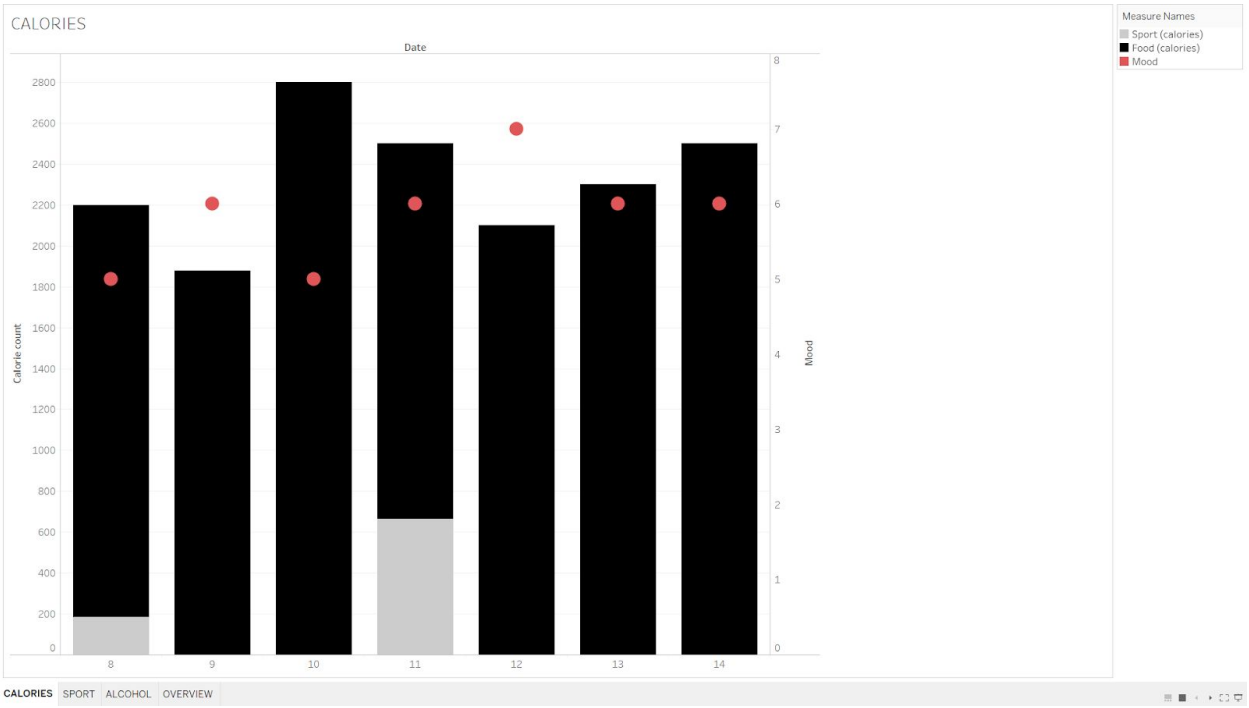


Figure 48, Calorie visualization participant 2

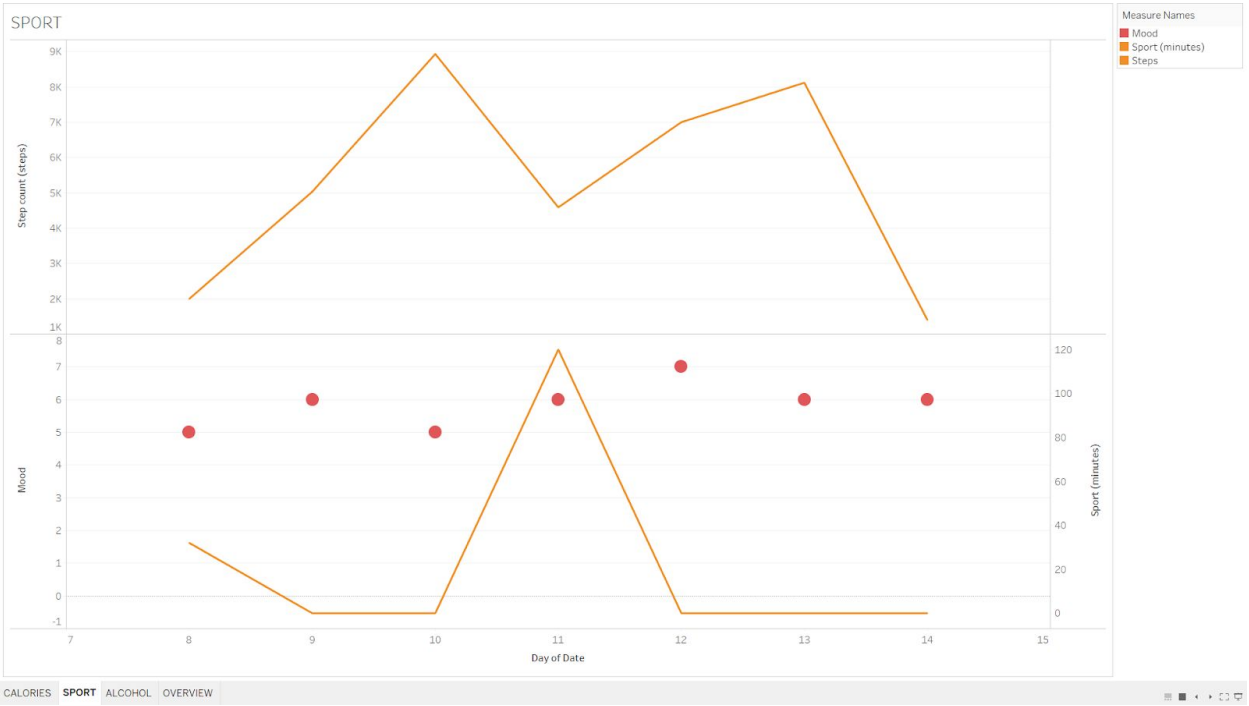


Figure 49: Sport visualization participant 2

Figure 50: Alcohol visualization participant 2

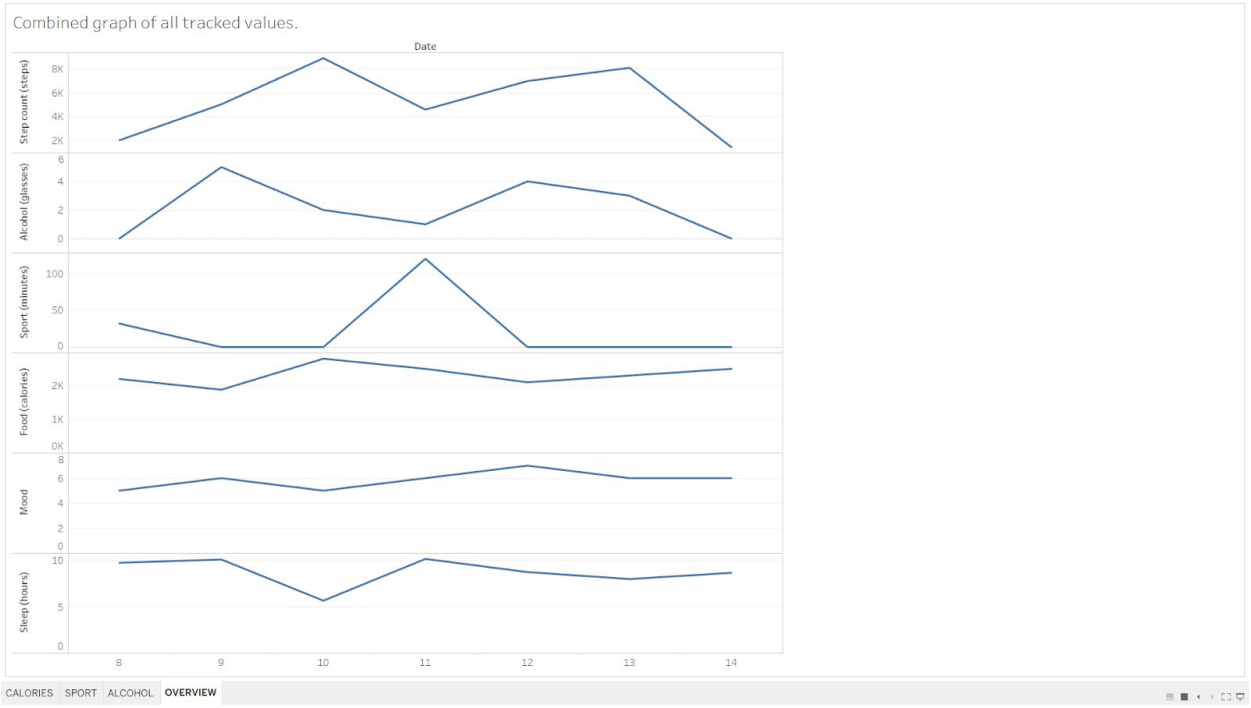


Figure 51, Overview visualization participant 2

Appendix D.III Visualization participant 3

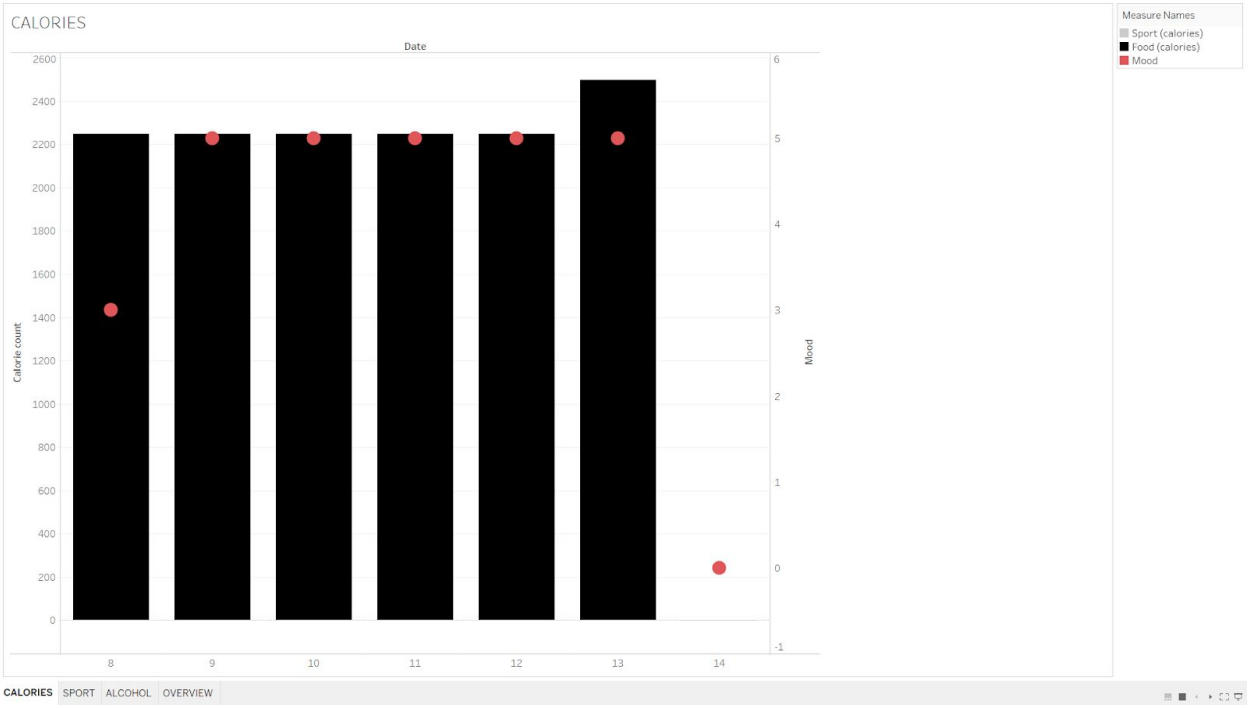


Figure 52, Calorie visualization participant 3

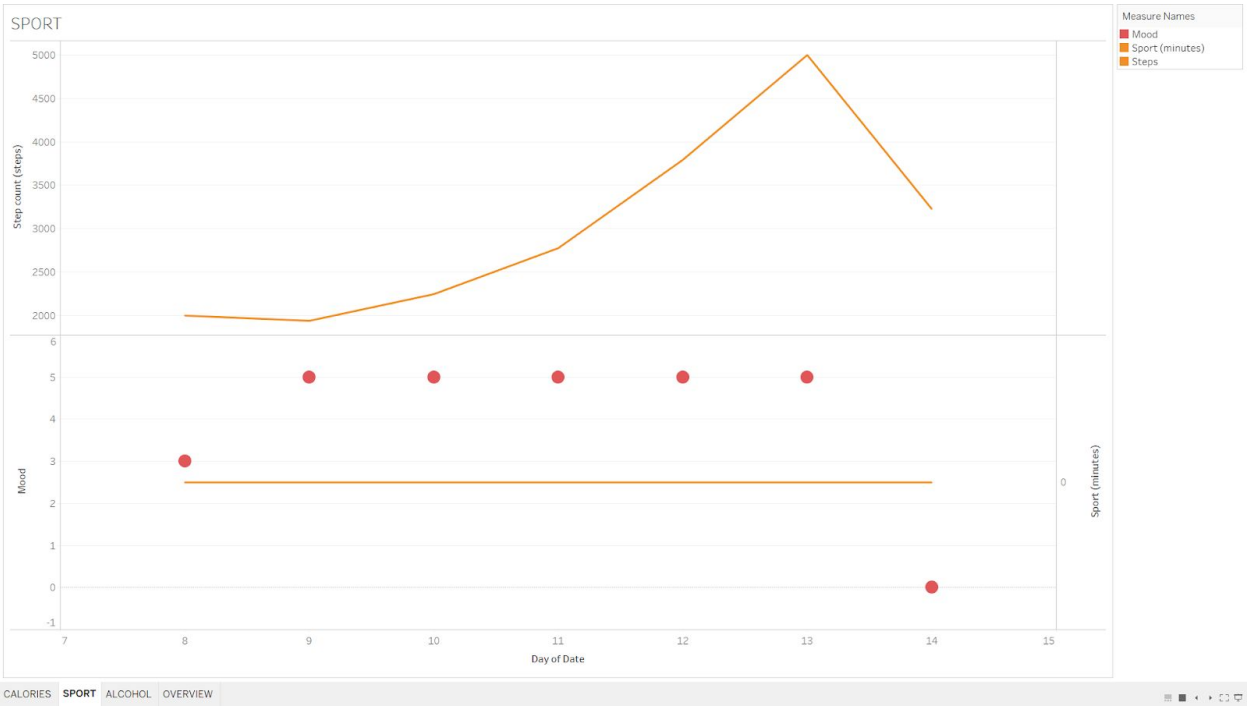


Figure 53: Sport visualization participant 3

Figure 54: Alcohol visualization participant 3

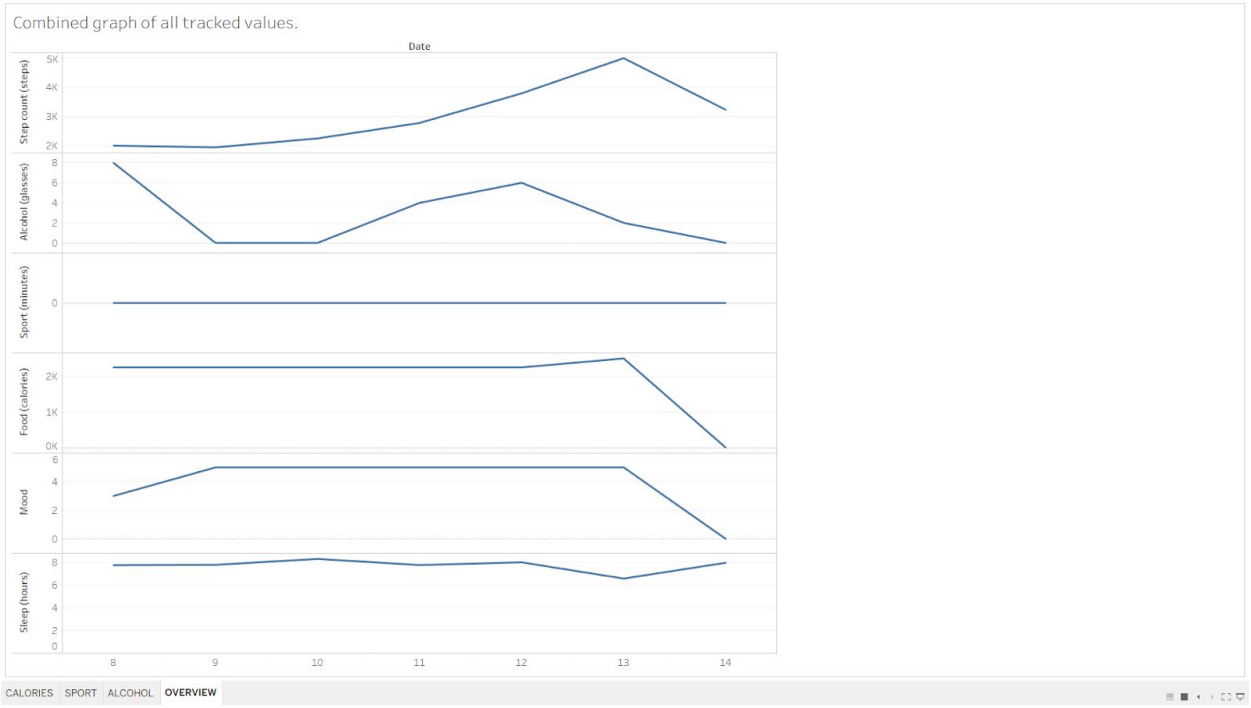


Figure 55, Overview visualization participant 3

Appendix D.IV Visualization participant 4

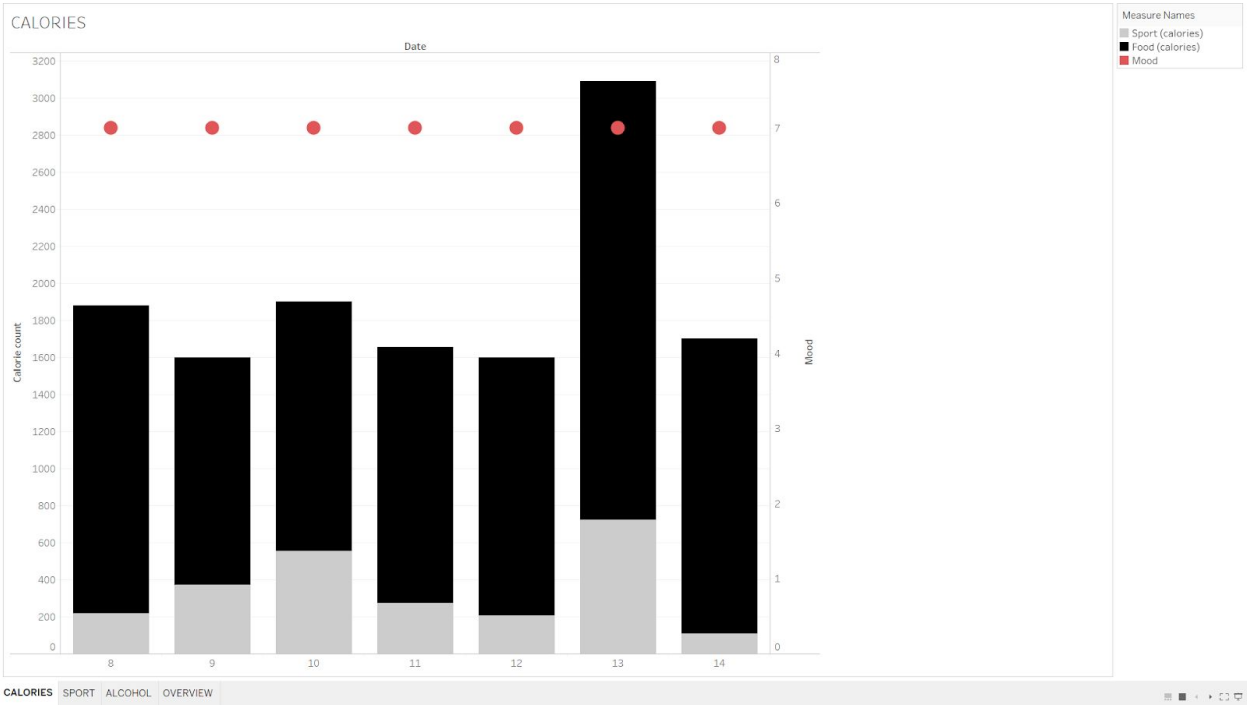


Figure 56, Calorie visualization participant 4

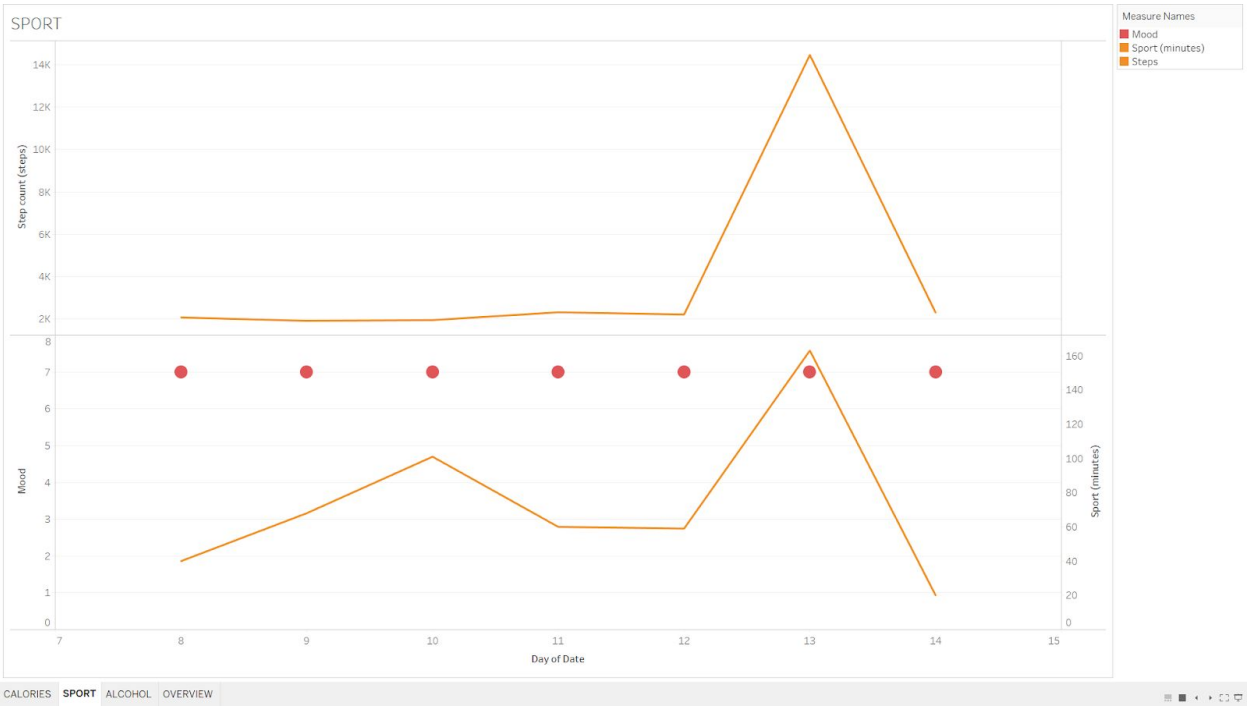


Figure 57: Sport visualization participant 4

Figure 58: Alcohol visualization participant 4

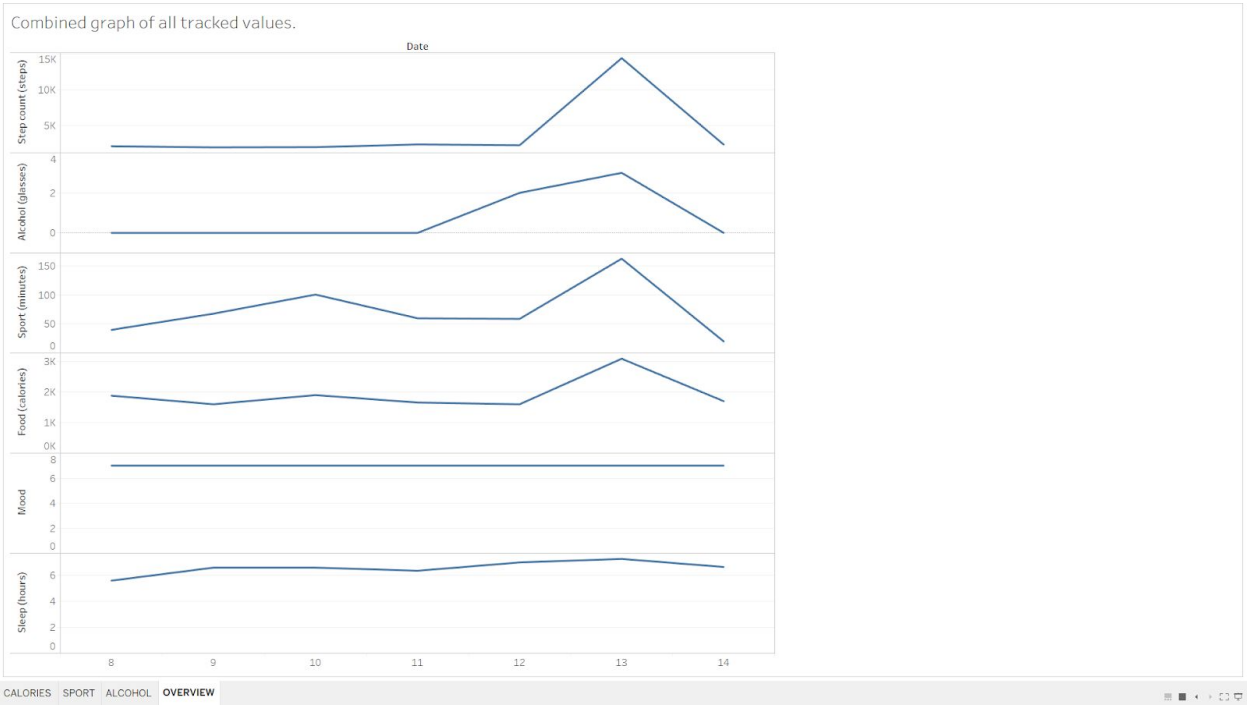


Figure 59, Overview visualization participant 4

Appendix D.V Visualization participant 5

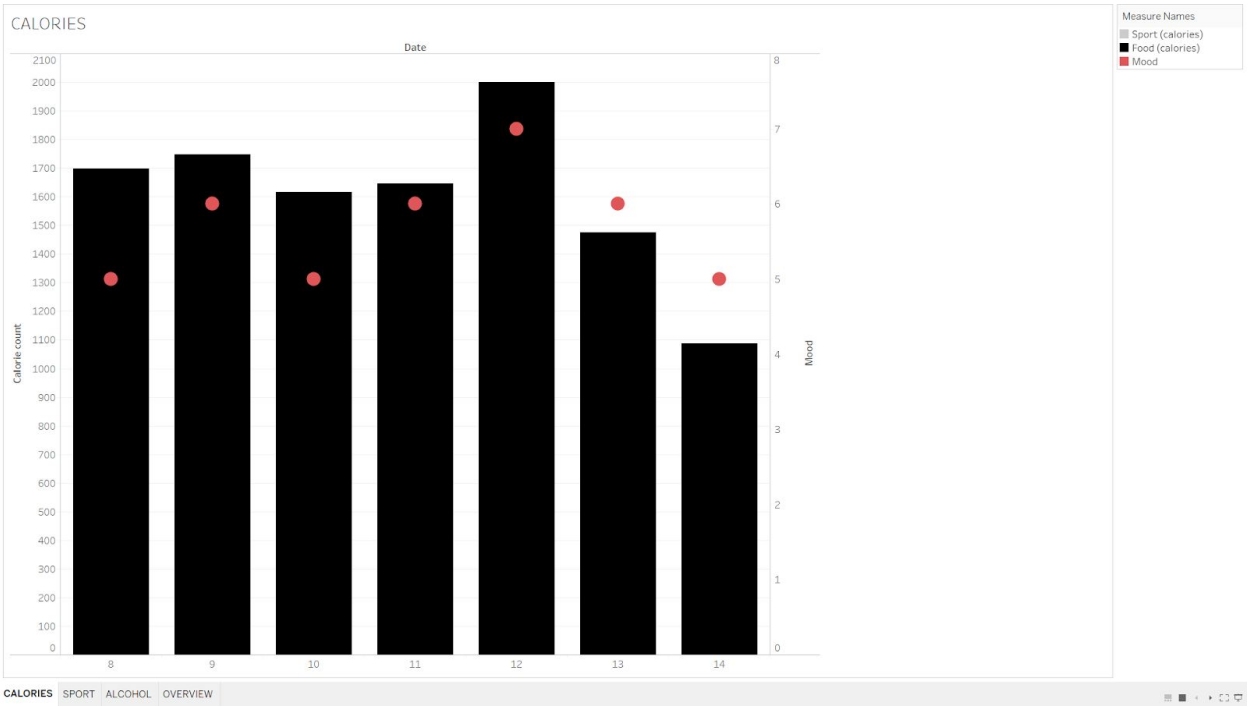


Figure 60, Calorie visualization participant 5

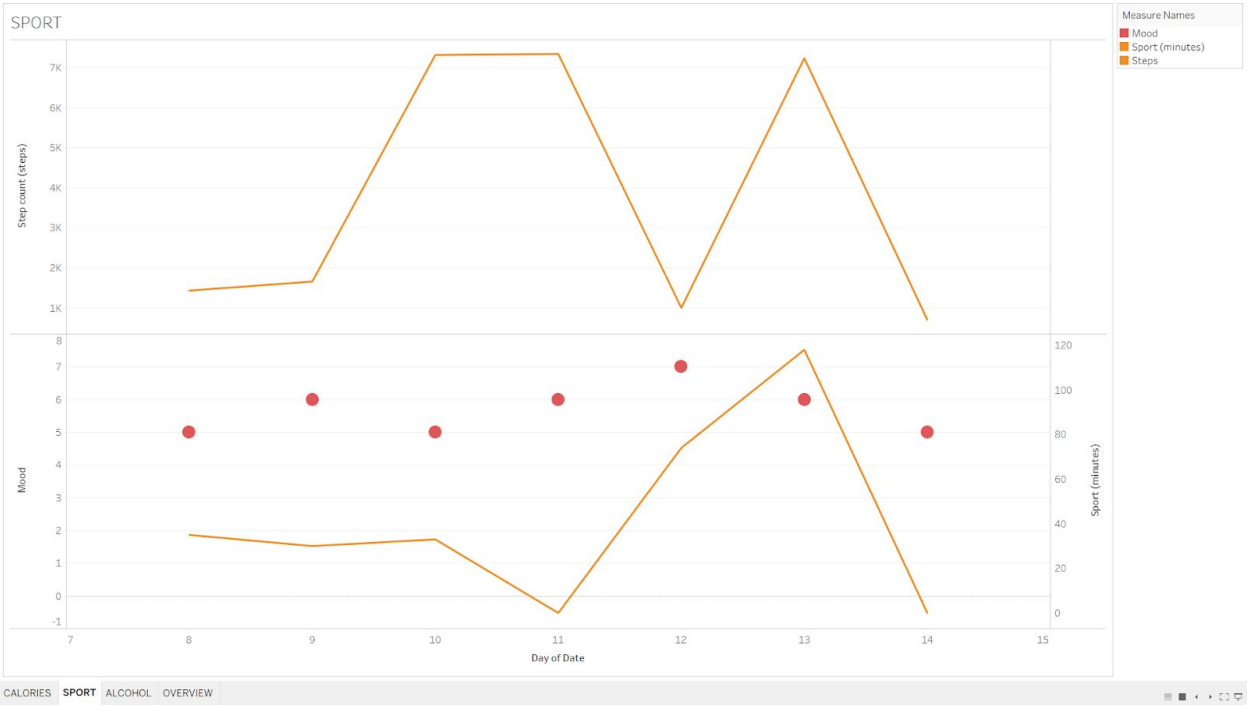


Figure 61: Sport visualization participant 5

Figure 62: Alcohol visualization participant 5

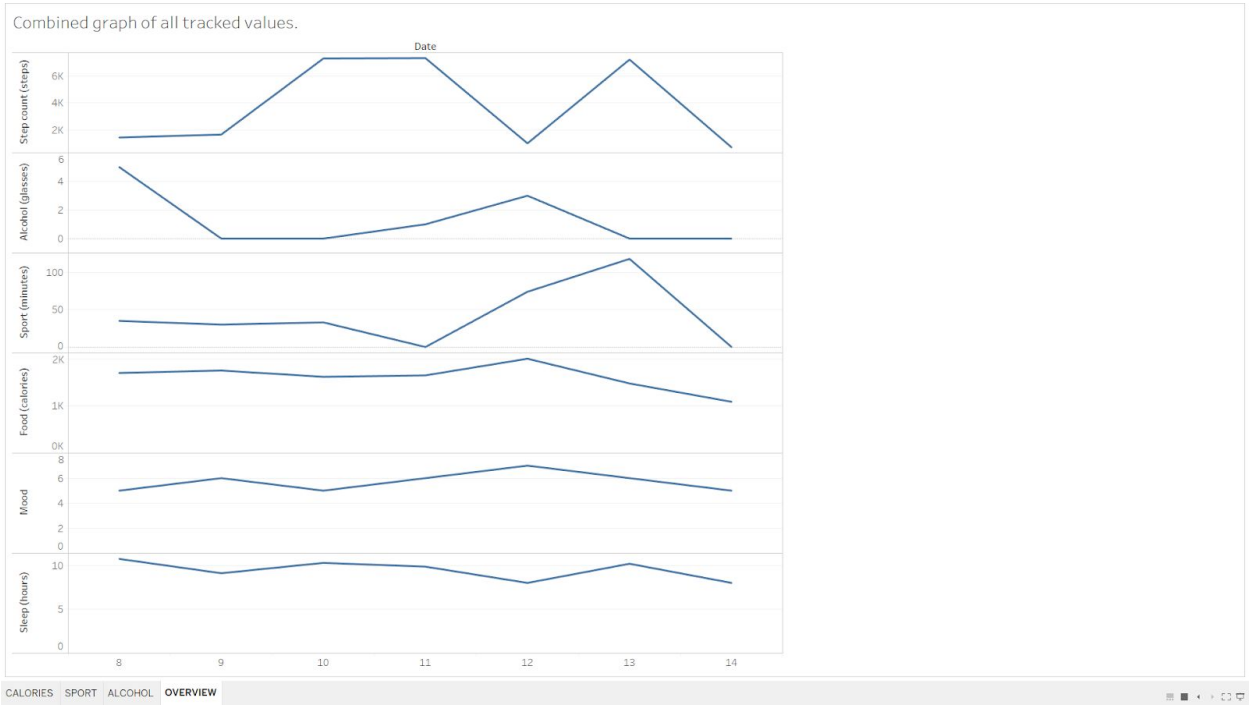


Figure 63, Overview visualization participant 5