Investigating reflective food tracking and the effect of domain knowledge on personal information system users

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Abstract

Global malnutrition is one of the worlds greatest health challenges. Various human computer interaction approaches to aid people in achieving healthier eating behaviour have been developed over the time. These approaches are of modernistic nature which has come under criticism in recent years where reflective design has been proposed as the alternative. The effect of tracking method, photo based or traditional, and the influence of domain knowledge or the absence thereof was studied. Sixty participants used one of four constructed smartphone applications over a period of two weeks. Photo based tracking was found to be more enjoyable compared to traditional tracking. The presence or absence of domain knowledge had limited to no effect.

Declaration

I hereby declare that this thesis is my own work. Any work that is not my own is acknowledged as references. This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

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List of acronyms

WHO	World Health Organisation
FAO	Food and Agriculture Organisation
kcal	Kilocalorie
RQ	Research question
SRQ	Sub-research question
UMC	Utrecht Medical Centre
APA	American Psychological Association
GNKQR	General Nutrition Knowledge Questionnaire Revised
SUS	System Usability Scale
P	Photo tracking
PK	Photo tracking & domain Knowledge
T	Traditional tracking
TK	Traditional tracking & domain Knowledge
IMI	Intrinsic Motivation Inventory
SIMS	Situational Motivation Scale
TSRI	Technology Supported Reflection Inventory
UU	Utrecht University

1. Introduction

Fighting malnutrition is one of the world's greatest health challenges. Malnutrition refers to the notion of excesses, deficiencies or imbalances in a diet that result in detrimental health effects. According to the World Health Organisation (WHO) as of 16 februari 2018, 1.9 billion adults are overweight while 462 million are underweight. Worldwide obesity rates have nearly tripled since 1975, and it is estimated that 41 million children aged 5 or younger suffer from being overweight. The vast majority of the world population lives in countries where obesity kills more people than people who are underweight [WHO, 2021]. Furthermore, the Food and Agriculture Organisation (FAO) estimates based on the 2017 global nutrition report [Hawkes and Fanzo, 2017] that *"88% of countries face serious burden of either two or three forms of malnutrition: acute and/or chronic undernutrition, micronutrient deficiencies, obesity and diet related diseases including type II diabetes, cardiovascular diseases and certain types of cancer."* The societal, medical and economic impact of global malnutrition are enormous. Various malnutrition statistics and visualised in Figure 1.1.

Food associated with negatively impacting health is typically more available and cheaper, such as foods high sugar and salt, resulting in the rise of overweight and obesity in both first and third world countries. It is even possible to be overweight while suffering from undernutrition due to the lack of micronutrients. This phenomenon, unfortunately, is quite commonplace.

This thesis attempts to combat this global malnutrition problem by harnessing the power of modern technology in the form of personal informatics with a reflective approach. Personal informatics is defined as *"systems as those that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge"* [Li et al., 2010]. For example, smartphones with the right app can be used as a personal information system. The fitbit is also a well known example. Typically, many approaches are of modernistic nature where the researcher or developer dictates what is desirable behaviour change. Modernistic approaches have been criticised in recent years which resulted in the idea of reflective design where the user is

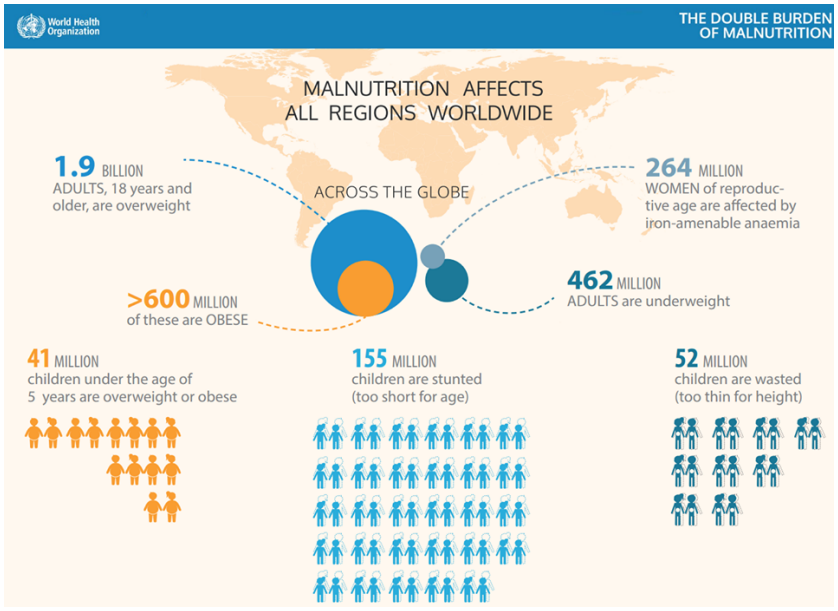

Figure 1.1: Global malnutrition statistics showing how malnutrition affects people on a global scale. [WHO, 2018]

being supported to exhibit to behaviour they want to exhibit without dictating what the user should do. Related works appear to point towards a need to understand how to design for reflection and how nutrition knowledge influences the user when using reflective personal information systems.

The next section starts with laying a theoretical foundation to reason about food and nutrition followed by the related work section discussing reflective informatics, food journaling, mindfulness and the research questions. The research questions were proposed based on the literature findings which can thus be found towards the end of the related work body. The section after the related work section is the method section in which the way the experiment was carried out will be discussed. The results will be discussed after the method section. Finally, the thesis closes with a discussion, conclusion and recommendations for future work.

2. Background

A theoretical framework to reason about food and nutrition is required since the chosen domain is food and nutrition. What will be discussed is why nutrition is important, a framework to classify foods, eating behaviour mechanisms, and daily recommended intakes. A summary is provided at the end.

2.1 Nutrition

A healthy diet is vital for solid nutrition and good health. It protects against many diseases such as cardiovascular diseases, diabetes, metabolic diseases and much more. Consumption of a variety of food is essential. A common and widespread way to classify food is using the six nutrient group classification framework [Deschênes, 2014]. The six nutrient groups are: carbohydrates, proteins, fats, vitamins, minerals and water. Carbohydrates, proteins and fats are typically grouped under the umbrella term 'macronutrients'. Vitamins and minerals are typically referred to as 'micronutrients'. This classification is very widespread as it is also used by the World Health Organization (WHO), Food and Agriculture Organization (FAO) among many other companies and institutions. The classification system is visualised in Figure 2.1.

The notion of a type of food that is consumed in large quantities providing people with the bulk of their energy is known as a macronutrient. Prentice identifies four classes of macronutrients: carbohydrates, proteins, fats and alcohol [Prentice, 2005]. Alcohol might be a surprising mention here as it is not included in the six nutrient groups. The reasoning is that alcohol does

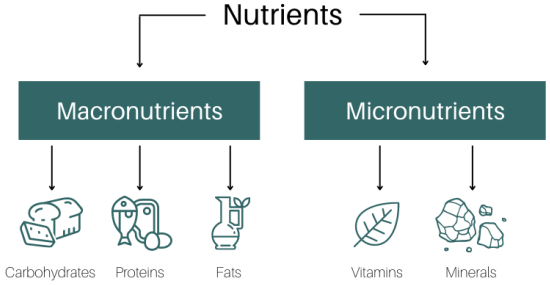

Figure 2.1: Common nutrient classification system. [Kay, 2021]

contain a large amount of energy
but it has zero nutritional value. Therefore, it is considered its own macronutrient category but is not included in one of the six nutrient groups. Water is also consumed in large quantities, and essential for biochemical processes, but it does not contain much energy and is therefore not considered a macronutrient. Micronutrients are nutrients that are only required to be consumed in small doses. Two different classes of micronutrients exist; vitamins and minerals. The next three sections further explore macronutrients, micronutrients and water respectively.

2.1.1 Macronutrients

Carbohydrates, proteins and fats are known as the macronutrients. Together they supply the bulk of energy in addition to facilitate biochemical processes [McKinley Health Center, 2014].

Carbohydrates can be found in many types of foods. Naturally they can be found in foods like potatoes, tubers, pasta and rice, but also in certain fruits such as apples and bananas. They are also present in processed foods such as cookies. Many types of carbohydrates exist, each having its own chemical formula. They are needed by the human body for energy and intestinal health. Generally speaking, carbohydrates can be categorised into simple carbohydrates, complex carbohydrates and fibre [McKinley Health Center, 2014].

Simple carbohydrates can be broken down further into monosaccharides and disaccharides. Monosaccharides only contain one type of sugar, such as glucose or fructose. Disaccharides contain two sugars, one always being glucose. Maltose, lactose and sucrose, three types of disaccharides, are colloquially known as sugar. Complex carbohydrates are polysaccharides, consisting of long chains of glucose. These chains have to be broken in order for the body to use them as energy. Therefore, complex carbohydrates take longer to digest and provide more sustained energy compared to sugars. Fibre is a special type of complex carbohydrate distinguished by the inability of the human body to break these structures. Even though fibres are unable to be broken down by the human body, they are important for proper functioning of the digestive system [McKinley Health Center, 2014].

Fats are essential to a healthy diet as they provide the human body with the ability to absorb certain vitamins, maintenance of cell membranes, general bodily growth and development, organ cushioning and energy. They can be categorised in saturated fats, unsaturated fats and trans fats. Each category being a chemical variation of the same baseline chemical formula. Saturated and trans fats have been linked with increased risk of cardiovascu-

lar disease whereas unsaturated fats do not increase the risk for such diseases. Fats can for example be found in meat, oils, fish, grain products, butters and milk products [McKinley Health Center, 2014].

Proteins, built from amino-acids, are important because they provide the human body with the ability to repair tissue, enable proper immune function, in body synthesis of essential hormones and enzymes, and preservation of lean muscle mass. Many animal products contain protein such as meats, fish, cheese, milk, but also non animal products such as nuts and legumes contain protein. The human body cannot synthesise all the amino acids that it needs on its own and it is therefore important that the ones it cannot synthesise are included in one's diet [McKinley Health Center, 2014].

Calories

Macronutrients supply the bulk of energy the human body needs to operate. The energy in food can be measured and is typically expressed on calories or kilocalories (kcal). A calorie can refer to a 'small calorie' or a 'large calorie'. A small calorie is defined as *"the amount of heat required at a pressure of one atmosphere to raise the temperature of one gram of water one degree Celsius that is equal to about 4.19 joules"* [Merriam-Webster Online, 2020]. A large calorie is closely related to a small calorie and is defined as *"the amount of heat required to raise the temperature of one kilogram of water one degree Celsius"* [Merriam-Webster Online, 2020]. Therefore, one large calorie is equal to one thousand small calories. The abbreviation 'kcal' is commonly used to refer to the notion of a large calorie. All foods and drinks consumed contain a certain amount of calories. Additionally, the body burns a certain amount of calories over time for energy, varying individually. When a person consumes more kcal than the body can burn, then the person will gain weight. The inverse is also true where a person will lose weight when less kcal is consumed than the body demands.

2.1.2 Micronutrients

Vitamins and minerals together are known as micronutrients. Essential for a healthy diet, but in very small quantities compared to macronutrients. Many different vitamins exist which the human body needs in different quantities, typically expressed in milligrams per day (mg/day). The following vitamins are essential to the human body: A, B1, B2, B3, B5, B6, B7, B9, B12, C, D, E and K. How much vitamin should be consumed to avoid deficiency and to avoid over consumption varies in the world. Daily recommended intake also varies from country to country. Although vitamins are needed in small

quantities, deficiency can lead to severe issues. Vitamins come from many different sources. Most enter the body through diet, however, vitamin D can also be synthesised by the human body through sunlight exposure [Meyers et al., 2006].

Minerals enable the human body to carry out necessary biochemical processes. They can be obtained by eating plant based food, animal based food and drinking water. Only very small quantities are needed, varying per mineral. There are five minerals more prominently present and required by the human body; calcium, phosphorus, potassium, magnesium and sodium. Other minerals, needed in even smaller quantities, are also known as 'trace minerals'; sulphur, iron, chlorine, cobalt, copper, zinc, manganese, molybdenum, iodine and selenium [Meyers et al., 2006].

2.1.3 Water

Water is essential in the human body as it makes sure cellular homeostasis and vascular volume can be maintained. Additionally, it functions as a transport medium to supply nutrients and remove waste. Water can be consumed by drinking water, beverages and even by eating food. Too little will lead to dehydration which can impair mental function, physical performance, blood pressure among others. Consuming an excessive amount of water leads to hyponatremia which can lead to central nervous system edema, lung congestion among other detrimental effects on the body. Ingesting excessive amounts of water is hard to achieve, as healthy humans have a tremendous ability to shed excessive water. The maximum amount of water the body can handle before acute water toxicity depends on the kidneys and is typically 0.7L - 1.0L per hour. Enough water is typically consumed by adhering to bodily thirst cues [Meyers et al., 2006].

2.2 Food intake and behaviour

The previous section dealt with decomposing foods into nutrient groups and observing why they are important. The next section deals with how the previously described nutrients can constitute a healthy diet as well as shortly describing eating behaviour mechanisms.

2.2.1 Daily recommended intake

Consuming the appropriate amount of kcal depends on how many macronutrients one consumes. The FAO/WHO recommends that carbohydrates con-

tribute 55-75% to the daily energy intake. Daily recommended intake for protein is 0.8 grams per kilogram of bodyweight per day, or providing 8-12% of total energy. Fat consumption should be 15-30% of total energy as recommended by the FAO [Nishida and Nocito, 2007]. It is important to note that carbohydrates and fats supply 4 kcal per gram whereas fats supply 9 kcal per gram.

How much of each micronutrient should be consumed? The each vitamin and mineral has a recommended daily dosage, varying for different parts of the world. Sticking to the recommendations should suffice and provide the human body with enough nutrients to carry out its natural biochemical processes [Joint et al., 2007]. Macronutrients supply the bulk of energy, typically expressed as kcal in food science. Daily, men roughly need 2500 kcal, and women need roughly 2000 kcal. This varies individually depending on activity levels, metabolic rate, age, among many other factors [Meyers et al., 2006].

Foods often contain multiple nutrients in varying amounts depending on the food in question. This makes the task of following a diet that meets all the dietary recommendations quite a difficult one. What should I eat, and how much? Various efforts have been made to guide people towards a healthy diet by instructing them what foods, not nutrients, to eat. Healthy diets become much more approachable, understandable and achievable this way. An example of such an effort is the American 'Healthy Eating Plate' initiative.

The 'Schijf van Vijf', is a dutch initiative that guides people towards healthy eating choices similar to the 'Healthy Eating Plate' initiative. It translates the daily bodily requirements of carbohydrates, protein, fat, vitamins, minerals and water into distinct food groups. The idea is that a person should eat at least one food from each group per day. It serves as a more approachable way to understand what constitutes a healthy diet. The 'Schijf van Vijf' is shown in Figure 2.2. There is some discrepancy between the recommendations of the FAO/WHO and the Schijf van Vijf mainly terms daily recommended carbohydrate intake. The FAO/WHO recommends that 55-75% of the daily energy should come from carbohydrate rich sources whereas the Schijf van Vijf recommends this should be roughly around 35%.

A diet that works for every individual does not exist. Some people are allergic to certain types of substances in food such as lactose. Some people follow certain dietary guidelines, focussing on nutrition, or focussing on morals, ethics and the environmental impact of food consumption. These individual differences mean that beneficial diets and eating patterns having to be personalised.

Some interesting findings were observed in a meta analysis on food re-

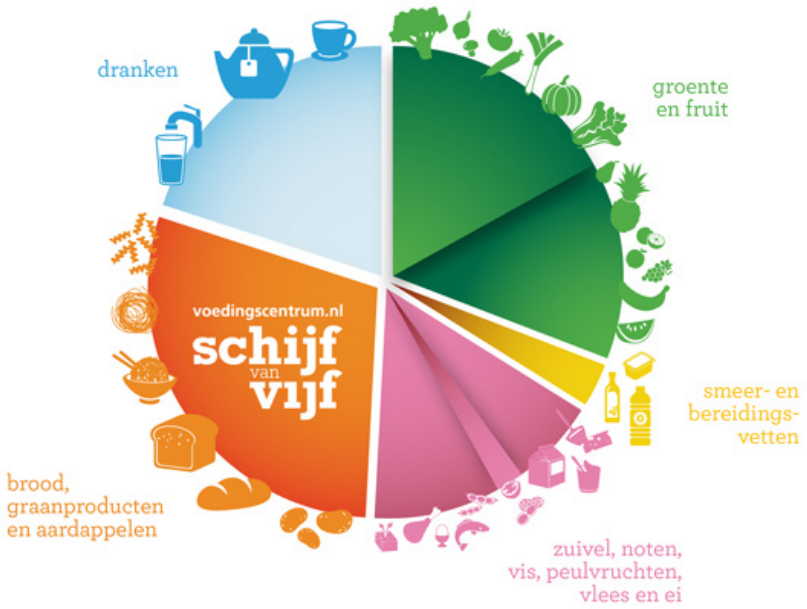

Figure 2.2: The 'Schijf van Vijf' consisting of five distinct groups; carbohydrates (orange), protein (pink), fats (yellow), fruits and vegetables (green), and water (blue). [Voedingscentrum, 2021]

lated studies by Harvard University covering mainly research from 2004 to 2012 [Harvard University, 2016]. The effect high quality nutrient sources have on health is far reaching. Generally speaking, the more processed or refined a food is, the worse it impacts your health. It does not seem to matter much in which balance the body is supplied with macronutrients, as long as there is somewhat of a balance. Eating nuts, contrary to popular belief, does not cause weight gain and have been linked with health benefits. Fruit juices contain as much sugars as sodas but contain more micronutrients. Current research remains inconclusive if meal frequency and snacking actually causes weight gain. However, multiple studies have demonstrated that larger portions served contribute to larger consumption without diminished consumption in subsequent meals.

2.2.2 Eating behaviour

Eating behaviour is governed by three feedback systems; homeostatic, hedonic, and cognitive [Gibbons et al., 2014]. Homeostatic eating is eating in response to perceived energy needs by the brain. The brain tries to regulate energy intake in such a way that not too little and not too much is consumed as both are detriments to bodily function.

Hedonic eating is related to the reward circuitry in the brain which evolved to reward when behaviour that increases chance of survival and procreation is exhibited such as eating. Activation of this system can lead to food consumption well beyond homeostatic needs. In some extreme cases the hedonic system can facilitate compulsive eating.

Cognitive feedback encompasses multiple sub feedback systems such as social, environmental and self regulation systems. In the cognitive system, the individual makes conscious effort to change their eating behaviour by for example consuming normally not consumed food or limiting portion sizes. It can be an effective strategy but requires constant effort, vigilance and willpower [Hall et al., 2014].

2.3 Summary

A good diet is essential for good health and disease prevention. Eating well requires the consumption of adequate amounts of macronutrients which consists of carbohydrates, fats and protein, in addition to the consumption of adequate amounts of micronutrients which consists of vitamins and minerals. Macronutrients supply the bulk of energy next to enabling biochemical processes. Energy consumption is typically measured in kcal. How much each

person needs to eat on a daily basis varies from person to person depending on age, activity levels, gender among other factors. Furthemore, humans also need adequate amounts of water.

The "schijf van vijf", is a dutch initiative that translates the nutrients into food groups as a way to guide people towards healthy eating choices.

Eating behaviour is governed by three feedback systems; homeostatic, hedonic and cognitive. Homeostatic is related to natural hunger triggers when the body is running low on nutrients. Hedonic refers to the reward circuitry that happens when consuming foods. Cognitive means the sheer willpower of individuals to control behaviour. These three systems are intertwined and interact with each other.

An adequate amount of information and theory has been provided to reason about food and nutrition. The thesis relies in later sections on the fact that the reader understand the concepts mentioned here. The next section discusses personal informatics and reflective design.

3. Related work

This thesis was initially inspired by a paper that provided 'crumbs', daily food challenges, to users to promote engagement and mindfulness [Epstein et al., 2016a]. The paper attempted to take a reflective approach as opposed to the more frequently used modernistic approach in personal information system design. They did this by having people use an app on their smartphones to take pictures of certain foods to complete certain food challenges. I wanted to further iterate on this work and identified various topics to investigate; personal informatics, reflective system design, food tracking and mindfulness.

The recent developments in the previously mentioned topics will be discussed one by one. Firstly, work related to personal informatics and reflective design will be explored, then food tracking, followed by mindfulness. Each section has a summary. A summary of the entire related work section will also be provided followed by the proposed research questions based on the literature findings.

3.1 Personal informatics and reflective design

Personal informatics are *"systems as those that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge"* [Li et al., 2010]. People that decide to start using a personal information system to track data and reflect on it seem to fall into two categories [Epstein et al., 2015]. The first category are people that start tracking out of curiosity, the second category are people that started tracking with clear self defined goals [Baumer et al., 2014]. Goal oriented trackers were found to do substantial background research on the things that they were tracking and were very considerate in picking and modifying a tracking tool to support their specific needs.

The 'lived informatics' model is a proposed model to describe how people use personal informatics in everyday life [Epstein et al., 2015]. Models that inspired the lived informatics model are the stage based model [Li et al.,

2010] and the transtheoretical model of behaviour change [Prochaska and DiClemente, 2005]. The lived informatics model starts with the deciding stage, where people decide to track, followed by the selecting stage in which they select a tool to track with. Then three ongoing processes describe the tracking & acting process in which trackers collect, integrate and reflect on their data. People may exit the tracking and acting stage by lapsing, caused by either forgetting, upkeep, skipping, or suspending. The model appears in Figure 3.1.

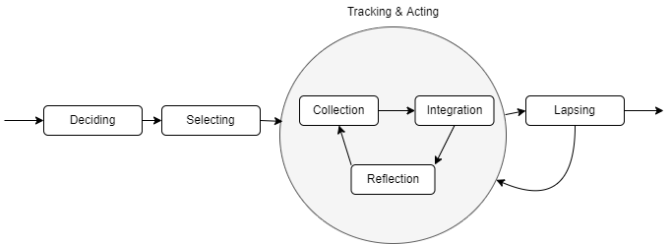

Figure 3.1: Redrawing of the lived informatics model.

The transtheoretical model of behaviour change has been used by numerous works cited in this thesis. The model helps understand how people adopt new behaviours and consists of five stages. The precontemplation stage, spanning more than six months, the contemplation stage, taking place within the next six months, the preparation stage, taking place within one month, the action stage, taking place in present time, and finally the maintenance stage where new behaviour is sustained for at least 6 months. Additionally, relapse, going back to a previous stage, may happen at any time [Prochaska and DiClemente, 2005] [Sutton, 1997]. People that want to change their behaviour typically will decide if they want to use self tracking systems in the preparation stage where they set the system up specific to their needs, after which they then use the system in the action stage to make concrete changes.

Designing personal information systems can be approached in a variety of ways. Three different design approach streams were identified; psychological stream, to effectively leverage cognitive psychology principles to design for personal informatics, the phenomenological stream, which deals with how technology is experienced and used, and finally the humanistic stream, which deals with cultural and social context in which personal informatics are used [Ayobi et al., 2016]. Ayobi, Marshall and Cox also observed that there was substantial research on how technology was used but less on how personal informatics is used in cultural and social context. Furthermore, they go on to say that translation interdisciplinary knowledge and utilising situated methods and sensing techniques are potential bearing directions for personal

informatics research. Additionally they also mentioned that different types of coaching is an under explored design space in personal informatics research.

Personal informatics is intended for users to reflect and learn from their own data. Hari Yetim argued in 2013 that human-computer interaction should focus on mindful and reflective approaches as opposed to modernist approaches [Yetim, 2013]. Modernist approaches are focussed on quantifying the world and figuring out what the most efficient method is to get from point A to point B. In line with Fogg's notion of reflection [Fogg, 2002], Brynjarsdóttir et al. observed in their corpus analysis of persuaded sustainability that nearly all papers had professionals or researchers determine what is desirable behaviour change and how to accomplish this behaviour [Brynjarsdottir et al., 2012]. This modernist approach is something which Brynjarsdottir et al. critique. They claim that modernist approaches have failed to produce meaningful solutions and are more focussed on repetitions rather than inventiveness. Mindful and/or reflective approaches focus more on supporting the user in making their own decisions. Although perhaps a slower process to achieve certain goals, the process is more meaningful and supports the user to better to sustain their altered behaviour. Thus, reflective design is perhaps worth investigating, which has been done by some researchers. However, the approach is still very new and mostly theoretical thus calling out to be studied in practice. Furthermore, 'microboundaries', small obstacles in technology used prior to an interaction preventing automatic or rushed behaviour, can enhance reflection, support mindful interactions leading to less errors and support for behaviour change [Cox et al., 2016]. In short, various cited work argues that modernist approaches might not always be best.

Baumer et al. found that not many papers that are aimed at reflection or reflective design cited a definition [Baumer et al., 2014]. The ones that did cite a definition had a very basic and surface level definition. Most papers that did cite a definition cited Schons definition: *"Practitioners solve these problems through use of conscious analysis of what they are experiencing and why their usual actions are not helping them to work effectively"* [Schön, 1938]. Reflection according to Schon happens in the moment. This observation of reflection happening in the moment is supported by Choe et al. which found that reflection happens when data is captured [Choe et al., 2017]. Whooley et al. acknowledges that personal informatics can support schons definition [Whooley et al., 2014]. Other findings suggest that reflection can also be about looking back at past actions and decisions and judging them as to why they produce the result that they produce. Thus, there is a distinction to be made between reflection-in-action and reflection-on action [Ploderer et al., 2014]. Reflection can further be decomposed according to Fleck's levels of reflection framework [Fleck, 2012]. Furthermore, Baumer

et al. observed that reflection per se is not measured, but instead it is assumed that reflection constitutes something which can and then is measured.

Three sequential phases to design for reflection have been identified [Baumer, 2015]. These phases are 'breakdown' followed by 'inquiry' followed by 'transformation'. At first, a puzzling situation is encountered, something surprising or confusing. Inquiry is then the conscious effort to know more and a desire to solve the puzzling situation. Transformation is then the actual change in behaviour. This described phenomenon could be related to cognitive dissonance theory. Cognitive dissonance theory is the idea that a person holding two or more different beliefs experiences psychological stress. The person will try to return to a state of cognitive consistency as a result of the experienced stress [Festinger, 1962]. During the breakdown, cognitive stress is experienced due to the lack of knowledge as opposed to two different beliefs. Thus, a person seeks cognitive harmony by expanding knowledge or beliefs. Baumers idea might not hold in all cases as there are a substantial number of people that start investigating themselves out of curiosity, not a puzzling situation. Thus, there is a need for a theoretical framework to account for this group of people.

People are eager to explore their own data when people are offered a clever visualisation [Choe et al., 2017]. They try to explain interesting emerging patterns from the visualisations often accompanied by recalling context and triggering forgotten memories. To interpret data, proper domain knowledge is required. Worsley calls out for research that investigates the ways people use food related knowledge [Worsley, 2002]. Worsley also mentioned that observing the effect of nutrition knowledge on final behavioural outcomes are unlikely to show exactly how nutrition knowledge influences behaviour. However, nutrition knowledge is strongly correlated with positive food intake in regards to fruit, vegetables and fat [Wardle et al., 2000].

3.1.1 Summary

Personal informatics as defined by Li et al. are systems to aid the user in gathering information for the purpose of reflection and self-knowledge. Two groups of people have been identified that decide to use such systems. Group one starts out of curiosity, while group two has clear goals in mind and picks a system to suit their specific needs. The intention of personal informatics is that people can learn from and reflect on their own information, and help exhibit the behaviour that the user wants to exhibit. This stands in contrast to modernist approaches which have been critiqued in recent years.

Modernist approaches typically have the researcher or developer decide what the best way is to get from point A to point B, and focus more on

attaining a goal rather than the journey towards that goal. Reflective system design has been coined as the antithesis to modernist design. The goal of reflective design is to have people decide their own course of action based on their gathered data and situate their behaviour depending on real life events. There is not a field wide adopted definition for reflection although most work that does cite a definition cites schon.

Baumer describes three sequential phases that can assist to design for reflection; breakdown, inquiry and transformation [Baumer, 2015]. Breakdown refers to a puzzling situation, inquiry to the desire for knowledge to solve or better understand the situation, and transformation to behaviour change. This idea could be applied to the group of self trackers with clear goals in mind. However, the group of curious self trackers typically do not start tracking because they encounter a puzzling situation. Another theory to take into account when designing for reflection is the theory of cognitive dissonance. This theory states that people experience cognitive stress by holding two different beliefs and as a result try to return to cognitive harmony by returning to one non-conflicting belief.

There is relatively little work that explores how to design for reflection [Baumer, 2015]. Additionally, Ayobi, Marshall and Cox have called out for the need to better understand how personal information systems are used in cultural and social contexts.

These are the identified ideas, concepts and developments related to personal informatics research and reflective design. The next section investigates developments in the field of food tracking.

3.2 Food journaling

Food journaling is the practice of keeping track of the food that one consumes and can be effective in combating malnutrition. Weight-loss patients who regularly food journal lost substantially more weight compared to patients that did not engage in journaling [Hollis et al., 2008]. Journaling is also useful to track allergies, diabetes and other diet induced problems [Cordeiro et al., 2015b]. Additionally, food journaling increases mindfulness [Hollis et al., 2008].

Traditionally, questionnaires and recall are used to track food consumption. Sytske Runia, head of the dietetics department at the utrecht medical centre (UMC), explained that patients are asked to track their food consumption with pen and paper. However, the rise of modern technology enables new opportunities for more effective food journaling. Especially smartphone apps, harnessing to power of the internet to access food databases, barcode

lookups and other handy features allow the journaler to be more effective in their journaling practices. Food journaling however, is not without its own set of hurdles.

One barrier to entry is people not knowing what and how much to journal. Finding calories for each ingredient in a meal and estimating quantities is found to be difficult. In some cases, people will on purpose eat food that is easier to track such as prepacked food which is considered an unhealthier alternative thus defeating the purpose of journaling in the first place [Cordeiro et al., 2015b].

Many food journal application have a database connection to enable calorie and nutrient lookup. Many of these databases are community efforts which raises reliability concerns. Therefore, users might be discouraged to journal because they find the databases hard to use or notice incorrect entries [Cordeiro et al., 2015b]. Social context can also be a hurdle for food journaling. Journalers find it embarrassing to log food in social context such as restaurants. Furthermore, accurate logging in such context is nigh impossible since all the ingredients and amounts used are unknown. Buffets are especially challenging due to the very large variety of different foods.

Food journaling remains difficult even when it is consistently done to the best of people's ability. Forgetting to journal food during the day leads to inaccurate data which heavily discourages journalers to continue logging due to missed calories or nutrients. Other every day disrupting events like holidays can break the habit of food journaling. Once the habit is lost, it is difficult to regain. Furthermore, food journaling requires a high level of engagement which can lead to exhaustion and reduced compliance [Barrett-Connor, 1991].

Data hoarding, entering a lot of entries in the food journal at once, is also an issue as it leads to more inaccurate entries. An additional complication is partially consuming the food which makes food journaling that much more challenging. Sometimes people purposely do not journal something unhealthy that they ate.

Helander et al. found that out of 190.000 downloads, only 3% of the people used a food tracking app for more than a week [Helander et al., 2014].

Cordeiro, Bales, Cherry & Fogarty explored photo based food journaling to mitigate some of the drawbacks of food journaling. They showed that photo based food journaling effectively support the capture of food intake and the reflection thereof [Cordeiro et al., 2015a]. Photos are easily interpreted, supporting recall and reflection and it helps identifying eating trends, context and feelings associated with eating. Required nutrient intake varies individually depending on many factors such as age, activity levels, gender, height and so forth. Additionally, required nutrient intake varies within the

same person from day to day. Therefore, exact counting of nutrients might be of little value, especially considering the effort required to do so accurately. No or lower judgement was observed due to the fact that nutrient are not counted. Zepeda and Deal support the findings by observing that photo based food journaling compared to pen and paper based journaling increase in-the-moment awareness of unhealthy eating [Zepeda and Deal, 2008].

There have been efforts made to make food journaling easier by automating the process but unfortunately the fruits of this labor are not ripe for picking yet. Automatization might undermine the mindfulness aspect of food journaling [Cordeiro et al., 2015b]. One study showed that a wrist worn device which reminds people to log food when eating motions are detected is an effective method to support sustained food journaling with a low false positive rate [Ye et al., 2016].

3.2.1 Summary

Food journaling is an effective practice to combat malnutrition. Traditionally, questionnaires and recall were used but modern technology provides new opportunities to food journal. Many barriers exist in current food journaling practices such as not knowing what and how to journal, unwillingness to journal in social contexts and food database reliability concerns. The focus of many contemporary food tracking solutions seems to be counting calories and/or macronutrients.

Photo based food journaling was proposed as a way to mitigate many drawbacks. Research shows that photo based food journaling can effectively capture food intake and the reflection thereof. Photos are easily interpreted supporting recall and reflection and helps to identify eating trends, context and feelings associated with eating. With photo based food journaling, exact counting of nutrients and calories is not the focus. This could be leveraged as an advantage as counting nutrients and calories is a mentally exhausting and time intensive practice. By relieving some of that stress, photo based food journaling supports the user to journal more easily. Lastly, some efforts have been made to automate food journaling. However, such methods are not ready yet for real world use and automatic food journaling can undermine the mindfulness aspect of journaling.

These are the current developments in field of food journaling. Mindfulness has been touched upon in the previous sections. The next section will delve deeper into this concept.

3.3 Mindfulness

Mindfulness is a practice stemming from ancient eastern philosophy. The practice has been gaining popularity in the west in the past 40 years, especially in the recent 20 where it has seen exponential interest [Williams and Kabat-Zinn, 2011]. Jon Kabat-Zinn was the first to use the concept of mindfulness in a scientific context by developing the Mindful Based Stress Reduction programme at the University of Massachusetts.

Kabat-Zinn defined mindfulness as *"mindfulness means paying attention in a particular way: on purpose, in the present moment, and non-judgmentally"* [Kabat-Zinn and Hanh, 2009]. Alternatively, the American Psychological Association (APA) defined mindfulness as *"a moment-to-moment awareness of one's experience without judgment."* In this sense, mindfulness is a state and not a trait. While it might be promoted by certain practices or activities, such as meditation, it is not equivalent to or synonymous with them [Davis and Hayes, 2011]. Both definitions capture the two key points of mindfulness; the first key point being that mindfulness should be non-judging, the second key point being the that mindfulness is about awareness in the present moment.

Mindfulness practice in the realm of cognitive psychology is believed to increase self awareness, acceptance, reduced reactivity to thoughts and emotions and the ability to respond in a healthy manner to negative experiences [Linehan, 1993] [Linehan, 2018]. Traditional cognitive therapy strategies attempt to disassociate, avoid or avert negative thoughts whereas successfully practicing mindfulness involves a non judgemental and decentered view of the practitioners own thoughts and emotions while being aware of them [Baer et al., 2005] [Blackledge and Hayes, 2001]. Thus, the successful practitioner of mindfulness becomes (more) aware off and accepts their negative thoughts and emotions without judgement.

One mindfulness techniques will be explained to illustrate how practicing mindfulness might look like. The first mindfulness exercise is called 'the thought parade'. In this exercise, the participant imagines that their thoughts are written on cards carried by marchers in a parade. The task is to observe the parade of thoughts as they pass by, without judging or intention to act, merely observing [Heffner et al., 2002].

But why is increasing self awareness and diminishing impulsivity important? Most of our behaviour is driven by automatic, non-conscious mental processes [Bargh and Chartrand, 1999]. Mindfulness specifically seeks to break the automatism that steers most day-to-day behaviour. Preliminary findings indicate that there is indeed a negative relationship between prac-

ticing mindfulness and impulsivity [Mantzios and Wilson, 2015].

In the context of food, mindfulness can be used as an effective acceptance based strategy to improve eating behaviour. Practicing mindfulness reduces food cravings in an overweight and obese population [Alberts et al., 2010] [Kristeller et al., 2014] and deemed an effective practice to treat binge eating disorder [Kristeller and Hallett, 1999]. Mindfulness based strategies also decrease body image concerns and dichotomous thinking in a population of women with disordered eating behaviour [Alberts et al., 2012]. Arch et al. found that mindfulness increased enjoyment and desire to eat more. The effect is slightly stronger for pleasurable food such as chocolate compared to mixed food such as raisins. Furthermore, mindfulness decreases the intake of 'junk food' but does not increase the intake of healthy food [Arch et al., 2016]. An acceptance based approach was deemed successful in treating an 15 year old female with anorexia nervosa [Heffner et al., 2002]. Eighteen out of twenty-one examined studies found positive eating behaviour changes [O'Reilly et al., 2014]. Overall, mindful based strategies are gaining substantial empirical support in their effective to treat problematic eating behaviour [Baer et al., 2005].

Attempts to integrate mindfulness approaches in personal informatics has also been made. Epstein et al. investigated a design approach to promote engagement and mindfulness in human computer interaction. They attempted to do this by giving participants daily food challenges via an app [Epstein et al., 2016a].

Some studies observed that participating in a mindful based stress reduction program in fact did not affect emotional eating, uncontrolled eating, energy intake or vegetable consumption [Kearney et al., 2012]. Additionally, some psycho-education of the general public may be required to have mindfulness practice take off. Resistance to mindfulness was found where it was referred to as 'hippy dippy nonsense'. Furthermore, christian people felt they were betraying their faith by practicing something stemming from buddhism [Mantzios and Wilson, 2015]. Thus, effectiveness of mindfulness practices may heavily depend on the beliefs and values of the person practicing them.

3.3.1 Summary

Mindfulness means being in the moment aware without judging. It is therefore a state and not a trait. Jon Kabat-Zinn was the first to apply the concept of mindfulness in a scientific context by developing the Mindful Based Stress Reduction programme at the University of Massachusetts. Practicing mindfulness has various positive effect associated with it such as increasing self

awareness, acceptance, reduced impulsivity and healthier responses to negative emotions and thoughts. Mindfulness achieves these positive effects by disrupting the automatic and non-conscious mental processes which for the most part steer our day to day life. Most mindful based approaches seem to deal with eating disorders such as compulsive eating, emotional eating, anorexia nervosa and so on. The effectiveness of mindfulness is not clear cut across all studies. Furthermore, some psycho-education might be needed so that western societies are more open to adopt mindfulness based practices.

The next part provides a summary for the entire related work section followed by the research questions emerging from the literature.

3.4 Related work summary

Personal informatics is still a relatively young but also promising field. More and more personal informatics tools are becoming more affordable and popular which bears great potential. It is clear to see that there is a push for research on reflective approaches in personal informatics and human computer interaction in general. A substantial amount of work is still theoretical with a few papers investigating real world application. Researchers have called out for studies that study how people user personal information systems in cultural and social context.

Furthermore, it seems to emerge from the literature that domain knowledge when tracking is a key factor in tracking success and racking sustainability. Baumers model of breakdown, inquiry and transformation suggests that knowledge serves as a catalyst in the inquiry stage. Both Schon's definition of reflection, Ploderer's distinction of reflection-in-action and reflection-on-action, Fleck' reflection framework and the definition of personal informatics by Li et al. suggest that domain knowledge plays a key role in understanding why current behaviour is not effective in and how one has to change their behaviour. Furthermore, Epstein et al. identified a group of self trackers that already had clear goals in mind which did substantial background research to help them track and understand their own data, signaling that domain knowledge is required to be able to reflect better on tracked data.

Collecting data in real world situations in the context of food with personal informatics is not without its own set of challenges. Traditionally, food tracking is done by recall and questionnaires. However, with the rise of modern technology more lucrative solutions have been developed which typically focus on quantified goals and quantifying food intake. Yet, barrier to tracking exist; database reliability concerns, uncertain how or what to track, the general difficulty of tracking, not wanting to track in certain situations, and

the feeling of judgement, shame or obsession when tracking. Photo based tracking has been proposed as a method to mitigate these tracking barriers. Photo based tracking is heavily underexplored in scientific literature as the proposed method is quite new. Efforts have been made to deploy photo based food tracking to increase engagement and mindfulness by having participants complete daily food challenges by eating and photographing the consumed food. Additionally, initial results of photo based tracking versus traditional methods look promising.

Various mindfulness work states that mindfulness is more a state of mind than a practice. However, one can practice certain techniques to reach a mindful state. A mindful state is about becoming aware of thoughts, emotions and feelings in the present moment without judging. Typically the notion of mindfulness has been applied in an attempt to help people suffering from serious mental conditions such as anorexia nervosa and compulsive eating. Furthermore, mindfulness seeks to disrupt the automatic and non-conscious mental processes which steer our day to day behaviour.

3.5 Research gap

I identified the following research gaps. Firstly, there is a push from the scientific community towards the research on reflective approaches as opposed to modernist approaches. Most work is theoretical thus calling out for real world investigation. Secondly, there is a clear need to study to what extend photo based food tracking is more advantageous than traditional methods and how people use it in day to day life. Thirdly, many papers appear to contain underlying tones of, but never explicitly claim, the idea that domain knowledge enhances reflective practices. After all, how can one make sense of their data without adequate knowledge? However, this implied relationship between tracking, reflection, domain knowledge and behaviour change is underexplored. Many studies seem to hint towards this relationship but it has never been the focus of any study.

4. Research questions

Various angles and topics that ought to be studied further have been identified. However, this thesis will focus on the following observations. The need to investigate photo based tracking in real day to day scenarios, and the effects of domain knowleddge on individuals engaged in food tracking activities. I hypothesize that domain knowledge is a valuable component that helps people to more effectively reflect on collected data and thus achieve desired behaviour at a quicker pace as well as provide additional motivation to change.

Thus, proposed are the following research questions.

RQ1: How do people use personal information systems in social and cultural context when using photo based food tracking compared to traditional methods.

RQ2: How does the presence or absence of domain knowledge alter the use of personal information systems in social and cultural context?

Photo based food tracking refers back to reflective approaches whereas traditional methods refer back to modernist approaches. Modernist approaches focus on quantifying the world and determining the most efficient path to get to the goal [Brynjarsdottir et al., 2012] [Fogg, 2002].

Ferrara et al. reviewed the seven most popular diet tracking apps which all share modernist commonalities such as quantifying the world by calorie counting and being modernist in the sense that it puts emphasis on achieving the set goal [Ferrara et al., 2019]. Photo based tracking is reflective in the sense that it does not focus on quantifying the world. However, user goals with reflective approaches may or may not be quantified.

The proposed research question are quite abstract and thus sub-research questions have been constructed which can be found below. Part of the the lived informatics model describes how people use self tracking tools once they have decided on a tool to use [Epstein et al., 2015]. This part consists of three

iterative phases: collecting; where data is collected, integrating; where data is made ready to reflect upon, and reflecting; where the user reflects on gathered data. The integration phase can be either trivial or time consuming depending on the tracking tool. In this research, we look to trivialize the integration phase and thus focus on collecting data and reflecting on data. Furthermore, photo based tracking has been proposed as an alternative to traditional methods but lacks real world investigation. Helander et al. found that out of 190.000 downloads, only 3% of the people used a food tracking app for more than a week [Helander et al., 2014], strengthened by the observation that the 'food4thought' app saw diminished use over time [Epstein et al., 2016b], thus identifying a need to investigate how to design personal information systems in such a way that they promote motivation to track. It is hypothesized that domain knowledge may enhance and help trackings sustain tracking practices.

The following four research questions refer back to research question one. They deal with 'collecting' and 'reflecting' of the lived informatics model, and the duration in which personal information system users find themselves in the 'tracking & acting' phase. Additionally, motivation and attitude towards trackers will be investigated.

SRQ1.1: How does photo based tracking support the user needs in terms of data collection compared to traditional food tracking in social and cultural context?

SRQ1.2: How does photo based tracking support the user needs in terms of reflection compared to traditional food tracking in social and cultural context?

SRQ1.3: How motivated are people to continue tracking when using a photo based method versus a traditional approach in social and cultural context?

SRQ1.4: What is the attitude of self tracking users towards a photo based food journaling method versus a traditional approach in social and cultural context?

The following five sub research questions refer back to research question two. The same idea for the previous four sub research questions apply for the next five sub research questions, but in regards to domain knowledge instead. Additionally, if people learn about food when domain knowledge is present is also investigated.

SRQ2.1: How does photo based tracking support the user needs in terms of collection with the presence of domain knowledge versus the absence of domain knowledge in social and cultural context?

SRQ2.2: How does photo based tracking support the user needs in terms of reflection with the presence of domain knowledge versus the absence of domain knowledge in social and cultural context?

SRQ2.3: How motivated are people to continue tracking with the presence of domain knowledge versus the absence of domain knowledge in social and cultural context?

SRQ2.4: What is the attitude of self tracking users towards an application with domain knowledge versus an application without domain knowledge in social and cultural context?

SRQ2.5: Do people learn about the nutrition with nutrition knowledge present in personal information systems?

The concept of mindfulness in personal informatics systems is not being further explored in this thesis due to two reasons. Reason one is that mindfulness seems to be used to treat deeper cognitive issues such as emotional eating, compulsive eating and anorexia nervosa which are out of scope for this thesis. Reason two is that studying the concept of mindfulness in personal informatics systems could be an entire thesis on its own. The choice has been made to not focus on mindfulness to not dilute the focus.

5. Design

I chose to use smartphone apps a means to conduct the main study. This section deals with the design of such an app from prototype concept to implementation and uploading apps to the app store or play store. First, rationale for setting up the prototyping process is discussed. Then, prototype concept, creation and evaluation is discussed. Finally, the implementation phase is discussed where real apps are created based on the prototyping process. The goal is to create an app that resembles a real, finished product as much as possible in order to study how people behave in real situations without the design interfering.

5.1 Introduction

The research questions refer to personal information systems. However, personal information systems can refer to a great deal of many different systems and devices. In the context of this research, I chose smartphone apps as the appropriate personal information systems to use for the thesis project. Everyone eats, we eat in many different places, and we eat at many different times. If there is one system which is with us at nearly all times capable of tracking what we eat, then it is the smartphone. As such, the research questions will be answered by having people use an app over some amount of time. Additional motivation to use smartphone apps is that the hardware and frameworks to develop such apps already exist. Therefore, increasing the speed of which tracking tools can be produced.

The aim of this research is to investigate how different reflective personal information system designs affect the user. Specifically, differences in terms of tracking method and the presence or absence of domain knowledge as can be inferred from the research questions. This means that some participants in the main study should have a different app functionality available to them than other participants.

Two possible methods of designing an app to fulfil this requirement have

been identified. The first method is to create a singular app with modular design where certain functionality can be turned on or off. For example, the presence of domain knowledge could be turned on or off in an attempt to create two different experiences. The second method is to create multiple standalone apps which each differ in functionality compared to one another.

I made the decision to use the second method. If the first method was chosen, then that means that the functionality a participant should have access to must first be configured by the participant him or herself. This adds an unnecessary hurdle as well as might come off as jarring. Building multiple apps does not have this problem but could be more work. However, it is theorised that the apps will have similarity and therefore reusable code to accelerate the implementation process. Therefore, required functionality will be split over multiple different apps. Naturally the question follows: how many different apps should there be and how should they differ?

5.1.1 App variations

The first research question calls for an investigation between traditional and photo-based tracking. Therefore, the need for different tracking functionality emerges. Because different app variations will be built. This means that there needs to be one app that allows for traditional tracking and another second app that allows for photo-based tracking. However, there is another research question. The second research question calls for an investigation of the effects of domain knowledge, or absence thereof. Therefore, there is also a need to have one app that contains the domain knowledge and another app that explicitly does not have it. From these requirements emerges the need to build four different apps. These four different apps variations are as follows.

Variation one, a photo based food tracking app with domain knowledge. Variation two, a photo based food tracking app without domain knowledge. Variation three, a traditional based food tracking app with domain knowledge. Variation four a traditional based food tracking app without domain knowledge.

A prototype will be built before any real app is built because prototyping makes it possible to concertize the idea and highlight unanticipated constraints. Building a prototype beforehand makes the main study more robust.

5.1.2 Design phase objectives

There are two objectives to meet during the design phase so that the main study becomes more robust.

The first objective to meet is to ensure that the design decisions minimally interfere with app usage during the main experiment. The app(s) should be intuitive to use and feel real. Furthermore, the design of the different app variations should be as similar as possible as to cause minimal interference with the end results. The intention of the main experiment is not to investigate the usability of the app, or the impact of design decision on user experience, but to investigate the psychological phenomena as a result of using the app. When the usability is poor, the focus of users shifts away from reflection and learning and instead shifts to the usability aspects.

The second objective to meet relates to SRQ 2.5. The idea is that people may use domain knowledge when available to contextualise their tracked data and in the process learn more about nutrition. To determine if this is the case, a survey will be administered before and after the main experiment to measure nutrition knowledge levels. It is important that the domain knowledge is sufficient in the sense that each survey question can be answered correctly with the help of the domain knowledge. Otherwise, the intended nutrition knowledge measurement technique will be unable to adequately pick up on whether people learned and retained nutrition information from the domain knowledge.

5.1.3 Constraints

There is a need to build four different apps for the main study, but only one prototype will be built for the pilot study. I made this decision to constrict the pilot study scope in an attempt to keep the project within time constraints. Building multiple prototypes and evaluating them all when they ought to be as similar as possible does not fit within the intended time constraints of the project. This could potentially lead to development problems further down the line or mask other unanticipated problems. However, these drawbacks are mitigated and accepted due to the fact that the four apps are vastly similar when abstraction is applied. Each variation needs a place to input data, and a place to feed data back to the user. The same navigational ideas should be applied to all apps. Additionally, the app designs need to be easily extendable with domain knowledge when needed. Further detail about the domain knowledge will be provided in section 5.2.3.

So, only one prototype will be built for the pilot study. I came to the decision to use the app with photo based tracking and domain knowledge as

the model for the prototype.

Since one of the design goals is to validate the domain knowledge, it has to have the domain knowledge. The prototype will thus be modelled after an app with photo-based tracking or traditional tracking. The choice was made to model the prototype with photo-based tracking in mind because creating a prototype which supports data input would be out of scope. Attempting to validate data input methods would likely already ask too much of the pilot study participants, and could be too much of a burden which poses a threat to the pilot study. Additionally, the idea is to make inputting data regardless of method as simple as possible. Therefore, the focus will shift towards navigational ideas rather than actually inputting data. Since navigational ideas should be the same for photo-based tracking and traditional tracking, photo-based tracking was chosen as pictures are naturally more intuitive than macronutrient counting.

This decision could potentially cause issues when building the apps for the main study as a way for users to input data in the traditional way has to be designed. This risk is accepted. Entering data will be made as simple and straightforward as possible. Other already existing apps will be used as inspiration on how to do this.

5.2 Prototype concept

Design factors play a significant role in perceived quality and emotion in smartphone apps [Bhandari et al., 2017]. Getting the design right is important because one of the goals was to create an app that looks and feels like a real finished product. Futhermore, the most popular apps show a high level of UI consistency [Jiang et al., 2018]. Therefore, popular apps shall serve as inspiration for my own app design in combination with the android app design guidelines. Design decisions are important. The prototype concept section discusses the design decisions starting with name, theme and colour scheme of the prototype followed by navigational concept and domain knowledge design.

5.2.1 Name, theme & colour palette

The prototype and eventual apps need a name. It is common practice to have the app name displayed in the landing screen at the top of the screen. In addition, having a name helps make the prototype feel more real and complete. A name provides a way to refer to the project both during the pilot study and the main study, and makes it so that participants may find

the app in the app- and play store. 'FoodFriend' has been chosen as a name. The intention was to make the name memorable, as well as portray the app as helpful and positive.

The theme of the app should be that of calmness and clarity to reduce cognitive load. Based on this idea, lightblue (#46c0db) was chosen as the primary colour. This colour is associated with calmness, low arousal states and comfort [Valdez and Mehrabian, 1994]. Text and icons on the light blue areas shall be white (#ffffff).

A large contrast is hard on the eyes. To reduce eye strain, the contrast was reduced while still maintaining clear readability. This results in the background colour and border colours becoming a very soft grey (#f2f2f2) instead of white, and text on backgrounds becomes a deep dark grey (#757575) instead of black. The goal is to have a large enough contrast to maintain clear readability but not have the contrast be so large that it causes eye strain. Furthermore, additional buttons shall have a complementary colour (#db4e46) in relation to light blue to draw user attention and create awareness that this button is probably important. This complementary colour is a brown-reddish blend. The used colour palette appears in Figure 5.1.

Figure 5.1: Prototype colour palette showcasing the primary colour, secondary color, greyscale colours for background and text, and white for text placed on the primary colour.

5.2.2 Navigation

Intuitive navigation is important to shift the attention towards tracking and reflecting instead of app usability. Intuitive navigation can be achieved by adhering to the android app design guidelines and using popular apps as inspiration. Firstly, I identified required functionality in order to understand how the navigation should work.

The prototype must have an input data screen, view tracked data screen and a domain knowledge screen in order to support the user in tracking data and browsing domain knowledge.

It is also important to consider where the user lands upon opening the application. From the landing screen, the user should be able to easily navigate to each function. I decided that the landing screen is the same screen where users can view their tracked data. I chose to do this so that users may easily and quickly view their tracked data. Additionally, upon first opening the app

the screen will naturally be empty. This makes it easier to understand and learn how to use the app in the beginning because the user is less likely to be overwhelmed due to not being immediately prompted to input data or read about nutrition and therefore reducing sensory and cognitive load. The user can navigate from the landing screen towards either the input data screen or domain knowledge screen. This navigation should be made possible with as little effort as possible.

I chose to place a button in the bottom right area of the landing screen that can take the user to a screen to input data. This allows the user to go from opening the app to inputting data with one click only. The button is easily accessible due to its user-friendly location. This button however is only present in the landing screen to minimise screen clutter when navigating around the app. Additionally, a button that takes the user to the data input screen will be present in the app header so that the user may navigate to the data input screen from any other screen, slightly enhancing navigation.

The domain knowledge is accessible through standard app tab bar navigation. To access the domain knowledge, the user has to swipe right from the landing screen, or alternatively tap the tap bar. Tab bar navigation is a common design pattern used in many highly popular apps and recommended to use by design guidelines.

One alternative I considered was making both data input and domain knowledge accessible with buttons placed in the bottom right. This alternative was considered but decided against to minimise accidental misclicks and also reduce screen clutter. Another alternative could have been to make both data input and domain knowledge reachable through tab bar navigation. However, this would make it less efficient as it would take two swipes instead of one to reach data input or domain knowledge, depending on implementation, from the landing screen. Lastly, navigation both in the prototype and real apps should support standard back button navigation.

These navigational concepts are brought together to create one navigational concept. The navigational concept is visualised in Figure 5.2. It is important to note that the user can always go back to the previous screen until the landing screen through standard back button navigation native to android and iOS devices. This functionality comes with the smartphone, not apps, and is therefore not included in the diagram. This functionality will be simulated in the prototype.

Users can navigate back and forth between the tracked data screen and domain knowledge screen through the tab bar. The data input screen should be able to capture a photo. Navigational components are not required here. Taking a picture will automatically navigate back to the tracked data screen. If the user does not want to take a picture they can use standard back button

navigation. The screen in which users can take pictures shall have a white cross to close the screen on iOS devices as this is a common practice.

The 'domain knowledge' in the domain knowledge screen is an abstract representation. I constructed the domain knowledge section based on the literature study and an interview with Sytske Runia, head of the dietary department at the Utrecht Medical Centre (UMC). The next section discusses how the domain knowledge section of the prototype took shape.

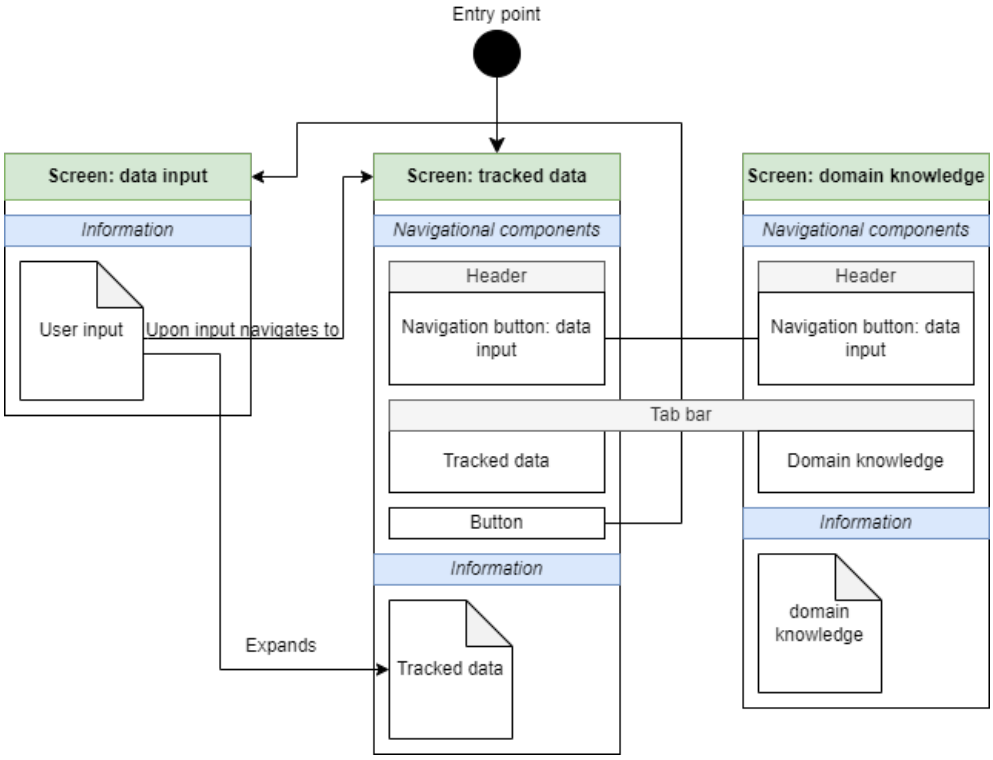

Figure 5.2: Navigational concept. The entry point points to the landing screen, which is the tracked data screen. Tab bar navigation allows for navigation between the tracked data screen and the domain knowledge screen through swiping to the left and right. Additionally, the data input screen is reachable from these other screens via the header as well as an extra button on the tracked data screen. The flow of data has also been visualised.

5.2.3 Domain knowledge

The design of the domain knowledge section of the app offered an interesting challenge. Two questions arose. How should users navigate through the domain knowledge, and what exactly should the content be? Sytske Ru-

nia, head of the dietary department at the Utrecht Medical Centre (UMC), provided support in answering these two questions.

First iteration

Firstly, I held a semi structured interview Sytske. The main goal of this interview was to identify how to present nutrition knowledge. Sytske was able to offer great insights due to her many years of experience in the field of dietetics. I identified the following key points through the first interview.

Information should be on 'MBO 4' difficulty to accommodate the average person. The 'schijf van vijf' is a great tool to teach about food and foodgroups and used in UMC Utrecht programs and treatments. A lot of misinformation circulates on the internet, therefore it is important to emphasise the credibility of the knowledge. Intelligence, motivation and interest are the most important qualities that determine how quickly people adopt new food knowledge. Knowledge and insight into your own habitual patterns is important. Intrinsic motivation is important to sustain new habits.

After the first interview, an initial draft was constructed to showcase the intended domain knowledge design. The ''schijf van vijf" has been adopted as the model to base the domain knowledge on as suggested by Sytske Runia. Each slice in the schijf van vijf will be explained what it contains, in which foods you can find these nutrients and why these nutrients are important. Additionally, some general information and information about calories shall be used to supplement the schijf van vijf information. I chose to do it this way as a result of the interview.

The first thing that users encounter when they navigate to the domain knowledge is an image of the ''schijf van vijf", supplemented by a short text describing the model and attempting to convince the user that the information is credible. Detailed information about each food group has been split over multiple screens instead of putting it all in one screen. Splitting the information should make it easier to browse. Additionally, users can click on a button to view information about calories and click on a button to view general information about food.

The information has been carefully constructed in accordance with the latest literature, information found on voedingscentrum.nl and the results of the first interview with Sytske Runia. Figure 5.3 showcases the initial design of the domain knowledge section of the prototype.

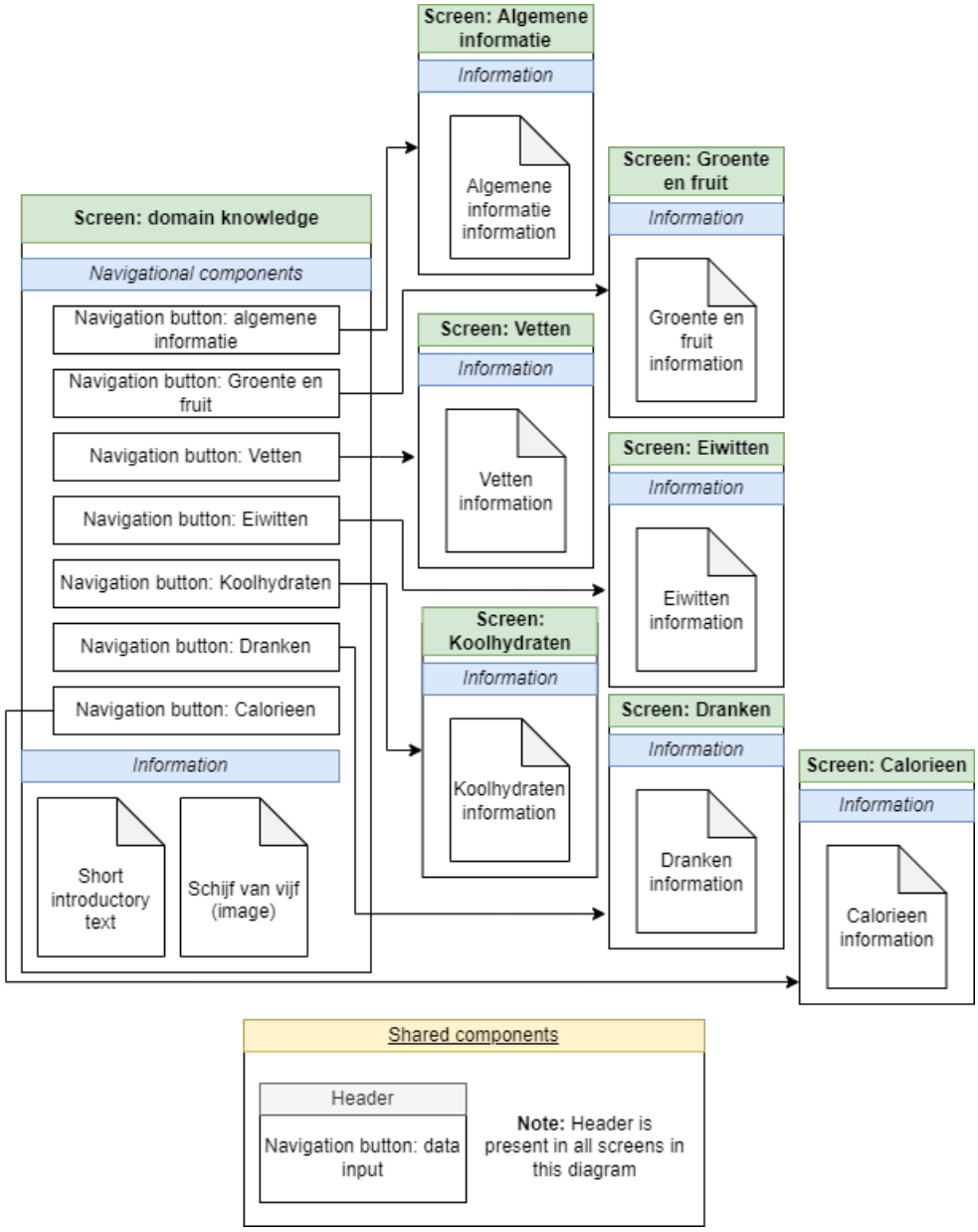

Figure 5.3: Domain knowledge concept. This model extends the domain knowledge screen from Figure 5.2.

Second iteration

The domain knowledge design and content was reviewed by Sytske through a second interview. Refinements have been made to the contents of the domain knowledge section based on the second interview. The changes mainly consisted of reformulating sentences to simpler forms, expanding the information by explaining why certain foods are healthier choices than others, and fixing spelling errors. The nutrition knowledge was deemed research ready after the final refinements. The navigational design did not change. The final nutrition information per screen can be found in A.

5.3 Prototype design

The prototype can now be built based on the prototype concepts from the previous section. App design guidelines found on developers.android.com were also used during prototype construction.

5.3.1 Prototyping tool

The online tool proto.io will be used to rapidly build the prototype. Proto.io is a web based app mockup tool. Because it is a mockup tool, that means that inputting data and then using that data to feed it back to the user is not possible, it can only be simulated. However, as discussed earlier, the focus of the prototype was shifted towards navigation and domain knowledge and therefore this constraint is not as significant. A substantial benefit of a web based tool is that the prototype is easily shared.

Other tools were considered as well based on prototype fidelity, ease of use, time to master, price and versatility. Proto.io is lower in prototype fidelity than other tools. However, the ease of use, time to master and price outweigh the drawback of low fidelity due to time constraints of the thesis project. Versatility is adequate for the project. All things considered, proto.io was judged as an acceptable tool to build the prototype.

5.3.2 Prototype creation

The prototype concepts were brought together in one web based app mockup. The landing screen can be observed in Figure 5.4. It was possible within the mockup to scroll down in the landing screen to view more photos of tracked foods. Navigating from the landing screen to the data input screen could either be done by clicking on the photo icon in the header or on the bottom right photo button. Taking pictures is not possible since this is a web based

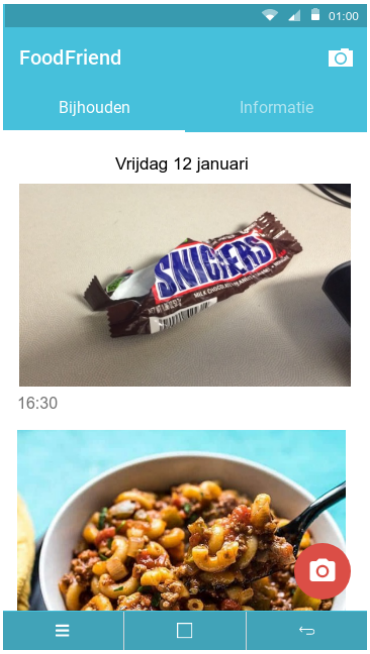

Figure 5.4: Prototype landing screen showcasing the navigational components and use of the color scheme. Some mock data has been added to demonstrate the intended concept

mockup, therefore a small text is displayed that says: 'Here is where you would take a picture'.

Navigating from the landing screen to the domain knowledge screen was possible by swiping right. Naturally, it was possible to go back by swiping left from the domain knowledge screen. The domain knowledge screen can be seen in Figure 5.5. A small bug occured when downloading the prototype screen images from proto.io. The bug is that 'bijhouden' is highlighted in the tab bar instead of 'informatie'. It was also possible to scroll down in the domain knowledge screen. The buttons to navigate to various nutritional topics could be found by doing so.

All screen images can be found in Appendix B. Unfortunately, on many screens one could scroll down but this information was not captured in the images. However, all the important information was captured and can be found in Appendix A.

Figure 5.5: Prototype domain knowledge screen. The buttons to navigate to the other screens are available when scrolling down, and are therefore not visible in this figure.

5.4 Pilot study

This section deals with the setup of the pilot study to validate the prototype. Measurement techniques and hypotheses will be elaborated upon first. Then, the pilot study format and contents are explained. Lastly, the participant recruitment method is explained.

5.4.1 Measurement techniques and pilot study design

To reiterate, the pilot study objectives are as follows. Validate the usability aspect of the design so that the design minimally interferes with the end results, and validate if the domain knowledge within the prototype is adequate enough to raise nutrition knowledge levels to a measurable amount.

The first goal is realised by having participants use the prototype and fill in a System Usability Score (SUS) survey to gauge the usability aspect of the design. Empirical evaluation of the SUS revealed the SUS to be highly robust and versatile [Bangor et al., 2008].

The second goal will be realised by picking a method to measure nutrition knowledge. For this research, that method is section 1 of the General Nutrition Knowledge Questionnaire Revised (GNKQR) survey. It has been demonstrated in earlier research that the GNKQR can measure nutrition knowledge [Kliemann et al., 2016]. Additionally, the GNKQR has been used in other scientific studies [Thompson et al., 2021] [Mo'ath and Attlee, 2021]. However, it has to be determined through the pilot study if the GNKQR is the right fit for this research as well. Detailed information about the GNKQR is given in section 4.4.2 as well as justification for only using section 1 and modifications made to the survey.

The GNKQR section 1 will be administered twice during the pilot study. Once at the start of the pilot to measure general nutrition knowledge. Then, a second time when users are allowed to use the prototype to answer each question to the best of their ability. If a significant difference is found, then the domain knowledge within the prototype is adequate enough so that the GNKQR section 1 can pick up on increased levels of nutrition knowledge if people learn the domain knowledge. Whether people actually learn the domain knowledge during the main experiment remains to be seen, but it must be verified if the domain knowledge is capable of raising nutrition knowledge levels and that the GNKQR section 1 can measure this.

It is expected that nutrition knowledge levels increase. This leads to the following hypothesis.

- H0: The true difference in nutrition knowledge level means is 0

- Ha: The true difference in nutrition knowledge level means is less than 0

5.4.2 General Nutrition Knowledge Questionnaire Revised

Focussing on a method to measure nutrition knowledge, the General Nutrition Knowledge Questionnaire Revised (GNKQR) is a survey that measures people's knowledge about food and nutrition from a few different angles.

The General Nutrition Knowledge Questionnaire (GNKQ) was originally developed in the 1990's but was revised due to the advancement of science and the better understanding between diet and disease (Kliemann et al., 2016). The outcome is the General Nutrition Knowledge Questionnaire Revised (GNKQR). The revised version features multiple sections. Section 1 deals with what advice people think experts are giving, section 2 deals with the awareness of food groups and nutrients, section 3 deals with food choices and nutrition labels, section 4 deals with health problems and disease in relation to diet, section 5 is simply the demographics part of the survey.

After careful examination of the survey, section 1 was identified as possibly appropriate to use as a measurement tool to detect increases in nutrition knowledge. The domain knowledge within the prototype is set up in such a way that people learn what food advice experts are giving, learn about what type of nutrients there are and what food groups they belong to. This section appears to be the best fit for this particular research. It might seem strange to not include section 2 as well. However, examination of this section reveals that the questions specifically target a certain piece of food and ask about specific nutrients within that piece of food. The domain knowledge will not be that specific as information is kept as concise as possible while still remaining comprehensiveness and usefulness.

Kliemann et al. found that section 1 produced a cronbach's alpha of 0.70 indicating acceptable levels of internal consistency. Furthermore, Cohen's effect size before and after online nutrition information interventions was the highest for section 1 at 0.7. On top of that, section 1 scored the best in terms of cronbach's alpha and effect size compared to the other sections of the survey. Therefore, section 1 is deemed appropriate for this research. Changes have been made to section 1 of the GNKQR because it was originally developed for UK citizens. These changes are as follows.

Firstly, Question 8 was changed to specify the fruit juice is from supermarkets. The original question implicitly refers to these supermarket juices. These supermarket fruit juices contain substantial amounts of added sugar

as well as acids that could damage teeth as well as contain less vitamins and minerals compared to juice made from fresh fruits and vegetables. Confusion might arise over the lack of clarity about the fruit juice source and therefore the question has been altered. Secondly, The original question 9 references the 'eatwell guide'. This has been changed to the 'schijf van vijf' as it is the closest dutch equivalent. As a result the possible answers have been slightly changed to different percentages to better fit the schijf van vijf. The new possible answers remained in the same order and have roughly the same difference margins between the possible answers. Finally, the entire survey was translated from English to Dutch to accommodate dutch citizens because this research takes place in the Netherlands and will use dutch participants.

5.4.3 Pilot study format

An online survey has been chosen as the appropriate format for the pilot study to minimise face to face interactions due to the global coronavirus pandemic. The entire survey is in dutch which means that any material used in the construction of the survey has been translated to dutch when applicable. The dutch adaptations for the GNKQR section 1 have been explained in the previous section.

The pilot study was made with the online tool Qualtrics. Utrecht University (UU) has a partnership with Qualtrics so that UU employees and students can use the tool, but also so that surveys automatically fit the UU theme. Perceived credibility and professionalism increases by having the UU logo and colours. Qualtrics also handles security and privacy.

5.4.4 Pilot study content

The survey consists of a consent form, a short demographic survey, section 1 of the GNKQR (twice), a link to the prototype and the System Usability Scale (SUS).

The survey starts with a consent form, confirming voluntary participation, explaining to the participant that he or she can quit at any point in time without explanation, confirming that the participant is over the age of 18, and explaining that responses are anonymous. The next part of the survey is a set of demographic questions. Only the minimum amount of questions has been asked to comply with UU guidelines. Only gender, age and any nutrition or dietician qualifications were deemed relevant based on the findings by Kliemann et al. (2016). Possible answers for age were split into 3 groups; 18-35 years old, 36-50 years old and older than 50 years. This split was adopted from the GNKQR. The GNKQR contained more demographic

questions but were not deemed necessary to ask due to the fact that Kiemann et al. did not find results where a certain demographic trait behaved substantially differently than others.

The survey continues with section 1 of the GNKQR. Simply to gauge the natural food knowledge the average dutch person possesses. Then, the participant is again asked to fill in section 1 of the GNKQR but with a twist. The twist is that now the participant is instructed to use the prototype to help answer the questions to the best of their abilities. This more or less forces the participant to extensively use the prototype if they want to answer each question correctly. As stated before, the idea behind this setup is to determine if the nutrition information within the prototype is adequate enough so that when learned, the GNKQR can pick up on the increased levels of nutrition knowledge.

Finally, the participant is asked to fill in the SUS to obtain a quick and dirty indication about the usability of the prototype.The participants were given the option to leave a comment after the SUS.

5.4.5 Participant recruitment

Participants for the pilot study were recruited by spreading the online survey link through social media, family, relatives and friends. People were also asked to forward the link to anyone that might be interested.

5.5 Pilot results

A total of 46 responses to the pilot study were recorded. 12 incomplete responses were removed which resulted in 34 responses used for data analysis. The sample consisted of 18-35 year olds (n=10), 36-50 year olds (n=5), and people older than 50 years (n=19). Furthermore, the sample consisted of male (n=12) and female (n=22) participants. None of the participants had any nutrition or dietary certifications.

The SUS score can range from 0 to 100 after normalisation. The observed average SUS score is 71.8 (n=34). Every question scored a 3, 3 meaning average, or higher except question 2, "I found the system unnecessarily complex", which scored slightly under 3 and coincidentally had the lowest score.

The maximum score for section 1 of the GNKQR is 18. The observed mean before the prototype is 13.24. The observed mean after people were instructed to use the prototype is 15.35. Performing an upper tail paired sample t-test (alpha = 0.05, df = 33, p = 1.351e-07) showed that **the null hypothesis should be rejected.** Furthermore, it can be observed that

some questions were actually made worse, although the amount of correct answers is only 2-3 less. Other questions were substantially answered better. The most significant observations have been summarised in Table 5.1.

Table 5.1: Significant observations in GNKQR scores

Question	**Correct before**	**Correct after**	**Difference**
2	4	26	+22
3.1	24	32	+8
3.2	13	29	+16
3.3	25	33	+8
4	15	25	+10
5	30	22	-8
6	22	30	+8
9	13	20	+7

Respondents could leave a comment at the end of the survey. A total of 7 comments were observed. An overarching trend could not be identified. Comment feedback included that the app felt minimalistic even for a prototype, add imagery to complement the text, evaluate grammar, the answer to question 5 of section 1 of the GNKQR was hard to find, the text was complex, and finally that the app could be further developed so that that it provides information based on health problems.

5.5.1 Implication

The observed SUS score of 71.8 indicates that the system design and usability is roughly average as the average score across research was found to be roughly 70 [Bangor et al., 2009].

The participants used the prototype in a web browser through proto.io. This means that a phone and app were simulated on a webpage. It is expected that users better use the system when it is a full fledged operational app on real phones. This should have a positive impact on user experience. Additionally, participants had to search through the app for answers to the GNKQR. This is not how users are expected to behave when using the app during the main study. Users are instead expected to simply browse the information to their needs or interests. This might have had a negative impact on the SUS score.

The translated and slightly modified section 1 of the GNKQR is an adequate measurement technique to detect if people absorbed and retained

domain knowledge, as well as an appropriate measurement technique of nutrition knowledge in the context of this thesis. Therefore, section 1 of the GNKQR will be used to answer SRQ 2.5.

The prototype was deemed successful enough to enter production based on these observations. However, domain knowledge will be slightly improved without retesting. The improvement only consists of minor simplifications of certain sentences and fixing grammatical errors.

5.6 Implementation

This section deals with post pilot study app development. It discusses the step from prototype to real apps. Additionally, the app variations and how they deviate from the prototype are discussed.

5.6.1 App variations

The need to build four different apps was identified in section 5.1. One prototype was built to base these four variations on. The variations are reiterated here and signified by giving them a capital letter based code. Clarification on the capital letter codes is as follows: "P" stands for "Photo", "T" stands for "Traditional" and "K" stands for "Knowledge". From here on out through the end of the thesis each app variation can be referenced through the variation code. Refer below to table 5.2.

Table 5.2: App variations overview

Code	**Variation**
PK	Photo tracking with domain knowledge
P	Photo tracking withour domain knowledge
TK	Traditional tracking with domain knowledge
T	Traditional tracking without domain knowledge

The prototype was built based on the FoodFriend PK variation. The difference between FoodFriend PK and FoodFriend P is simply only the domain knowledge. Thus, the only deviation that has to be made is omitting the domain knowledge. This in turn turns the tab bar obsolete. Thus, the tab bar can be removed. In other words, FoodFriend P only needs to support users in taking pictures and displaying those pictures.

The tracked data format (for both variations) is picture feed accompanied by timestamps when the picture was taken congruent with the prototype with

one exception. The exception is that photos are not 'grouped' under a date but simply each foto shall have a date and timestamp when it was taken directly under it. Users can scroll through this picture feed to review older fotos.

5.6.2 Traditional tracking

The most significant deviation from the prototype is the tracking method. What traditional tracking entails has been explained in the research questions chapter but shall be reiterated here. Traditional tracking in this thesis means the counting of macronutrients. This is typically done by observing food labels and sometimes weighing each product. Traditional tracking within the app shall support the tracking of macronutrients. Calorie intake will automatically be calculated based on the user input. Micronutrient counting is excluded due to steep increased effort and complexity because there are a lot of micronutrients. Additionally, most existing applications also omit micronutrient counting.

Two input methods will be offered. The first method is directly entering the macronutrients and giving the entry a name. Sometimes the direct contents of a product can be observed from the packaging. Implementation of the first input method is shown in Figure 5.6. The second method is that of copying the macronutrient values per 100 grams from the food label and then entering the weight of the food. The app shall then automatically calculate the correct macronutrient values.Implementation of the first input method is shown in Figure 5.7. Additionally, calories consumed are automatically calculated for both input methods. Users can also provide a name for each set of macronutrient information they enter so that they can remember to which food the macronutrient information refers to.

Figure 5.6: Traditional tracking input method 1. Users can enter any name for their data entry. Macronutritional information only accepts numbers but can be left blank.

Figure 5.7: Traditional tracking input method 2. Users can again enter any name, but here the user is asked to enter the information on nutrition labels and the weight of the product. The app performs the required calculations automatically.

Tracked data can be viewed in the landing screen as congruent with the prototype design. However, this data is different from a photo. Therefore, some design for data display has to be made. The simplest approach I personally could think of was taken which is to simply feed back the information the user entered into the system in a neat fashion supplemented with a timestamp. This design concept can be seen in Figure 5.8. This design was eventually implemented into the appropriate apps.

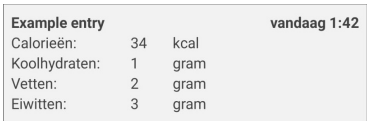

Figure 5.8: Macronutrient data design concept showing the placement of the entered name, macronutritional information and a timestamp.

Saving all the tracked data in the landing screen will eventually lead to a long list of data entries. Steps have been taken to make the traditional tracking variations more approachable. The landing screen shall contain a summary element of all tracked data for that day. This element resets each new day. The summary element shall sum up every macronutrient respectively. Additionally, the summary of each day is logged and displayed

in another screen. The tab bar is extended so that the users may navigate to this screen.

Users will be allowed to leave the macronutrient input fields empty which will then automatically default to 0. It shall be possible to leave all macronutrient fields empty and only provide a name. Input is ignored when all input fields are left empty.

FoodFriend TK is exactly the same as FoodFriend T version except for the fact that the domain knowledge is absent in FoodFriend T compared to FoodFriend TK. Thus, FoodFriend T shall have one less tab bar option. FoodFriend TK will have a tab bar with states: 'bijhouden', 'overzicht', and 'informatie'. FoodFriend T will have a tab bar with states: 'bijhouden', and 'overzicht'.

5.6.3 Additional prototype deviations

Each app variation shall be equipped with a question mark button placed in the header. This button will take the user to a help screen. The help screen contains contact information as well as support for data input. The support information shall vary based on data input method for each variation respectively. A header shall also be present in the data input screen for FoodFriend TK and FoodFriend T.

Only relevant when data is collected during the main study: the help screen shall also contain an 'invisible button'. When this button is clicked seven times in a row, then, with the user's consent, the dates (without timestamps) when data (either sets of macronutrient input or pictures) was added and when the app came to the foreground will be sent to the researcher. The button is obfuscated on purpose as to make the app appear as complete as possible and not as a research tool.

5.6.4 App development

React Native with Expo has been chosen as the framework to build the apps with. React Native allows for simultaneous development for both android and iOS systems. Expo sits on top of React Native and provides an extra set of tools to make app development slightly easier.

Simultaneous development saves a lot of time and increases the amount of possible participants that could be recruited for the main study.. On top of that, it would otherwise be impossible to develop for iOS systems as there was no access to apple machines to write 'xcode'. As such, a cross platform development tool was deemed the ideal choice.

Web based app development tools have also been considered for app development, but this route was not chosen as writing code from scratch in React Native would offer more freedom as well indepence from third parties.

5.6.5 App store and play store

The apps were uploaded to the app store and play store to make it as easy as possible for participants to install the app as well as improve trust in the app since both stores apply app review before making builds publically available.

The play store accepted all app variations. However, the app store only accepted one out of four versions because the other versions are too similar to the one accepted version. TestFlight was used to circumvent this issue. TestFlight is an app beta testing application by Apple. This application allows users with a beta test invitation to install apps without going through the app store. However, the beta builds available through testflight also have to be first approved by Apple. Each beta build for the three versions not available on the app store were approved and thus installable through TestFlight.

5.6.6 Privacy

Tracked data is only stored locally on the phone on which the app is installed. The data is not stored on any other device or server. Additionally, the data cannot be accessed remotely by any party. The only data that can be sent to the researcher requiring permission from the user is the dates without timestamps on which a data entry was entered and the dates when the app came to the foreground. Both dates are in YYYY-MM-DD format, thus omitting exact times so that only data that needs to be collected is collected and nothing more.

6. Evaluation

The evaluation chapter details the study design, participant recruitment strategy, apparatus used, study procedure and the observed results.

6.1 Study design

The study design follows a 2x2 factorial design paradigm. There are two independent variables with each two levels. The first independent variable is the tracking method with levels; traditional tracking, and photo-based tracking. The second independent variable is domain knowledge with levels; presence, and absence. Each group gets linked to one of the four app versions as described previously in the implementation section.

During the study participants will be asked to track their consumption with the use of one of the aforementioned apps. Participants will be asked to track for a total of two weeks. Various surveys are administered before and after the tracking period which will be described in detail in the coming sections.

6.2 Participants

Participants needed to meet four criteria. The first criteria is that the participant has to be over the age of 18 in order to provide legal consent to voluntary participation. The second criteria is that the participant currently does not suffer from an eating disorder. The reason for this is that eating disorders are out of scope for this thesis project in addition to the uncertainty of the effects of the apps in relation to eating. Therefore, including participants with eating disorders poses a grave risk. The third criteria is that participants are somewhat interested in tracking consumption either out of curiosity or with a goal in mind. It is theorised that people participating in the experiment meet his criteria otherwise they would most likely decline

participation. The final and fourth criteria is that the participant owns a smartphone.

Participants are recruited through social networking, business networking, the distribution of flyers, social media posts and approaching random people in person in accordance with, at the time, current government issued corona pandemic related constraints.

A total of 62 participants were recruited. Two participants stopped during the experiment leaving a total of 60 participants evenly spread among four groups. The sample consisted of 18-35 year olds (n=36), 36-50 year olds (n=9), and people older than 50 years (n=15). Furthermore, the sample consisted of male (n=21), female (n=38), and 'would rather not say' (n=1) participants. The sample did possess dietary or nutrition certification (n=1).

6.3 Apparatus

The following apparatus were used to conduct the main experiment and carry out the tasks described in the procedure section. A consent form to obtain informed consent. A demographic survey. The GNKQR, administered twice, to measure nutrition knowledge levels before and after the main experiment. App installation available either in the play store, app store, or TestFlight. A checklist to confirm the app functions as intended. A computer device with a microphone, audio recording software and internet connection. Semi structured interview documents to support the interview process. The Intrinsic Motivation Inventory (IMI) with subscales interest/enjoyment, pressure/tension, effort/importance, value/usefulness, the Situational Motivation Scale (SIMS) and the Technology Supported Reflection Inventory (TSRI) with subscales insight and exploration.

6.4 Procedure

The procedure follows three stages: initial setup, main experiment, and experiment roundup.

Initial setup

An appointment has been made with each participant upon recruitment. In this initial appointment participants are randomly assigned to one of the four groups, helped installing the app, walked through the app to check if everything works, given instructions on what to do, and sent a short questionnaire to fill in.

Participants are tasked to track their consumption based on what they are curious about or based on their goals if they have any for a period of two weeks. This means participants are free to track everything that they eat, or focus on specific parts of their diet. For example, participants could focus only on fruit consumption. Furthermore, it is explained to the participants that app usage is not mandatory. At any point unforeseen events can occur which could hinder the participant. This is done to lessen the burden of participation and represent a more real way people would actually use food tracking apps.

Furthermore, participants are informed that their data input is private. The data stays locally on the phone and cannot be observed by anyone other than the participant himself. The only data that can be extracted, only with participant consent, is dates without timestamps when a data entry was entered and the dates without timestamps when the app came to the foreground.

The short questionnaire consists of the consent form, the demographic survey and the GNKQR section 1.

Main experiment

Participants are using the app in their everyday life for a period of two weeks during the main experiment. Participants were free to use the app however they saw fit, including not tracking at all. If anything goes wrong with the app, the participants were instructed to contact me personally and I would attempt to resolve their issues as soon as possible. After the two week period participants were sent a message explaining the two weeks are over and asked to schedule an appointment to round up the experiment.

Experiment roundup

Participants are asked to fill in four questionnaires, participate in an interview and send logged data from the app during the final appointment. The two questionnaires administered were the IMI with subscales: interest/enjoyment, pressure/tension, effort/importance, value/usefulness, the SIMS, the TSRI with subscales insight and exploration, and again the GNKQR section 1. The interview is aimed at the data collection and data reflection experience. The interview is semi structured and can be viewed in Appendix D. Finally, the logged data is retrieved with participant consent.

6.4.1 Method of analysis

The IMI, SIMS, TSRI subscales and GNKQR are scored with their own specific scoring method. These scores will be analysed using the Aligned Rank Transform (ART) ANOVA test to determine if there is statistical significance. Additionally, the scores are also visualised to further explore and understand the differences and similarities. The interviews will be analysed through thematic analysis [Braun and Clarke, 2006]. Finally, logged data has been visualised as heatmaps. These heatmaps are studied to gain insight in how often the app was used, supplementing interview data, and to attempt to identify any trends, similarities or differences between the groups.

7. Results

This section presents the results of the main study. The IMI, SIMS and TSRI scale results are presented first followed by the GNKQR survey results. Then, logged tracking performance results and lastly the interview results are presented.

7.1 IMI, SIMS & TSRI

The Intrinsic Motivation Inventory (IMI) subscales that were used were: interest/enjoyment, pressure/tension, effort/importance, value/usefulness. In addition to the IMI subscales, the SIMS scale and TSRI with subscales insight and exploration were also deployed. The results of each of these scales were gathered as per protocol defined by the scales. Visualisations of the results can be found in Appendix E, only one visualisations is presented outside of the appendix because of relevance and brevity.

A Two-Factor Aligned Rank Transform (ART) ANOVA was performed to analyse the effect of tracking method and domain knowledge on each of the chosen IMI, SIMS and TSRI metrics.

A Two-Factor ART ANOVA revealed that the tracking method had a statistically significant effect on interest/enjoyment ($F(1, 56) = 11.661, p = .001$). Domain knowledge did not have a statistically significant effect on interest/enjoyment (F(1, 56) = .025, p = .875) and neither did the interaction effect between tracking method and domain knowledge ($F(1, 56) = .302, p = .585$). A Tukey's HSD post hoc test was performed and showed a significant difference ($p = .016$) between the interest/enjoyment score between group P ($M = 4.572, SD = .840$) and group T ($M = 3.535, SD = .709$). Other pairwise comparisons were not significant ($p > .05$). The interest/enjoyment subscale scores were visualised in Figure 7.1.

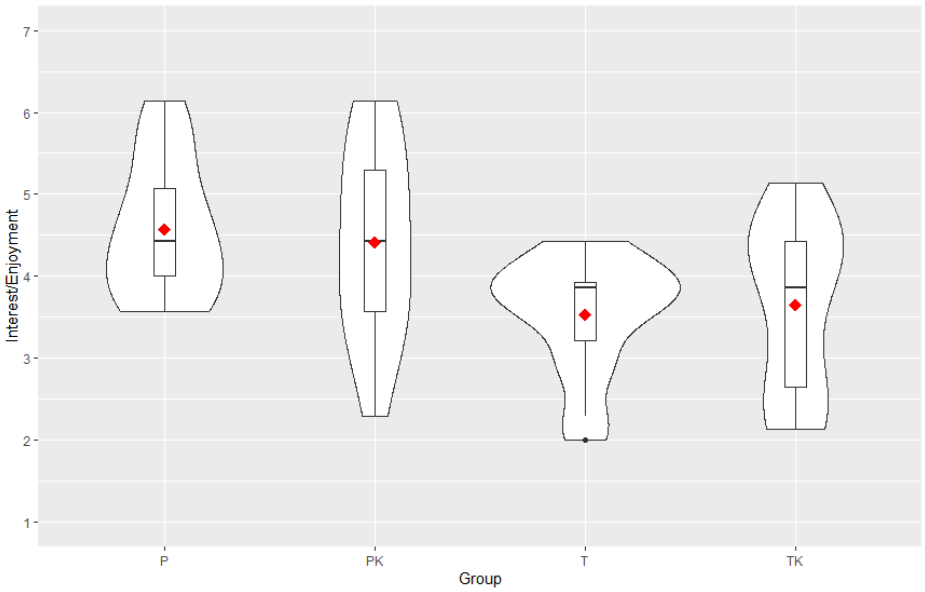

Figure 7.1: Interest/Enjoyment subscale scores showing the difference between groups. The difference is largest between groups P and T.

A Two-Factor ART ANOVA revealed that there was a statistically significant effect of domain knowledge on pressure/tension ($F(1, 56) = 5.263, p = .023$). Tracking method did not have a statistically significant effect on pressure/tension ($F(1, 56) = .036, p = .851$) and neither did the interaction effect between tracking method and domain knowledge ($F(1, 56) = 1.377, p = .246$). A Tukey's HSD post hoc test was performed but found no significant pairwise comparisons ($p > 0.05$). Paradoxical at first, however Tukey's HSD post hoc is a more conservative test compared to the Two-Factor ART ANOVA which accounts for this finding.

All other Two-Factor ART ANOVA tests did not find significance, but will be reported in full in order to be transparent and exhaustive. Results are also summarised in Table 7.1, Table 7.2, and Table 7.3. Two-Factor ART ANOVA tests revealed no statistical significant effect of tracking method ($F(1, 56) = 2.390, p = .128$), domain knowledge ($F(1, 56) = 2.026, p = .160$), or the interaction effect ($F(1, 56) = .462, p = .499$) on effort/importance; no statistical significant effect of tracking method ($F(1, 56) = 3.278, p = .076$), domain knowledge ($F(1, 56) = 1.397, p = .242$), or the interaction effect ($F(1, 56) = .054, p = .818$) on value/usefulness.

Table 7.1: IMI subscale results

Subscale	**Factor**	**df between**	**df within**	**F value**	**P value**
Interest/enjoyment	Tracking method	1	56	11.661	.001
	Domain knowledge	1	56	.025	.875
	Interaction effect	1	56	1.377	.585
Pressure/tension	Tracking method	1	56	.036	.851
	Domain knowledge	1	56	5.263	.023
	Interaction effect	1	56	1.377	.246
Effort/importance	Tracking method	1	56	2.390	.128
	Domain knowledge	1	56	2.026	.160
	Interaction effect	1	56	0.462	.499
Value/usefulness	Tracking method	1	56	3.278	.070
	Domain knowledge	1	56	1.397	.242
	Interaction effect	1	56	.054	.818

There was no statistical significant effect of tracking method ($F(1, 56) = 3.387, p = .07$), domain knowledge ($F(1, 56) = .120, p = .730$), or the interaction effect ($F(1, 56) = .188, p = .666$) on intrinsic motivation; no statistical significant effect of tracking method ($F(1, 56) = .635, p = .429$), domain knowledge ($F(1, 56) = .013, p = .909$), or the interaction effect ($F(1, 56) = .141, p = .709$) on identified regulation; no statistical significant effect of tracking method ($F(1, 56) = 1.294, p = .260$), domain knowledge ($F(1, 56) = .188, p = .666$), or the interaction effect ($F(1, 56) = .424, p = .518$) on external regulation; no statistical significant effect of tracking method ($F(1, 56) = .000, p = .983$), domain knowledge ($F(1, 56) = .980, p = .327$), or the interaction effect ($F(1, 56) = .426, p = .517$) on amotivation.

Table 7.2: SIMS results

Metric	Factor	df between	df within	F value	P value	
	Tracking method	1	56	3.387	.070	
Intrinsic motivation	Domain knowledge	1	56	.120	.730	
	Interaction effect	1	56	.188	.666	
	Tracking method	1	56	.635	.429	
Identified regulation	Domain knowledge	1	56	.013	.909	
	Interaction effect	1	56	.141	.709	
	Tracking method	1	56	1.294	.260	
External regulation	Domain knowledge	1	56	.188	.666	
	Interaction effect	1	56	.424	.518	
	Tracking method	1	56	.000	.983	
Amotivation	Domain knowledge	1	56	.980	.327	
	Interaction effect	1	56	.426	.818	.517

There was also no statistical significant effect of tracking method ($F(1, 56) = 1.166, p = .285$), domain knowledge ($F(1, 56) = 1.803, p = .185$), or the interaction effect ($F(1, 56) = .007, p = .931$) on insight. no statistical significant effect of tracking method ($F(1, 56) = 1.008, p = .320$), domain knowledge ($F(1, 56) = .353, p = .555$), or the interaction effect ($F(1, 56) = .000, p = .989$) on exploration.

Table 7.3: TSRI results

Subscale	Factor	df between	df within	F value	P value
	Tracking method	1	56	1.166	.285
Insight	Domain knowledge	1	56	1.803	.185
	Interaction effect	1	56	.007	.931
	Tracking method	1	56	1.008	.320
Exploration	Domain knowledge	1	56	.353	.555
	Interaction effect	1	56	.000	.989

7.2 GNKQR

The difference between the pre and post study GNKQR scores were computed and analysed, again, with a Two-Factor ART ANOVA. A Two-Factor ART ANOVA revealed that there was no statistical significant effect of tracking method ($F(1, 56) = .693, p = .409$), domain knowledge ($F(1, 56) =$

$1.587, p = .213$), or the interaction effect ($F(1, 56) = 1.514, p = .224$) on the differences of GNKQR scores.

7.3 App usage

App usage was investigated through visualising the logged data during app usage. This logged data tracked on which dates the app came to the foreground and on which dates a data entry was recorded. Deleted items are not counted. The logged data has been visualsed as heatmaps. These heatmaps were used to gain insight into the general app usage levels per participant per day. Each group has two heatmaps, one heatmap to visualise how often data was entered, and one heatmap to visualise how often the app came to the foreground. This means that there are eight heatmaps in total. One heatmap out of eight total has been provided in Figure 7.2. To save space, all heatmaps are made available in appendix F.

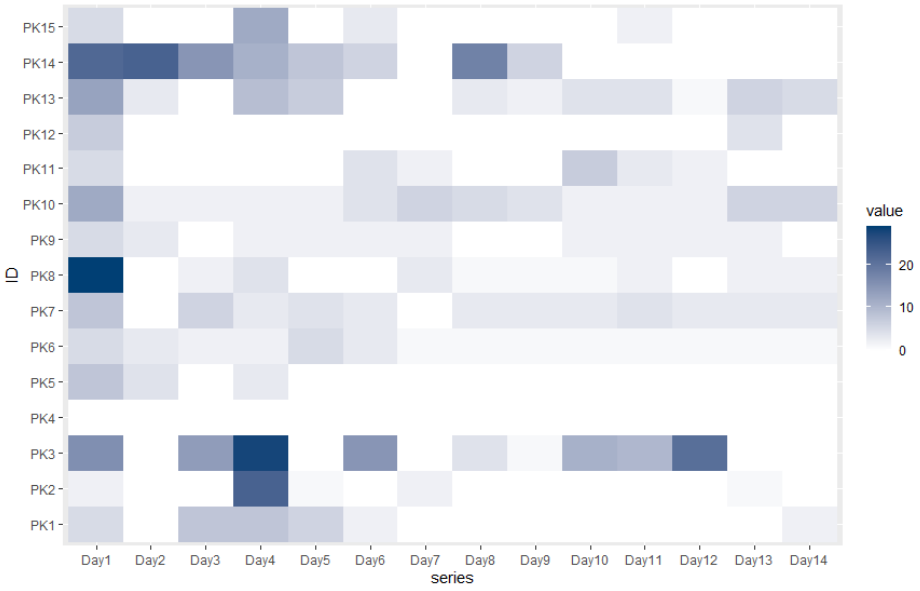

Figure 7.2: Amount of times the app came to the foreground in group PK per participant per day.

Group PK

Six participants used the app for less than a week, one of which did not use the app at all. Two participants used the app extensively during the first

week but not as much during the second. The other participants appear to have used the app moderately but somewhat consistently.

Group P

Four participants used the app for less than a week in contrast to the seven participants that used the app every day or almost every day. The other participants appear to have used the app moderately but not per se consistently.
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Group TK

Three participants used the app moderately for the first six days and then decided to not use the app anymore. One participant used the app for four days during the middle of the experiment. Furthermore, six participants barely used the app, four of which not using the app at all. Additionally, there were four participants that tracked their consumption for the entirety of the experiment duration. Finally, one participant used the app for seven days sporadically.

Group T

Two participants used the app in the first week then stopped. One participant used the app for nine days then stopped. Furthemore, two participants used the app throughout the entire two weeks but not consistently. The other participants used the app only sporadically. There appeared to be an observable decline in app usage after the first week.

7.4 Interviews

Thematic analysis of the interview data was performed. A total of 8 hours and 46 minutes of data was transcribed and coded afterwards. Based on the semi structured interview format, nine different themes were identified. Lapsing, data gathering, social and private context, data reflection, domain knowledge, personal insights, motivation to change, recurrent tracking, and finally technical difficulties. Additional observations has been added as a tenth theme to report on observations worth mentioning but not fitting under the nine predefined themes.

Various aspects about the app experience could not be determined for every single participant because some participants used the app for 1 day or less. Not every participant was therefore able to answer questions about, for

example, app usage in private versus social settings. Data that appears to be missing is absent due to this circumstance. Supplied quotes were originally in dutch but have been translated in spirit.

7.4.1 Theme 1: Lapsing

Lapsing in group PK occurred mainly by forgetting to track as 10 participants identified this was their source of lapsing. Degrees of forgetting varied heavily and happened mostly because people reported having busy schedules and losing interest.

A reason for lapsing in group P was also forgetting to track where 8 participants reported this was the main reason. Two other participants reported that their habit of not having their phone with them at times of eating was the main reason for lapsing.

Seven participants in group TK reported that forgetting to track was the main reason for lapsing. Two additional participants reported that there was an interaction effect between forgetting and effort to track for their lapsing.

[...] it was difficult. Look, if you eat a pizza is is really easy, because you just enter what is on the backside of the box, but I often eat fresh vegetables. That makes tracking a lot harder because you dont know how much is in there so you have to look it up which requires a lot of effort [...] Forgetting played a role but was not the primary reason.

Three participants in group T reported lapsing due to forgetting to track. Five participants reported to lapse due to the time and attention requirements being too high. Five participants reported there was an interaction effect between forgetting and too high time and attention requirements to track as a reason for their lapsing.

7.4.2 Theme 2: Data gathering

Participants in group PK commented the following on the topic of data tracking.

Logging healthy food causes positive reinforcement and works motivational. (PK6). Logging data was an overall positive experience where it causes you to think a little bit more about food but a goal oriented design would work better for me personally. (PK10). Taking pictures leads to more awareness. (PK11). Taking pictures was fun to some degree but also somewhat confrontational because I focussed on unhealthy snacks. Being able to add some

text to a picture would be beneficial for me. (PK14). Taking pictures does not interest me, often I took them too late and photographed an empty plate. (PK15).

Two participants reported that having some option to log data at a later time after eating would help them. The general sentiment in group PK was that participants felt that the app made them more aware of their food consumption or behaviour surrounding food consumption, but did not learn something new.

A subset of four participants from the participants that reported they had most trouble with remembering to take pictures in group P reported that they took photos of receipts, packaging, empty plates, or empty glasses post food consumption. One of these four participants experienced this negatively. Two participants reported on creating their own goals to pursue during the experiment. One participant reported to experience formidable confrontation. Four participants reported that the app helped them become more aware of their consumption. One participant enjoyed taking pictures that looked nice, focussing more on picture aesthetics. Four participants explicitly reported that they judge themselves or their diet as healthy and therefore did not see tracking as something relevant to them. One participant reported that pictures did not trigger them enough to cause meaningful emotion or action. Seven participants reported that a function to enter data post consumption or a reminder to track would be beneficial to them. One participant mentioned that taking pictures was an overall more enjoyable experience than tracking nutrients with other apps. Another participant mentioned that they would enjoy having the app give specific nutrition advice based on their pictures.

General sentiment in group TK was that the app was easy to use but it required time and effort but the app was not found to be complex. Three participants only entered names without nutritional values. Tracking fresh ingredients remained very difficult.

Two participants in group T reported that the app was easy to use. However, one experienced this as positive, the other as negative because the simplicity and open nature does not provide much guidance. One participant focussed on tracking breakfast only as this was easiest to do, while another participant tracked dinner only as that meal has the most variety and would be most insightful, breakfast was boring. Three participants decided to only input names at some point. One participant only tracked carbohydrates. Tracking fresh ingredients or tracking meals prepared by other people whether friends, restaurants and the like was deemed very difficult and as a result was not done.

7.4.3 Theme 3: Social and private context

Six participants in group PK reported that it did matter if they tracked in a social or private context. Four out of six reported that social context makes it so that tracking is easier forgotten to do. One participant reported feeling more pressure in social settings.

What I noticed is that when making pictures you have to take time for them in the moment. Imagine you could enter data as text in hindsight, during lunch I do not find it classy to take pictures. (PK2)

Another participant reported that tracking in a social setting could be a positive experience as food tracking could be used as a topic of conversation. Eight participants reported that tracking in a social or private context did not matter for them. One of these eight reported that some person made some comment in a social context which caused the participant to feel awkward.

Five participants in group P reported that it mattered if they tracked in a social or private context. The reasons given are as follows. It was easier for one participant to track in a restaurant because it was easier to make more beautiful pictures of food. Another participant reported that they disliked the idea of photographing inside a restaurant. This participant among two others reported that social settings distracted them more which made it harder to remember to track. One participant reported that due to the nature of their work their access to their phone was restricted and thus tracking became more difficult. Seven participants reported that the difference between a private or social setting did not matter.

Five participants in group TK reported that it mattered if they tracked in a social or private context. One participant out of these five mentioned that they consider it rude to be using a phone while eating in a restaurant as well as mentioning that social interaction makes it easier to forget to track, however, social situations can enable people to help each other remember to perform certain tasks.

For example, yesterday I went out to eat and then I thought, oke, I have to track, but I am not going to go on my phone because I am out to eat, and then I forgot to track when I got home. But, when I was eating with a girlfriend that also used the app we helped each other remember to track. (TK1)

Other sentiment included that social settings cause less time to be available to track and social settings cause more distraction. One participant out

of these five would enter all data at the end of the day. Six participants reported that it did not matter if they tracked in a social or private context. Sentiments from these six include that they did not experience many social occasions and that they would not experience judgement from others because of healthy eating choices.

Eight participants in group T reported that it did matter whether they tracked in a social or private setting. Four out of these eight participants reported that social settings were distracting and therefore were more prone to forgetting to track. Three out of these eight reported that they did not know exactly what was in the food which makes tracking difficult. One out of these eight reported that they simply did not prefer to track in social situations. One participant reported that it did not matter whether they tracked in a social or private setting.

7.4.4 Theme 4: Data reflection

Both notions from standing literature about reflection, reflection on action and reflection in action, were observed to occur in each group to varying degrees varying per person. Exact distinctions remain unclear.

Every participant experienced reflection as a result of app usage except one due to technical difficulties. The general experience with data reflection in group PK could be described as not learning anything new per se, but becoming more aware about food consumption.

I am very aware of what I eat and drink, and what is good and what I should change. You are being confronted with with something you already know, it is confrontational, but not new information. (PK3)

Four participants experienced data reflection as confrontational where one of these four also reported that data reflection was experienced as shocking.

I decided to photograph all the unhealthy things, and I can tell you it is confrontational when you scroll back after two weeks of logging [...] shocking, if you only take pictures of unhealthy foods, you only see unhealthy foods. (PK14)

Two participants reported that data reflection was not confrontational to them. One participant reflected on their pictures at the end of the experiment out of curiosity. Data reflection was only possible in limited form for one participant because the scroll functionality was broken.

Fourteen out of fifteen participants in group P reported that they experienced reflection. Degrees of reflection varied heavily with most people reporting that they reflected on their pictures between 1 and 3 times. Five participants reported that reflecting on their pictures made them more aware of what they ate, but did not necessarily learn something new. Three participants showed their pictures to other people. Four participants experienced reflection as neutral. Two participants reported that they experienced positive emotion as a result of pictures judged as healthy.

[...] seeing healthy pictures when opening the app triggered a good feeling [...] (P10)

One participant looked through the pictures once to figure out the last time broccoli was eaten, another mentioned that if they thought someone else was able to look at their pictures too they would make different choices. Finally, one participant judged themselves negatively as a result of some of their pictures.

Five participants from group TK reported not having experienced reflection as a result of using the app, one of which reported intending to do so but ended up not doing it. Another stated that the numbers did not mean anything to them, in contrast to another participant which stated that a lot was already known territory due to their intensive sportive past. Seven participants reported having experienced reflection supplemented by the following statements.

Entering data caused me to reflect so that there was no need for me to scroll back. (TK1). I came to the realisation that I eat very little protein, the app helped me gain insight however interpreting numbers remains difficult. (TK2). I looked back on the data to look at how the app functions and to look at consistency in my eating habits. (TK3). I was already aware of what I ate but the app still offered insight and was a little confrontational. (TK4). I looked back once but the times when I entered data did not match which demotivated me. (TK6). It was fun but also practical looking back to see what I ate, however, nothing surprising.(TK8). I looked back once to see how the app works. I looked back to check if I ate enough. (TK14)

Nine participants in group T reported experiencing reflection. Two out of these nine reported that contextualising and interpreting their numbers was immensely difficult.

[...] I do not know much about food numbers, how are things supposed to

look at the end of the day? (T3)

Five out of the nine stated that they gained some insight as a result of reflection. One participant reported that positive emotion was experienced as a result of tracking data judged as healthy. One participant reported that reflection caused them to be more considerate of their eating choices.

7.4.5 Theme 5: Domain knowledge

Three participants in group PK experienced the domain knowledge positively. These three participants commented the following:

[...] being engaged and I would like a link to more information sources. (PK2). [...] fun and educational but it does not contain new information. (PK8). [...] the domain knowledge having a pleasant structure and being easy to use and containing partly already known information but also partly functioning as a refresher. (PK15)

Six participants reported having a neutral experience with the domain knowledge where the contents were quickly skimmed as they reported that it did not contain new information for them. Zero participants reported having a negative experience. Five participants did not engage with the domain knowledge at all due to not identifying a need to do so either because they judge themselves or their diet as healthy.

Zero participants in group P expressed feeling a need to look up information outside the app to contextualise their pictures.

One participant from group TK experienced the domain knowledge positively where this participant stated that it was fun to read but also most information was already known. Three participants had a neutral experience where one mentioned a different information structure would suit better, the others reported that the information was already known to them. Zero participants reported having a negative experience. Nine participants did not use the domain knowledge with all but one participant stating that they did not need the information or that the information was already known to them. The other participant mentioned that they were sceptical about the 'schijf van vijf' and often did not agree with this model and the 'voedingscentrum' institution.

[...] I am convinced that my keto diet is healthy, but 'voedingscentrum' would very much disagree [...] often times the 'voedingscentrum' is behind on modern science. (TK8)

One participant in group T reported having checked online what normal kcal amounts were for the average person. Fourteen participants reported not feeling a need to look up outside the app information to better understand and contextualise their tracked data. Nine out of these fourteen participants reported that they did look up online what the nutritional contents of some foods were in order for them to be able to track.

7.4.6 Theme 6: Personal insights

Four participants in group PK reported having gained personal insights which include the following.

my eating behaviour is boring with a lot of repeating meals. (PK1). I realised lacking enough liquid and fruit consumption. (PK3). That I do not eat enough fruit (PK4). Nine participants did not report having gained any new personal insights.

Two participants in group P reported having gained personal insights which include the following sentiments.

Becoming more aware in the sense that you eat more things than you realise (P1). Having gained a better understanding of at what times food was consumed. (P9). Ten participants reported not having gained new personal insights, often things were already known.

Ten participants in group TK reported having gained personal insights which include the following statements.

I learned that I eat consistently (TK3). I gained more insight into what I exactly eat. (TK4). I often was not aware of how much I actually eat in a day. (TK5). There were more moments in a day where I ate than I had anticipated. (TK6). I tracked for only one day but it was enough to teach me that I eat too little, it was an eye opener. (TK10). I ate very little prepackaged foods which made tracking difficult. (TK11). I realised I have to eat more, it was something I already knew but the situation was more severe than anticipated. (TK14). Three participants reported to not have gained any personal insight.

Seven participants in group T reported having gained some personal insight that includes the following statements.

I was less able to track as anticipated but that is fine because I have previous tracking experience. (T2). It was useful to learn about food. (T3). I learned that I did not mind tracking food intake as much as I thought I would. (T6). My breakfast and lunch are nearly always the same. (T8). I learned that prepackaged food contains more calories compared to non prepackaged food. (T10). I eat the same thing many times. (T14).

Six participants reported not having gained personal insights. One elaborated stating that they had already gained personal insights through previous tracking endeavours.

7.4.7 Theme 7: Motivation to change

Three participants in group PK reported that the app motivated them to change their behaviour. Motivation to eat healthier, exercise more, and eat more varied was observed. Eight participants reported not experiencing motivation as a result of using the app. Sentiment included that the period was too short to cause significant motivation to change and already having a healthy weight and diet.

Yes, I changed my eating habits, eating healthier, more exercise. (PK2)

Zero participants in group P reported experiencing motivation to change as a result of using the app. Ten participants reported not experiencing motivation. Reasons given include that four participants judged themselves or their diet as healthy and therefore did not see reason to change. One participant reported that the time period to change was too short.

[...] I know what eathing healthy is, and know what I eat, so for me there is not really motivation. (P3)

One participant in group TK stated that the app motivated them to change. Nine participants mentioned that using the app did not cause motivation to change. The most stated reason was that there is no need for motivation. One participant mentioned that the app could motivate them in different circumstances.

Two participants in group T explained that they experienced motivation to change. One of these two reported that they are motivated to better monitor their behaviour when it comes to shopping and hunger. The other reported that he or she is motivated to think more consciously about food.

Eleven participants reported not being motivated to change.

Healthy alternatives are often more expensive [...] sometimes, depends on my financial situation, depends on how busy I am. (T6)

7.4.8 Theme 8: Recurrent tracking

Seven participants in group PK reported that they are open to track their food consumption again with the app they used or another. One of these seven reported that they would prefer another tracking method, another reported that they would track again if the app allowed for tracking with numbers.

If I were to track again, then I would like an app with numbers, because I already know generally what is healthy and what is not, numbers would tell me more. (PK13)

Another reported that reminders would significantly help. Two participants reported that they will most likely not be tracking their food consumption again. Four participants were doubtful if they would track again with one participant clearly stating they would avoid food tracking apps that use numbers.

Ten participants in group P reported that they are open to track their food consumption again with the app they used or another. Sentiments from these ten participants include: would appreciate automatic photo analysis, would like to express food consumption in numbers by counting nutrients, tracking food consumption is always interesting. One participant reported that they would not be open to track again due to not seeing a reason to do so.

Four participants in group TK reported that they are open to track their food consumption again with the app they used or another. However, three out of these four participants mentioned they would like additional functionality to assist them such as database lookups and creating presets. Seven participants reported they would not track again with the most cited reason being that there is no necessity to do so. Other reasons include that one participant already tracked once before in a similar fashion and therefore doing it again has diminished value. Another participant mentioned that they would maybe only use the app to check once in a while. One participant was doubtful as they stated that tracking requires significant effort but it is useful.

[...] it is not required, there is no neccesity, I eat healthy and am of health weight. Maybe if circumstances change such as sickness then I would consider tracking. (TK7)

Eight participants in group T reported that they would be open to track food intake again with some app at some point in the future. General sentiment from these eight participants include that they would like an app that is easier to use. Four participants reported not being open for recurrent tracking. General sentiment for these four includes that tracking is not important for them and that they would like a goal.

7.4.9 Theme 9: Additional observations

Additional observations worth mentioning in group PK include the following sentiments.

I was more concerned with taking nice pictures instead of food. (PK1). Confrontation triggered me to better watch my food intake. There was always a motivation to become more healthy, the visual stimulus, although sporadically, triggered me to look at how I can be more healthy (PK2). I gained more insight in my behaviour around food than food itself [...] I also felt like I was being watched. (PK4). I would like to be able to sort photos. (PK7). I saw the value of the app in general but not for me personally. I noticed that photos were cropped which I did not like. (PK8). I have been on diets before and hated writing down what I ate, however, taking photos was not so bad. (PK10). [...] automatic photo analysis could be useful if possible. I would like to enter a goal and focus more on counting. (PK11). I enjoyed taking pictures because counting is difficult and makes me insecure. (PK12). Photos were of little value because you could not exactly tell what was in the food. (PK13). Photographing everything you eat is a lot of work. (PK15).

Additional observations worth mentioning in group P include the following sentiments.

[...] change in behaviour takes longer than two weeks. Need more time, but gained insight nontheless. (P1). I would like to have a goal oriented app but do see the value of the app. (P3). This app could be useful for dieticians. (P5). At one point I photographed a receipt. (P7). I would like a filter to better navigate my photos. (P9). My sister participated in the experiment too and there were times where we motivated each other to take pictures. Scrolling through the photos after some time using the app inspired me to

make some meals I made previously.(P10). Pictures are very confrontational as there is no hiding by writing, this works faster, social support is constructive. (P11). I understand the value of the app but it is not suited for me, I would like a goal oriented app. (P13). I moved the app to the start screen to help me remember to use the app. (P10).

Additional observations worth mentioning in group TK include the following statements.

[...] I logged everything at the end of the day. (TK2). I wanted to see how easily I could learn a new habit, this was my main motivation for joining the experiment [...] I ate more of the same because inputting data would be easier. (TK3). Numbers are not necessary, more important for me is how the day was in terms of activity levels and mood. (TK12).

Additional observations worth mentioning in group T include the following statements.

I would like to have information about food and a goal. (T3). I would like to know the environmental impact of my eating choices. (T6). I would like it if the app can contextualise the numbers based on me regarding aspects such as age and gender. [...] I downloaded another app to compare user friendliness. (T7). Push notifications would help me. (T8). Sometimes I thought that eating prepackaged food would be easier to track. (T10).

7.4.10 Theme 10: Technical difficulties

Four participants in group PK reported experiencing technical difficulties varying in severity. One participant mentioned picture loading took a long time. Another participant reported that the app only temporarily stored the photos. Later it was revealed it was because the participant did not grant full permissions. One participant was unable to scroll down in their picture feed. Finally, one participant deleted some pictures from the gallery which resulted in some pictures missing in the app.

Five participants in group P reported experiencing technical difficulties to various degrees. Sentiments include the following. Photo loading took some time which caused me to double check if the photo was stored in the gallery which was detrimental to the user experience. App asking permission to store a photo with every photo being taken. The back button on the screen when taking a picture did not work for one participant. Manipulating

the FoodFriend gallery folder caused the order of pictures in the app to shift. The dates of all pictures taken all defaulted to '24 oktober' for unknown reasons.

Participants in group TK did not experience technical difficulties. However, suggestions of improvement were made. These suggestions include being able to create presets, allow for database lookups, allow for barcode scanning and being able to manipulate data entry timestamps.

Participants in group T did also not experience technical difficulties and again suggestions for improvements were made. Four participants reported that they would like it if they could change the times of inputted data so that they were better supported in inputting data at a later point in time after consumption. Others reported that database support, presets, or copying data entries would be supportive to their tracking needs.

8. Discussion

Potential ethics issues, interpretation of the results, limitations of the study and directions for future work are discussed in this chapter.

8.1 Potential ethics issues

It was unexpectedly observed that Qualtrics records the date and time when a survey was answered. Cross referencing this information with data from my phone agenda, Microsoft Teams data and personal Whatsapp data can make it in theory possible to determine which survey was answered by whom. However, participants could simply take the survey at a later time if they so wish and thus cross referencing can never be fully accurate. This undermines the notion of anonymous data collection nonetheless. However, I personally have no interest in linking data to individual participants. Additionally, only I, the author, could theoretically cross reference the data. For outsiders, even my supervisor, the data is guaranteed anonymous.

Another potential ethical concern has to do with data construction. One participant was unable to send over the data that records how many times the app came to the foreground and how many data entries were recorded. However, through the interview, this data was approximately reconstructed. It is not possible to ever know if the reconstructed data was accurate. The choice has been made to reconstruct the data instead of omitting it because the participant was able to accurately and convincingly describe during the interview how the app was used.

Participant distribution amongst the groups was as random as possible with one exception. The exception was that people within the same household were given the same app version whenever possible. The reasoning is that it was expected that participants living within the same household would at some point during the study communicate about the app and that would influence their opinion on the app based on what version the other person had. This influence was deemed more significant than sticking to the

true random distribution of the participants. This occurred for 4 households affecting the distribution of 8 participants.

8.2 Interpretation

App usage across the entire study and within groups varied heavily when looking at the app usage results and interview results. There was a significant difference to the extent to which people tracked. Some tracked the entire two weeks, some sporadically and others somewhere in between. Additionally, some only focussed on their breakfast, some only on their dinner, some tracked everything while others tracked only snacks. Furthermore, some tracked purely out of curiosity while others defined their own goals. This last finding is congruent with current literature. Additionally, two participants tracked because they wanted to help the researcher as explicitly stated by them. It is theorised that this phenomenon could reoccur in real world scenarios when people would track consumption while being supported by a professional such as a dietician. There does not seem to be any characteristic regarding app usage that separates one group from the others. Therefore, it appears that the tracking method or the presence or absence of domain knowledge does not seem to matter in terms of tracking performance. Perhaps aspects such as personality, thoughts, beliefs, current eating behaviour and attitude towards eating are stronger determinants of tracking behaviour.

The results of this research support the existing theory about barriers to engage in tracking. Indeed people reported that they were unsure about what and how much to journal. Across all groups people tracked what they wanted. It was, in correspondence with current literature, observed in one instance that the consumption of pre packaged food was done on purpose so that tracking would be easier. The existing literature also found that database reliability concerns exist. The intentional omission of any database resulted in many respondents to call out for one to support their tracking in the traditional tracking groups. One could argue that community build databases, despite the issues surrounding them, are preferred over having no database at all especially when it comes to tracking fresh, non packaged foods. The literature also stated that social contexts can be detrimental to tracking by for example inducing feelings of shame. This research observed this phenomenon as well. However, a more prevalent sentiment was that social contexts are simply more distracting and therefore people forget to track. Going one step further, social contexts in which other people also track can lead to situations where tracking people support each other in the tracking process. Furthermore, existing literature reported that food

journaling requires high levels of engagement which can lead to exhaustion and reduced compliance. Also this phenomenon was observed during the study, but only in the traditional tracking groups by a few participants. This phenomenon was not observed in the photo based tracking groups. Therefore, one could assume that photo based tracking is to a lesser extent prone to tracking exhaustion. Finally, the notion of data hoarding as described by the literature was also observed during this research. In the case of photo based tracking, people simply did not track or at most tracked an empty plate or glass if the situation still allowed it. In the case of traditional tracking, people would enter everything they ate at the end of the day or sometimes even the day after. It is difficult to assess whether photo based tracking methods should have some function to input data at a later point. On one hand, this encourages data hoarding which can lead to inaccurate data. On the other hand, perhaps tracking something is better than tracking nothing at all. Another angle could be supporting people in remembering to track so that inputting data at a later point in time is not necessary.

Both notions of reflection from standing literature, reflection in action and reflection on action, were observed to occur within each group to varying degrees varying per person. Tracking method and the presence or absence of domain knowledge does not seem to be of significance when it comes to supporting reflection. However, there appear to be different aspects about reflection that people engage in. Some people within the traditional tracking groups could contextualise their numbers easily while others could not which led to diminished reflection for them. Some people within the photo based tracking groups could easily reflect upon their pictures while for others the pictures did not mean much. Some people reflected on their eating behaviour such as the times and frequency of eating. In some cases people would be inspired to prepare the same meal they had tracked at some point in the past. Furthermore, tracking data judged as healthy would in some cases trigger a positive emotional response. Very few participants reported to not have experienced reflection at all either due to lack of app usage or disinterest. Generally speaking, people became more aware of things they already knew but did not learn anything new. For a few this was enough to trigger behaviour change while for others it was not. It remains unclear whether this behaviour change will be sustained long term. Perhaps these varying experiences with reflection were due to the free and open nature of the apps, or perhaps due to each individual being different in their own unique way.

The interest/enjoyment metric showed that the photo based tracking method is perhaps slightly more enjoyable or interesting than the traditional based tracking method. This finding is supported by the interview results

where substantially more people within the photo based groups reported to be open to track again in the future with some app compared to the traditional tracking based groups. Potentially the interest or enjoyment would be the same if the traditional tracking method provided more data input support through barcode scanning, database lookups and preset creation as participants also have indicated.

The pressure/tensions IMI subscales scores could be explained in two ways. Firstly, nearly all participants reported there was no need to change eating behaviour which could explain the scores. Secondly, the scores could be explained due to the open and free nature of the experiment, participants could use the app however they liked, and therefore did not experience substantial pressure. The open and free nature could also explain the effort/importance scores. Most participants got something out of the experiment which could explain the value/usefulness scores.

Intrinsic motivation scores varied greatly. It remains unclear why this is the case. It may be depending on factors like attitude in relation to food, self image, beliefs and so on. The identified regulation scores are similar to the intrinsic motivation scores. Identified regulation means that behaviour is adopted if deemed beneficial for the sake of being beneficial. The external regulation scores could also be explained by the free and open nature of the experiment. It was attempted to make participants very aware of the fact that their tracked data remained on their phone and was not viewable by anyone. The guaranteed privacy and the individualistic nature of the task likely contributed to the external regulation scores as they are. The amotivation scores are most likely explained by the idea that people participating in the experiment want to aid the researcher to some degree and therefore are always to some degree motivated to perform the activity.

The insight scores show that domain knowledge is likely insightful for a small subset of participants, for most it is not. The large variance in exploration scores can perhaps be attributed to the variance in food knowledge participants possess. Having solid knowledge helps contextualise and understand the data, having poor knowledge does the opposite. Another explanation could be that some people are simply more interested in food and exploring tracked data than others.

Domain knowledge was not extensively used by participants. Some browsed the contents briefly when it was present in their app version while others did not make use of the provided domain knowledge. Nearly all participants reported that the contents of the domain knowledge when browsed were already known to them. Additionally, it appears to be so that when a person judges their diet as healthy or their current health status in relation to food consumption as healthy, then there is little need to learn more about food

and thus domain knowledge is only quickly skimmed at best by most people. Again, variance in behaviour is present here too in the sense that very few participants, but some nonetheless, read the domain knowledge in its entirety. The results of the performed statistical tests support the interview results in the sense that participants that read the domain knowledge only briefly read it as opposed to studying it.

8.3 Limitations

The GNKQR, IMI, SIMS, and TSRI were resources used and originally written in english. These resources were translated to dutch without validation. This could pose a threat to the reliability of the results.

Fewer participants were recruited than desired. In the end, fifteen participants were recruited per group and used in data analysis resulting in a total of sixty participants for the main study. Drawing conclusions and generalising results becomes harder with fewer participants. Detecting outliers becomes more difficult, and the effect of outliers if there are any is much stronger which could skew the results. Nonetheless, I argue that fifteen participants per group is enough to at least gain some form of insight into how people use reflective personal information systems in the context of food.

Age distribution per group appeared to represent the total age distribution with the exception of group T, which only included participants aged between 18 and 35. There is a chance that the age distribution significantly affects the results. Therefore, further exploration of the data was required. Further exploration was performed by examining only data from participants aged 18 to 35 per group and comparing that data to the overall results per group for each metric. No significant deviations were revealed and thus it assumed that age did not have a significant effect on the data.

The result of the GNKQR pre main study survey was assumed to be normally distributed but data analysis showed this varied per group. The shapiro wilk test showed that the distribution of the GNKQR scores in the pre main study survey were normally distributed for groups PK, P, and TK, but not normally distributed for group T. These results raise reliability concerns. Furthermore, it was observed during the study that some participants asked for clarification if the questions in the GNKQR applied to them or applied to the general populace. It is unclear how many actual participants experienced the same confusion and how many participants interpreted the questions not as intended. This observation poses a serious and significant threat to the validity of the GNKQR results.

Some participants encountered technical difficulties when using the photo

version. These difficulties included slow photo loading. Loading could take up to several minutes. Two participants encountered issues with app permissions where the app would not permanently store all photos. On some android devices the app asked explicit permission for each photo. It remains unclear exactly why this happened on some android devices but not others. Furthermore, the scroll functionality did not work for two participants. These technical difficulties pose a threat to the results, but the technical difficulties were only experienced as minor obstacles as identified through the interviews.

8.4 Future work

Nearly all the participants included in the study were healthy, which means having no signs of serious underweight, overweight or significant diet related problems. A drive to change was less prevalent because of this. It would be interesting to see how a photo based food tracking approach would function in a population which has diet related problems. One study cited earlier in this thesis found that overweight or obese people preferred knowing the amount of calories in tracked foods rather than just tracking a picture. However, one participant in this research was also overweight and had been on many diets before. This person mentioned during the interview that he or she hated counting calories. Tracking consumption with photos was a more positive experience for him or her than previous tracking endeavours. Of course, one cannot draw conclusions from one participant alone, yet it still makes you wonder what role reflective technologies and photo based tracking technologies could play. Additionally, being overweight or obese is just a small piece of the malnutrition problem. Therefore, I call out for future research that focuses on photo based tracking approaches and reflective design paradigms, perhaps combined with mindfulness concepts, to better understand how these technologies may help individuals that struggle with all diet related issues.

Photo based food tracking could also be beneficial for dieticians and their patients alike. Tracking with photos was found to be likely to be slightly more enjoyable and easier to perform which in turn could lead to more complete data. Additionally, dieticians could infer more information from pictures than written words or calculated macronutrients. For example, a picture of a meal containing potatoes, vegetables and meat could be more insightful for dieticians than written words, because you can immediately see the portion size and relative distribution. Therefore, dieticians might be able to give more precise advice relevant to the patient. Future research incorporating photo

based tracking in dietary practises could further explore exactly how this technology could be beneficial by supporting dieticians and patients alike.

Lapsing due to forgetting to track remains a big obstacle as observed in this research as well as current literature. Future research could focus on how to support people in remembering to track. Photo based food tracking technology is still a relatively young technology with great untapped potential. Further improving this technology and research on how to effectively leverage this technology is likely to aid in combating the global malnutrition problem. Another angle of improvement to this technology is to perhaps incorporate mindfulness concepts in an attempt to create a mindful photo based tracking experience as mindfulness has already been observed as a beneficial approach in standing literature bodies.

The amount of people that participated is rather low which makes generalising the results and drawing conclusions difficult. More research is needed to understand how people might use reflective tracking technologies and photo based food tracking technology so that these technologies, once better understood, can be leveraged more effectively.

9. Conclusion

The final chapter reflects on the findings in relation to the study aims and discusses contributions made.

This research aimed to investigate how to support people in making healthier food choices through personal informatics in order to combat the global malnutrition problem. It attempted to do this by utilising reflective approaches differing in tracking method and the presence or absence of domain knowledge. The approaches intentionally were void of any form of goal setting. The results indicate that photo based food tracking supports reflection on par with established food tracking methods. Further findings indicate that photo based tracking is slightly easier to perform than traditional tracking. Photo based tracking does appear to be a slightly more positive experience due to reported willingness to track food intake again with some application in the future combined with the interest/enjoyment subscale results. Additionally, motivation to track among the participants appeared equal amongst groups indicating that tracking method does not impact motivation to track. Finally, the presence or absence of domain knowledge does not seem to have any significant effect except for the indication that domain knowledge can be perceived as slightly insightful by a small subset of people.

This research demonstrated that photo based food tracking is likely a viable alternative to traditional tracking. It is probable that photo based tracking is a method more suited for reflective approaches than traditional tracking. Additionally, it was also demonstrated that an approach void of any goal oriented paradigms can support people in terms of reflection. This research also observed that the presence or absence of food related domain knowledge in the app appears to have limited effect on how people use food tracking apps.

Another contribution of this research is that current standing literature findings have been strengthened by the findings of this research. Yet, new insights have been gained. More insight has been gathered on how people use reflective technology. It seems probable that aspects such as personality, attitude towards food, beliefs about food and aspects of similar nature

are stronger determinants of how people use food tracking technology than the investigated aspects of tracking method or the presence or absence of domain knowledge. Furthermore, photo based food tracking or reflective design approaches are likely not miracle solutions that are strictly better in every way. It appears to be so that different people have different needs and therefore some people would prefer a photo based tracking method or a reflective approach while other people would prefer traditional tracking methods or modernist design philosophy. In more cases than not, a photo based tracking method is probably found to be more enjoyable. These contributions are important in order to effectively advance reflective food tracking technology so that it could one day perhaps be deployed on a large scale to the benefit of individuals and society alike.

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A. Domain Knowledge Contents

Screen: Nutrition information main screen
Text: De schijf van vijf is afgestemd op de gemiddelde gezonde nederlander. Scroll naar onderen en klik op een van de onderwerpen om meer te weten te komen. Raadpleeg bij problemen altijd een deskundige.

Screen: Algemene Informatie
Text: Algemene Informatie

Het lichaam heeft voedsel nodig om goed te kunnen werken. Elke beweging die gemaakt wordt, elke keer dat je ademhaalt, het kost allemaal energie. Die energie krijg je door te eten. Naast energie zitten er ook belangrijke voedingsstoffen in eten. Die voedingsstoffen zorgen ervoor dat je lichaam gezond blijft. Bijvoorbeeld, mensen met een ijzer tekort kunnen extreem moe worden. Voedsel is dus ontzettend belangrijk. Maar hoe weet je nu wat je lichaam nodig heeft?

De schijf van vijf is gemaakt om te laten zien hoe een gezond en gebalanceerd dieet eruit ziet. Het is de bedoeling dat je elke dag iets eet uit elk deel van de schijf van vijf. De schijf van vijf bestaat uit de volgende vijf delen: koolhydraten, vetten, eiwitten, groente & fruit, en dranken. Bijvoorbeeld, een dieet van alleen maar eiwitten is dus zeer onverstandig omdat je dan veel andere belangrijke stoffen niet binnenkrijgt.

Voedingsdeskundigen raden aan om regelmatig en verspreid over de dag te eten. Elke dag ontbijten kan ervoor zorgen dat je de rest van de dag regelmatiger eet zodat je minder in verleiding wordt gebracht om ongezonde snacks te eten.

Gezonde en ongezonde keuzes

Wat wel en niet gezonde of ongezonde keuzes zijn hangt helemaal af van je eigen situatie. Bij ondergewicht moet je veel calorieën eten om aan te komen. Bij overgewicht is het precies andersom, dan moet je weinig calorieën eten

om af te vallen. Meer informatie hierover in het aparte stukje over calorieën. Er zijn wel producten die altijd ongezond zijn.

Producten met veel zout, verzadigde vetten en toegevoegde suikers zijn ongezonde keuzes, ongeacht jouw eigen situatie. Maar waarom zijn deze producten ongezond? In de volgende stukjes tekst gaan we dieper in op zout, verzadigde vetten en suikers.

Het lichaam heeft zout nodig, maar je krijgt al genoeg binnen zonder extra zout te gebruiken. Teveel zout kan zorgen voor een verhoogde bloeddruk en nierschade. Producten met veel zout zijn bijvoorbeeld chips, pizza, soep in blik en kant-en-klaar maaltijden. Een keer deze producten nuttigen is niet zo erg, maar let op dat je ze niet teveel eet.

Het lichaam heeft ook vetten nodig. Vetten zijn erg belangrijk omdat ze hormoonaanmaak ondersteunen en helpen bij het behoud van zenuwcellen. Onverzadigde vetten zijn gezond. Verzadigde vetten en transvetten zijn ongezond. Verzadigde vetten zijn ongezond omdat ze hart- en vaatziekten, overgewicht en kanker kunnen veroorzaken. Transvetten verhogen de kans op hart- en vaatziekten.

Suikers zijn niet per se ongezond maar zitten wel vaak in ongezonde producten. Je maakt dus gezondere keuzes door producten met veel suiker te vermijden. Voor mensen met overgewicht is het verstandig om suikers te vermijden omdat deze je eventjes veel energie geven waarna de energie snel afneemt. Door deze snelle afname van energie krijg je een hongergevoel waardoor je blijft je eten.

Veel producten die veel zout, verzadigde vetten en toegevoegde suikers bevatten zijn zwaar bewerkte producten. Bewerkte producten zijn verse producten die op een bepaalde manier zijn klaargemaakt of veranderd. Zwaar bewerkte producten zijn dus producten waar heel veel aan is veranderd. Door bewerking wordt eten ongezonder. Voorbeelden van zwaar bewerkte producten zijn: fastfood, kant-en-klaar maaltijden, koek, gebak en frisdranken. Daarbij komt dat zwaar bewerkte producten ook vaak veel calorieën bevatten en weinig vitaminen en mineralen.

Voedseletiketten

Je kunt veel informatie vinden op voedseletiketten. Bekijk ze eens om te weten te komen wat er wel en wat er niet in een product zit. Ook kun je producten zo met elkaar vergelijken om erachter te komen wat de verschillen zijn.

Voor uitgebreidere informatie over voedseletiketten of voedsel in het algemeen wordt u aangeraden om een kijkje te nemen op de website van het voedingscentrum.

Screen: Calorieën
Text: Calorieën

Je lichaam heeft energie nodig zodat je kunt blijven bewegen en nadenken. In alles wat je eet of drinkt zit energie. Deze energie wordt vaak uitgedrukt in kilocalorieën (kcal). Hoeveel kilocalorieën je nodig hebt verschilt op basis van je geslacht, leeftijd, lengte, hoe actief je bent en andere factoren. Volwassen vrouwen hebben ongeveer 2000 kilocalorieën per dag nodig. Volwassen mannen hebben ongeveer 2500 kilocalorieën per dag nodig. Hoeveel kilocalorieën je echt nodig hebt is dus lastig te zeggen en hangt af van veel factoren. Hoeveel je nodig hebt zal ook per dag verschillen.

De grootste bronnen van calorieën zijn koolhydraten, vetten en eiwitten. Deze voedingstoffen leveren veel energie. Teveel energie wordt opgeslagen als vet in het lichaam waardoor je dus dikker wordt. Als er te weinig energie in het lichaam komt, dan zal het lichaam vet gaan verbranden om dit energieverlies op te vangen. Hierdoor wordt je dus dunner.

Elke gram koolhydraat (inclusief suiker) en eiwit levert 4 kilocalorieën, terwijl elke gram vet 9 kilo-calorieën levert. Elke gram vezel levert 2 kilocalorieën, en elke gram alcohol levert 7 kilocalorieën.

Screen: Koolhydraten
Text: Koolhydraten

Koolhydraten vormen een belangrijke bron van energie voor het lichaam. Koolhydraat rijke producten bevatten ook vaak vezels die belangrijk zijn voor een goede spijsvertering. Koolhydraten zijn dus belangrijk.

Gezonde bronnen van koolhydraten zijn volkoren graanproducten zoals volkoren pasta, bruin brood, couscous, aardappel en havermout. Deze producten bevatten niet alleen veel koolhydraten maar zijn ook volkoren. Volkoren producten bevatten vezels. Vezels zorgen voor een goede spijsvertering en ze zorgen ervoor dat je minder snel honger krijgt.

Minder gezonde bronnen van koolhydraten zijn bijvoorbeeld witte rijst, witbrood, witte pasta en beschuit. Deze producten bevatten wel veel koolhydraten, maar erg weinig of zelfs geen vezels. De vuistregel is dus dat volkoren producten gezonder zijn omdat deze vezels bevatten.

Er zijn veel meer koolhydraat rijke bronnen dan hier genoemd. Bekijk het etiket op een voedselproduct eens om erachter te komen hoeveel koolhydraten er precies in zitten. Bekijk vergelijkbare producten eens om erachter te komen wat de verschillen zijn.

Suikers

Suikers zijn hele korte koolhydraten. Doordat ze kort zijn worden ze snel opgenomen en krijg je snel veel energie. Dit is vaak teveel energie voor het lichaam. De extra energie die het het lichaam niet nodig heeft wordt opgeslagen als vet. De energie van suiker is ook snel weer weg. Hierdoor word je moe en krijg je sneller honger. Op deze manier eet je al snel teveel waardoor je dikker wordt. Daarom wordt het over het algemeen afgeraden om producten te eten waar veel suiker in zit. Teveel suiker eten kan ook bijdragen aan het ontwikkelen van diabetes.

Screen: Vetten
Text: Vetten

Vet is een bron van energie en een belangrijke bouwstof voor het lichaam. Vet helpt bij het aanmaken van hormonen en onderhoudt de zenuwen en hersenen. Het is daarom belangrijk genoeg vetten binnen te krijgen.

Vetten kunnen verdeeld worden in drie groepen. Dit zijn: onverzadigde vetten, transvetten en verzadigde vetten. Onverzadigde vetten zijn gezonde vetten. Transvetten en verzadigde vetten zijn ongezonde vetten. Ze zijn ongezond omdat ze hart- en vaatziekten, overgewicht en kanker kunnen veroorzaken. Het is niet heel erg om een keer verzadigde vetten of transvetten te eten, maar probeer het te beperken.

Onverzadigde vetten (gezond) kun je bijvoorbeeld vinden in vette vis (zoals zalm, haring of makreel), zonnebloemolie, lijnzaadolie, olijfolie, koolzaadolie, halvarine, margarine, avocado's, en noten.

Verzadigde vetten en transvetten (ongezond) zitten vaak in verwerkt voedsel zoals kaas, worst, vet vlees, koeken, gebak, snoep, en snacks zoals patat en bitterballen. Verzadigde vetten zitten ook in zuivelproducten. Hoe magerder het zuivelproduct, hoe minder verzadigde vetten erin zitten.

Kijk eens op de voedseletiketten van de producten die je gebruikt om te zien wat voor vetten er precies in zitten. Vergelijk de producten die je normaal koopt ook eens met alternatieven.

Screen: Groente en fruit
Text: Groente en fruit

Het is belangrijk om groente en fruit te eten omdat deze vitaminen, mineralen en vezels bevatten die het lichaam nodig heeft om goed te kunnen blijven werken. Het voldoende en gevarieerd eten van groente en fruit verminderd ook de kans op zeer veel ziekten.

Het is belangrijk om zowel groenten als fruit te eten. Dit is omdat groenten en fruit nogal verschillen in wat voor vitaminen en mineralen erin zitten. Door van beide groepen iets te eten krijg je over het algemeen de vitaminen en mineralen binnen die je nodig hebt.

Voedingsdeskundigen raden aan om dagelijks ongeveer 250 gram groente en 2 porties fruit te eten. In totaal dus zeker meer dan 5 porties groente en fruit per dag.

Fruitsap uit de supermarkt bevat over het algemeen minder vitaminen en mineralen dan verse groenten en fruit. Daarnaast bevat fruitsap ook heel veel suiker. Daarom staan 2 glazen fruitsap uit de supermarkt gelijk aan 1 portie groente en fruit.

Screen: Eiwitten
Text: Eiwitten

Vis, peulvruchten, vlees en ei zijn rijk aan eiwitten. Eiwitten zijn erg belangrijk voor het lichaam. Ze helpen met het behoud en de groei van spieren. Daarnaast gaan eiwitten ook infecties tegen.

Gezond eten dat veel eiwitten bevat zijn bijvoorbeeld (vette) vis, schaal- en schelpdieren, bonen, linzen, noten, (onbewerkt) vlees, tofu, tempé en eieren.

Eiwitten kunnen verdeeld worden in plantaardige eiwitten en dierlijke eiwitten. Plantaardige eiwitten kun je bijvoorbeeld vinden in bonen, linzen en noten. Dierlijke eiwitten kun je bijvoorbeeld vinden in vlees, vis, ei en zuivel. Het is aanbevolen om eiwitten te eten van beide groepen. Dit is omdat er in de ene groep voedingsstoffen zitten die de andere groep niet heeft. Gevarieerd eten is dus erg belangrijk.

Noten

Noten bevatten naast veel eiwitten ook veel onverzadigde vetten en kunnen daarom veel energie leveren. Omdat er zoveel energie in nootjes zitten is het niet nodig om veel nootjes te eten. Een handjevol per dag verlaagt al de kans op hart- en vaatziekten. Goede opties zijn ongezouten nootjes en pindakaas van 100% noten of pinda's. Minder gezonde opties zijn gezouten nootjes, nootjes met toegevoegde chocola of suiker en borrelnootjes.

Zuivel

Kaas, melk, kwark en yoghurt. Zuivel is populair in Nederland en is een rijke bron van eiwitten, vitaminen en mineralen. Maar, elke type zuivelprod-

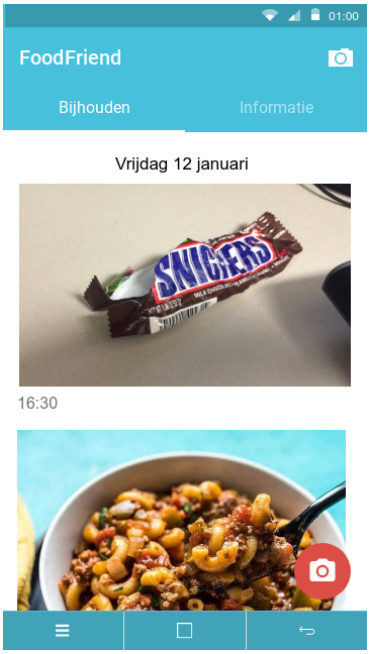
uct bevat verzadigde (slechte) vetten. De meest gezonde zuivelproducten zijn magere zuivelproducten met weinig toegevoegde suikers. Magere zuivelproducten bevatten minder verzadigde (slechte) vetten. Kaas is over het algemeen minder gezond omdat deze vaak veel zout en verzadigde vetten bevatten.

Screen: Dranken
Text: Dranken

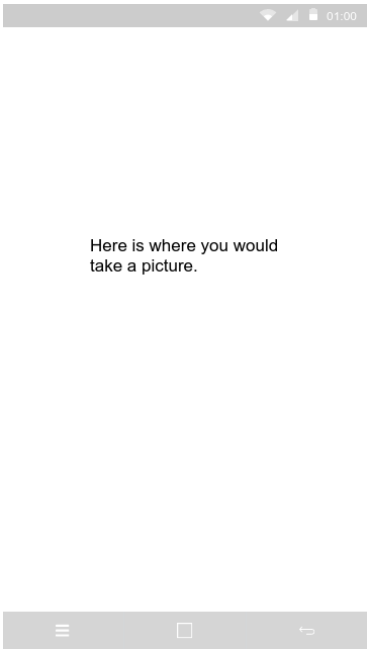
De mens bestaat voor ongeveer 60% uit water. Je verliest vanzelf water door bijvoorbeeld te plassen en te zweten. Het is dus belangrijk genoeg water te drinken zodat je lichaam kan blijven functioneren. Een goed functionerend lichaam voorkomt ziekten. Daarnaast zorgt water er ook voor dat gifstoffen je lichaam sneller verlaten. Deskundigen raden aan om dagelijks 1.5 tot 2.0 liter water te drinken.

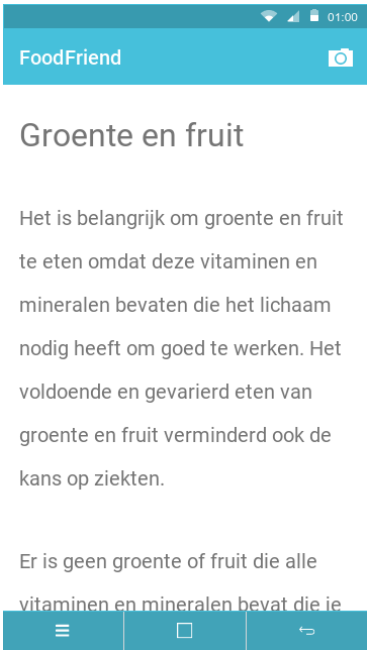
Water, groene thee en zwarte thee zijn de beste keuzes om water binnen te krijgen. Tot op zekere hoogte zijn ook kruidenthee en koffie goede bronnen. Dranken waar veel suiker in zit en alcoholische dranken zijn ongezonde keuzes. Alcohol bevat naast suiker geen voedingsstoffen en is daarom niet opgenomen in de schijf van 5. Mocht u toch alcohol willen drinken, dan raden voedingsdeskundigen aan maximaal 1 glas alcohol per dag te drinken.

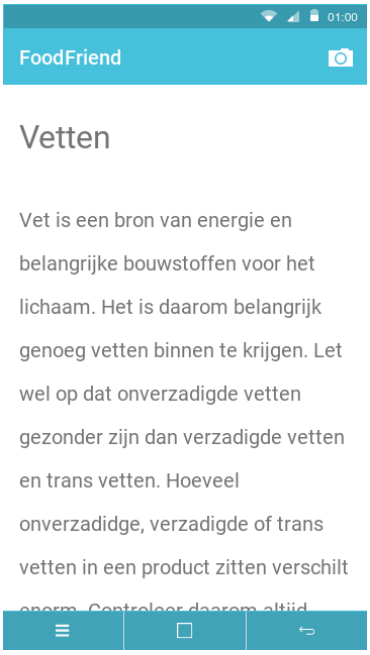
B. **Prototype screens**

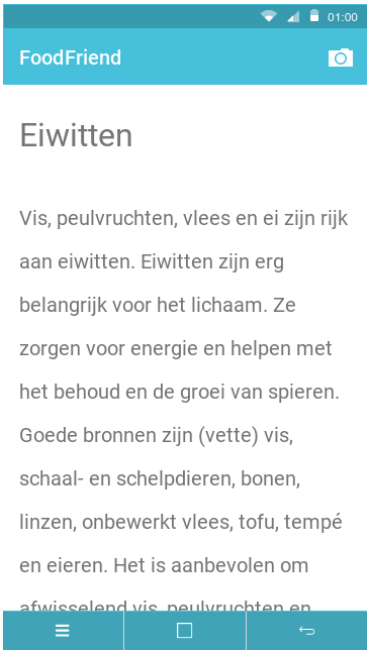

01:00
FoodFriend
Bijhouden
Informatie
Vrijdag 12 januari
SNICKERS
16:30

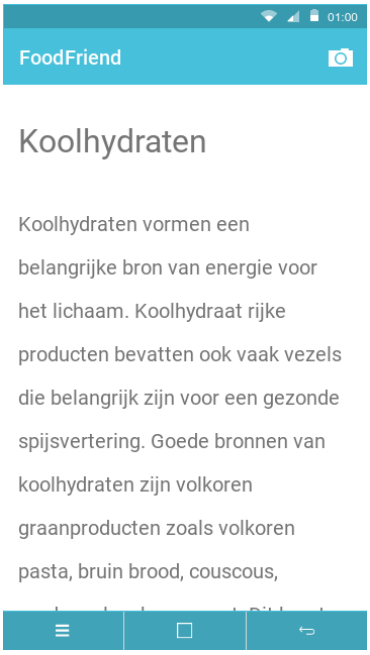

01:00
FoodFriend
Bijhouden
Informatie
De schijf van vijf is afgestemt op de gemiddelde gezonde nederlander. Scroll naar onderen en klik op een van de onderwerpen om meer te weten te komen. Raadpleeg bij problemen altijd een deskundige.
voedingscentrum.nl
schijf van vijf

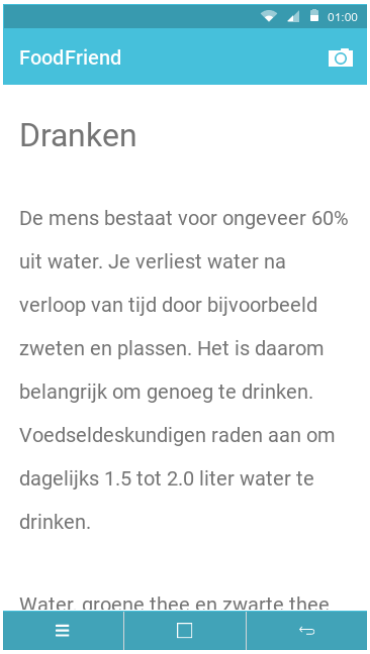

01:00
Here is where you would
take a picture.

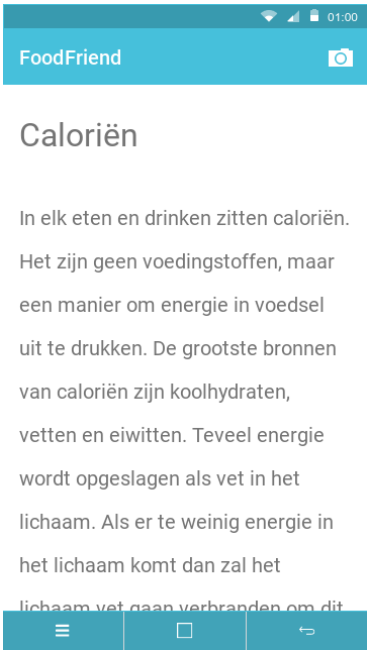

01:00
FoodFriend
Groente en fruit
Het is belangrijk om groente en fruit te eten omdat deze vitaminen en mineralen bevaten die het lichaam nodig heeft om goed te werken. Het voldoende en gevarierd eten van groente en fruit verminderd ook de kans op ziekten.
Er is geen groente of fruit die alle vitaminen en mineralen bevat die je

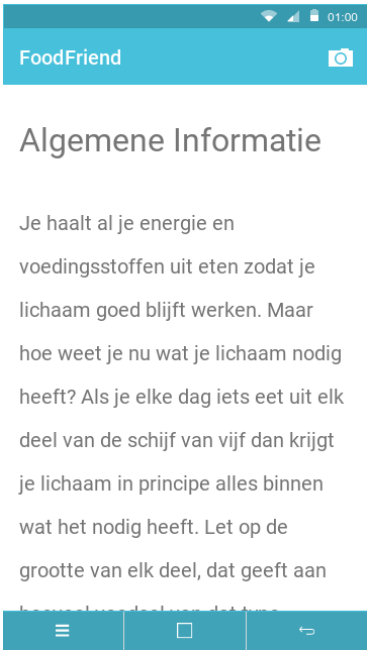

01:00
FoodFriend
Vetten
Vet is een bron van energie en belangrijke bouwstoffen voor het lichaam. Het is daarom belangrijk genoeg vetten binnen te krijgen. Let wel op dat onverzadigde vetten gezonder zijn dan verzadigde vetten en trans vetten. Hoeveel onverzadidge, verzadigde of trans vetten in een product zitten verschilt


01:00
FoodFriend
Eiwitten
Vis, peulvruchten, vlees en ei zijn rijk aan eiwitten. Eiwitten zijn erg belangrijk voor het lichaam. Ze zorgen voor energie en helpen met het behoud en de groei van spieren. Goede bronnen zijn (vette) vis, schaal- en schelpdieren, bonen, linzen, onbewerkt vlees, tofu, tempé en eieren. Het is aanbevolen om


01:00
FoodFriend
Koolhydraten
Koolhydraten vormen een belangrijke bron van energie voor het lichaam. Koolhydraat rijke producten bevatten ook vaak vezels die belangrijk zijn voor een gezonde spijsvertering. Goede bronnen van koolhydraten zijn volkoren graanproducten zoals volkoren pasta, bruin brood, couscous,


01:00
FoodFriend
Dranken
De mens bestaat voor ongeveer 60% uit water. Je verliest water na verloop van tijd door bijvoorbeeld zweten en plassen. Het is daarom belangrijk om genoeg te drinken. Voedseldeskundigen raden aan om dagelijks 1.5 tot 2.0 liter water te drinken.
Water, groene thee en zwarte thee


01:00
FoodFriend
Caloriën
In elk eten en drinken zitten caloriën. Het zijn geen voedingstoffen, maar een manier om energie in voedsel uit te drukken. De grootste bronnen van caloriën zijn koolhydraten, vetten en eiwitten. Teveel energie wordt opgeslagen als vet in het lichaam. Als er te weinig energie in het lichaam komt dan zal het


01:00
FoodFriend
Algemene Informatie
Je haalt al je energie en voedingsstoffen uit eten zodat je lichaam goed blijft werken. Maar hoe weet je nu wat je lichaam nodig heeft? Als je elke dag iets eet uit elk deel van de schijf van vijf dan krijgt je lichaam in principe alles binnen wat het nodig heeft. Let op de grootte van elk deel, dat geeft aan

C. General Nutrition Knowledge Questionnaire Revised section 1 dutch adaptation

GENERAL NUTRITION KNOWLEDGE QUESTIONNAIRE REVISED (Dutch translated)

Dit is een vragenlijst, geen toets. Het is belangrijk om de vragenlijst zonder hulp in te vullen. Als u het antwoord niet weet, markeer dan 'weet ik niet zeker' in plaats van gokken.

1. Denk je dat voedseldeskundigen adviseren om meer, hetzelfde, of minder te eten van de volgende voedingstypen?

	Meer	Hetzelfde	Minder	Weet ik niet zeker
Fruit	✓	☐	☐	☐
Voedsel en drank met toegevoegde Suikers	☐	☐	✓	☐
Groenten	✓	☐	☐	☐
Vet voedsel	☐	☐	✓	☐
Bewerkt rood vlees	☐	☐	✓	☐
Volkoren producten	✓	☐	☐	☐
Voedsel met veel zout	☐	☐	✓	☐
Water	✓	☐	☐	☐

2. Hoeveel porties groente of fruit worden door voedingsdeskundigen geadviseerd om dagelijks gegeten te worden? Eén portie kan bijvoorbeeld een appel zijn, of een handjevol gesneden wortelen.

2	☐
3	☐
4	☐
5 of meer	✓
Weet ik niet zeker	☐

3. Van welke type vetten zeggen voedingsdeskundigen dat je er meer of minder van moet eten?

	Minder	Meer	Weet ik niet zeker
Onverzadigde vetten	☐	✓	☐
Transvetten	✓	☐	☐
Verzadigde vetten	✓	☐	☐

4. Welke type zuivel is volgens voedingsdeskundigen het beste om te drinken?

Volle producten (bijvoorbeeld volle melk)	☐
Magere producten (bijvoorbeeld magere melk)	✓
Halfvolle producten (bijvoorbeeld halfvolle melk)	☐
Geen, zuivel producten zouden vermeden moeten worden	☐
Weet ik niet zeker	☐

5. Hoe vaak per week wordt door voedingsdeskundigen aangeraden om vettige vis (bijvoorbeeld zalm of makreel) te eten?	
1-2 keer per week	✓
3-4 keer per week	☐
Elke dag	☐
Weet ik niet zeker	☐
6. Hoeveel alcoholhoudende dranken zou men volgens voedingsdeskundigen dagelijks maximaal mogen drinken?	
1 glas voor mannen en vrouwen	✓
2 glazen voor mannen en vrouwen	☐
2 glazen voor mannen en 1 glas voor vrouwen	☐
3 glazen voor mannen en 2 glazen voor vrouwen	☐
Weet ik niet zeker	☐
7. Hoe vaak denk je dat voedingsdeskundigen adviseren om te ontbijten?	
3 keer per week	☐
4 keer per week	☐
Elke dag	✓
Weet ik niet zeker	☐
8. Als een persoon 2 glazen vruchtensap (uit de supermarkt) op een dag drinkt, als hoeveel van de dagelijkse portie groente en fruit telt dit dan?	
1 portie	✓
2 porties	☐
3 porties	☐
Weet ik niet zeker	☐
9. Volgens de schijf van vijf (een richtlijn die de verhoudingen weergeeft tussen soorten voedsel die mensen zouden moeten eten om aan een evenwichtig en gezond dieet te voldoen), hoeveel van iemands dieet zou moeten bestaan uit koolhydraat rijk voedsel?	
15%	☐
30%	✓
50%	☐
Weet ik niet zeker	☐

D. Semi structured interviews

Semi structured interview 1: data collection focussed
Questions can be answered in any order.
Phase 1: Introduction
Goal: Set participant at ease
Method: Start with thanking the participant for doing the interview, an introduction about why the interview is important and ask very broad questions to get the conversation going
Questions:

- What was your experience with capturing data?
- What was your experience with capturing data when in private (e.g. at home cooking)
- What was your experience with capturing data when in in the presence of other people (e.g. someone comes over for diner, this is one of the few feasible scenarios due to Corona lockdown)

Phase 2: Digging deeper
Goal: Get deeper understanding
Method: Keep asking questions relevant to what the participant has mentioned before. Additionally, when the participant is at ease ask more detailed questions.
Questions:

- How often did you capture data? (e.g. captured every meal)
- Did you ever stop capturing data? If yes, did you ever resume capturing data?
- Was there any reason why you stopped/didn't stop capturing data?

- If you could, would you like to continue capturing data after the experiment?

More questions depend on answers in phase 1
Phase 3: Conclusion
Goal: Wrap up the interview and tie up anything left unclear or unanswered
Method: Ad hoc
The questions in this phase depend entirely on phase 1 & 2. There is not much predicting here. Participants will always be asked if they still want to share something in regards to data collection. At the very end the participant is thanked again for his time and effort.

Semi structured interview 2: data reflection focussed
Questions can be answered in any order.
Phase 1: Introduction
Goal: Set participant at ease
Method: Start with thanking the participant for doing the interview, an introduction about why the interview is important and ask very broad questions to get the conversation going
Questions:

- What was your experience with reflecting on captured data?

Phase 2: Digging deeper
Goal: Get deeper understanding
Method: Keep asking questions relevant to what the participant has mentioned before. Additionally, when the participant is at ease ask more detailed questions.
Questions:

- How often did you reflect on data?
- Was there anything you learned about yourself by reflecting on the data?
- Did you ever try to gain a deeper understanding of your data by looking up information about food?
- Did reflecting on the data motivate you to change your eating habits?

More questions depend on answers in phase 1
Phase 3: Conclusion
Goal: Wrap up the interview and tie up anything left unclear or unanswered
Method: Ad hoc
The questions in this phase depend entirely on phase 1 & 2. There is not much predicting here. Participants will always be asked if they still want to share something in regards to data collection. At the very end the participant is thanked again for his time and effort.

E. IMI, SIMS, and TSRI subscale metric results visualisations

The following figures are the observed scores for each metric on the IMI, SIMS and TSRI subscales visualised. Violin plots have been used supplemented by a red diamond shape which signifies the mean.

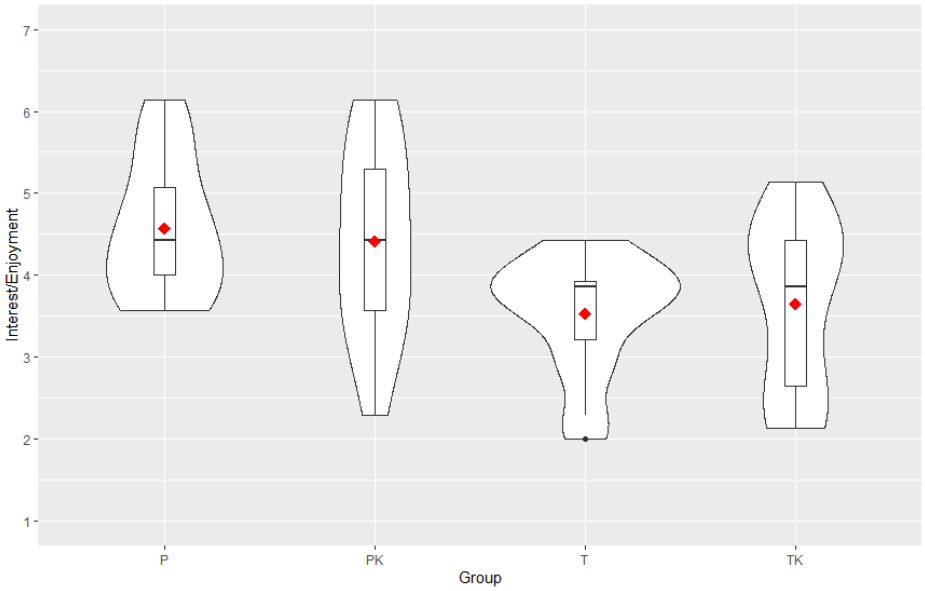


Figure E.1: The interest/enjoyment scores visualised from the IMI survey

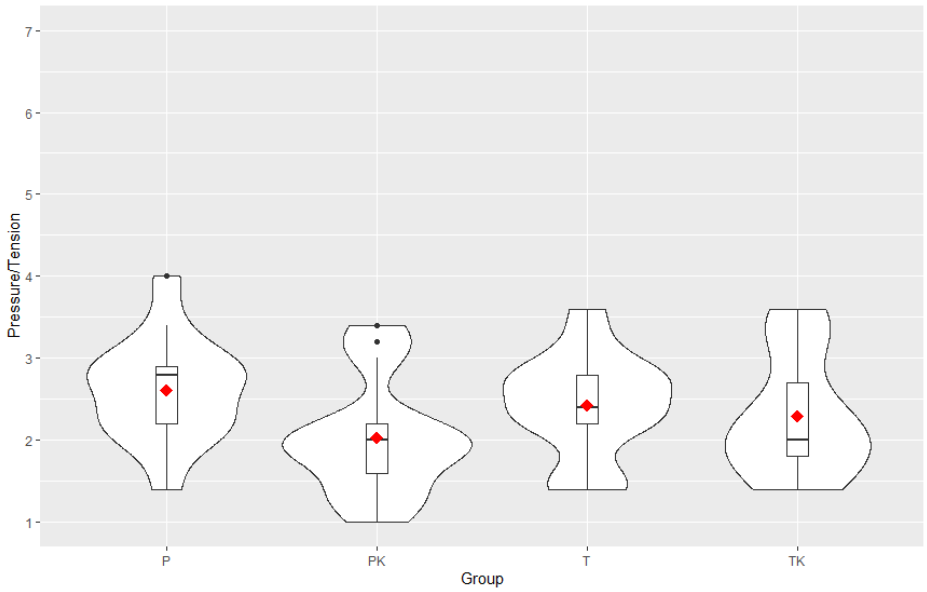


Figure E.2: The pressure/tension scores visualised from the IMI survey

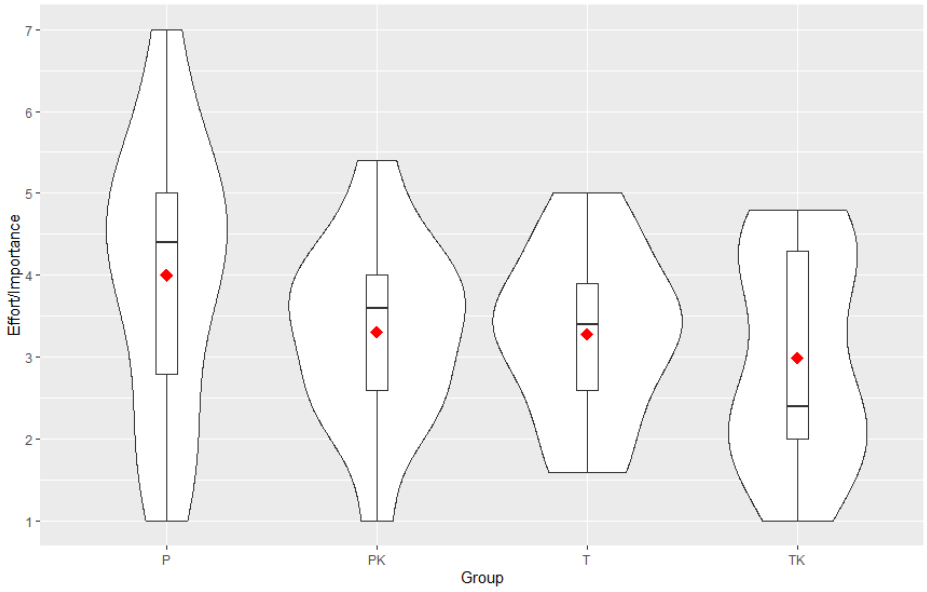


Figure E.3: The effort/importance scores visualised from the IMI survey

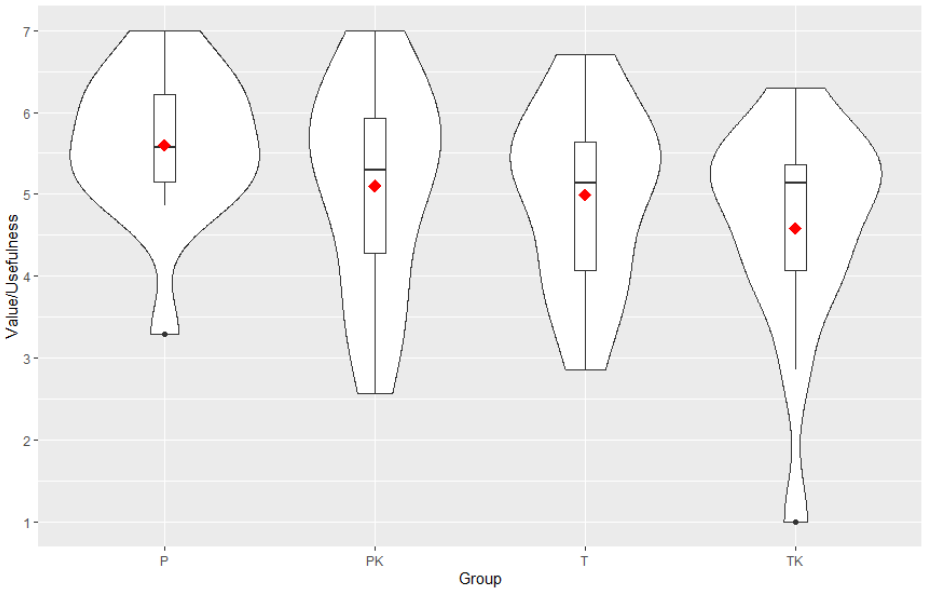


Figure E.4: The value/usefulness scores visualised from the IMI survey

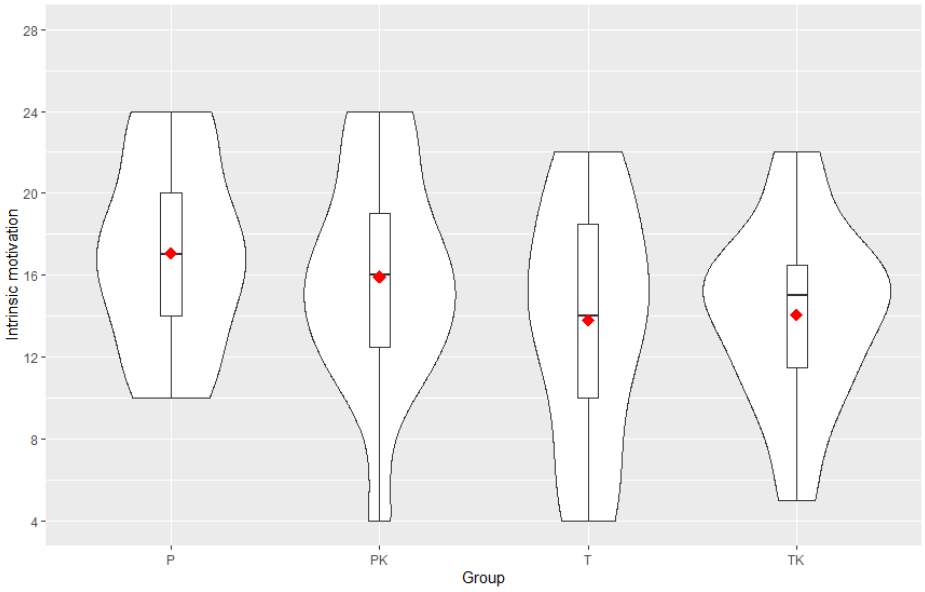


Figure E.5: The intrinsic motivation scores visualised from the SIMS survey

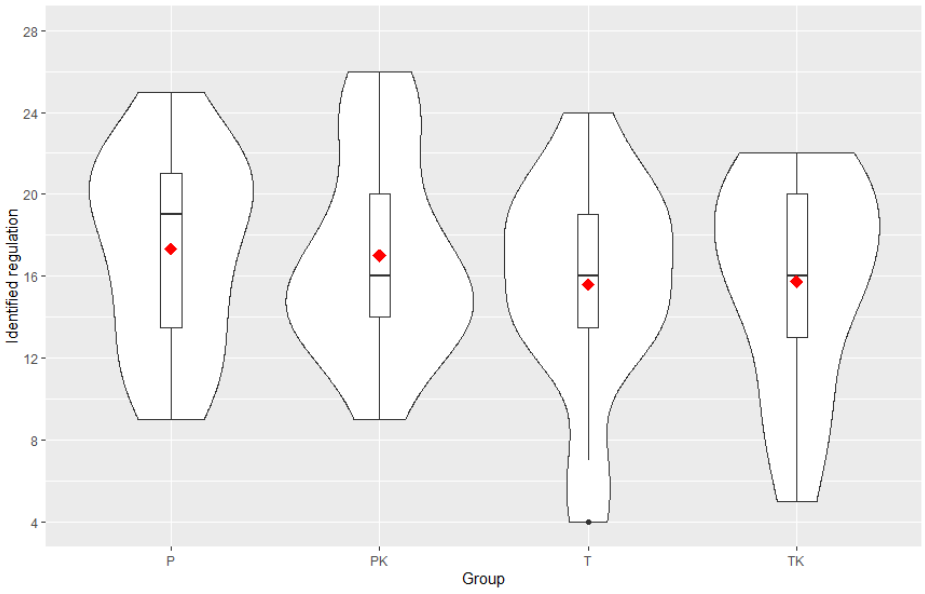


Figure E.6: The identified regulation scores visualised from the SIMS survey

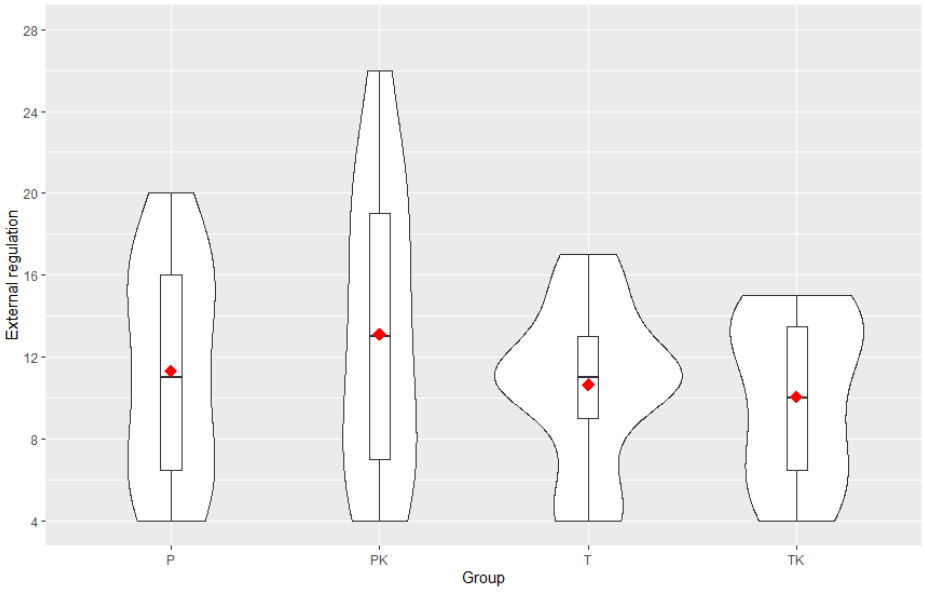


Figure E.7: The external regulation scores visualised from the SIMS survey

Figure E.8: The amotivation scores visualised from the SIMS survey

Figure E.9: The insight scores visualised from the TSRI survey

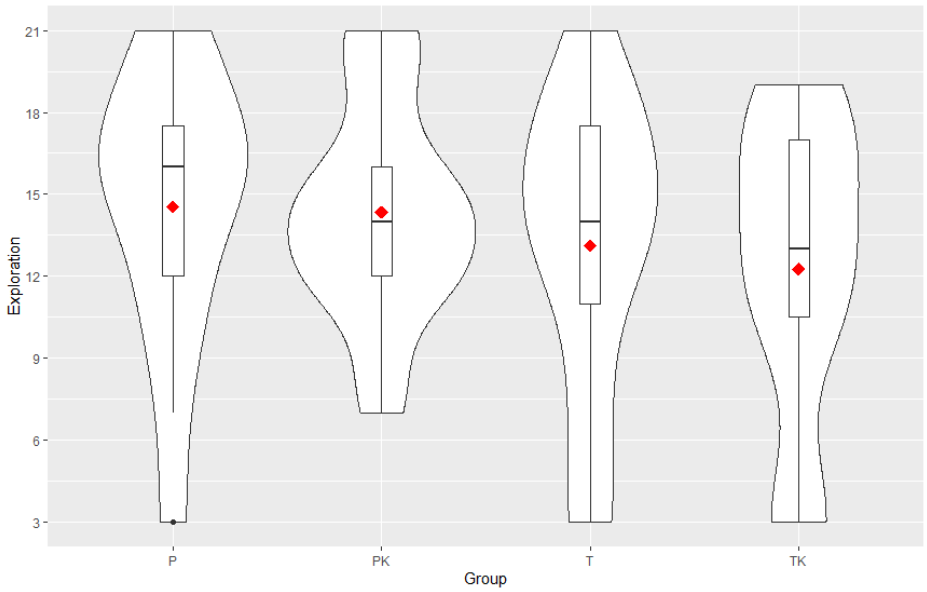


Figure E.10: The exploration scores visualised from the TSRI survey

F. Logged data heatmaps

The following holds for each heatmap. The x-axis holds the values of 14 columns each representing a day in the study. The y-axis is divided into 15 rows where each row represents one participant in the group. The more intense the colour is in a cell, the more activity was recorded on that day for that participant. It is important to note that the colour intensity scaling varies across heatmaps, refer to the legend for each heatmap. A white cell represents no activity recorded for that day for each heatmap. Heatmaps for group T and TK will naturally have a larger range of possible scores because one meal can consist of multiple entries whereas a single photo can capture an entire meal.

Group PK

The results of the amount of times the app came to the foreground for group PK has been visualised in Figure F.1. The amount of data entries recorded has been visualised in Figure F.2.

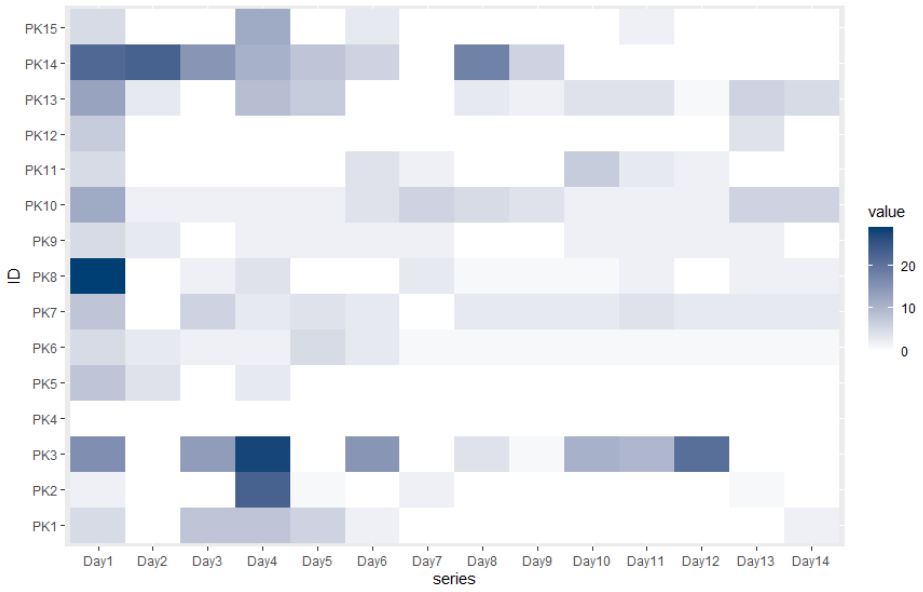


Figure F.1: Amount of times the app came to the foreground in group PK

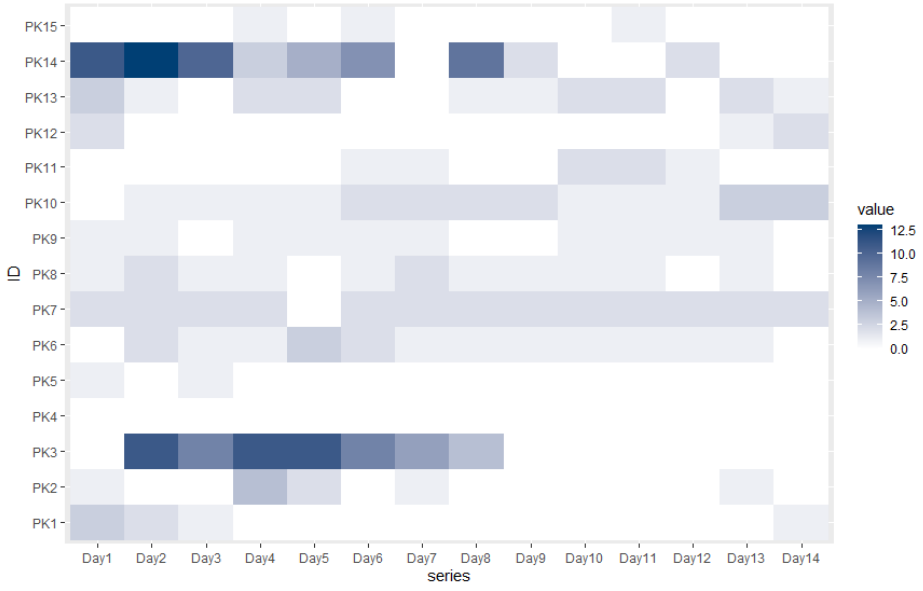


Figure F.2: Amount of photos logged in group PK

Group P

The results of the amount of times the app came to the foreground for group P has been visualised in Figure F.3. The amount of data entries recorded

has been visualised in Figure F.4.

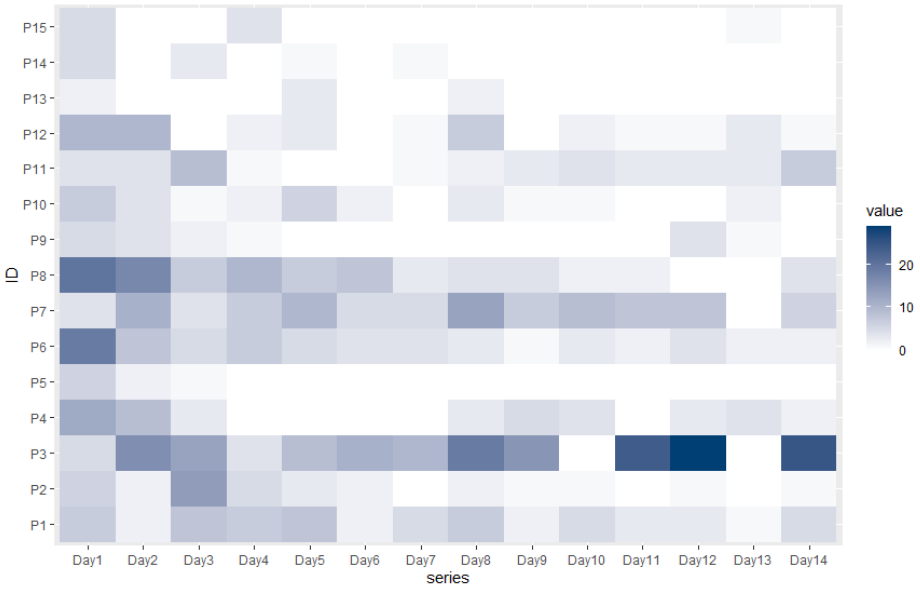


Figure F.3: Amount of times the app came to the foreground in group P

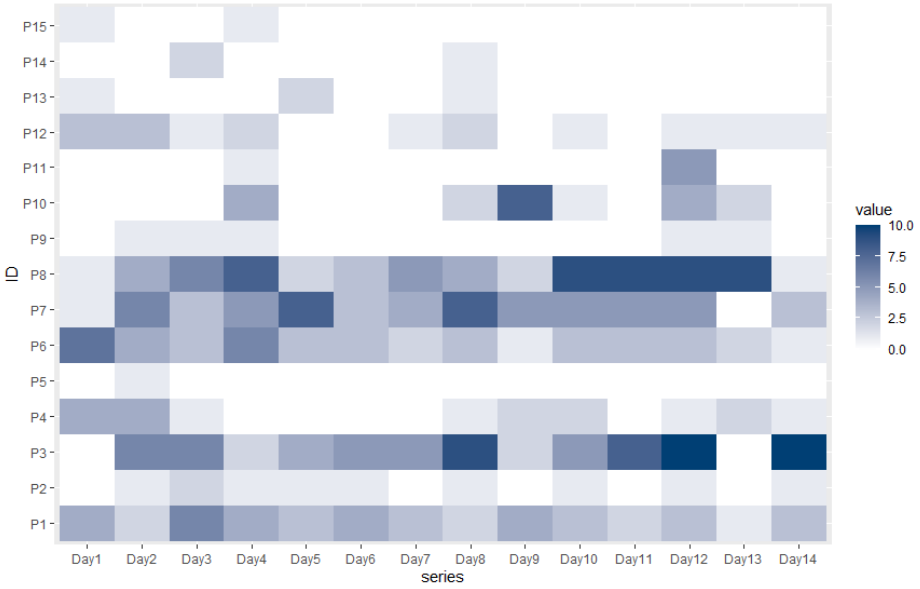


Figure F.4: Amount of photos logged in group P

Group TK

The results of the amount of times the app came to the foreground for group TK has been visualised in Figure F.5. The amount of data entries recorded has been visualised in Figure F.6.

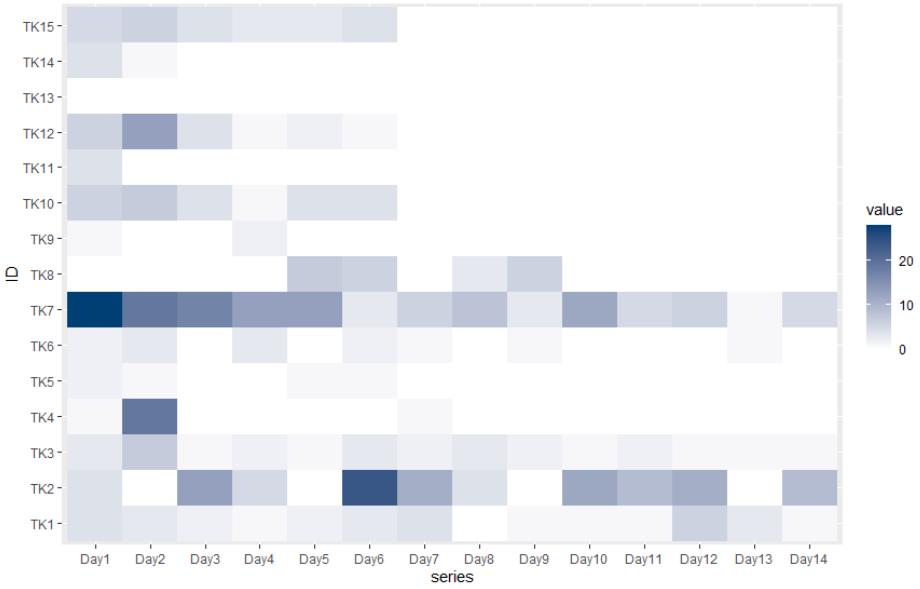


Figure F.5: Amount of times the app came to the foreground in group TK

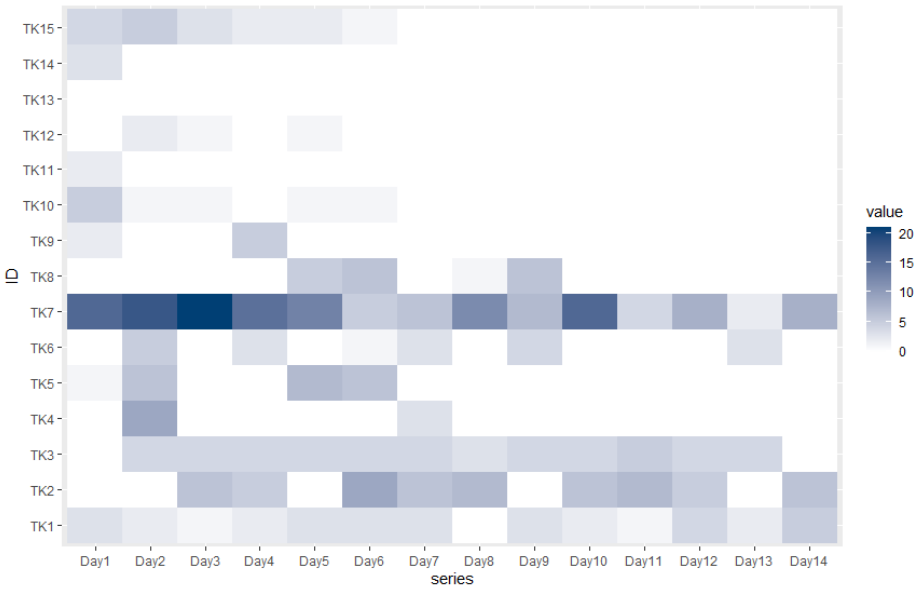


Figure F.6: Amount of data entries logged in group TK

Group T

The results of the amount of times the app came to the foreground for group T has been visualised in Figure F.7. The amount of data entries recorded has been visualised in Figure F.8.

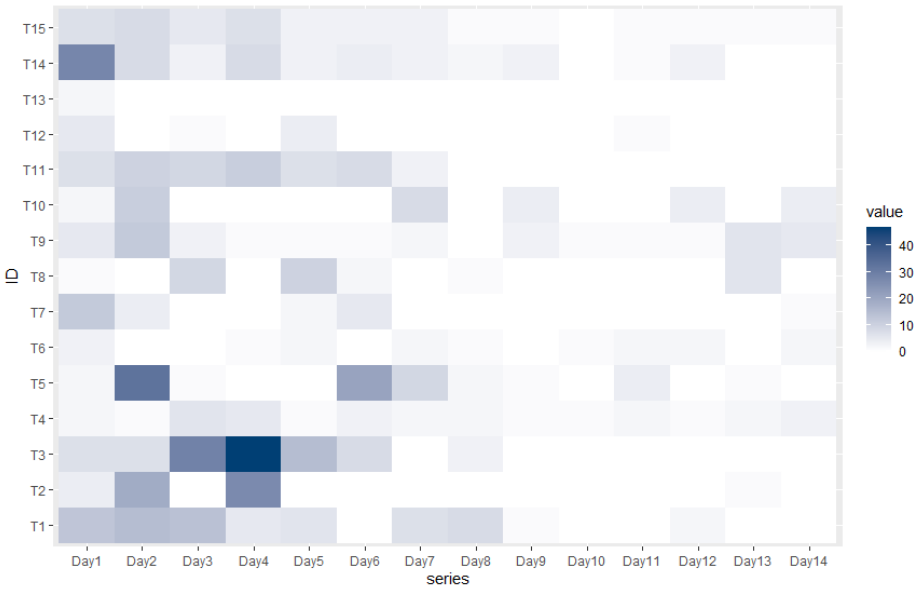


Figure F.7: Amount of times the app came to the foreground in group T

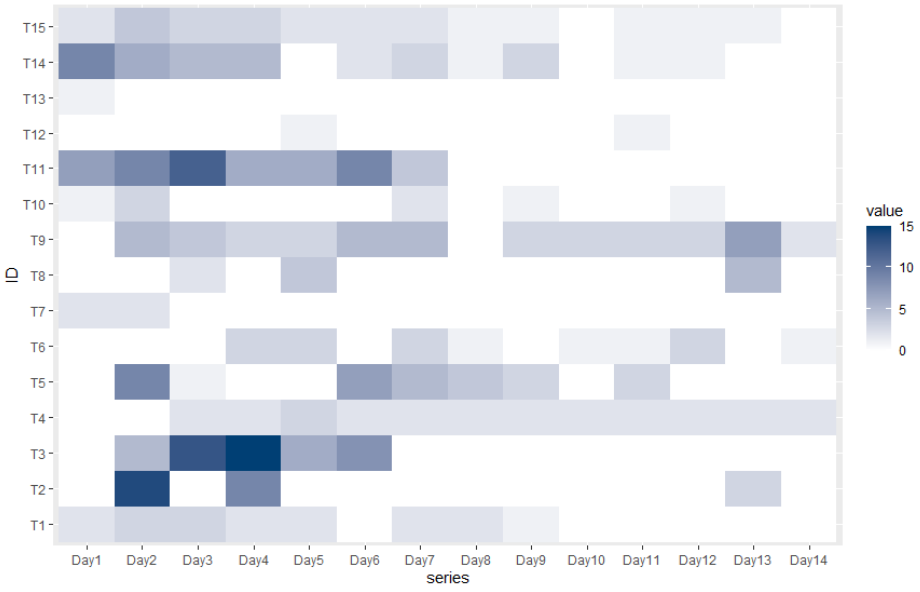


Figure F.8: Amount of data entries logged in group T