Digital twins and dietary health technologies: Applying the capability approach

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Chapter 6
Digital twins and dietary health technologies: Applying the capability approach

Abstract: Dietary apps are being used to provide information about the content of one's diet, the nutritional content of food, and when one should eat it. These apps are said to provide greater empowerment to individuals to gain control over their health, diet, and physical well-being. Self-tracking is set to expand through the use of technologies, such as artificial intelligence (AI), internet-of-things (IoT), and "digital twin" technology (DT). This chapter evaluates a DT project, through the lens of the capability approach, to analyze what capability-related concerns arise in such a project. The main research question we hope to answer is: to what extent does this DT affect individuals' capabilities to eat healthily?

This chapter proposes to use the capability approach to evaluate a DT project. The DT project that we evaluated highlighted a number of key concerns when evaluated through the context of the capability approach, such as that technology teams need to factor in the diversity and different needs of individuals to benefit from these technologies (for example, the individual, social, and environmental conversion factors). The chapter demonstrates to what extent this DT project affects individuals' capabilities to eat healthily.

Keywords: capability approach, dietary apps, ethics, health technology, freedom, autonomy, healthcare, user-centric design, capabilities, value

6.1 Introduction

Personalized health tracking has become popular, such as activity tracking and nutrition-related health registration. Through wearables and apps, one can track data about their steps, daily activities, and sleep. One can register food intake, apps can tell you what you can and cannot eat and set reminders of when and how much to eat. These technologies provide an opportunity to take responsibility for one's physical well-being and health. One type of self-tracking technology which offers great promise

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for this is the use of a digital twin (DT). It offers a leap forward in self-monitoring and our ability to manage our health and well-being.

However, as with many digital technologies, there are also concerns about what types of risks, impacts, and ethical concerns may arise from the use of such technologies. If the end user is not accurately defined, understood, and represented, there is the potential that misleading or false information will be construed about them. There is the potential that certain groups within society are not included at all, which may have as a consequence the inability for them to use the technology, the creation of harmful bias because their group's data has not been included, or their data has been included, but it leads to discriminatory results. There are also concerns around the fairness of using digital health technologies, accessibility, and ensuring individuals' safety during use. Because of these concerns, it is important to evaluate DT technologies during all stages of development and use them to identify and tackle these social and ethical issues.

There have been evaluations of DT in such a diverse range of applications (such as aviation, healthcare, and agriculture), but their scope is usually limited to technical challenges in these fields. While the ethical and social impact of DT has started to receive more attention in recent years [1–8], it is still a new area of research with little research being conducted on providing frameworks on how to deal with the unwanted and undesirable risks and impacts of these technologies.

In healthcare DT applications, which is our focus, the capability approach has recently been shown to be effective in health technologies [9–12]. The capability approach may provide an insightful way to categorize and reflect upon, some of the main issues and challenges within a project whose primary aim is to enable individuals to fulfil the capability of being healthy. Therefore, we use the capability approach to evaluate a DT project in healthcare.

The DT project that we evaluate is an ongoing project based in the Netherlands which focuses on improving the diet of individuals who are currently overweight and at risk of cardiovascular disease and other health-related illnesses. The DT monitors and predicts long-term increases in the individual's blood sugars (glucose) and blood fat (triglyceride) after dietary changes. Based on these findings, the DT can provide recommendations to the end user to improve their diet. We analyze this DT through the lens of the capability approach to answer: to what extent does this DT affect individuals' capabilities to eat healthily?

The chapter starts by providing a brief overview of DT technologies (Section 6.2) and the capability approach (Section 6.3). Section 6.4 provides an overview of the methodology employed during our interviews with seven interviewees from the DTP and the subsequent follow-up workshop with four of them. Section 6.5 consists of our main findings conducted through this empirical analysis.

6.2 Digital twins

A DT is the virtual, digital equivalent of its physical counterpart [13], which could be an object or a living being. DTs are a means to help understand a complex physical object when it is difficult or costly to investigate or experiment with the object itself. For example, a flight simulator is a DT that helps pilots to train and maintain their skills for flying an aircraft, without the cost, risk, and hassle involved with using a real aircraft for this purpose. The DT term and concept were first introduced by NASA and has since found its way into a variety of areas, such as industry [14], manufacturing [15, 16], smart cities [17, 18], agriculture [19, 20], energy [21], and healthcare [22].

Verdouw et al. [20] provide a typology of DTs that covers a range of usages, from *imaginary* DT (a conceptual entity that depicts an object that does not yet exist in real life), *monitoring*, *predictive*, and *prescriptive* to *autonomous* DT (autonomously deployed with full control) and *recollection* DT (maintaining the complete history of the physical object that no longer exists in real life). Although designing a DT is not yet a straightforward process [23], the increasing maturity and availability of enabling technologies such as the internet of things (IoT), artificial intelligence (AI), machine learning, and data science facilitate the integration between DT and physical object.

There are both technical and nontechnical challenges involved in the development of DTs. Technical challenges include the need for an IT infrastructure for connectivity and data analysis, modeling issues such as the availability and processing of data that may be poor or incomplete, variations in input data type or resolution, and the trade-off between domain-specific versus generic knowledge [19]. Nontechnical challenges concern privacy and security of data and trust [22]. The personal data used to feed the DT may be sensitive, and therefore privacy should always be respected, and data security should be ensured. Other nontechnical challenges refer to the risk to individuals, impact on society, and environmental sustainability of the technology. The nontechnical challenges, of DT in healthcare, are the primary focus of this chapter.

In healthcare, there is a rise in devices that are cheap, easy to implement and easy to connect to a cloud-based framework [14, 24]. This is promising for the use of DT in healthcare [14]. Firouzi et al. [25] propose the use of DTs to tackle an epidemic like Covid-19, by monitoring a population's physical location, movements, and health status using their smartphone data and sensors, or to raise an alert when someone's body temperature is suddenly increasing, indicating an infection. Another application area of DTs is for healthcare practitioners: Laaki et al. [25] introduced a prototype DT of a person's arm to allow a specialist to perform remote precision surgery. A different promising area of healthcare applications is the use of a DT to monitor, diagnose, and predict health, especially for elderly people who carry wearable devices on their bodies [14]. For the purpose of this chapter, we focus on the application of DT in dietary apps.

6.3 The capability approach

The capability approach was first developed by Amartya Sen and Martha Nussbaum [26–33].[1] It is a well-recognized ethical-economic approach that can be used to evaluate the empowerment, or impediment, of individuals' freedoms.[2] The capability approach states that one's well-being is closely tied to one's capabilities to fulfil it. To fulfil one's capability to ensure that one is well nourished and healthy depends upon whether one has the resources for that, but also the capability to properly transform those resources. Individual, social, and environmental conditions determine whether these capabilities can be realized (these are called "conversion factors" in the capability approach). Conversion factors are "one's ability to convert resources and goods into freedoms and well-being" [12]. The capability approach states that simple equal redistribution of resources is not enough if these resources do not carry equal ability to convert them into usable benefits.

It is not sufficient to rely on the distribution of resources to ensure equality, well-being, and dignity. Instead, the focus shifts toward how individuals can use these resources to fulfil what is considered a life worth living. For example, in traditional resource-focused positions of equality, the distribution of bicycles equally among people would fulfil certain equality requirements. However, there is such a wide variety of people and thus, also, a wide variety of benefits that can be derived from a bicycle. For example, if someone cannot cycle, is in pain when they cycle, or cannot use the bicycle, to begin with (e.g., a wheelchair user), then the value of that bicycle is not equal or comparable to those who can use it freely and comfortably to go places or for improving their health [26].

The capability approach claims that the outcome of distribution may be the same in a given situation, but the choice and freedom exhibited may be strikingly different. For example, Sen compares two people: one who are fasting (for perhaps religious, cultural, or health reasons) and another who are starving (because of lack of accessibility, availability, or utilization of food resources). The starving individual does not have an alternative, it is not their choice that they are starving, they have no capability or capacity to do otherwise. Whereas the individual who is fasting is doing so by choice and has the option to change their situation if they want to.

1 This paper will concentrate on Sen's capability approach.

2 However, the capability approach is called an approach because it does not set out strict normative requirements, but can be adapted and formulated into more concrete theories: 'The CA is an "open-ended and underspecified framework, which can be used for multiple purposes" [34]. This is why Robyens state that when one specifies the approach and applies it for use with a particular purpose, we should speak of a "capability theory," instead. For example, Martha Nussbaum formulates ten key capability requirements; thus, it becomes a capability theory. Others [11] combine Nussbaum's theory with value-sensitive design into another capability theory.

The capability approach begins with one's inputs, or what the individual has to achieve or realize their capabilities. This is always evaluated by the possible conversion factors (individual, environmental, and social) that may inhibit or allow one the ability to convert one's inputs into the freedom to achieve certain outcomes. Take the example of a woman using the internet; this is dependent upon whether or not she has an internet connection where she lives (environmental), if she is prohibited from using it in her culture/society (social), or if she has the relevant skills to use it (individual). The capability to realize these achievements (functionings) is affected by the level of choices available and the degrees of agency when carrying out the actions to realize the capability, which in their turn are usually affected by individual agency, personal history, social context, and external control (see Figure 6.1).

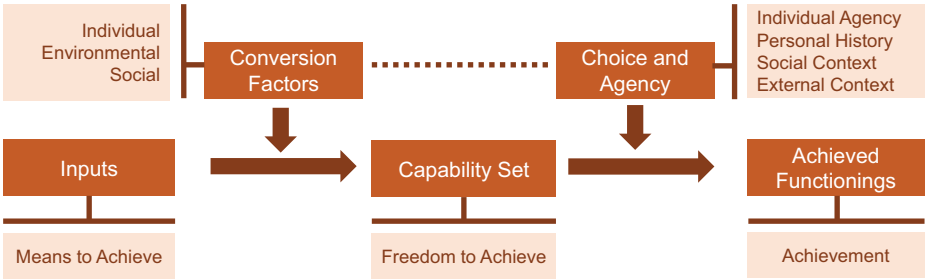

Figure 6.1: The capability approach process (adapted from [59], original from [60]).

6.3.1 The capability approach and health

The World Health Organisation (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [35]. Health is usually referred to as holistically and understood as the well-being of the individual. Nordenfelt proposes that health should be understood as one's well-being and the ability to realize one's goals [36]. While Venkatapuram defines health as the "abilities to be and do things that make up a minimally good, flourishing, and non-humiliating life for a human being in the contemporary world" [37].

Venkatapuram claims that health capabilities are quite diverse in range because of the many aspects, choices, and diversities of health in the world. Because of the importance of health for achieving our life's goals, ambitions, and daily tasks, it is such a fundamental capability to possess. One could view the capability of being healthy as a "meta-capability," as it allows all other capabilities to be possible: "Health is a meta-capability, an overarching capability to achieve or exercise a cluster of inter-related and basic capabilities to be and do things" [37].

While some of our health conditions are reliant on natural health dispositions, genetics, and biology, many are largely affected by our actions and behaviors, as well

as our external environment and particular social conditions that affect our health (e.g., poverty, lack of resources, and inability to obtain healthcare). In addition, many of these social conditions can also have a direct effect on our biological conditions (e.g., birth defects attributed to maternal health issues caused by social inequalities). Social conditions and health conditions often have an interlinked effect, as well (e.g., a person loses their job because of health issues, then they cannot afford their healthcare, which in turn, increases their anxiety, depression, and exacerbates their health issues) [37].

The capability of health relies on the choices available to the individual, the knowledge that they have about health and nutrition, their physical abilities, and also, their desire to be healthy, and many other factors. The capability of health requires the integration of health outcomes with one's health agency [38]. Health agency, according to [38], is the individual's ability to realize health objectives as one's values and that they are an agent toward their health. Health agency is "what one's realized actions are compared with potential actions," and "health functioning is the outcome of the action to maintain or improve health" [38]. Health technologies are being proposed as one way to help further realize one's health agency (see Figure 6.2.).

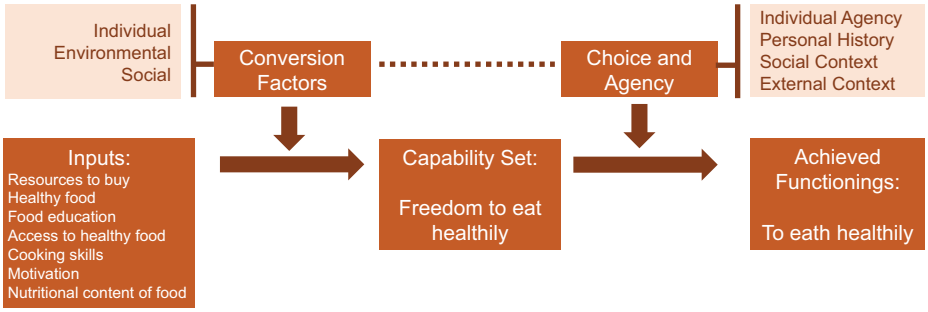

Figure 6.2: The capability approach process of eating healthily.

6.3.2 The capability approach and health technology

Considerable research has been conducted on the link between technologies and the capability approach [39–48]. Technology is often seen as a type of input or a conversion factor to realize one's capabilities. Technology also has a transformative effect on capabilities, in some instances completely altering values, goals, and aims, in life. For example, the capability of being connected with other humans and the ability to socially interact has not only been improved by (or exacerbated by) digitalization, it has altogether transformed our very understanding of what it means to communicate with others.

In the context of health technologies, the link to the capability approach has only been made relatively recently, with several papers specifically focusing on this connection [9–12]. While these four papers have helped inform our research, this chapter is different in many respects. For example, our chapter is empirical (which, only [11] is); it does not focus on VSD (e.g., [9–11]); and our chapter concentrates on DT technology (which none of the other papers do). The application of the capability approach to DT can be considered a special case of the application of the capability approach to technology in general.

6.4 Methodology

The methodology of this chapter adopts the main structures and themes found in the capability approach, outlined in the previous section, to answer to what extent does the DTP that we examine affect individuals' capabilities to eat healthily. The main aim of conducting interviews was to focus on how team members within a DTP view justices and injustices and how they are responding to such concerns. We conducted seven interviews and a workshop with participants to see if implicit or explicit issues around justice and capabilities emerged, evaluated through the main themes of the capability approach: inputs, conversion factors, and choice and agency.

Our interviews were conducted in English, throughout March–May 2021, through Microsoft Teams. The seven individuals that we interviewed came from a wide array of disciplinary backgrounds (such as computer scientists, economists, and consumer behavior experts) and had different roles in the project (see Table 6.1).

Table 6.1: Interviewees for DTP.

Interviewee	Role in project
1	Consumer acceptance development
2	Consumer acceptance development
3	Project manager
4	Algorithm developer
5	Mathematical modeler
6	Modeler
7	Content project leader

The seven interviewees were all work packages or project leaders and had the largest roles in the project. The overall project was relatively small, so there was a limit to how many people could be involved in the interviews and workshops. For the analysis of the interviews, we adopted a grounded qualitative data analysis procedure [49]. We identified what were the main themes discussed during the interviews, discrepan-

cies, or divergences with the interviewees' answers, and the most significant points related to the end users' capabilities.

We also conducted a workshop with four of the interviewees for follow-up information in October 2021.[3] The 1.5-hour workshop aimed at addressing some of the issues raised during the capability approach-focused interviews to ensure that the interviewees considered, promoted, and incorporated these values within the DTP. The results of the workshop are differentiated in the in-text citations by including "workshop" in the parenthesis.

6.5 Findings

The DTP aims to monitor and predict the increase in blood sugar (glucose) and blood fat (triglyceride) after dietary changes. It does not target changes in these levels from meal to meal but implements a broader evaluation of consistent dietary changes and their effects on blood and fat levels. The purpose of this is to evaluate how dietary changes affect blood sugars and fats to encourage long-term dietary improvements. This is because both glucose and triglyceride levels are indicators of risks related to cardiovascular disease and other illnesses.

The DTP should function as a way to replicate how the individual responds to certain foods, become visualized through the technology, and support the end user. The DTP had a specific demographic: people who suffer the worst from high-fat levels in their blood (interviewee 2). The target group largely consisted of people in their 50s and 60s + with BMIs over 25. The end goal of the DTP is to develop accurate and predictive algorithms that can monitor and map the effects of dietary changes on blood-fat levels and to provide recommendations, menus, and dietary advice, to the end user.

The DTP enables individuals to eat more healthily by controlling the glucose and triglyceride levels in their blood. The DTP is trying to achieve the capability of bodily health, through a sub-capability of eating healthily (Section 6.5.1). Of course, other sub-capabilities would lead to bodily health, such as refraining from dangerous activities, getting exercise, and reducing stress; but these other sub-capabilities are not the main focus of the DTP. To achieve capabilities, such as eating healthily, one must have certain inputs or resources to achieve them (Section 6.5.2): resources to buy food, food education, cooking skills, motivation, and the nutritional content of food. One also needs specific conversion factors to transform these resources into realizing the capability to eat

3 Unfortunately, it was impossible to find suitable dates and times where all seven participants could attend, so we had to compromise, hosting the event with only four of the original interviewees (interviewees 1, 2, 3, and 4). Despite this, we sent this paper to all seven interviewees for their feedback and insights.

healthily (e.g., individual, environmental, and social conversion factors) (Section 6.5.3). Some factors also affect choice and agency to materialize capabilities (Section 6.5.4).

6.5.1 Capability to be healthy (by eating healthily)

The overall aim of the DTP is to enable individuals to be healthy (interviewee 7). It aims to achieve this by monitoring and predicting the increase in blood sugars (glucose) and blood fat (triglyceride) and to control/reduce high levels of glucose and triglycerides in the blood level, through changes in one's diet. These are the *means* to achieve the capability of being healthy (interviewee 6). However, the DTP does not account for everything in the broad spectrum of requirements that enable health. It is specifically focused on health through better dietary practices, thus, it is the capability to *eat healthily*, rather than, say, the entire range of factors that impact our *overall health* (e.g., stress-reduction, exercise, living in less polluted environments, and avoidance of high-risk hobbies).

Therefore, the DTP aims to promote the capability to be healthy through healthy dietary practices, or more concisely, the capability to eat healthily. This does not mean that the project views this as the only factor relevant to health, nor does it say that it is the most important. It simply focuses on one aspect within the wider parameters of being healthy. The objective is that the DTP provides insights into what happens to one's blood sugars (glucose) and blood fat levels (triglyceride) after changes in their diet. As these levels are indicators of one's health, the DTP examines how one can control their blood sugars and blood fat levels, through dietary practice, to allow them to be healthy (or healthier).

6.5.2 Inputs

To achieve the capability to eat healthily, one needs certain inputs/resources. One needs resources to obtain food, education, cooking skills, motivation, and the nutritional content of food. There are many variables required to eat healthily, and the DTP enables individuals to do this by providing inputs, such as menus, recipes, and diet recommendations. Many of these inputs would be amalgamized within one resource – the DTP. However, the DTP does not attempt to fulfil every input required to eat healthily because some would not be possible, such as the resources to buy, and accessibility to, healthy food (interviewee 1, workshop).

6.5.2.1 Dietary education

To eat healthily, one needs nutritional knowledge about what foods are healthy and how to eat healthily. Food knowledge and dietary education are vital for taking control of one's health through better dietary practices. The end user also needs to be given information in the right way for it to be understandable. There are many different approaches to disseminate information, for example, 1. recommendation "Try to avoid full-fat yoghurt"; 2. command "Full fat yoghurt is a no-go for you"; or 3. educative "The fat in dairy is bad for your veins, so it's better not to eat it. Instead, choose the low-fat variety. You could also consider eating a soy alternative."

The interviewees stated that they provide information in a positive way, expressing what individuals *should eat*, as opposed to what they should avoid. For example, "we don't say: avoid fat yoghurt but: try soy" (interviewee 1, workshop). They stated that evidence points against using negative restrictive dietary information [50]. Interviewee 1 stated that their recommendations would come in the form of social norms recommendations [51], aiming to share the advice of what has been effective for other people in their demographic: "It could be advantageous to them to hear what other people do. Reducing uncertainty if they see what other people are doing. It might help them in their decision, social proof" (interviewee 2, workshop).

6.5.2.2 Knowledge from nutritionists

Another input often required to enable individuals to choose healthier diets is advice from a nutritionist about what they should eat. Within the DTP, some of the interviewees stated that there was a strong desire to include qualified health professionals, but that their involvement was quite limited (interviewees 1 and 2). This was down to the scope of the project (an investigative pre-commercial research-focused project). It would be a useful addition to getting insights from physicians and nutritionists about how the data from the DTP could be assessed and used to benefit the health of the individual (interviewee 6).

6.5.2.3 Motivation

Whether or not one is motivated to eat healthily, and also, what forms of motivation are in place to help one to continue eating healthy, are important for success. Within the DTP, interviewee 3 stated that end users are already very motivated to cooperate and eat more healthy. They interact with people who are facing health problems and want to find out ways to turn this around. Interviewee 3 mentioned that it is often challenging to motivate someone to use these dietary technologies for preventive care (rather than curative) because there is less impending risk.

Many of the interviewees stated that they provide information to the user, but ultimately, it is up to the user to enter their details honestly and improve their dietary practices. Some of the main challenges that the DTP team had were: how can we make this attractive for people to begin with; will they be able to work with it; will they be able to interpret the results; and will they keep using it?

Motivating individuals to use health apps is challenging (interviewee 1, workshop). It is difficult to keep individuals engaged, even for cancer medicines, which are fundamental for the users' survival (interviewee 1, workshop). The same holds for health apps, but there is a need to improve engagement, acceptance, and usability [52]. Some ways to do this are through "rewards, point saving, and gamification" (interviewee 1, workshop).

6.5.2.4 Knowledge about your body

An additional, but often overlooked, aspect of eating healthily is knowledge about how your body responds to different diets. This concerns the knowledge that you may have received about diet and nutrition, while also understanding how it affects you, as an individual. People react differently to certain diets and foods, so it is not a "one-size-fits-all." This point is reinforced in the DTP because it aims for personal changes to one's blood-fat levels after dietary changes, and how they are going to improve this through diet (interviewee 7).

The effect of dietary change is quite personal, which was one of the reasons for the DTP's development in the first place. Individuals' blood is monitored (interviewee 6), and individuals often get a combination of glucose measurements, information about their guts, and what changes are occurring (interviewee 3). They receive personalized health data and recommendations about how changes in their diet have affected the levels of fat in their blood.

6.5.2.5 Food logging

Another factor that often helps people to eat healthily is the ability to track and log their food intake. Some interviewees stated that individuals often underreport what they eat (interviewees 1 and 2) [53]. This may be reduced if there is an effective way to log what they eat. An issue with this is that it is difficult to see if the user is entering this information correctly and honestly. In addition, Feng et al. [54] indicate that users' ability to process and interpret the information produced by tracking devices and apps is not always clear. One disadvantage of the DTP is that it does not measure such compliance, which can lead to incorrect reporting and skewed results.

6.5.2.6 Technological access

To use the DTP, there is also the assumption that individuals have access to a smartphone (interviewee 1, workshop) and internet access (interviewee 2, workshop). This assumption relies on the country that is being targeted. For example, the DTP is specifically targeting users within the Netherlands, where the internet is 95%, and mobile connections are 99% of the population [55], so the DTP has much fewer barriers than less-technologically-developed countries.

6.5.3 Conversion factors

Throughout the interviews it became clear that there was not much discussion about the environmental, social, and individual conversion factors associated with the DT because the project is not working on the interface or how the end user will use it (interviewees 4, 5, 6, and 7). Most of the interviewees agreed that the DT should be usable for the end user, allowing them to convert the DT information into a healthier diet. Thus, following the capability approach, one needs to take into account environmental, social, and individual, conversion factors.

6.5.3.1 Environmental conversion factors

Environmental conversion factors relate to what is required within one's environment to allow one to convert resources into capabilities. Environmental conversion factors are "aspects of one's geographical location are climate, pollution, the likelihood of earthquakes, and the presence or absence of seas and oceans. Among aspects of the built environment are the stability of buildings, roads, and bridges, and the means of transportation and communication" [34].

In the context of eating healthy, this means that one must have access to healthy food where one lives (e.g., the infrastructure to allow the transportation of food produce) and be able to cook the food (e.g., electricity and energy to cook the food and clean running water). For the DTP, one needs access to an adequate internet connection (to, at the very least, download the app; and perhaps, use it), and adequate roads and infrastructure so that they can obtain healthy food.

For the DTP, one of the main challenges identified was the prevalence of "snack bars"[4] in poorer neighborhoods in the Netherlands, and often, the difficulty to pur-

4 A snack bar sells mostly deep-fried, salty, sugary, and generally, very unhealthy food.

chase healthy food for the same price and convenience (interviewee 1, workshop). This makes it increasingly difficult for individuals from poorer neighborhoods to stick to healthy diets.

6.5.3.2 Individual conversion factors

Individual conversion factors relate to one's internal abilities to convert resources into something useful. This can depend upon one's sex, physical conditions, intelligence, metabolism, or senses. For example, "[i]f a person is disabled, or if she is in a bad physical condition, or has never learned to cycle, then the bike will be of limited help in enabling the functioning of mobility" [34].

In the context of the DTP, interviewees 1 and 2 stated that they look at the physical needs of end users (e.g., will the food make them sick). Interviewees 4 and 5 stated that there is a lot of variation between people, such as genetics, biological mechanisms, and different groupings; and as a result, there will be different responses to food intake among users of the DTP. This should be identified and incorporated within the DTP (interviewee 4).

Most interviewees addressed the difference in dietary preferences on an individual case-by-case basis: individuals may be vegetarian or unable to eat certain foods because of religious reasons. They attempt to overcome these challenges by identifying meal plans that incorporate this kind of information about the end user. The DTP also incorporates meal planning based on allergies and foods that users cannot eat (interviewee 2, workshop).

Many other important individual conversion factors should be considered when developing technologies, such as the personal requirements to use the app itself, e.g., if one is deaf, blind, physically disabled. What languages will it be in? Will it be usable by people with dyslexia? The interviewees stated that they were looking into ways to integrate software and hardware to facilitate such diversities (interviewee 2, workshop).

6.5.3.3 Social conversion factors

Social conversion factors refer to the social aspects that may allow or prevent individuals from realizing their capabilities: "Social conversion factors are factors stemming from the society in which one lives, such as public policies, social norms, practices that unfairly discriminate, societal hierarchies, or power relations related to class, gender, race, or caste" [34].

In the context of the DTP, interviewees stated that public policy should encourage individuals to eat healthier (e.g., lowering tax on fruit and vegetables). To use the DTP, one also would need to live somewhere where it is socially acceptable to make dietary changes or freely choose their diets (peer pressure). Furthermore, living some-

where where one can use technology freely and without prejudice is also very important. Social conversion factors were not considered a significant issue for the Dutch-focused DTP but could be more problematic in other countries, with more social stigma about diet.

6.5.4 Choice and agency

A very important theme that arose during the interviews was the choice and agency of the individuals using the DT and how this affected an end users' empowerment [56–58]. For example, one may feel disappointed or frustrated if one does not meet the required goals that they set out or the benefits promised from using the DT (interviewee 1, workshop). Also, "in some situations, these things can cause feelings of guilt" (interviewee 2, workshop). Some people could become obsessed with using DTs, causing them psychological harm. There should also be the freedom to *not know* about one's health, so the information from DTs should not be forced onto people unwillingly (interviewee 1, workshop).

Conversely, some interviewees stated that end users could receive positive emotions from using the DT: "It could be empowering that you have more feedback if you see results when food logging is in place and objectively measured" (interviewee 2, workshop). This will be hard to achieve in practice for *this* DTP, because of the lack of immediate rewards for the end user (interviewee 1, workshop). Because the DTP can only see a difference between lipid levels, and the impacts of dietary changes on the blood fat level every 12 weeks, this makes it difficult to motivate users because of the lack of immediate progress or rewards (interviewee 4, workshop).[5]

An additional concern that was highlighted was if there is external pressure on users to use the app in the first place (e.g., by governments, insurance, or tech companies). For example, the interviewees stated that they did not intend for the DTP to be used by insurance companies. However, they were aware of ethical issues if insurance companies used such technologies to exploit users, by offering users lower premiums to those who comply or the opposite to those who do not (interviewee 2, workshop). They also stated that it is unlikely that the government will use the DT, in a similar way to Covid-19 apps, because of the high (and immediate) risk factor of the latter. The DTP is more focused on individual choice and the risk is seen as far lower, and something of personal responsibility, rather than of a general societal concern (interviewee 1, workshop).

The overall processes outlined in the DTP can be seen in Figure 6.3.

5 It was noted that there have been no consistent studies done on measurements for periods any sooner than this that the researchers knew of, except for one extreme calorie-restrictive diet, which took place over six weeks.

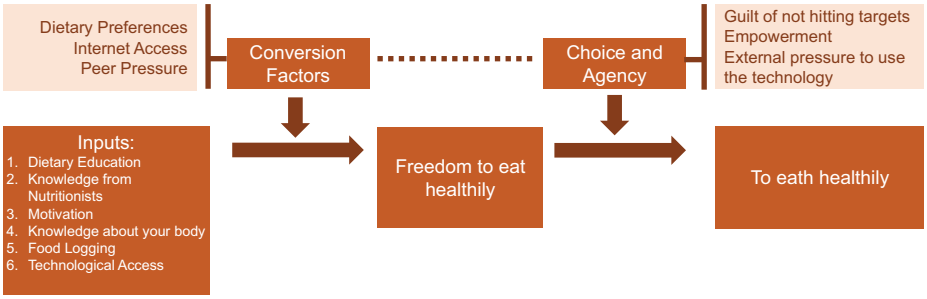

Figure 6.3: The capability approach process in the DTP.

6.6 Conclusion

The interviewees repeatedly stated the importance of defining the end user and acquiring information that would accurately represent them (to remove harmful bias, reduce inaccurate readings, and improve predictions about end users). For example, the DTP is aimed at middle-aged end users in the Netherlands with BMIs over 25 (interviewee 4), which is the data that their algorithms are trained on. Therefore, providing recommendations for fit 20-year-olds, with the same data would (likely) be misleading.

The capability approach outlines key factors required to ensure individuals can achieve the capabilities promised by technologies, such as the DTP. While some of these may go beyond the scope of the technology (e.g., access to clean water or food), this knowledge could still be incorporated into the technology to make it more usable for individuals in different situations. For example, someone needing access to healthy food and the resources to buy it. This input is quite challenging for people with low incomes and poor access to fresh/healthy food. While it is not possible to answer complex political and economic problems when developing a DT, it may still be beneficial to incorporate an awareness of these issues into the development of such technologies. A DT could be designed to identify an individual's food budget and costs of groceries and provide suggestions for cheaper local options. Individuals may log foods that they have access to (physically and economically) so that the menus are more tailored toward the food sources they can acquire.

This chapter evaluated a DTP through the lens of the capability approach. The focus was on evaluating to what extent does this DTP affect individuals' capabilities to eat healthily. One finding of our chapter was that although there was a general understanding of the intended end user in the DTP, the DTP team showed that on more detailed user issues such as assumptions, end goals and specific needs, there was no consensus among the members of the team. Analyzing this project through the lens of the capability approach can serve as a useful instrument to create awareness of who the user is, what the assumptions of the user are, and what their needs are.

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