

How Smart Objects Can Support Reflections on Health Behaviour Change



HOW SMART OBJECTS CAN SUPPORT REFLECTIONS IN HEALTH BEHAVIOUR CHANGE

Master Thesis

M.Sc. Design for Interaction

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Using smart objects to help people reflect on their health behaviors, so that they learn how to make their change processes fit themselves.

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Design for Interaction, M.Sc.

February 2023

Preface

With this project, two challenging yet exciting years at TU Delft come to an end. When I started on this journey, I aimed to complement my computer science background with a human-centered approach to tackling actual individual and societal problems. I have since developed an immense passion for psychology and behavior change that has become a focus during my master's program. Especially in an age where technology uses cognitive biases to grab our attention and manipulate our behaviors, I believe that it is paramount to help individuals and societies resist and change those. Throughout my studies, I became equipped with the necessary methods, skills, approaches, and a complementing creative way of thinking, to design for that goal. This graduation project is the last episode of this 2-year journey, where I am given the opportunity to combine past and present skills into a single endeavor.

To my excellent research team, thank you Jos and Marco for your trust and guidance throughout this entire project. Your mastery of behavior change and design was paramount in helping me make decisions. Thank you for your feedback and critical questions, your kind words when I struggled, your dedication to making this my own project, and for helping me become a true designer.

To the volunteers who participated in my studies, thank you for the time and energy that you gifted to this project. Your input truly guided this project and it would not exist without you.

To Lena, my girlfriend, thank you for your infinite support, inspiration, and compassion. Thank you for your selflessness when I needed to give this project an unforeseeable amount of space and time. Thank you for always encouraging me with tips, tricks, and self-made cookies.

To my family and friends, thank you for your unconditional love and support, as well as have me remember to also take time off.

To my readers, I hope that you can learn something new, or maybe even be inspired to integrate more moments of deliberate reflection in your everyday lives.

Executive Summary

People and societies thrive on their ability to change behaviors towards healthier ones. The pressure on healthcare systems can be eased, people become happier, and the tackling of problems like climate change is accelerated. Yet, in the face of today's age of technology providing instant gratification, the delayed rewards of behavior change make it hard to act on what individuals intend to do. Besides, changing behaviors is highly complex and individual, and it needs strategies and interventions that account for such differences.

Reflections can lead to learning and better self-understanding, and thus have the potential to help individuals find how to best change their behaviors. By learning something about themselves, individuals also develop motivation to continue their goal pursuit. Technology, which can often be counterproductive to the tasks of reflection, is capable to accelerate learning by various means. It aids remembrance, can create the necessary time and space, show new perspectives, and has the power of personalization. The aim of this project is therefore to support individuals with technology to help them reflect on their health behavior change. Thereby, people will be empowered to reach their health goals.

This project is guided by the following research questions: (1) How do people reflect in their everyday lives (2) How can people be supported to reflect on their behavior? (3) How can we design for reflection? and (4) How can smart objects support a reflection process?

In a quest to answer the above questions, this project yields several significant results: First, it gives a comprehensive overview of the literature around reflections, how technology can support them, and how they can help in the behavior change process. It reveals that a reflection is an abstract, deliberate thinking process in which people review their experiences to find connections, gain new understanding and reassess themselves and their behavior. This process is characterized by deliberateness, slowness, intentionality, and inefficiency. Technology can help to create the right reflection environment, trigger remembrance, show helpful information, create connections, and help to find personalized strategies for change.

Second, a contextmapping study with 8 participants identified people's process of reflecting, as well as 9 reflection needs that can be summarized as follows: Many of people's reflections are surface-level, happen after negative events, trigger coping mechanisms, and need quick solutions. However, people want to

have more proactive reflections characterized by curiosity and learning, but those require time, mental space, and a trigger, of which the first two are often missing. In their reflections, people go back and forth between considering various pieces of information such as data, feelings, and memories; and connecting it in different ways to come to a new understanding. People need to be guided through the gathering and connecting of relevant information without being distracted. Although people hope to learn how they can better reach their health goals, a reflection often leads to rumination or overthinking- something people desperately seek to avoid.

Next, a review of over 25 reflection concepts in the literature identified 4 design mechanisms and 5 design principles that opened up a design space. Design concepts can support reflections through the means of dialogue, information, expression, or the environment. Design principles are high-level concepts that, if implemented in design concepts, lead to reflections. Such were temporal perspective, data analysis, comparison, discovery, and mindfulness, with each being divided into subcategories. This led to the creation of a design vision, which was to use technology to create a distraction-free reflection environment that helps people identify barriers and enablers in their behaviors and find strategies for achieving their health goals.

Finally, a design concept and a prototype are created and evaluated to help people reflect on, and find new strategies for, their health behavior. The "Reflection Card" consists of a portable physical card with two displays, and a digital application. Guiding questions and an abstract visualization trigger people to reflect on their behaviors by speaking with the card. It uses artificial intelligence to identify barriers and enablers to their current strategies. The digital app tracks the evolution of barriers and enablers and generates a personalized strategy for behavior change based on the individual reflections. Key features of the reflection card concept are defined, evaluated and finalized.

To conclude, this thesis makes a solid argument of why and unveils a space of how to support and design for reflections in a behavior change process. Through key literature insights, user reflection needs, a design space, and a design concept, this project hopes to contribute to helping people change behaviors and thereby increase personal flourishing and tackle societal problems.

Table of Contents

01	INTRODUCTION	11	06	DESIGN CONCEPT: THE REFLECTION CARD	101
1.1	Project Introduction		6.1	Concept Summary	
1.2	Project Approach		6.2	Concept Narrative	
1.3	Chapter Overview		6.3	Physicality	
02	REFLECTIONS IN BEHAVIOUR CHANGE	23	6.4	Card Displays	
2.1	Related Work on Reflections		6.5	AI Architecture	
2.2	Reflection Models		6.6	Digital Application	
2.3	Benefits of Reflection		6.7	Key Concept Features	
2.4	Technology as Reflection Support		6.9	The Road to the Concept	
2.5	Discussion		07	CONCEPT EVALUATION	123
03	REFLECTIONS IN EVERYDAY LIFE	39	7.1	The Evaluation Study	
3.1	The Contextmapping Study		7.2	General Results	
3.2	The Reflection Process		7.3	Concept Adjustments	
3.3	Trigger		7.4	Final Key Features	
3.4	Support		08	DISCUSSION & CONCLUSION	147
3.5	Capture		8.1	Discussion	
3.6	Discussion		8.2	Future Work	
04	DESIGNING FOR REFLECTION: A TAXONOMY	69	8.3	Conclusion	
4.1	Introduction		8.4	Reflecting on the Project	
4.2	Concepts Presented		09	REFERENCES	158
4.3	Design Mechanisms		10	APPENDIX	170
4.4	Design Principles				
4.5	Design Features				
4.6	Discussion				
05	TOWARDS A DESIGN CONCEPT	89			
5.1	Interaction & Embodiment Guidelines				
5.2	Bridging User Needs, Design Space, and Theory				
5.3	The Design Vision				
5.4	A Design Proposal				

REFLECTION

ULTIMATELY

INVOLVES

CHANGE

-Baumer, 2015

01 Introduction

In this first chapter, I give an introduction into the project of designing an intervention that helps people to reflect on their behaviour change. I cover its relevance, the challenges that are faced and the current research status. I will also present the aim and scope of the project, as well as introduce the main research questions. I will continue to summarizing the approach that this project took, and go through each of the taken steps in more detail. Lastly, I provide a reader's guide to the different chapters in this report.

1.1 Project Introduction

RELEVANCE

Helping people to reach change their health behaviour leads to personal flourishing and a higher quality of life. Over the last years, the emergence of self-help books and news articles prove that people slowly become more conscious about the benefits of being able to change one's behaviour and becoming healthier. More and more, people believe that they can change their lives for the better through the results of the efforts they undertake. However, most people's behaviours still don't correspond to what they set out to do (Sheeran, 2002). People are growth-oriented beings which is essential for their vitality and well-being (Ryan & Deci, 2000), but growing and reaching goals requires some level of effort, discomfort, and motivation. At every instance of the fresh start effect- most famously on New Year's Eve- people set new health goals around sleep, eating behaviour, exercise, etc. Only about 20% of new years' resolutions are successful in the long term (Norcross & Vangarelli, 1988). Even in face of the abundance of self-help tools and resources out there, people still struggle to maintain their health behaviours (Lee et al., 2017). Although people show a desire to change their health behaviours, they are rarely able to do so in a sustainable way.

The ability to change one's health behaviour also gives people stronger tools to deal with processes of change in general, and withstand the setbacks and hardships of everyday life that are inevitable. It helps to develop self-understanding, resilience, and an ability to cope with failure. Helping people to change their health behaviours can be a stepping stone for reaching goals, and experiencing growth, which is an intrinsic aspiration positively related to vitality, well-being, and self-actualization (Deci & Ryan, 2000).

The ability to change one's health behaviour is not only principal to personal success, happiness, and flourishing, but it also fundamentally contributes to the achievement of societal goals. In 2019, the Annual WIN World Survey reveals that almost a quarter of people consider themselves leading an unhealthy life, which raises the odds of developing chronic diseases. These problems that develop from unhealthy behaviours such as smoking or bad eating put increasing pressure on healthcare systems around the world that are in desperate need for preventing such diseases. One way to conquer that problem is by providing individuals the necessary tools and knowledge to make more conscious health choices.

By empowering individuals to change their health behaviours, they will also

Why is it an important goal to help people change their behavior?



be able to change other behaviours with more ease. This potentially creates an opportunity to tackle more complex societal problems like climate change or waste pollution that rely on structural changes but also, at its core, on individual's everyday actions.

CHALLENGES

Changing behaviours towards healthier ones is often a process that demands time and effort. Individuals need to find out about their goal, come up with a plan and find the necessary motivation to put themselves in discomfort over and over again. Especially through the abundance of basically everything, and the ubiquitous nature of technology, individuals have become acquainted to 24/7 comfort and instant gratification. While the seeking of such everyday comfort is questionable at least, it restrains people's ability to change and engage in effortful tasks that drive change but will rarely provide immediate rewards or signs of progress. With such easy access to limitless rewarding behaviours, it is clear that resisting these forces, overcoming hyperbolic discounting (the human tendency to place higher value on small immediate rewards than large rewards later), and sticking to behaviours that are in line with long-term health goals feel like a Sisyphean task (a task that seems endless end futile).

Not only is changing health behaviours an effortful process, but a complex one too. When embarking on a quest to change one's behaviour, individuals often become lost in the complexity of influences, and the infinite landscape of techniques and methods. People struggle to find the right strategies to change and the interventions to use that fit for them, at different times in the change process (Fedlmeier et al., 2022). Changing health behaviours is influenced by personal preferences and beliefs, social context such as family situations and the relationships with friends, as well as greater societal influences like norms, politics, culture and others. This variety and complexity of influences, as well as the landscape of methods and interventions to support behaviour change, prove that there is no one-size-fits-all solution to changing behaviours. Successful change is dependant on the ability to identify and address contextual influences to a certain behaviour (DiClemente, 2007). Individuals need to learn what fits them and their context best at any given time (Milkman, 2021) to engage in sustainable behaviour change.

Why is difficult to change behaviours?



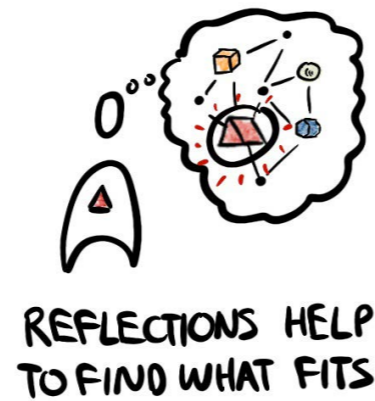
OPPORTUNITY

Reflections are proven to help people learn and gain self-understanding, proving to be a useful tool to engage in successful behaviour change. Reflections are helpful whenever users need to learn about themselves or their change process. The phases of behaviour change process that require most learning is in transition from contemplation to preparation, and from action to maintenance (Prochaska & Velicer, 1997). At the beginning of the change process, reflections lead to individuals knowing what goal they want to reach and what initial strategy to use. In the later stage, reflections help to reevaluate their strategy based on learnings and make it fit for the time, context, and their personalities. Reflections can lead to learning and self-insight (Baumer, 2015) and engaging users into reflection has been identified as a key value to enable successful behaviour changes for individuals (Li, 2010; Mamykina, 2008). They help to “find what fits” (Fedlmeier et al., 2022).

Technology can support every level of reflections from revisiting past events to finding relationships and creating fundamental change (Fleck & Fitzpatrick, 2010). In the past, technology has been used to enable learning (Pea, 1985) and technologists have been looking into the role that technological artefacts can provide to support reflections (Norman, 2003; Sengers et al., 2005; Romero & Mateas, 2005). This emphasises the opportunity to use smart objects to support individuals in their reflections.

The powers of technology to support people in reflections can be used in a design process. Designing for reflection has been identified as an early stage research opportunity within design research (Baumer et al., 2014). Sas and Dix (2009) also note that it is still in its infancy. Also in domains like cognitive and learning sciences, designing for technology that supports reflection is of great interest (Ghajargar et al., 2018). At the moment, there is a lack of understanding on how to design reflections so that they lead to successful behavior change. There is an important opportunity to learn more about the reflection process, key design elements that lead to reflections, and how technology can support such reflections (Slovak et al., 2017).

Why are reflections important?



AIM & SCOPE

This project aims to contribute to the knowledge on how to help people reflect on their health behaviour, focusing on the latter stage when people are in the midst of changing their health behaviors (see Figure 1). The intended effect is that this will help people to learn about their influences on the change process, how to personalize their goals, behaviour change strategies, and interventions that they use so that their behaviour change can be most successful and sustainable. The focus of this project is not to actively help people change their behaviours, but it is about them finding the right reflection moments, leading deep, positive reflections, and reaching insights which then inform their change process. It is about people being able to make their own informed decisions on how they can best reach their goals. For some people this might result in the changing of the goal itself, the strategy in place, or in no change at all. All these outcomes are considered successful and any of them help people tailor their behaviour changes to their unique contexts and likings.

To achieve the above goal, this project aims to use some form of intelligence, as they provide a particular opportunity to help people reflect and learn (Pea, 1985; Fleck & Fitzpatrick, 2010). Simultaneously, there is a lack of comprehension on how technology can assist in the reflection process (Slovak et al., 2017). Rather than designing technology that helps people change their behaviours, this project takes a contrary approach of using technology to help people reflect and make conscious decisions. Often times, smart objects are designed to tell people what to do, but I aim to help them find out themselves if, and how, they want to change. The main goal of information technology has been to make people more efficient, but this project seeks to explore how it can contribute to making space for reflections.

This project is therefore guided by the following research questions:

1. How do people reflect in their everyday lives?
2. How can people be supported to reflect on their behaviour?
3. How can we design for reflection?
4. How can smart objects support a reflection process?

This project's target group are young adults between 23 and 35 years that are currently in the process of changing a health-related behaviour, and are working and/or studying. We focus on reflections in the last phase of a behaviour change process where a behaviour has already been tried for a certain amount of time, and the goal is to tailor the strategy and goal (see Figure 1). Restricting the target group's age and occupation allowed to filter for people that were most likely to experiment with change, but also cognitively able to reflect, as well as reflect on their reflections; a task that is generally difficult and influenced by many biases.

On a meta-level, this approach of making people in control of their change

What is the goal of this project?

SUPPORT INDIVIDUALS
WITH TECHNOLOGY
TO HELP THEM REFLECT
ON THEIR HEALTH BEHAVIOR CHANGE

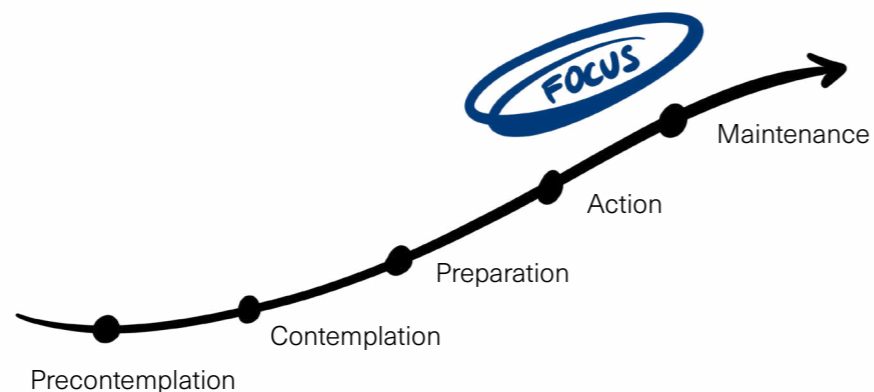


Fig. 1: TTM framework by Prochaska & Velicer (1997)

process is connected to explorative self-experimenting (ESE) (Fedlmeier et al., 2022), who developed a method to help people find the right behaviour change interventions for them. In a framework of defining, planning, probing, and reflecting, people iterated on different strategies to reach their goal until they found their best fit. This project zooms in on the the last part of that cycle to support people in their reflections and gaining insights most valuable to the change process (see Figure 2).

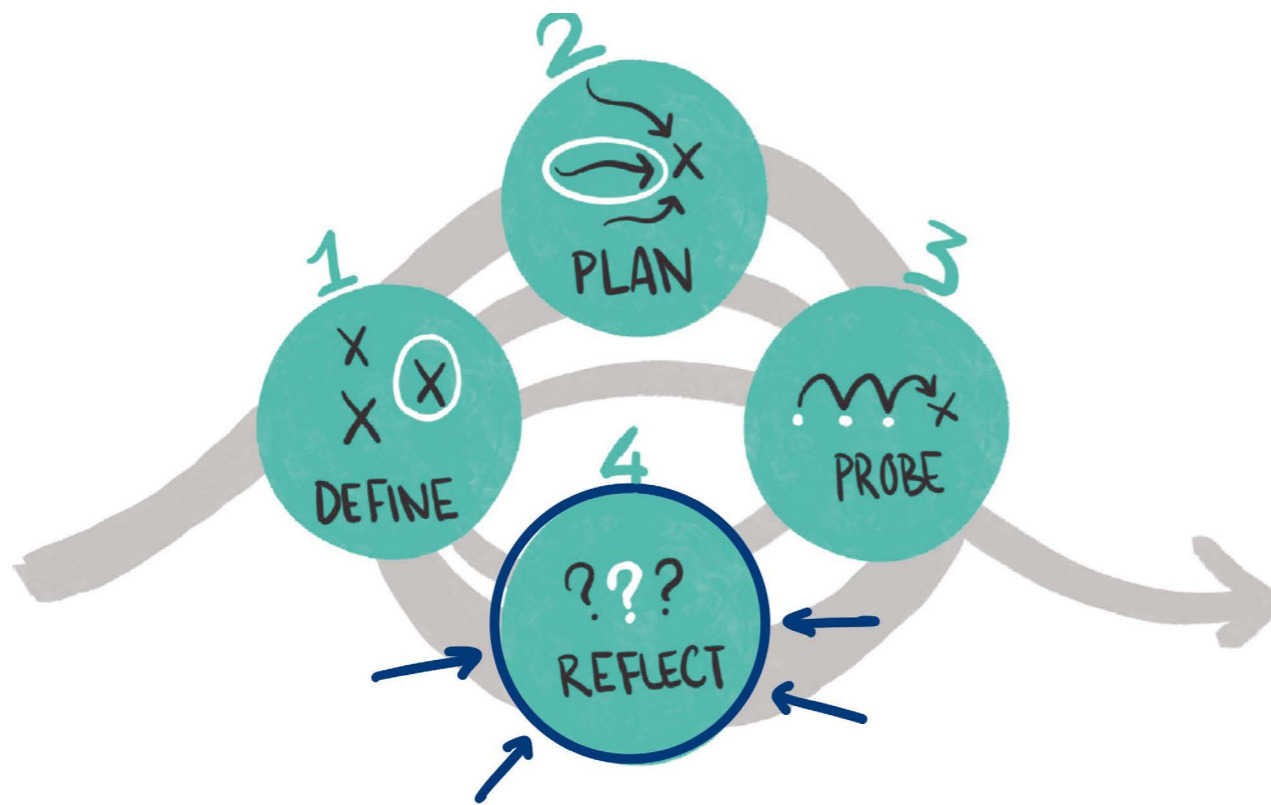


Figure 2: ESE process framework by Fedlmeier et al. (2022) with a focus on reflections

1.2 Project Approach

To understand the outcomes and findings presented in this report, it is essential to introduce the approach that is taken and the methods that are used. The following section gives an overview of how results were yielded throughout this 100-day research and design project.

GENERAL APPROACH

The overall approach that this project has taken resembles that of a double diamond process, but doing two iterations in the first diamond (see Figure 3). The double diamond approach is a common design process that goes in phases of discovering the problem, defining how to address that problem, developing a design, and delivering a final concept or prototype (Design Council, 2005). Discovery and developing phases are about exploration and expansion, while decisions are made and things are synthesized in the defining and delivering of the project. The first diamond is about finding opportunities while the second one is about creating solutions for the defined opportunities. This project adapts the double diamond model by conducting two iterations of the 'discover' and 'define' phase, for both finding opportunities in user needs as well as in creating a design space. It was essential to research on both of these ends to connect them into a design proposal.

The 5 episodes of this project link directly to this process, are further explained below, and can be seen in more detail in Figure 4.

1. Exploring the problem

In the first step of the project, the focus was on exploring the current research around reflections, behavior change, and technology. A thorough literature review was done, that drew from the domains of learning theory, psychology, human-computer interaction, design, and behavior change theory. This part of the project helped to define initial models to be worked with throughout the project, as well as get preliminary results on the state-of-the-art in reflections and their related concepts. It helped to start with baseline knowledge, get initial results to the

research questions, and be rightly equipped to set up a research study.

2. Exploring how people reflect in their everyday lives

In the second part of this project, a contextmapping study (Visser, 2005) was conducted with the goal of getting to know how people reflect in everyday life. This part was particularly targeted towards research questions 1 and 2, around how people reflect in their everyday lives. This study allowed to identify key reflection needs across the reflection process, that could be addressed in a design concept to support people in reflecting on their health behaviours.

3. Exploring a design space for reflections

This part of the project focused on establishing a design space for reflections by finding key mechanisms, principles, and design features that lead to reflections. To this end, a portfolio of more than 25 literature concepts that focused on reflections, was assembled and analyzed. This provided a starting point for designing an artifact to address the user needs identified in part 2.

4. Designing a concept to help people reflect

After integrating the learnings from the contextmapping study, literature research, reflection concepts, and rapid prototyping into initial ideas, a design proposal was created. This proposal was then converted into a research artifact. In iterations of designing and building, the design concept was refined until it aligned with the theory, intelligence, and embodiment. Preliminary features were defined.

5. Evaluating the concept & communicating the results

In the last phase of the project, the design concept was evaluated in a study with the intended target group to create a final version of the concept's features. All the created knowledge is then converted into a project report as well as a concept video that shows the interaction with the envisioned reflection artefact.

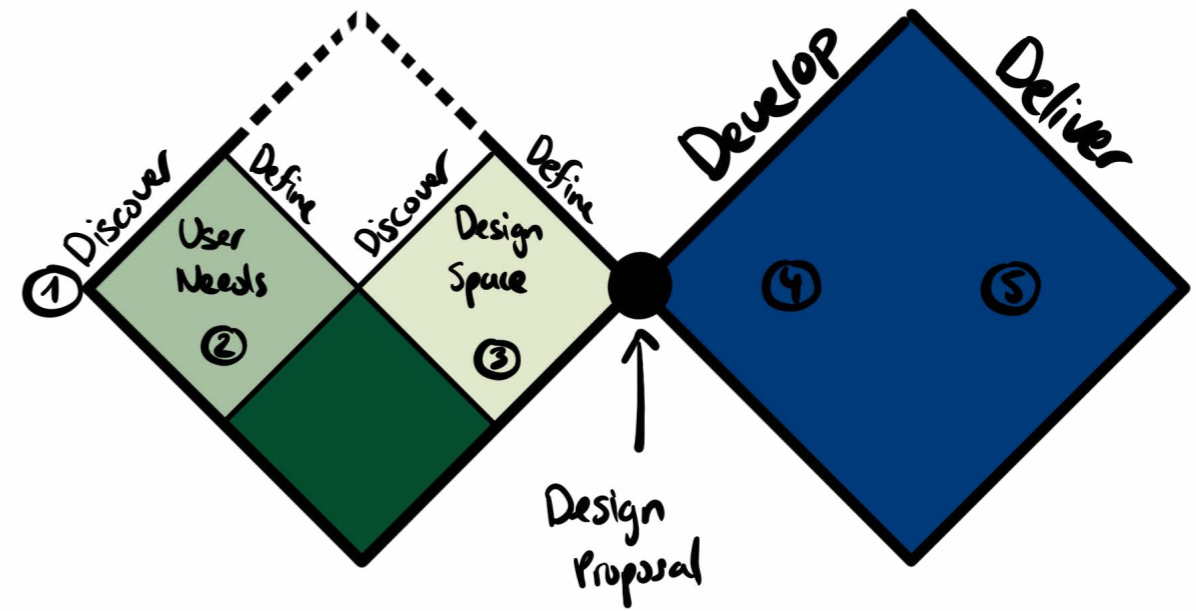


Fig. 3: Adapted double diamond design process, showing the steps in this project

OBJECTIVES	1	2	3	4	5
1. Exploring the problem	2. Exploring how people reflect in their everyday lives	3. Exploring a design space for reflections	4. Designing a concept to help people reflect	5. Evaluating the concept & communicating the results	
Research questions: How can reflections help to change behaviors? How can technology help to reflect and change behaviors?	Research questions: How do people reflect in their everyday lives? How does it feel to reflect? What is the process of reflecting?	Research questions: How can we design for reflections? How do people want to reflect? What artefacts help people to reflect and what are their qualities?	Research questions: How do people want to interact with a smart object? How can intelligence help in reflections? How can we connect it to a behavior change?	Research questions: How does the design concept address this project's goal? How can the project contribute to literature? What are the main results? What are its limitations?	
ACTIVITIES	Literature review	Contextmapping	Concept analysis	Prototyping	Project Report
Main activities: Reviewing over 50 papers in the fields of HCI, psychology, behavioral sciences, design, and others.	Main activities: <ul style="list-style-type: none"> Creating a sensitizing booklet Running a diary study with 8 participants over 1 week, with daily exercises 40-minute follow-up interviews 	Main activities: Doing a thorough analysis of a selection of over 25 design concepts on how to help people reflect.	Main activities: <ul style="list-style-type: none"> Setting up a design proposal Creating a design concept Different design methods to iterate on the concept 	Main activities: <ul style="list-style-type: none"> Evaluation study Creating communication materials such as a video and project report 	
OUTCOMES	Literature insights that lead to first reflection models as well as give a broad understanding of related theories and background information.	The contextmapping allowed to map a reflection process , and it identified 9 core needs that people have in their reflections.	The concept analysis enabled to identify common design mechanisms, principles, and features that lead to reflections or support the reflection process. A design proposal was created in the next step.	The prototyping resulted in the creation of a design concept , as well as a physical and digital prototype. Preliminary features were presented.	The evaluation resulted in final concept features that helps people to reflect on their health behaviour, as well as a video on that concept and a project report on the entire research.

Fig. 4: Detailed project approach

1.3 Chapter Overview

This report presents the main results gathered throughout the research & design process. The chapters of this project report align with the different phases introduced in the last section (Figure 5). Chapter 2 introduces connections between reflections, behavior change, and technology identified in the literature. It also presents the models that are used and referred to across the report. Chapter 3 presents the insights of a contextmapping study that resulted in 9 core reflection needs. Chapter 4 reviews a catalog of design concepts that support reflections and establishes a taxonomy of mechanisms, principles, and features that lead to reflections. In Chapter 5, results from all the research activities are synthesized, and a design proposal is created. In Chapter 6, the design concept that supports reflections on the behavior change process is presented. In Chapter 7, the design concept is evaluated and key features are presented. Chapter 7 is a discussion of the presented results, an outlook for future research, and a reflection on the project. Every chapter focuses on the methods used and the results that were gathered, rather than on the entire process of researching and designing.

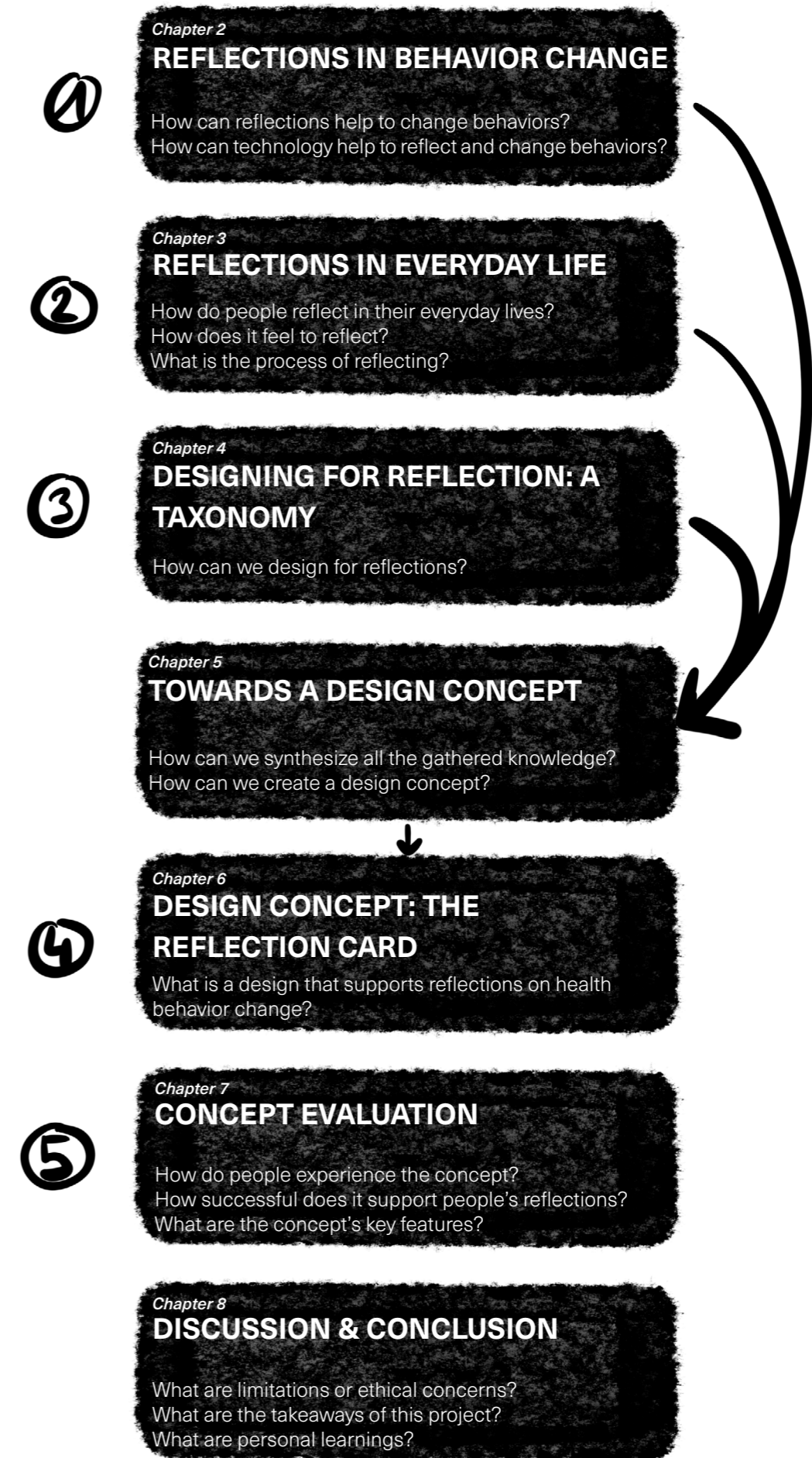
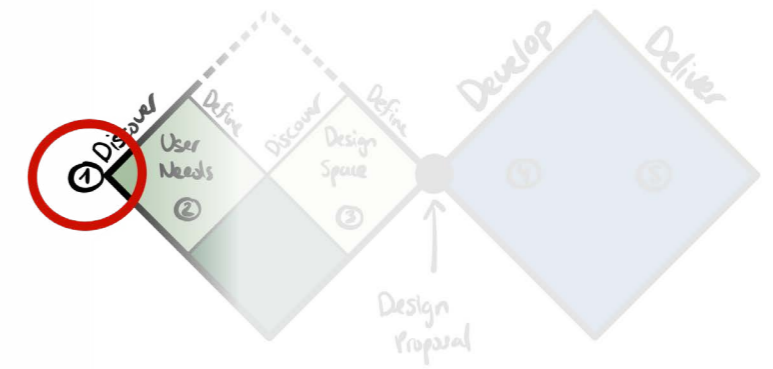
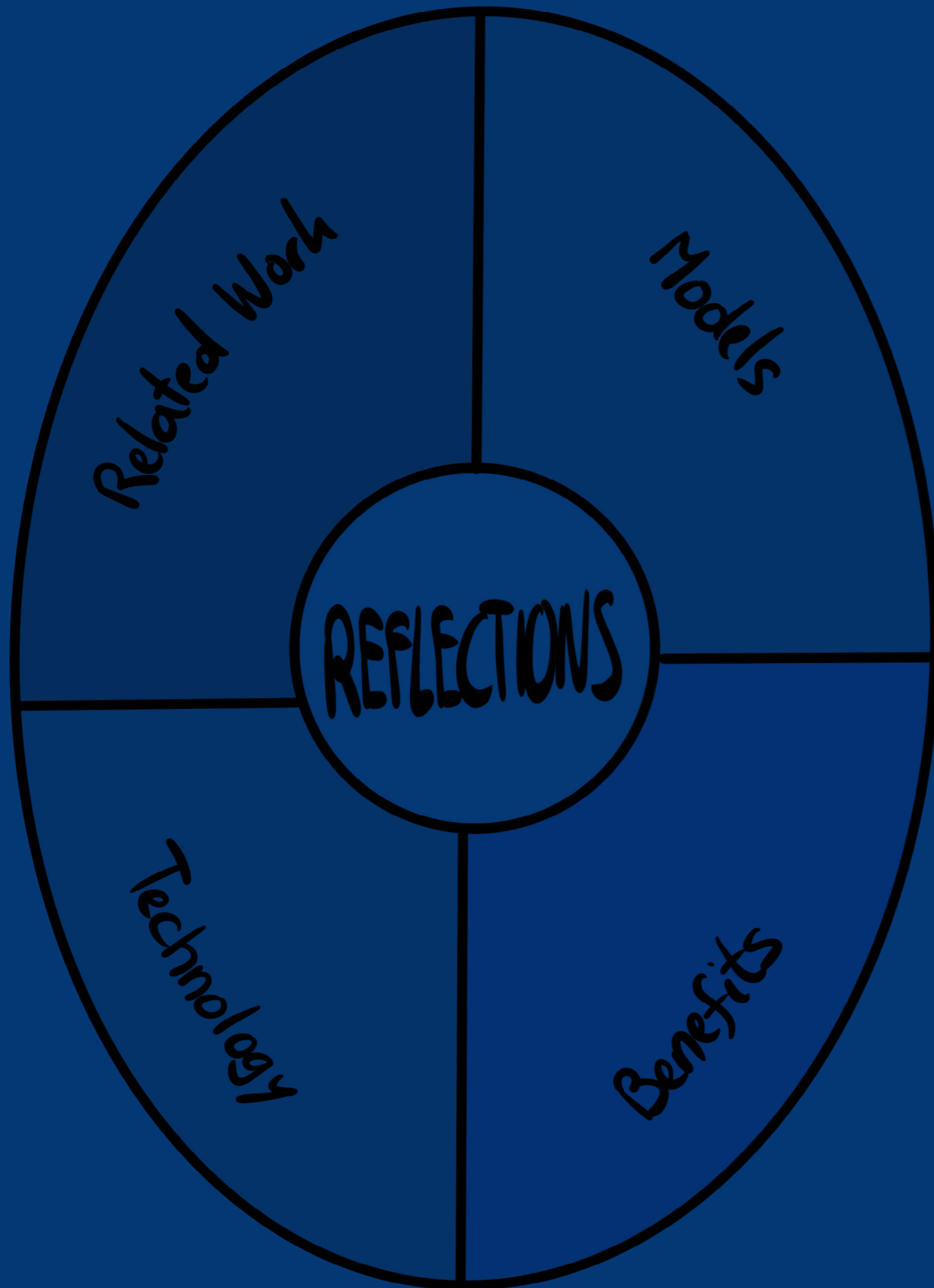


Fig. 5: Chapter reading guide



02 Reflections in Behaviour Change

This chapter aims to explore the existing body of research on the topic to get a first understanding of reflections as a concept and how they can be supported by technology to sustain the behavior change process. Through a review of the literature across human-computer interaction, behavioral sciences, psychology, learning theory, and design, a first overview of the concepts was gained, and connections between reflections, technology, and behavior change were drawn. Also, an initial framework for reflections was created that guides this project and will help to establish a design space.

2.1 Related Work on Reflections

INTRODUCTION

Reflection is a concept that has been studied for decades but has only recently become a focus in Human-Computer Interaction (HCI). Especially the use of technology to design for reflection has emerged as an area of interest (Baumer, 2014; Li et al., 2010). This increasing interest aligns with many of the concerns related to the third wave of HCI, which revolves around considering aspects of the human experience such as emotions, domestic life, and culture, rather than focusing on productivity and effectiveness of workplace-related tasks (Bødker, 2006). Aligning with the aim of this project, designing for reflection has emerged when the focus has shifted towards helping individuals lead a better life, by helping them to change their health behaviors for example.

Baumer et al. (2015) define different areas that discuss reflections among technology users. The first one draws from the theory of personal informatics, with reflections being an essential component of the stage-based model of personal informatics systems (Ian, 2011). Here, the approach is for technology to help people assemble the information necessary for reflection and gaining self-knowledge. People who want to (1) examine personal information, (2) collect it, (3) integrate it, (4) reflect on it, and then (5) proceed to act on it, can successfully change their behavior through gaining self-knowledge. However, current personal informatics systems do not offer enough support for reflection (Choe et al., 2015) and assume that reflections will occur automatically when information is presented. Another area that uses technology to drive reflections is slow technology, a contrary approach to efficiency as the goal of most technology (Hallnäs & Redström, 2001). Slow technology leads to reflection by users needing time and regular interactions to make sense of the technology's utility.

However, the term "reflection" is still fuzzy in its use and draws from many different scientific domains. In cognitive psychology, reflection is seen as a particular way of thinking that is characterised by its non-automatic character. In his book *Thinking, Fast and Slow*, Kahnemann describes this effortful and deliberate way of thinking as System 2 thinking (Kahnemann, 2011). Norman differentiates between experiential cognition and reflective cognition, in which the latter represents some form of deliberate and intentional way of thought to create novel work and foster creative capacity (Norman, 1993. Things that make us smart). To Moon, this form of reflective thinking is also directly linked to learning (Moon, 1999), making reflections a concept that is widely discussed in education.

The intersection of design, technology, and reflections prove to be exciting and informed by various scientific domains. **Deliberateness, slowness, intentionality, and inefficiency** are core paradigms that also go against many of the qualities that today's world is designed around. However, it remains unclear how reflections can be defined exactly.

TOWARDS A DEFINITION

There are many ways in which reflections have been defined over the past decades and throughout scientific fields. In design, Schön (1983) describes reflections as a way of thinking that enables problem-solving through the construction of understanding and reframing. This way of thinking is a deep, slow, and effortful process (Norman, 1993). Mols et al. define the process of reflecting as "Considering and analyzing past, present, and future experiences in order to reassess our thoughts, beliefs, feelings, and actions regarding our everyday life" (Mols et al., 2016). In psychology, a reflection is defined as "remembering plus further analysis" in the life review model (Staudinger, 2001). This process of remembering involves abstraction, comparison, and categorization. Most research on reflections draws on psychology and learning sciences, dating back to as far as 1933. One of the earliest definitions of reflections was introduced by philosopher and educational reformer John Dewey for whom reflections were a deep consideration of experiences and actions which lead to discovering relationships. A reflection is "a systematic, rigorous, and disciplined way of thinking. It is a meaning-making process through which people move from one experience to the next with a deeper understanding of its relationships and connections" (John Dewey, 1933). Boud suggests a similar definition in his work on "reflection in learning" by stating that reflections are an exploration of experiences to come to new understandings and appreciations (Boud et al., 1985). Finally, Moon also defines reflections as a thinking process but focuses on the fact that it analyses complicated or unstructured ideas and that there is no obvious solution (Moon, 1999). Drawing from all these ideas, I'd like to conclude that **a reflection is an abstract, deliberate thinking process in which people review their experiences to find connections, gain new understanding and reassess themselves and their behavior.** This definition has been assembled through an analysis of the most common components of past definitions and qualities of reflection, such as the components of "thinking", "process", "understanding", "analysis", and others.

While many definitions have been developed in past research, after doing a thorough literature analysis, Baumer et al. concluded that most definitions were

" Without
[reflection]
~~do~~
judgment
of
experience
would be
possible
at all. "

-Kant, 1790

brief and surface-level. Baumer et al. also argued that many definitions of reflection did not ground in theory (Baumer et al., 2014). They presume that this is the result of a lack of deep engagement and consideration of the phenomenon of reflection. Reflections being related to a meta-cognitive process indeed makes it hard to grasp and scientifically analyze, and therefore difficult to measure as well. Reflection remains a notion that is difficult to fully grasp (Copeland et al., 1993; Laboskey, 1994).

MEASURING REFLECTIONS

The fact that there is no fully theory-based definition of reflection is both the reason and a consequence of reflections being difficult to measure. Little is known about how to measure reflections or if they can be measured at all. A meaningful or equitable direct assessment of reflection can become intractably difficult (Sumison et al., 1996). While brain measurements can give us some hints about cognition, it largely remains a process within the self that is not readily available for analysis (Baumer et al., 2014). This is also why many papers and concepts treat reflections not as a goal for themselves, but as a means to an end for e.g. increasing well-being or changing behavior. Although there is a clear difference between reflecting itself, and the effects of that reflection, the quality of reflections is often measured by the effectiveness of their desired effects. This wrongly assumes a causality between the effectiveness of the intended result and the level of reflection. Thus, papers that e.g. build a support system for reflections to increase well-being conclude that their system was successfully leading to deeper reflections from measurements of increased well-being.

Some approaches indicate how one could directly measure reflections, providing theoretical frameworks, simple tools, or complex physiological measurements. Some frameworks from various scientific domains indicate different levels of reflection from habitual action or remembrance to critical thinking and making new thought connections. Based on these, self-report questionnaires have been created to find out where thought processes would situate on such scales. Examples are the questionnaire by Kember et al. (2000), the Self Reflection and Insight Scale (SRIS) by Grant et al. (2002) or the Private Self-Consciousness Scale (PrSCS) that measures individuals' tendencies to have deeper reflections (Fenigstein et al., 1975). Qi et al. (2013) found physiological changes in temperature or pulse rate in periods of reflection that could be used to measure them.

While the approach of measuring reflections based on the success of their intended effect is wrong when assuming that they are causally related, this project aims to both evaluate the quality of reflections and the intended consequence of sustaining behavior change. When it comes to the quality of the supported reflection,

a questionnaire similar to the one by Kember et al. (2000) will be adapted for the design concept that is created in this project. This questionnaire (see Appendix C) will focus on the different levels of reflection, as defined by Fleck & Fitzpatrick (2010): Revisiting, describing, exploring relationships, fundamental change, and wider implications. This model will be more thoroughly explained in the following section. However, what became clear throughout this literature review and was also emphasized by Benvelzen et al. (2022), is that there is still an urgent need to better understand and evaluate how reflection support systems influence reflections.

2.2 Reflection Models

REFLECTIONS IN TIME

Reflections do not happen as instantaneous moments in time, but they occur over some time and in different stages. I have analyzed and synthesized multiple reflection models to conclude with the model of Mols et al. (2016) that will help to create a design space for reflection (see Figure 6). This stage-based model gives a starting point to position systems that support reflections in that reflection process. There are three distinct phases in this framework which are the trigger, support, and capture phases. Mols et al. undermine that these stages can overlap and systems to support reflections can support one or multiple of these phases. They align closely with the stages identified by Atkins and Murphy (Atkins & Murphy, 1993), which are the awareness of thought, critical analysis, and development of a new perspective. The approach by Kocielnik et al. (2018) also aligns with these stages, renaming them to “noticing”, “understanding”, and “future actions”.

In the trigger phase, an individual is pushed by the system to start thinking and thus introduce the reflection. There are many different ways in which a trigger can present itself. In the support phase, individuals are supported in their thought exploration, finding relationships, and gaining new understanding. They are supported in deepening their reflections as much as possible. In the capture phase, individuals are supported in taking their newly gained knowledge into the world and acting on their new insights. In the context of behavior change, concepts should help people to convert their reflection learnings into behavior change adjustments. This model will help us to analyze existing reflection concepts and select a positioning of our design concept in the reflection process.



Fig. 6: The reflection process (Mols et al., 2016)

REFLECTIONS IN SPACE

Reflections do not only have a timely dimension, but they also encompass different layers of depth. The model introduced in this section is provided by Fleck & Fitzpatrick (2010), converted to HCI from Bain’s 5Rs framework of guiding people through reflections (Bain et al., 2002), and inspired by Moon’s (1999) 5 levels of learning. The different layers of reflection go from description, reflective description, dialogic reflection, and transformative reflection, to critical reflection which is defined as the deepest level of reflection (see Figure 7). Higher levels are considered most reflective, and can only follow if lower levels are reached first (Hatton & Smith, 1995).

In the first level, individuals revisit experiences and describe them factually without going into much detail. This is not yet considered reflective thinking. In the next level of reflective description, individuals include reasons and justifications in their thinking, but still superficially and descriptively. The next phase is where relationships between experiences and pieces of information are explored and questioned, hypotheses are created, and different points of view are considered. In level 4, fundamental change is reached by revisiting experiences, knowledge, or beliefs with the intent to challenge and question them. This leads to a change in understanding and/or practice. The deepest level of reflection occurs when level 4 conditions are satisfied, but wider implications such as social dynamics, ethical issues, cultural biases, and more are considered in the thought process. This last level of reflection is only rarely reached (Fleck & Fitzpatrick, 2010).

In this project, I will use the layers of this model as reflection criteria to measure the design concept. It will allow assessing the depth of reflection that the design concept achieves and thereby give an indication of how successfully the concept supports reflections on people’s health behavior. Next up, I introduce the benefits of reflections and how they can lead to successful behavior change, which is a core premise of this project.

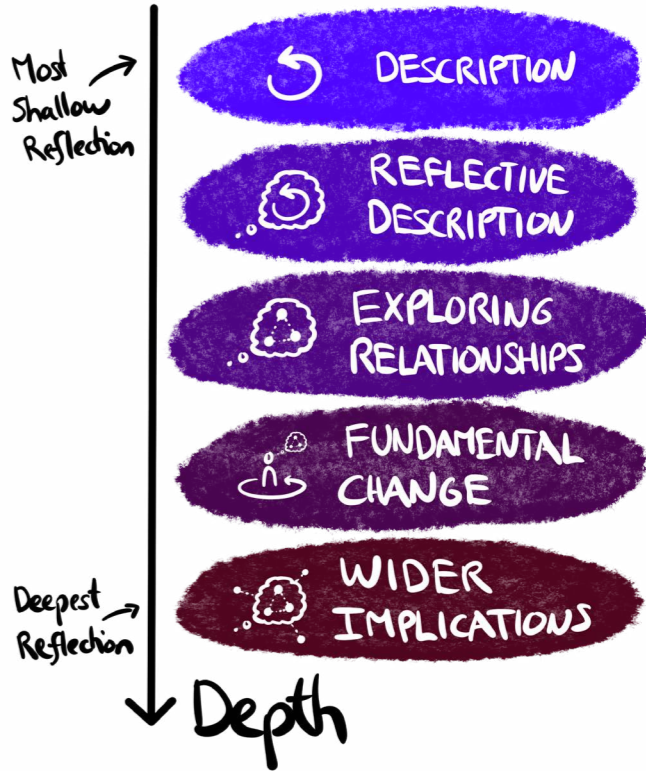


Fig. 7: The reflection depth layers (Fleck & Fitzpatrick, 2010)

2.3 Benefits of Reflection

REFLECTIONS LEAD TO LEARNING

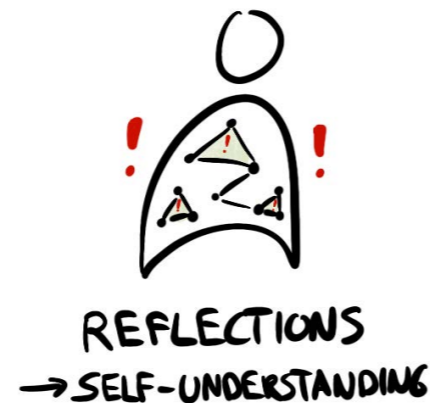
Amongst the many benefits that reflections prove to bring, revolving around increased well-being, stronger appreciation of everyday life, more positivity (Lyubomirsky et al., 2005), and better dealing with negative events (Pennebaker & Chung, 2011), the fact that it leads to learning is the most established benefit. In 1966, John Dewey stated: "We do not learn from experience. We learn from reflecting on experience." (Dewey, 1966). Moon also introduces reflections in the field of education, saying that reflections were directly linked to learning (Moon, 1999). Reflections enable learning that leads to problem-solving (Schön, 1983) and allows to create novel ideas (Norman, 1993). Various definitions of reflection include the idea of gaining new understanding as a direct consequence, and so does the definition I have synthesised. Gaining new understanding is a form of learning that allows individuals to make new connections based on old knowledge, rather than learning entirely new things.

Apart of leading to general new understanding of everyday life, reflections specifically help to gain self-understanding and self-knowledge (Mols et al., 2016). Linking to the quantified self (QS) movement, personal informatics involve the collection of data to lead to reflections that help individuals learn new things about themselves and find new patterns in their behavior. This kind of meaning-making through the exploration of information helps individuals to draw new connections between behaviors, attitudes, beliefs, and general knowledge. This can then inform future mindsets and actions (Porter, 2017).

REFLECTIONS HELP BEHAVIOR CHANGE

As a consequence of leading people to learn new things about themselves and their behaviors, reflections can support a behavior change process. Reflections have the potential to make people more aware of their underlying behavioral needs (Lee et al., 2015), understand their barriers and enablers for behaviors and increase their focus on higher-level goals (Carver & Scheier, 2000) (Trope & Liberman,

Why and how do reflections help behavior change?



2010). Through increasing their clarity of self-understanding, individuals get to know more about their feelings and behaviors, as well as identify patterns and habits (Isaacs et al., 2013). All of these elements are central for purposeful, directed change (Carver & Scheier, 1998). All of this increases the odds of people adopting more realistic strategies for behavior change (Kocielnik et al., 2018). Reflections serve as a preparation for deciding on new and more informed possible future changes. When people are in the midst of a behavior change process, which is the focus of this project, reflections help to find and adopt the best strategies for health behavior change (Fedlmeier et al., 2022). In her framework of Explorative Self-Experimentation, a method that helps individuals find their best strategy and intervention for change, reflections are an essential part of its iterative process (see Figure 2).

Reflections can not only lead to more successful behavior change by individuals finding their best suited strategy for change, but reflections can also fuel individual's motivation to sustain their behavior change process. Whether it is related to the gaining of self-understanding, or to the qualities of reflections, they seem to increase people's positive attitudes towards their behaviors, which can in turn enhance motivation. Reflections can lead to uncover slow changes and appreciate small steps of progress (Mols et al., 2016). Reflections can also lead to generalize from positive experiences and events, and frame negative events as teaching important lessons (Isaacs et al., 2013). Individuals tend to become better at tolerating short-term discomfort (Fujita & Han, 2009), an experience that is inevitable in any form of change process. Through regular reflections, individual's motivation for sustaining their behaviour changes is fueled (Ploderer et al., 2014).

Concluding, **reflections can support a behavior change process by increasing people's motivation and helping them find their best strategies for change** (see Figure 8). **Engaging individuals in reflections has therefore been identified as a key element to successfully change health behaviors** (Li, 2010; Mamykina, 2008). Reflections are increasingly seen as an alternative to persuasive behaviour change methods (Baumer et al., 2014), especially in changes that focus on health (Anderson et al., 2007). While this review proves that reflections can lead to successful behaviour changes, such a connection is not guaranteed. Reflections need to be carefully designed to fit into an individual's specific context, address his or her needs, and support his or her specific change process at any point in time. That is the aim of this project.



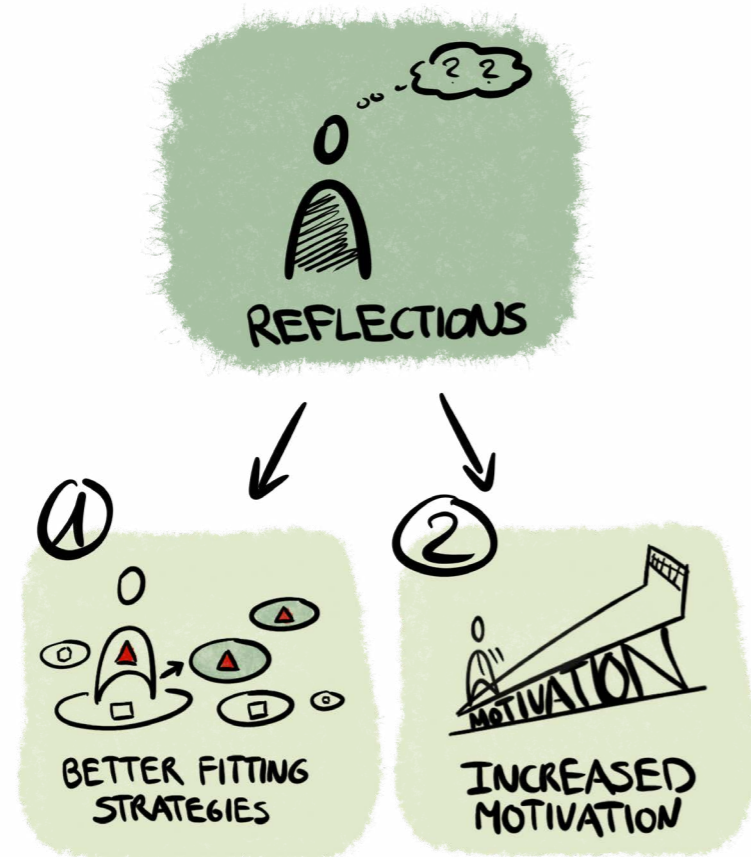


Fig. 8: Benefits of reflections in the behavior change process

2.4 Technology as Reflection Support

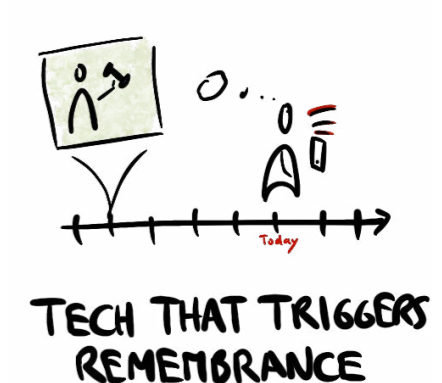
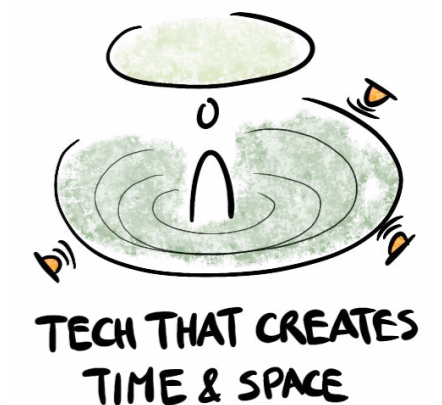
TECHNOLOGY TO TRIGGER REFLECTIONS

Several over-arching barriers have been identified to keep people from reflecting in their everyday life, which technology could help to tackle. First, people need to have time to reflect (Fleck & Fitzpatrick, 2010), a resource that is often overly exploited in people's hectic everyday lives. According to the reflection process model by Mols et al. (2016), reflection support systems should help to trigger people into a reflection. Indeed, the second need is that people also need a reason or at least an encouragement to start a reflection (Gustafson & Bennett, 2002; Moon, 1999; Fleck & Fitzpatrick, 2010). From the levels of reflection model by Fleck & Fitzpatrick (2010), we know that reflections need to start from revisiting experiences, being the entrance to deeper levels of reflection afterward.

Technologies can facilitate reflections by creating time. While many of today's technologies create time by making people more efficient and productive, the creation of time that leads to reflections is of a different nature. Here, we talk about unlocking time through mindful engagement and intentional inwards-directed attention, or *presence*. Slow technology is an umbrella term coined by Hallnäs & Redström (2001) to describe technology that supports reflections by claiming time and presence. Such technology is designed to be intentionally slow to encourage people to reflect on it. It is a design philosophy that turns its back on efficiency and functionality but promotes the conscious use of technology as such (Hallnäs & Redström, 2001). An example would be a doorbell that plays fractions of a song and only turns into a recognizable song through multiple uses over time and by paying conscious attention.

Technologies can also facilitate reflections by triggering people into remembrance. Such technology supports the first phase of the reflection process (Mols et al., 2016), as well as the first level of reflection depth (Fleck & Fitzpatrick). Smart objects have the potential to sense and interpret events in an individual's context by interacting with multiple other parties (Kortuem et al., 2010), which creates an opportunity to develop sensing triggers that can determine the best timings (Mols et al., 2016). Smart everyday things can even act as collaborative partners to engage individuals in activities that they were not initially motivated to do (Rozendaal, 2016). When it comes to the content of such triggers that lead to remembrance, technology can be of great help by providing records of

AI TRIGGER



experiences, knowledge, and events (Fleck & Fitzpatrick, 2010). Again, the rise of the quantified self (QS) movement in which more and more people use life-logging devices, provides the data necessary for starting to reflect. The next section will inform about that.

TECHNOLOGY TO SUPPORT REFLECTIONS

In the support phase of the reflection process by Mols et al. (2016), technology can help to bring people into deeper levels of reflection. This help is needed because people often do not know how to reflect (Porter, 2017) and need structure in their reflection process (Fleck & Fitzpatrick, 2010).

Description: As the basis for engaging in reflective thought, many authors agree that computing technologies help to access knowledge that would otherwise be unavailable to individuals. Especially wearables that capture an individual's interactions in everyday life support remembrance and thereby also introspection (Byrne & Jones, 2009). Personal informatics technologies are designed to collect relevant data for self-reflection (Bentvelzen et al., 2022). Any type of content such as behavioral data, photos, videos, and more, can be recorded with the help of technology and thus support revisiting of experiences like in a digital journal (Fleck & Fitzpatrick, 2010). However, it is important to note that the capturing and presentation of data are not sufficient to engage people in a reflection. In fact, most self-tracking tools do not support explicit reflection on the captured data (Choe et al., 2015).

Reflective Description: The second level of reflection (which is the first level defined as "reflective" rather "simply" thinking) in which individuals think about explanations, can also be supported by technology. Asking reflective questions is a method that is often applied in counseling, but can be used by technology as well (Fleck & Fitzpatrick, 2010). Although reflections are often seen as an individual experience, the help that other people can provide to reach this level by asking questions explains why many people engage in social reflections (Mols et al., 2016). A digital reflective partner could be a support system that helps people reach this level of reflection. Digital annotation tools are also a way in which technology triggers people to seek explanations.

Exploring Relationships: Technology can help people to identify patterns and find relationships in their thoughts and experiences by making them see things from multiple perspectives (Boud et al., 1985; Schön, 1983). Just like other people can also be of help to reach this level by sharing their different perspectives

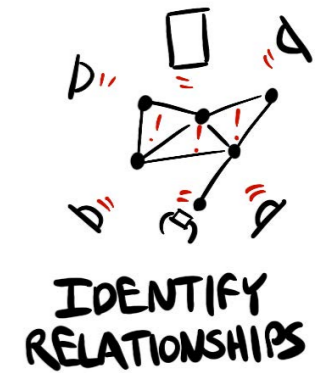
SUPPORT



with individuals, technology can change their perception and help them draw connections (Mols et al., 2016). Many tech concepts that help people to reflect use their data-capturing capabilities, then alter that data to defamiliarize people with it and present it back to offer new perspectives for reflection (Romero and Mateas, 2005). Verbeek (2005) states that "many forms of technological mediation are possible that transform our access to the world in myriad ways, some of which open up to us new ways of access unavailable to 'naked-eye' perception". Creating such new perspectives helps to find relationships and engage in level 3 reflections.

Fundamental Change & Wider Perspectives: There are not many technology support systems to reach transformative change and think about wider perspectives and thus support the deepest kind of reflections. Since the deeper levels follow the more shallow kinds of reflection, the same technology that helps people in remembrance, explanations, and finding relationships, could build on that support to also help individuals reach transformative change and think about wider perspectives. However, Fleck & Fitzpatrick (2010) argue that the technology's main role is to focus on, and support, the foundational processes and resources of reflection.

An over-arching capability of technology that helps people in their reflection is its power of personalization. While it's proven hard to capture any personal changes, such as the fluctuations of identity (Baumer et al., 2014), technology can help to identify personal behavior change motivators and barriers, attitudes, and social factors to tailor reflections to individuals (Kocielnik et al., 2018). While this section provided an overview of how technology is used in the 'support' phase of a reflection, the next section dives into the current tech support to take individual's self-insights into the world.



TECHNOLOGY TO CAPTURE REFLECTIONS

There is not much literature on concepts that use technology to capture reflections and help people act on their gained self-understanding. Some concepts like the Reflection Companion (Kocielnik et al., 2018) or the Conversational Agent (Olafsson et al., 2019) use digital conversation partners with approaches inspired by counseling. At the end of the user's interactions with them, they make suggestions for improving the behavior based on the preceding reflections. However, it is particularly important to help people in this stage of the process since people are frustrated when they are unable to act on their takeaways (Nakamura et al., 2021). I believe that only through capturing much of individuals' everyday context can technology help them to meaningfully incorporate the newly gained knowledge into their lives.

In conclusion, **technology can help to reflect in much of the reflection process and across many different levels, from engaging in superficial reflections to becoming absorbed in deep reflections.** The ideal reflection process mapped by the models of Mols et al. (2016) and Fleck & Fitzpatrick (2010) would be to create an ideal reflection environment, trigger people into remembrance, support them in reaching the deepest reflection level, and then help them integrate their learnings into their health behavior change strategy (see Figure 9). Most of the supporting technology is driven by sensor-based technology that captures everyday life experiences and behavioral data.



2.5 Discussion

Over the last sections, the potential of reflections to support behavior change, and for technology to help in that process, has become evident (Purpura et al., 2011; Lee et al., 2015; Baumer et al., 2014; Li, 2010; Mamykina, 2008). A reflection is an abstract, deliberate thinking process in which people review their experiences to find connections, gain new understanding and reassess themselves and their behavior. This new understanding and reassessment can lead to increased motivation and a more suitable behavior change strategy. A reflection is a process that happens in time and varies in the level of its depth. Technology provides many capabilities to support reflections both in space and time, but it needs to be wary to keep the reflective qualities of deliberateness, slowness, intentionality, and inefficiency. The introduction of technology can often become counter-productive to the task of reflection because it creates a distractive environment focused on efficiency (Aipperspach, 2011).

While much of this review so far has focused on the benefits of reflections, I also want to touch upon its dangers. When people reflect on their experiences, they can sometimes focus on negative emotional aspects, which can end in rumination or overthinking (Nakamura et al., 2021). While increased self-understanding is often framed as a desirable goal, such can also involve discouraging revelations (Kocielnik et al., 2018). Lyubomirsky et al. (1999) talk about them as dysphoric self-reflections, and state that some individuals are more prone to such an approach than others. Some individuals might lack the skills or resources to take a constructive problem-solving approach in their reflections and can't guide their reflections toward self-insight (Grimley & Lee, 1997). Most concepts that support reflections do not focus on preventing rumination or overthinking but assume that there will be positive effects only (Mols et al., 2016). In this project, I want to harness the potentially positive impact of reflections on behavior change while also foreseeing negative consequences.

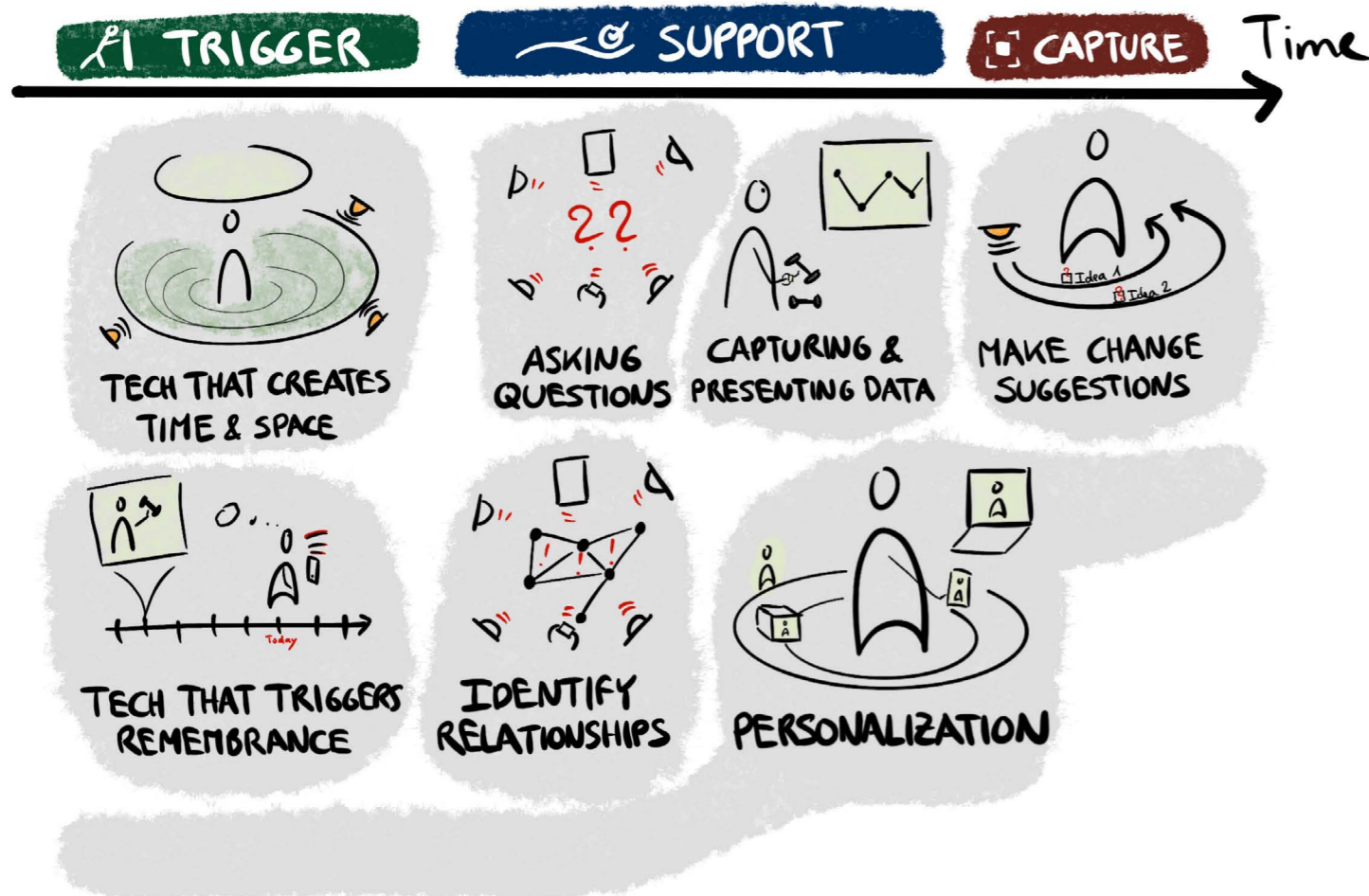
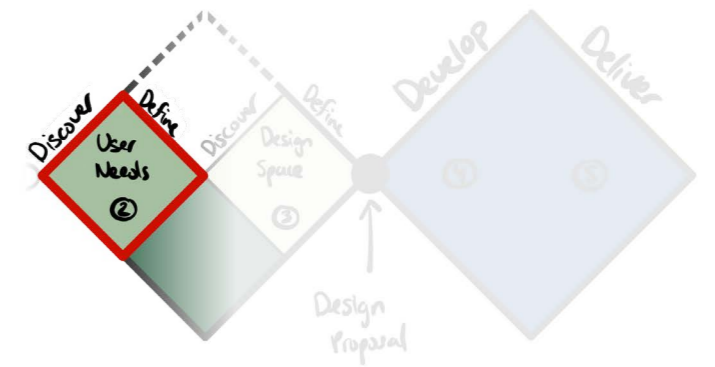


Fig. 9: How technology can help through the reflection process



03 Reflections in Everyday Life

In this chapter, a study on how people reflect in their everyday life is conducted. This will help to understand people's reflection processes, the presence of reflections in their life and on their behaviors that they try to change. It will give indications of how it feels to reflect, what people expect from their reflections and what it leads to in reality. While the literature review has shown that reflections can lead to sustained behavior change, this section focuses on how such reflections need to look and feel like. I will present 9 identified reflection needs that would support people in their health behaviour reflections.

DAY 1

What do I associate with reflections?

When you think of reflections in general, what words come to mind? Pick 5 words from the Day 1 material, and write 5 words on your own. Then, write down how you would define a reflection.

My reflection stimulators

After the left task, open day 2 material and attach the 3 things that make you reflect most, on this page (and shortly explain why it makes you reflect most).

DAY 5

Reflecting on your reflection

What was particularly hard about yesterday's reflection? Situate it below and explain.

From reflection to action

When you think back to yesterday's reflection, is there anything you learned (about yourself, your behaviour, or anything else)?

Learning #1

I think I am trying to search for things that have the influence on my life, and try to change them so most of the things become better. And it by an accident, because the effort.

Learning #2

I reflect more because it's necessary that I need a certain space / moment. However, I do need a quiet place where I can reflect.

Learning #3

Looking your time for a real reflection is necessary, because it's about the things that force you to think of yourself.

DAY 3

My reflection process

Think about the times you have reflected before and after. How do you feel about it? What are the things that trigger you to reflect? How do you feel about it? How do you feel about it? How do you feel about it?

DAY 4

What was the procedure?

How did you go about the reflection? What were the questions you asked yourself, thoughts that popped up in what order? (Write a small paragraph)

How did it feel to reflect?

Pick (an) element(s) from the day 4 material that fits the experience you just had and attach them here (this might be abstract, but just go by your intuition).

Color: Blue

Why: It's a color that makes me feel a little bit sad, but it's also a color that makes me feel a little bit happy.

Mood: Indifference

Why: I've always been with being indifferent, I don't really care about anything.

Touch: Ice

Why: Reminds me of the cold feeling in my hands when I'm sitting on the ground.

What was the procedure?

How did you go about the reflection? What were the questions you asked yourself, thoughts that popped up in what order? (Write a small paragraph)

I think myself, why I don't reflect that often? In what way can I be more reflective? What would be a better time to meditate or pray?

How did it feel to reflect?

Pick (an) element(s) from the day 4 material that fits the experience you just had and attach them here (this might be abstract, but just go by your intuition).

Color: Green, Yellow

Why: The sun was shining bright, I was sitting under a tree.

Mood: Happy

Why: The weather was nice, I think I can make time for meditation.

Touch: Grass

Why: The day had some ups and downs.

3.1 The Contextmapping Study

In this section, the insights from the contextmapping study will be presented. They are structured by the framework of Mols et al. (2016) that divides the reflection process into a trigger, support, and capture phase. The trigger section is about the necessary conditions that allow for reflections, as well as the moment when people start to reflect. The support section looks into the reflection process itself, what people's thought processes are, how they structure this process, and what they help themselves with. The capture phase is about the steps after the reflection process itself and how people convert their reflection result into real-world use. Most of these findings are relevant not only for reflections on a specific topic such as people's goals and behaviours, but for reflections in general. I will specify when people have reported notable differences.

METHOD

The contextmapping study took about 2 weeks in preparation, 2 weeks in execution, and another 2 weeks in mapping all the insights. 8 Participants (1 pilot) were recruited between the age of 23 and 31, of whom 6 were women and 2 were men. 7 of 8 participants were active in the design field, but at various professional stages. Some were in the middle of their master's program, others had just graduated, and some already worked in the industry. At the period of the research, all of them were engaged in a health behaviour change process, with their goals ranging from eating less industrial sugar, working out more, pursuing a FODMAP diet, to meditating more regularly. The contextmapping study aimed to answer the following three guiding questions, coming from this project's main research question of how people reflect in their everyday lives:

- What is the process of reflecting?
- What are barriers vs. enablers of reflection?
- How does it feel to reflect?

In the first part of the study, in coherence to the present-past-future framework by Visser (2005), participants were given a sensitizing workbook (see Appendix A for full workbook, exercises, and material) to develop a better understanding of their reflection behaviours. Contextmapping particularly helps the researcher

to dive deep into people's everyday lives to best understand people's needs. It is a qualitative approach of gathering contextualized and rich data from only a few individuals. The provided workbook was set up like a diary, with one exercise to do each day, taking no more than 10 to 15 minutes. Participants were also provided the necessary physical elements to complete the activities that were supposed to be reflective and fun. In Figure 11 you can find the questions that drove the exercises on each day. In Appendix A you can find all the workbook exercises. On the first day, participants had to create a mindmap and thereafter develop their personal definition of reflection. They should also indicate the benefits they were expecting from reflections. On day 2, they had to pay attention to the reflections in their everyday lives and make pictures of objects, places, and environments that triggered them to reflect on their health goal that they indicated in the workbook. Participants later also had to pick things that triggered most reflection from a set of material provided. Each piece of material was connected to a design principle such as comparison, ambiguity, provocation, etc. The activity on day 3 asked participants to map their last reflection process to the trigger-support-capture framework by Mols et al. (2016). Participants were encouraged to think about the where, when, and why in each stage. Day 4 asked people to reflect for 5 minutes on the spot and reporting the thought process through which they went. Then, they had to think back on how it felt to reflect. On the last day, people could indicate the struggles they had during the last reflections, as well as the learnings they took away from the reflections and the study.

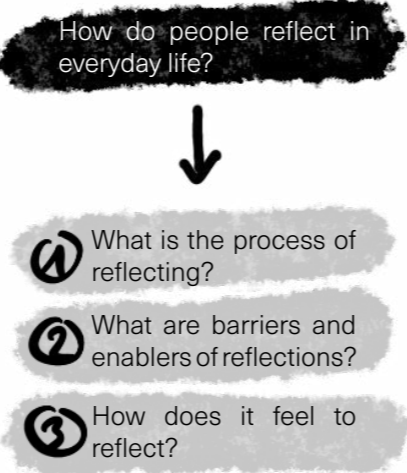


Fig. 10: The leading questions of the study



Fig. 11: Overview of the workbook activities and their driving questions, activities, and material

After finishing their workbooks, a follow-up interview with each participant was conducted. This was necessary to go through the workbook together, dig deeper into interesting findings and remarks, and it allowed for deeper reflections on the research questions. Each interview was individually prepared with participant's respective workbooks in mind, took 30 to 40 minutes and took place the day after participants had finished their diary. This allowed the sensitizing to have the freshest possible effect and therefore allowed for reflections of higher quality. The interview questions roamed around reflection triggers, their ideal reflection environment, the support that they seek in reflections as well as the tools that they use, the effects of reflections on their behaviour, and the pain points when reflecting. The interview ended with a discussion on ideas to improve a reflection process (see Appendix A for full interview guide).

ANALYSIS

Before I dive into the results of the above study, I want to explain the process of analyzing the workbooks and interviews. When going through people's workbooks, I was summarizing the key takeaways from each exercise, focusing finding answers to the leading questions that can be seen in Figure 10. I summarized their reflection definition, what leads them to reflect, what people use to support their reflections, what they (expect to) learn, and how their process of reflecting generally unfolds. These key takeaways for each participant were written down on digital post-its in the online collaboration tool Miro (<http://www.miro.com>). A similar approach was taken for the interviews: I looked back through each of the recordings and wrote down the quotes that answered the questions set up for the interviews. These questions resembled those of the workbook, although the interviews were intended to ask more specific follow-up questions and clarify the workbook results. Each interview was informed by the analysis of the respective participant's workbook.

With the key insights and quotes that matched the research questions, a digital "on-the-wall" analysis approach was taken in Miro to cluster insights in two different ways. First, to develop a holistic understanding of the reflection process, the insights were put on a timeline from the start until the end of the reflection process. The framework of Mols et al. (2016) helped to do that. This analysis process led to the meta-level reflection process explained on page 44. The second way of clustering the insights was done by regrouping all of them according to the study questions. Then, similarities between the insights were looked out for and regrouped within that question. The goal of this analysis was to get a better understanding of how people concretely reflect in their everyday lives and it led to the identification of 9 reflection needs, of which an overview is shown on page 47.

3.2 The Reflection Process

A reflection process always consists of a trigger that gets people to start a reflection, and a back & forth between assembling bits of information, and trying to make sense of them in different iterations. Sometimes, a reflection leads to action afterward (see Figure 12 for full process overview). At the heart of a reflection is the topic that people start to think about. On a meta-level, there are many similarities between people and their reflection processes, but individuals vary a lot in each step of the process, and in different reflection instances. Although people have personal tendencies for tools they like to use or triggers that gets them to reflect, each reflection instance even differs for the same individual.

Reflections can be triggered in many different ways, from events ("I reflect a lot after significant events happening", P8), to someone's environment ("Environments that remind of the behaviour trigger reflection", P7), or an object in that environment. The qualities of objects that get people to think revolve around comparison, behavioural data presentation, ambiguity, abstractness, and others. Different triggers, combined with personal tendencies and mindsets, get people started on either a proactive or defensive reflection. A proactive mode is a reflection led by curiosity and a desire to learn, whereas in a defensive reflection, people want to just find solutions to their frustration or acceptance of their failures ("It is a lot about converting negatives into positives", P3). Both modes will be explained in more detail below. In participant's everyday lives, they barely have the necessary time and mental space to actively engage in deep reflection "The hardest thing about reflections is that they take time" (P5). In their reflections, people try to assemble as much information as possible that is relevant to come to the desired outcomes ("What helps in reflection is a variety of triggers that make you think about what the trigger means", P4). Many different methods such as remembering, looking at data,

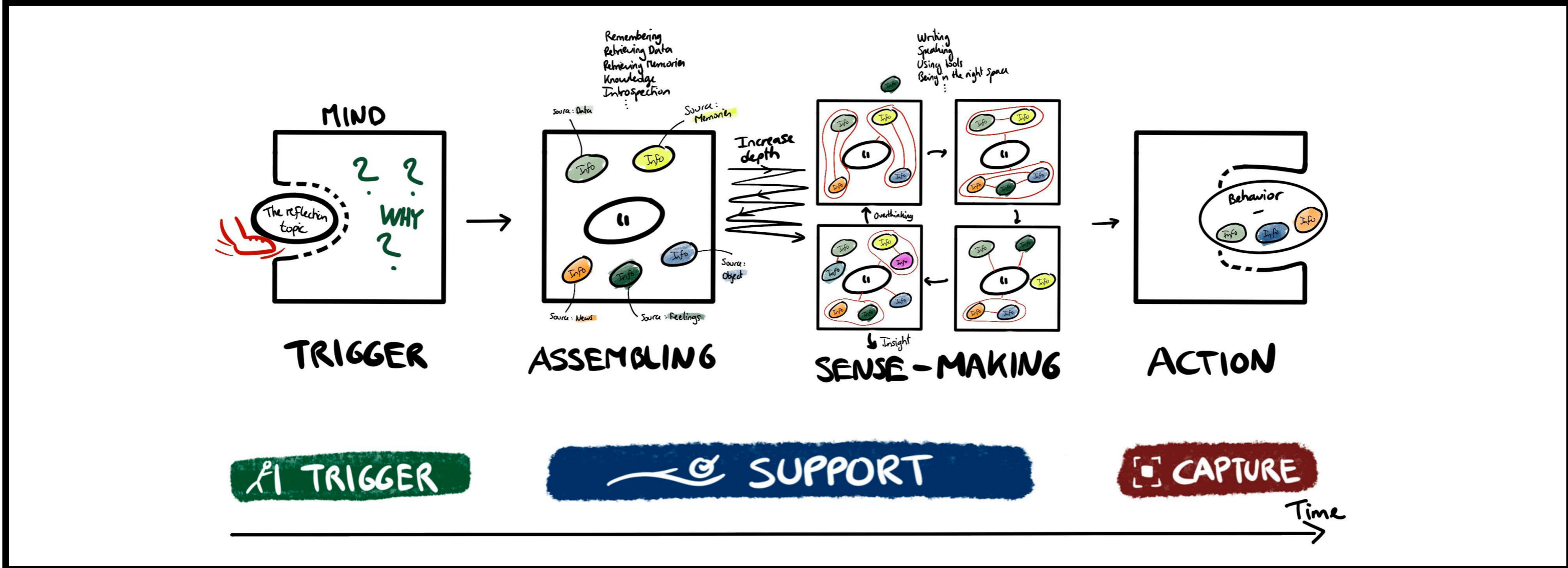


Fig. 12: The reflection process as executed by participants

searching for memories, inspecting one's knowledge or feelings, can help to find new relevant information. On a quest to make sense of the gathered information, people ask why-questions, combine information in multiple ways, develop new perspectives and search for new possible explanations (see "sense-making" in Figure 12). They do so through writing (P6, P7), talking with others (P4, P6, P8), using applications or objects (P1, P4, P6), or by creating changes in their environment (P1, P2, P7, P8). While people's ideal result is to learn new things about themselves and their behaviours ("Reflections help me to know why I behave a certain way, learn from it, and know better for the next situation", P1), not reaching good conclusions can also end in rumination or overthinking ("Reflections easily lead to overthinking", P3), something people try to avoid. In proactive reflections, people sometimes also simply enjoy the state of reflection without needing clear take-aways ("Sometimes reflections do not result in anything but can still be interesting", P7). When a reflection leads to learnings, people want to integrate that in their current behaviour change strategy so that they can most successfully reach their goals ("Reflections lead to better learnings about how to get to my goals", P2).

Synthesizing every participant's definition of their reflection process into one definition, participants described their reflection as a process of analyzing & questioning reasons for past events and behaviours in the context that they occurred in. Thereby, they expect that reflections will lead to better accept their behaviours and to gain self-understanding that can improve future behaviors.

Figure 13 shows an overview of the 9 reflection needs that have been identified in this study and will be presented in the upcoming sections.

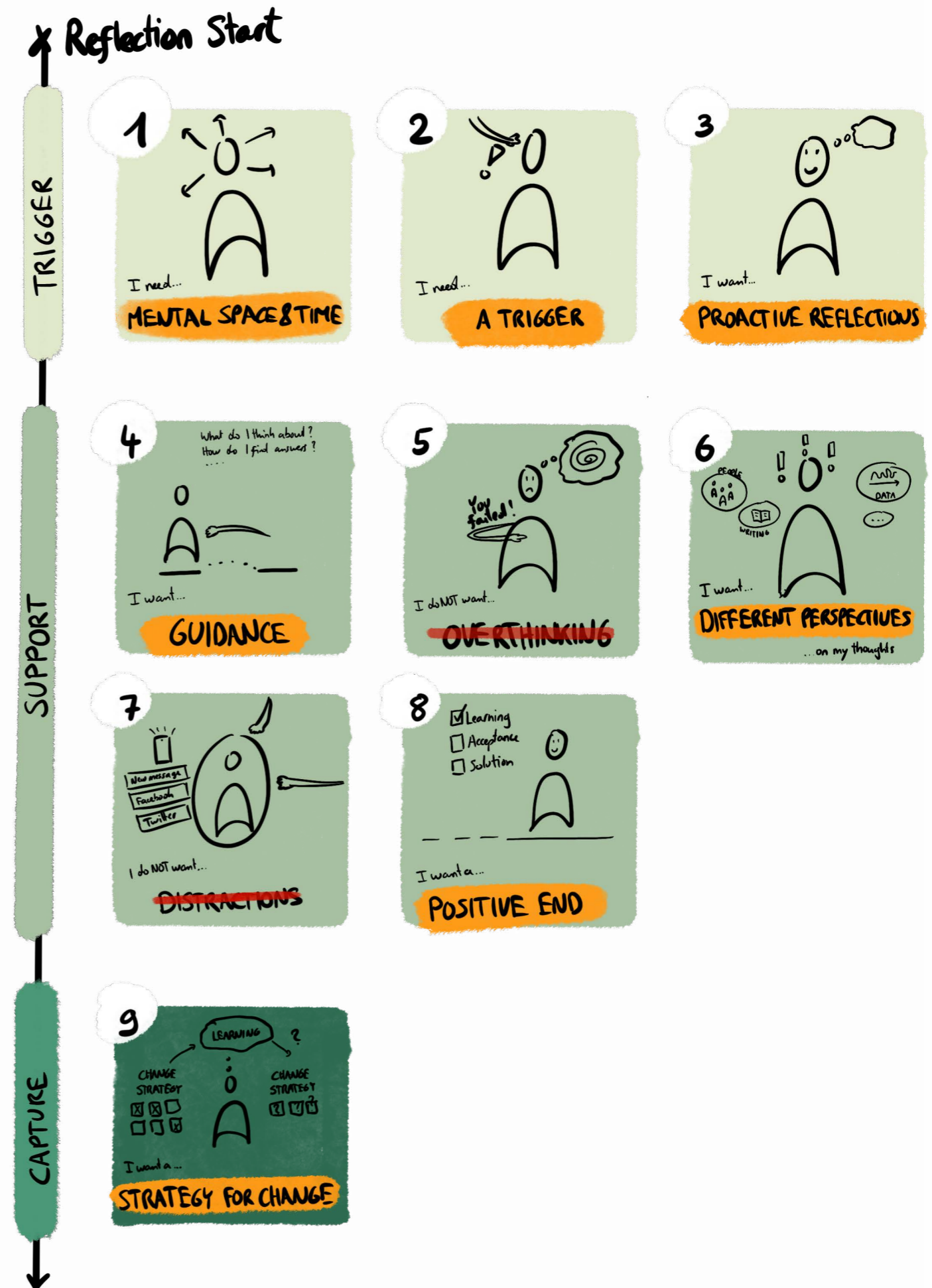


Fig. 13: 9 reflection needs across the reflection process

3.3 Trigger



#1 PEOPLE NEED TIME & MENTAL SPACE TO REFLECT

People's everyday lives are characterized by getting things done and being efficient in doing so. Time and attention are people's most valuable assets and they are constantly on the lookout for optimizing both. The fast-paced routines that most people have, lead them to always run behind the things they want to do, with a laser-focus on what they should be doing next. Rarely is there time for pausing and actively taking time to think about things that have passed. "I barely reflect through self-initiative" (P4). "The noise of a daily routine hinders reflection" (P3). "The hardest thing about reflections is that they take time" (P5). "I had difficulties to find time for reflections" (P7). "I get caught up in the routine of the day. I just need to be given the time to reflect" (P8). Participant 8 even claimed that if she was only given 5 free minutes during the day, she would use them to reflect.

Not only do people lack the time to reflect, but they are also rarely in a mental state that provides room for reflections. People's minds are constantly on the lookout for the next productive thing to do. At the same time, when people do not have to think about their work or studies, they let themselves be entertained or distracted. Through constant stimulation of people's brains by the technologies around them, they have become unable to deal with empty time; a condition that can lead to reflections (Hallnäs & Redström, 2001). "Reflection moments occur when there is nothing else to think about" (P4). "I don't usually sit down to reflect" (P7). "You need to have time and space to have reflection moments" (P6). "The situation needs to present time and space for thought" (P7).

People do not actively take time to reflect because they lack time and mental space to do so. At the same time, people express a desire to have moments like these. "It feels good to reflect, especially in contrast to my busy everyday life" (P2). "I would love to have a routine of reflections" (P7). At the moment, such moments occur mostly at beginnings or ends (P2, P3), most frequently when people are in motion (P1, P2, P3, P4, P6). It also helps to be alone (P3, P4, P6), in nature (P2, P4), or in a distraction-free environment in general (P2, P5, P8). Almost all the participants expressed that commutes such as train, bus, or bicycle rides presented a great reflective environment. Also a morning or evening walk in nature was frequently mentioned as a moment that provides time and space for a reflection. Lastly, the time just before going to sleep presented a good opportunity to reflect as well. Outside reflections often happen in action (walk, run, bike,...), while inside they

happen in comfortable situations (sofa, shower, bed,...) (Mols et al., 2016).



Fig. 14: People need time and space to reflect

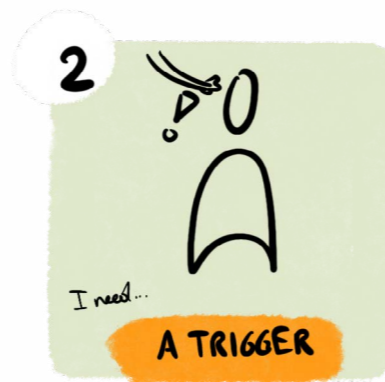
#2 PEOPLE NEED A TRIGGER TO REFLECT

Even if the situation presents the best possible conditions for reflections, people still need to be triggered to reflect. In most cases, people need a reason or at least an encouragement to engage in a reflection process (Moon, 1999; Fleck & Fitzpatrick, 2010). There are many different ways that people are currently being triggered to reflect (see Figure 15 & 16). This trigger is essential because it gives people a clear starting point, which is something that they need. "In self-initiated reflections, it can be hard to know what to start to think about" (P2).

The most persuasive triggers for reflection are when a negative event has happened that represents a form of behavioural failure to participants. One participant reported to reflect after she ate something that did not align with her eating goals, another reflected after she missed a train although she wanted to be more punctual. "After that, it is like a very short reflection. I'll be like: Ah, next time I have to leave five minutes earlier", P2. One participant reflected after he got an e-mail reminder about a course assignment, failing his goal of being more proactive. "This e-mail really made me think about how unorganized I was", P5. Especially when these events have negative impacts beyond individuals is when the urge to reflect becomes even stronger. However, reflections can also occur after positive events of a behaviour, such as after a successful workout session, or after receiving a good course grade. These are things that happen and trigger a reactive reflection from participants.

Other triggers that lead to reflections on a specific behaviour is when people are reminded of their goal through different mediums and characteristics. What they have in common however, is that people need to see a connection or association to their behavioural goal. Any information that is sedentary to the behaviour can trigger a reflection on that behaviour (Gouveia et al., 2015). For the participant who wants to exercise more, her exercise mat or her journal was a regular trigger. Even the weather can lead to people feeling good, an emotion that people might associate with their behaviour. "I think there always needs to be a trigger. It can be as far as nice weather- feeling good- what about my behavior?", P7. Other than objects, feelings, conversations, and data related to a behaviour, there are other (object) qualities that can lead to a more general reflection: abstractness, provocation, ambiguity, surprise, or showing new perspectives (as identified from the workbook exercises).

In certain environments that present the most ideal conditions for reflection, it sometimes happens unconsciously without people realizing the trigger to their reflection. Participants report that in such environments, thoughts are able to run much more freely which can then lead to reflecting on their behaviours by the mind



wandering to a certain thought. These types of reflections are very rare because the characteristics of everyday life are so contrary to the ideal conditions (time, mental space, as well as bodily active, in nature, alone) for reflections to just "happen". Still, even if the conditions are right, "there still needs some trigger to reflect on the specific behaviour" (P7) and not just on life in general.

Only one participant mentioned that he schedules regular time for reflection on the specific health behaviour. However, he only does so because of regular meetings with a doctor that forces him to fill out specific reflection exercises. This proves that people do not actively set out to reflect on their health behaviour change.

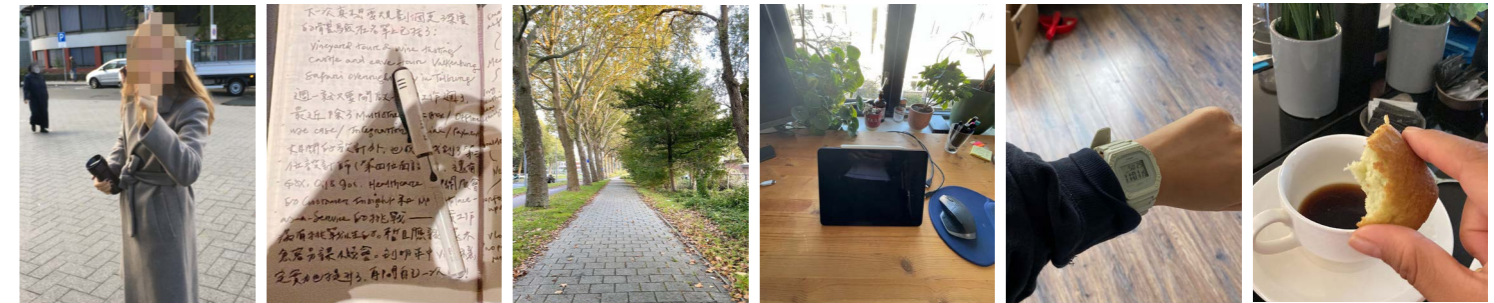


Fig. 15: Things that got had people reflect, as part of the workbook exercises

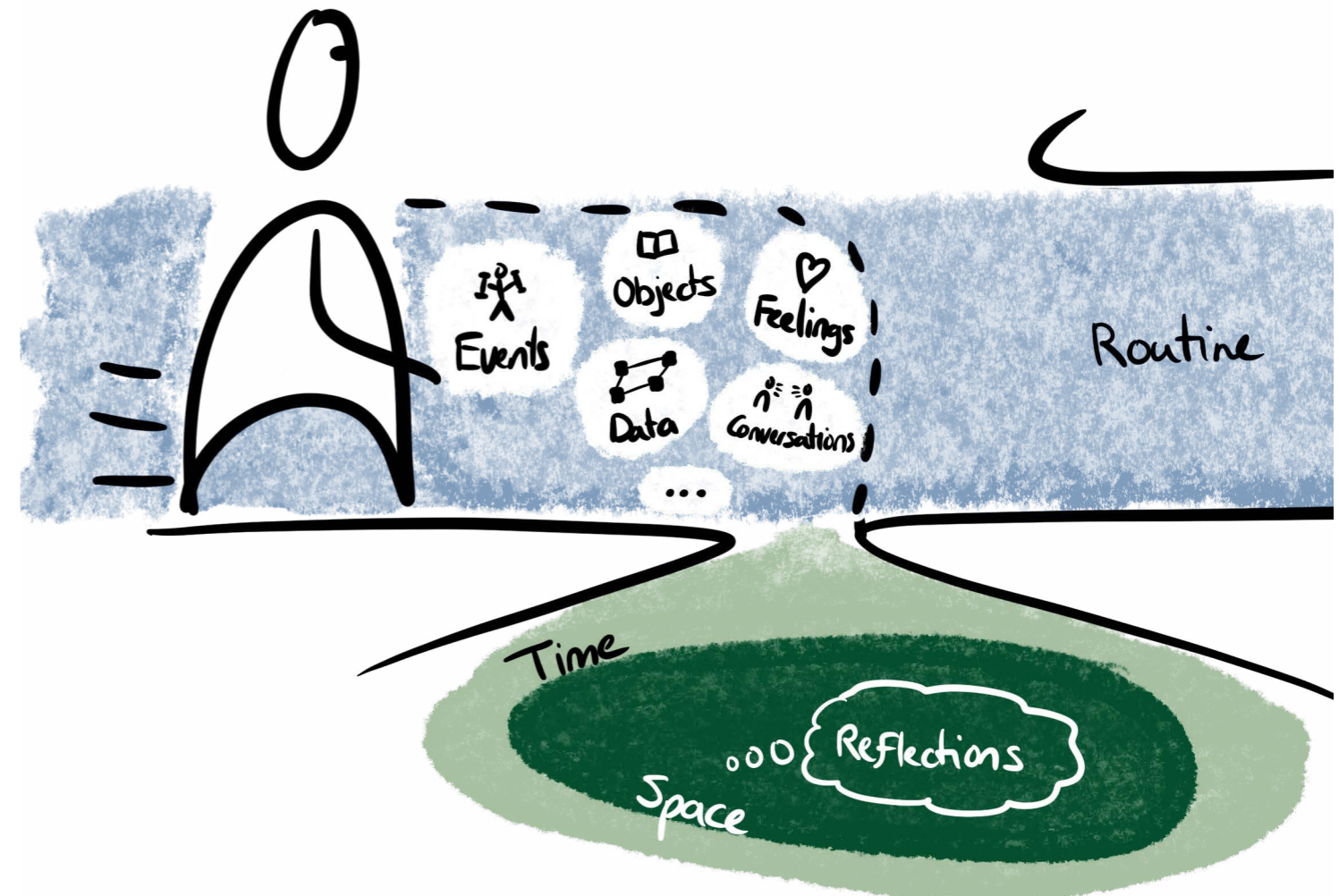


Fig. 16: The kinds of triggers that get people to reflect

#3 PEOPLE WANT TO HAVE MORE PROACTIVE REFLECTIONS

There are 2 reflection modes that have very different qualities and expectations: proactive and defensive mode. While both are needed, people clearly prefer the experience of a proactive reflection. These modes describe a mindset that people are in when they reflect.

The first reflection mode is the one that people want to have less of, which we name the defensive mode (inspired by the similarities to the defensive mode by Caroline Webb (2016)). It is however the most frequent mode of everyday reflections. These kinds of reflections are quick reactions to negative events, like a form of coping behaviour. They are triggered by self-doubt, frustration, insecurity and need quick solutions. "I reflect to prevent something worse from happening. My everyday reflections are often triggered by events that cause annoyance, regret, and feelings of failure" (P2). These reflections are often shallow, guided by emotions and can often result in rumination. They are not only triggered by bad events, but also by being reminded of behavioural failure through some other means (e.g. by conversations that occur, objects in the environment, or the confrontation of behavioural data). The likelihood of people going down the defensive reflection route also depends on their personal predispositions (Lyubomirsky et al., 1999). In the contextmapping study, some participants reported a greater occurrence of such reflections, while others had more proactive reflections.

Still inspired of the terminology by Webb (2016), the second reflection mode is the proactive mode, in which people are entering reflections with a positive perspective, and the aim to learn about themselves and their behaviours (see Figure 18). This mode is most often triggered by the right reflection environment or by a positive event, and it is characterised by curiosity and discovery. The goal here is less to convert negatives into quick solutions, but to engage in a process of self-development and learning. These reflections are usually much deeper and result in more valuable knowledge. "The more intentional reflections make you think more about the behaviour" (P5). "I need to take my time to reflect and not rush it- otherwise I rush into decisions that were not thought through properly" (P3). These kinds of reflection are a desired state by themselves and don't necessarily lead to anything to be enjoyable. "Reflections can be enjoyable by themselves" (P3). "Reflections are interesting for the state of reflection itself" (P2). Although it takes effort to think deeply about one's behaviour, it is a comfortable, enjoyable state (see Figure 17). Participants report such reflections as relaxing (P2, P3), warm (P2, P5, P7), bright (P2, P8), and comfortable (P7). People want to have more of such reflections because they are enjoyable, feel good, and provide greater understanding and insight that can inform their behaviour change process. "Intentional reflections are of deeper focus and can be more insightful" (P7).

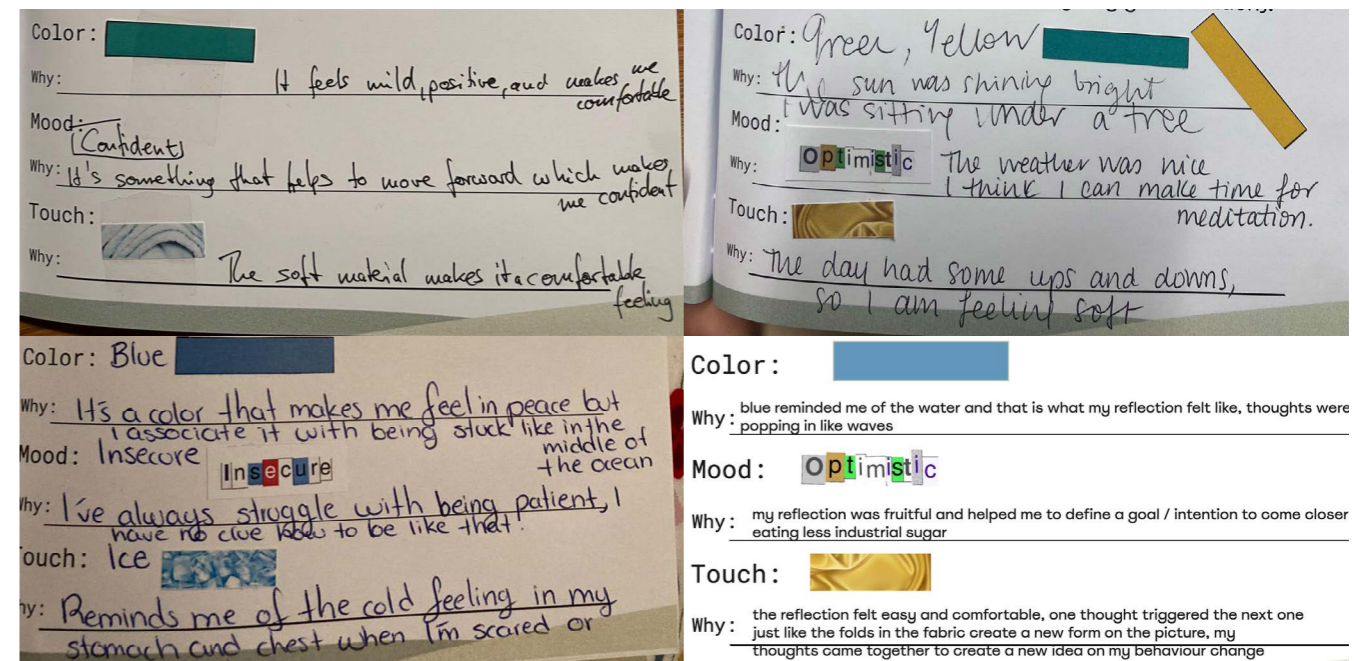


Fig. 17: Some people described reflections as cold and feeling insecure (defensive) while others report them as soft, bright, and comfortable (proactive)

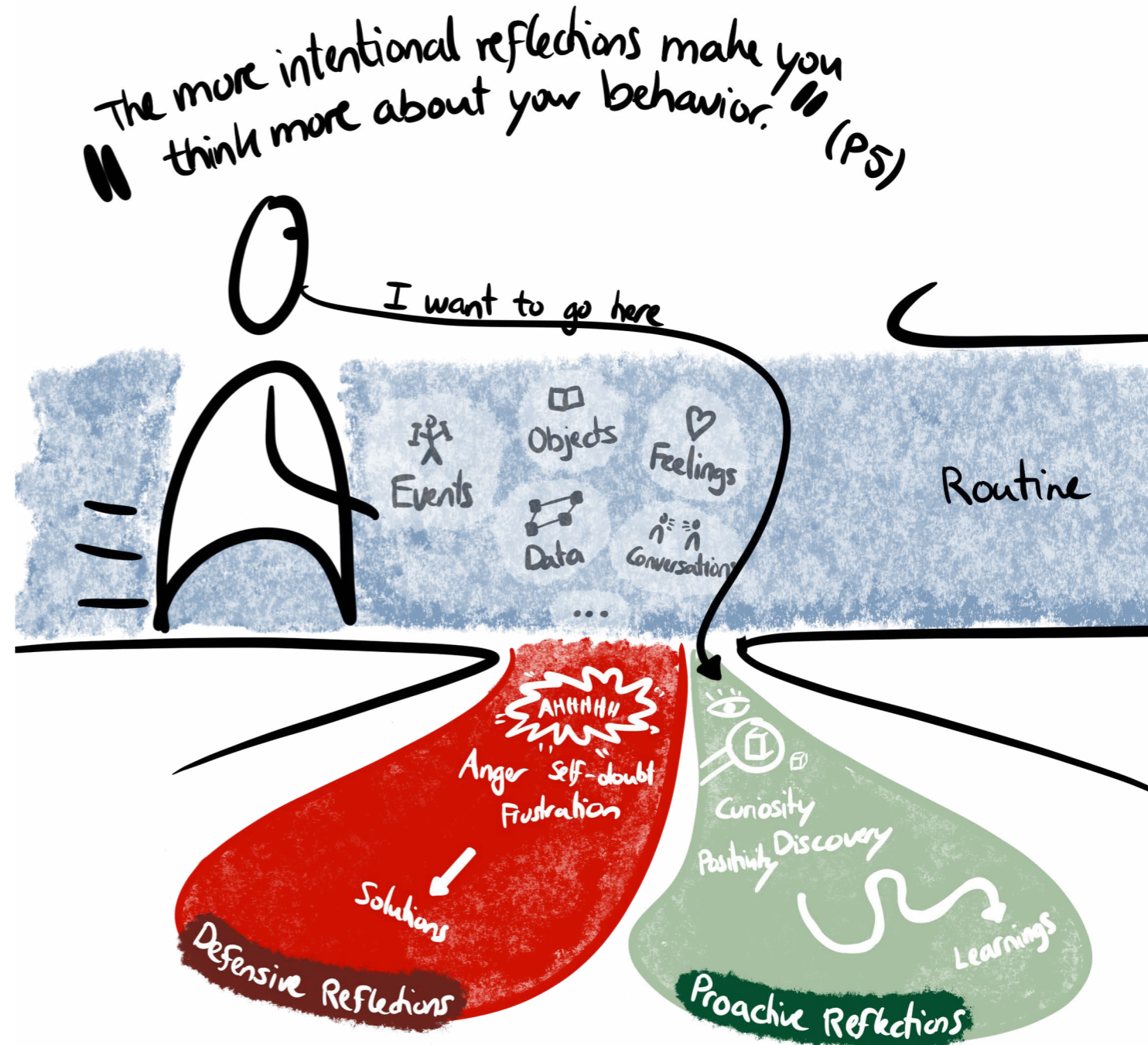


Fig. 18: Defensive vs. Proactive Reflections

3.4 Support

#4 PEOPLE NEED GUIDANCE ON HOW TO REFLECT

The reflection process that people report to be going through is usually very unstructured, fuzzy, and followed by intuition (see Figure 20). Depending on the reflection mode, people search for different end results; i.e. quick solutions and coping behaviours or insights on themselves and their behaviour. However, in both kinds of reflections, participants often tried lots of different things for both retrieving more information to inform their reflection, as well as ways to make sense of that information. In the same reflection, they use different strategies like looking back at memories, writing things down, talking with friends, referring to data, etc. Also, when another reflection comes around, people seem to rediscover what works best for them and rethink their approach. The same participant that likes to reflect with a friend in one instances, refers to a digital note-book in another instance, or just sticks with his own thoughts the third time (P7).

This results in people being stuck in a process that goes in waves of positives and negatives, with no proper guidance on how to reach their goals. Therefore, participants often feel overwhelmed, or not knowing how to proceed, which leads them to being frustrated. In defensive reflections, people want to have guidance on how to convert negatives into positives whereas in proactive reflections people want to know how they can come to conclusions in a more structured way. "For me, it is a lot about converting negatives into positives" (P3). "My reflective process goes in negative-positive waves" (P4). "In my reflections, I go back and forth between positive and negative things" (P5). From not knowing what to think about ("It can be hard to know what to start to think about", P2), to helping in the process ("Sometimes you get stuck and don't know how to proceed", P3), and converting that into insights ("It is a lightbulb effect from thinking about the behaviour to new learnings", P6), people want more guidance in reflections. Fleck & Fitzpatrick (2010) also agree that structured guidance in reflection is of "particular value".

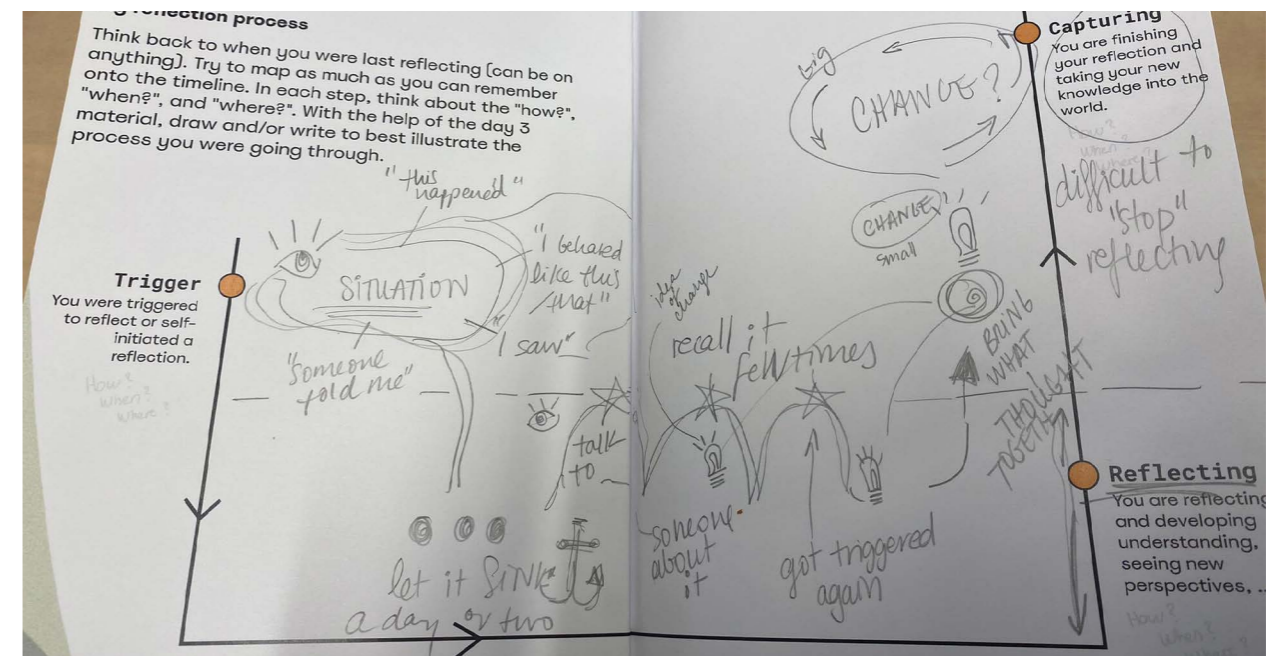


Fig. 19: One participant's reflection process, with its fuzziness being evident

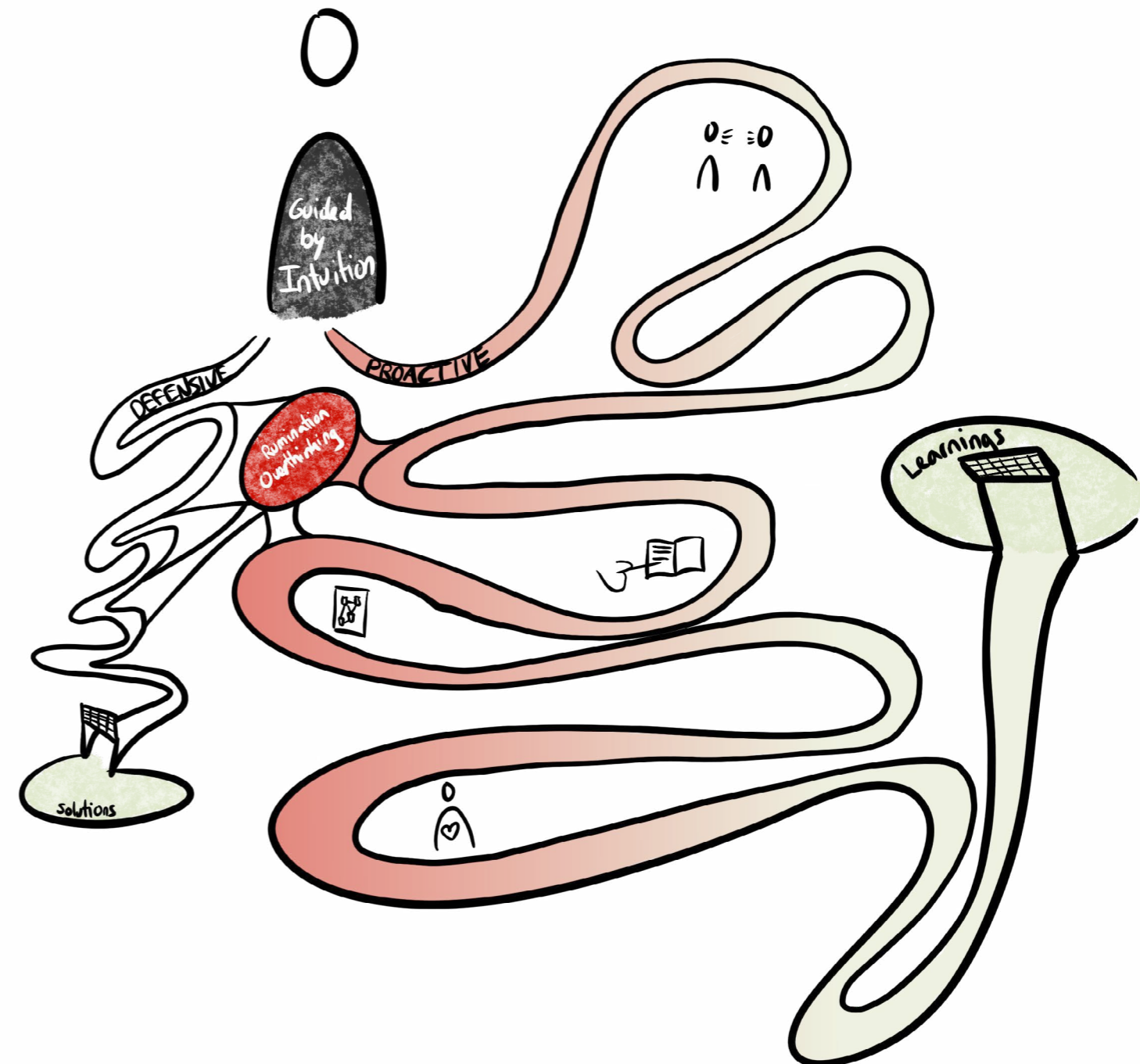


Fig. 20: The fuzziness of the reflection process

#5 PEOPLE WANT TO STAY AWAY FROM CRITICISING AND OVERTHINKING

As we have already touched upon, the defensive mode of reflecting is about quickly converting negative events and emotions into something more positive. While defensive reflections are more vulnerable than proactive reflections, many of the participants reported that any kind of reflection could make them think about other bad events where they failed their behaviours and criticised themselves heavily. This can then lead to rumination or overthinking. Through reflections, people risk to make discouraging revelations (Kocielnik et al., 2018) "It is hard to rationalize emotions and come to solutions without loosing myself in feelings" (P3). "The hardest part is to confront your failures" (P2). "I struggle to stay away from criticizing in a reflection" (P8). That is why many people seek support in reflections by consulting past successes, and finding other outside, non-judgmental, objective explanations to their failure. Non-judgmental approaches of reflections are encouraged in counseling (Olafsson et al., 2019).

Some participants however mentioned that even negative behaviours can be framed positively or that they could even be motivational for change. "The negative things help me to change something and the positive ones help to sustain changes that are already made" (P5). This relates to what has also become clear through the conducted study, which is that reflection is a skill, and it is more successful for people that cultivate a positive, resilient mindset. People have different abilities for introspection and analysing, as well as dealing with their thoughts. Reflection is a developmental process that can be supported in order to increase people's reflective abilities (Moon, 1999; Ward & McCotter, 2004). Self-reflection may for some requiring little or no effort, while for others it can be an effortful process.



"I struggle to stay away from criticizing in a reflection (P8)"

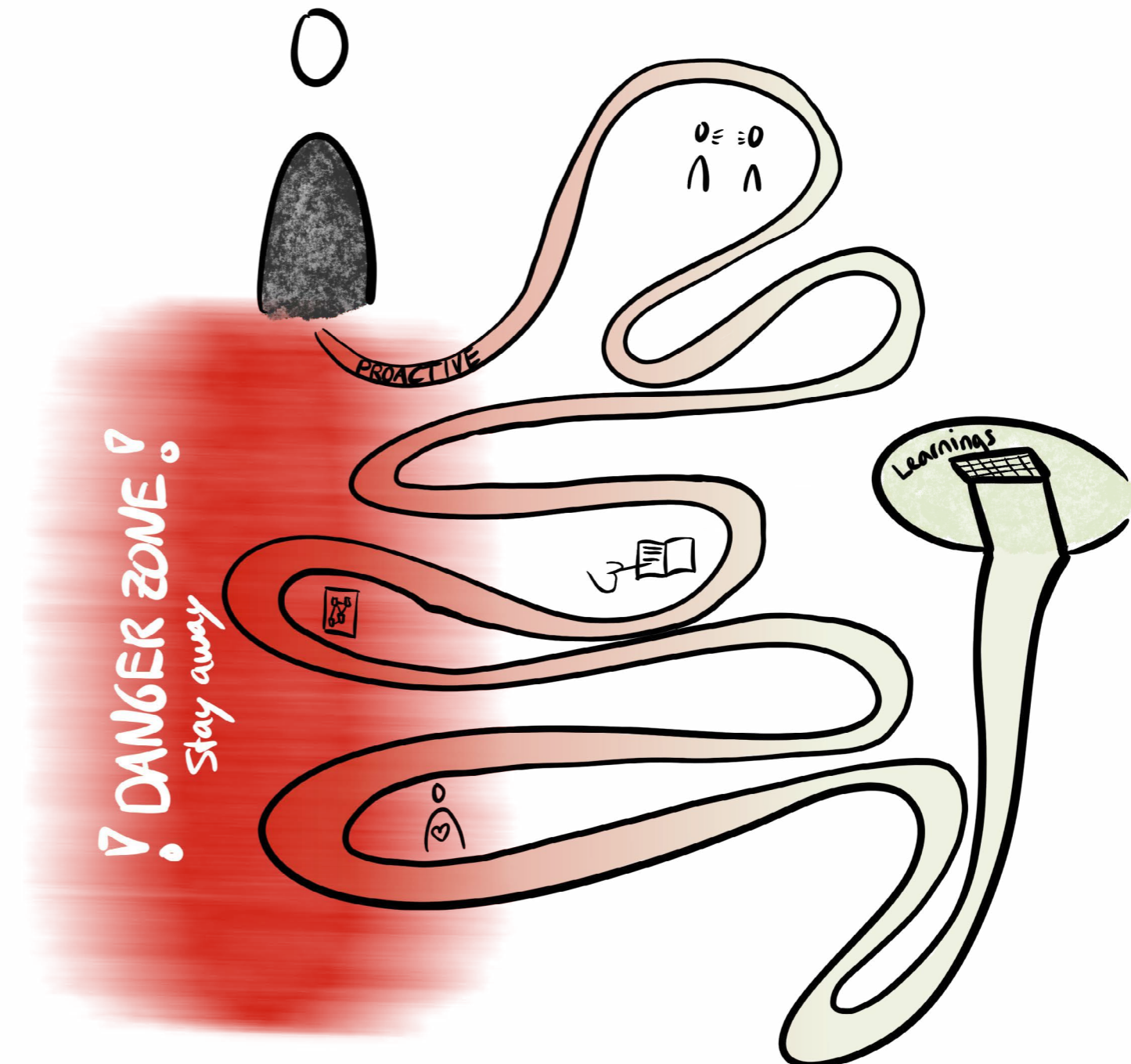


Fig. 21: People want to stay away from criticizing and overthinking

#6 PEOPLE WANT TO GAIN MANY DIFFERENT PERSPECTIVES ON THEIR BEHAVIOUR, INFORMING THEIR REFLECTION

In order to develop understanding and reach insights, people assemble many different information sources, as well as different perspectives on that same bit of information (see Figures 22, 23, and 24). "My reflection process is almost like triangulation: Gathering multiple points of view to reach the best possible conclusion" (P6). This information should help to trigger new thoughts ("What helps in reflection is a variety of triggers that make you think about what the trigger means", P4) to reach self-understanding ("I usually talk with people to learn from it", P3). Participants look back to different past events that are connected to the behaviour, although they report to sometimes have a hard time remembering. "It is hard to remember previous behaviours" (P6). People generally tend to underestimate how interesting it is to recall everyday experiences, which makes them unmotivated to create support systems for remembrance (Xu, 2011).

Participants acquire different information from many different resources. These include journals ("I have a gratitude journal which helps me reflect", P8), tracking apps ("I want to see a quick-glance overview of behavioural patterns", P6), other people ("I find it very helpful to reflect with other people", P7), their feelings and emotions ("A question I ask myself a lot is: how am I feeling?", P6), different senses ("Stimulations of different senses helps reflection", P3), objects ("Different (random) triggers help detach from the fixation", P4), contextual factors ("I think about the influence of other people on my behaviour", P1), or even social and political situations ("In my reflections, I also think about other people, society, political things", P5). While the latter take into account wider perspectives, a sign that the reflection is of greater depth (Fleck & Fitzpatrick, 2010), most common information sources were behavioural logging tools such as journals or apps, as well as other people. Again, predispositions and character traits play a role here too; some people tend to rely more on other people, while others reflect mostly by themselves. "I do not need any specific tools or people to help me reflect" (P5).

The way that people treat the information that they assemble is through connecting it in different ways. Then, all participants reflected through asking themselves questions on the information, and why-questions seem to be particular helpful. While why-questions are at the heart of developing understanding, participants also help themselves make sense of the information through talking with others, writing things down, and developing different perspectives on the same information in their minds. Talking with others especially helped to deal with emotions (P4, P6, P8), while writing things down helped to offload negative thoughts (P6) as well as making sense of messy thoughts (P7). Most of people's thought process however happens in their minds, and it has become clear that they use lots of different strategies to vary their perspective on information: Externalizing thoughts, trying to reframe them, shifting their own perspective, etc.

When reflecting upon their behaviour change process, people specifically want to find out about enablers and barriers to their behaviour change and to reaching their goals. This helps them to learn about their behaviour and themselves, so that they can adjust their strategy and change more successfully. People have a need to identify contextual problems around behaviour change and act upon them to achieve successful change (DiClemente, 2007). Learning about one's tendencies helps to identify enablers and barriers to one's behaviour change (Fedlmeier, 2021).

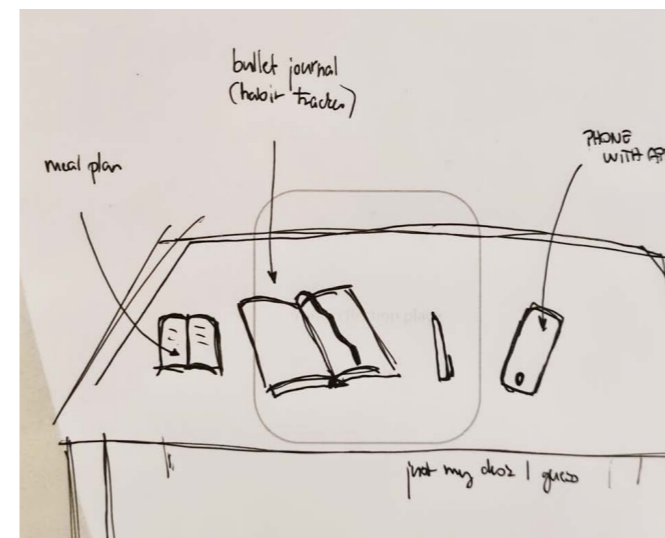
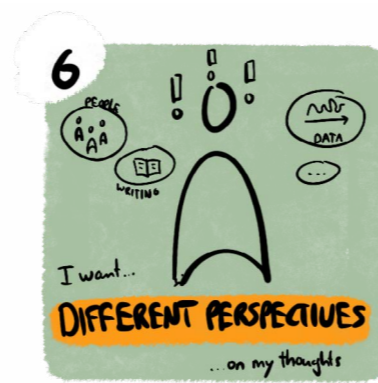


Fig. 22: Some of the objects that one participant used to help her reflect

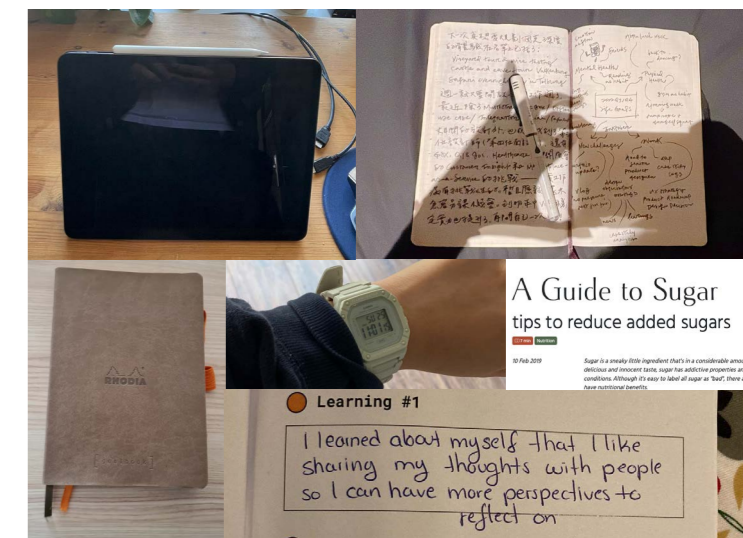


Fig. 23: Other things that helped people in their reflections, mentioned in the interviews

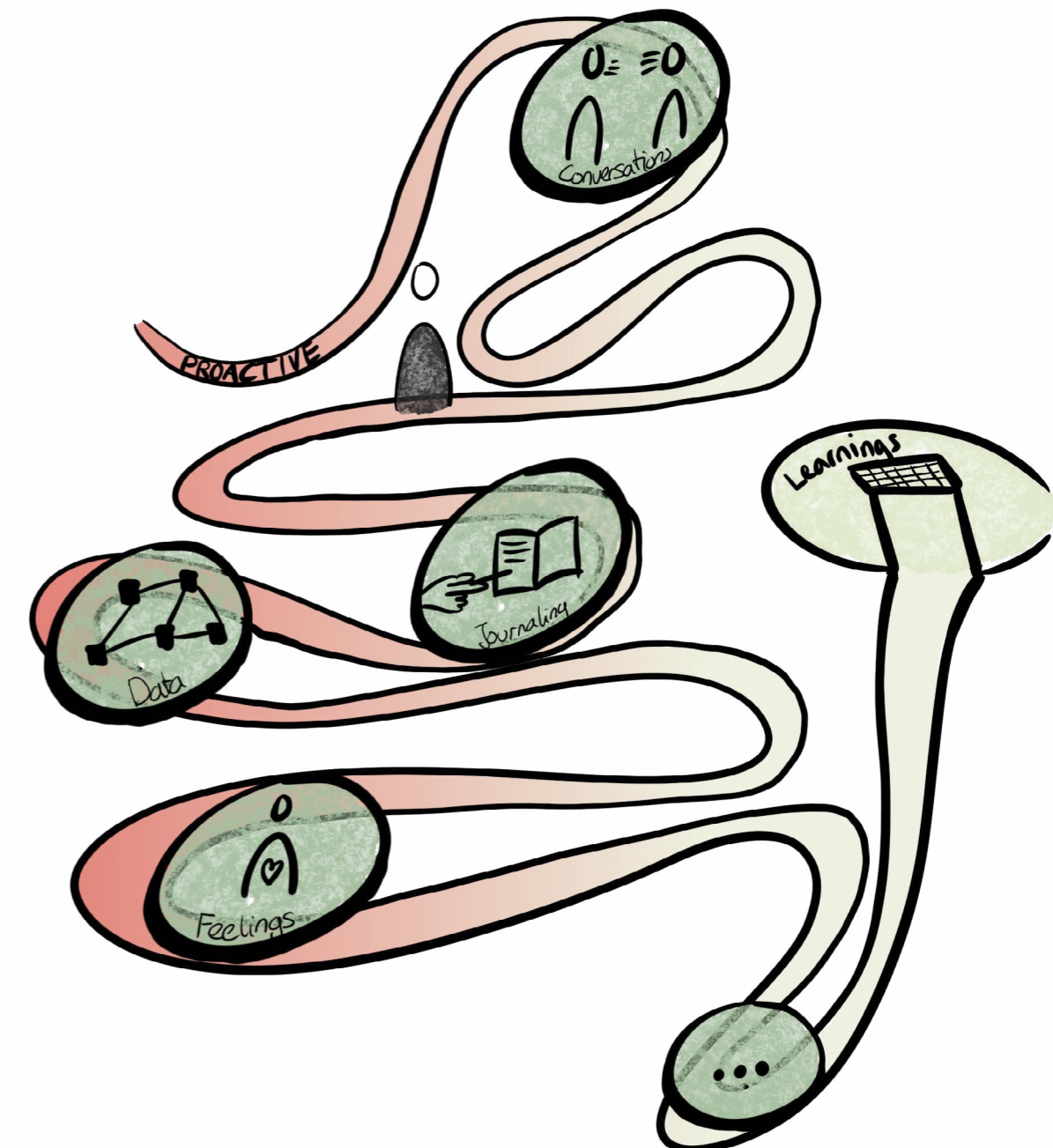
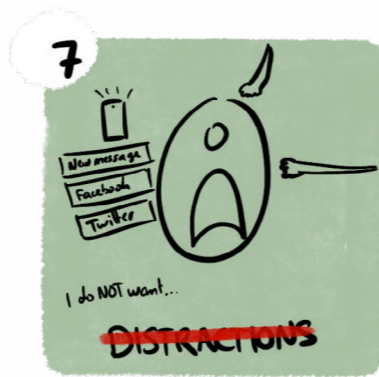


Fig. 24: The things that people refer to in their reflection process

#7 PEOPLE DON'T WANT TO USE DISTRACTING TECHNOLOGIES WHEN REFLECTING

While some people like to reflect together with other people, a reflection always creates an atmosphere where full focus is a condition or a consequence. This distraction-free character of a reflection environment aligns with the key elements of restorative environments (Kaplan & Kaplan, 1989) which can lead to reflections. This is why all participants reported in some form that it was important not to be distracted when reflecting. "The places where reflections occur should be free of distractions" (P5). "I think the greatest challenge in reflections is not being distracted" (P1). "Distractive technology is a direct opponent to my behavioural goal" (P2). "I want my ideal reflection environment to be free of distractions" (P3). The participant 7 learnt through the contextmapping study that he needed a "quiet place with little distractions" to reflect. Literature also indicates that people don't want distracting technologies between themselves and their reflections (Mols et al., 2016). Aipperspach (2011) has shown that some existing technologies can indeed be counterproductive to the task of reflection because they provide omnipresent potential distractions. Slow technologies (Hallnäs & Redström, 2001) introduce a contrary approach where technology is used to create a space where distractions are prevented and reflections can occur. I also believe that technology can be used to keep people away from being distracted and lead them to engage in focused reflections.



"I want my ideal reflection environment to be free of distractions"

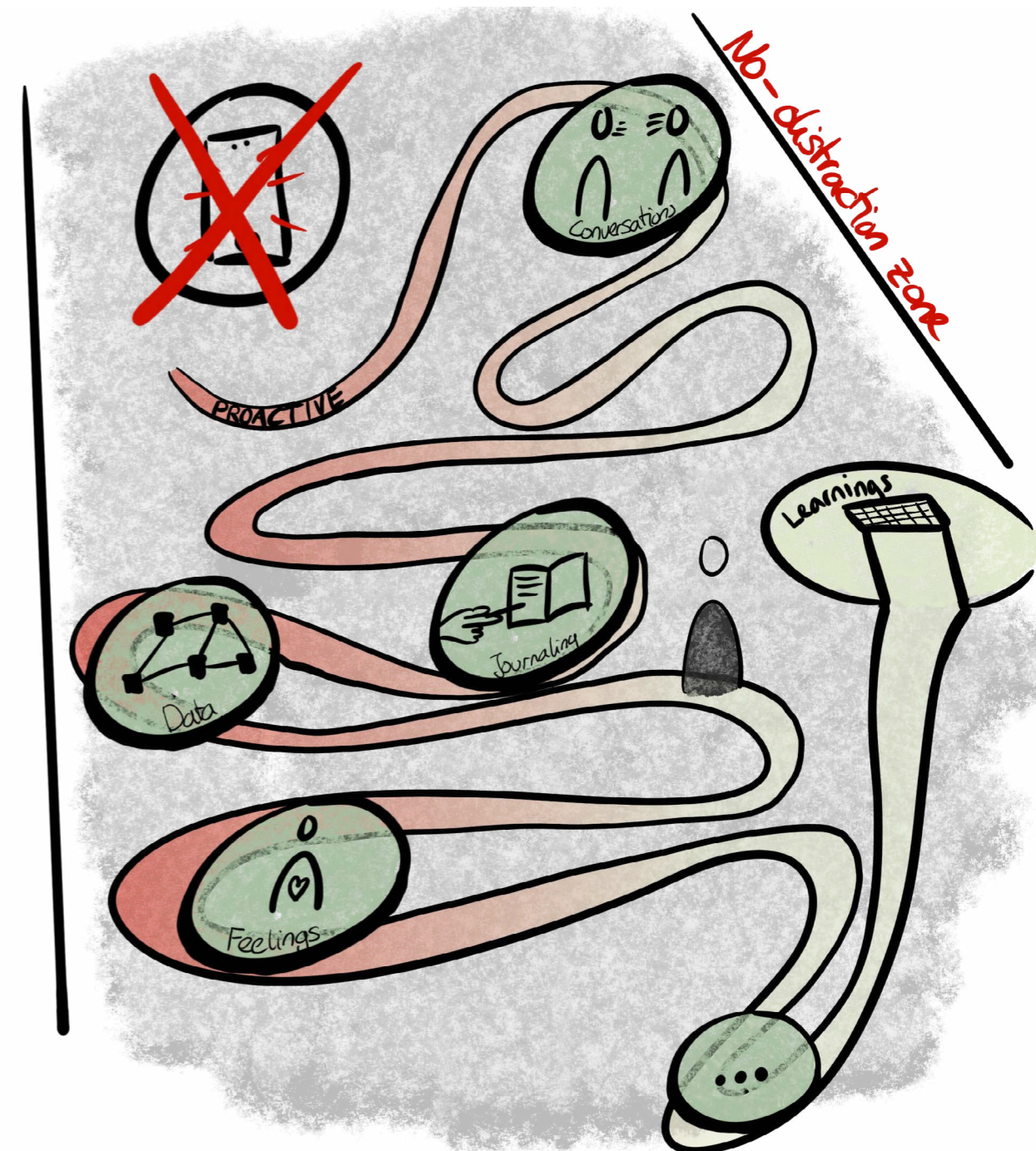


Fig. 25: The no-distraction zone that reflections should be

#8 PEOPLE WANT REFLECTIONS TO END ON A POSITIVE

In both defensive and proactive reflections, people want them to end on a positive note. For people in defensive mode, they want their reflection to quickly lead to solutions or acceptance. For example, the participant who reflected after missing her train quickly needed to come up with a strategy and commitment for not missing the train next time, since she wanted to be more punctual and organized. She tried to find explanations in contextual factors to reach acceptance and stay away from self-criticising. She wanted to find explanations outside her self, which led her to acceptance and a commitment for the future. Her negative thoughts needed to be converted into positive ones (see Figure 26).

In proactive reflections, participants approach their reflections, even those that arise from a behavioural failure, with more curiosity and willingness to learn. In such reflections, people want to end with a new learning about themselves or their behaviour (understanding). "The desired outcome of the reflection and behaviour is knowledge" (P6). People expect their reflections to lead to a deeper understanding of the barriers and enablers of their behaviours (P5, P7, P8) or to give them a sense of progress towards their behavioural goal (P1, P4, P6). Learnings are the most sought-after positive results of reflections and they ideally inform the behavior change process.

Sometimes reflections can also be an interesting state to indulge in, and clear outcomes are not needed (P3, P7, P8). "Reflections can be just for the fun of rethinking, or the state of reflection itself" (P3). These mostly happen in ideal reflection environments where people have time, mental space, and ideally are in nature, bodily active, and by themselves.

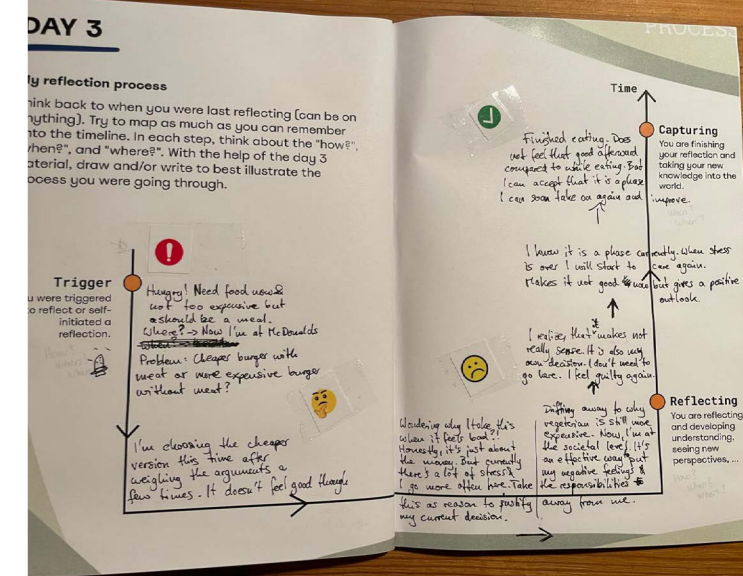
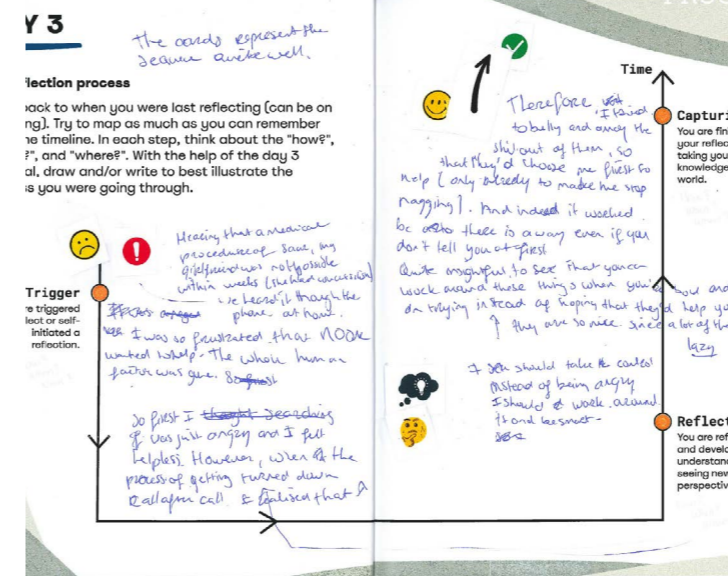
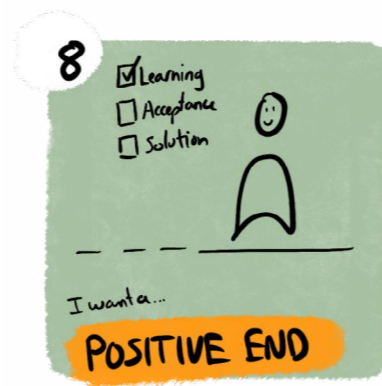


Fig. 26: Many participants start their reflection feeling bad (red exclamation mark) and hope to end on a positive (green check mark)

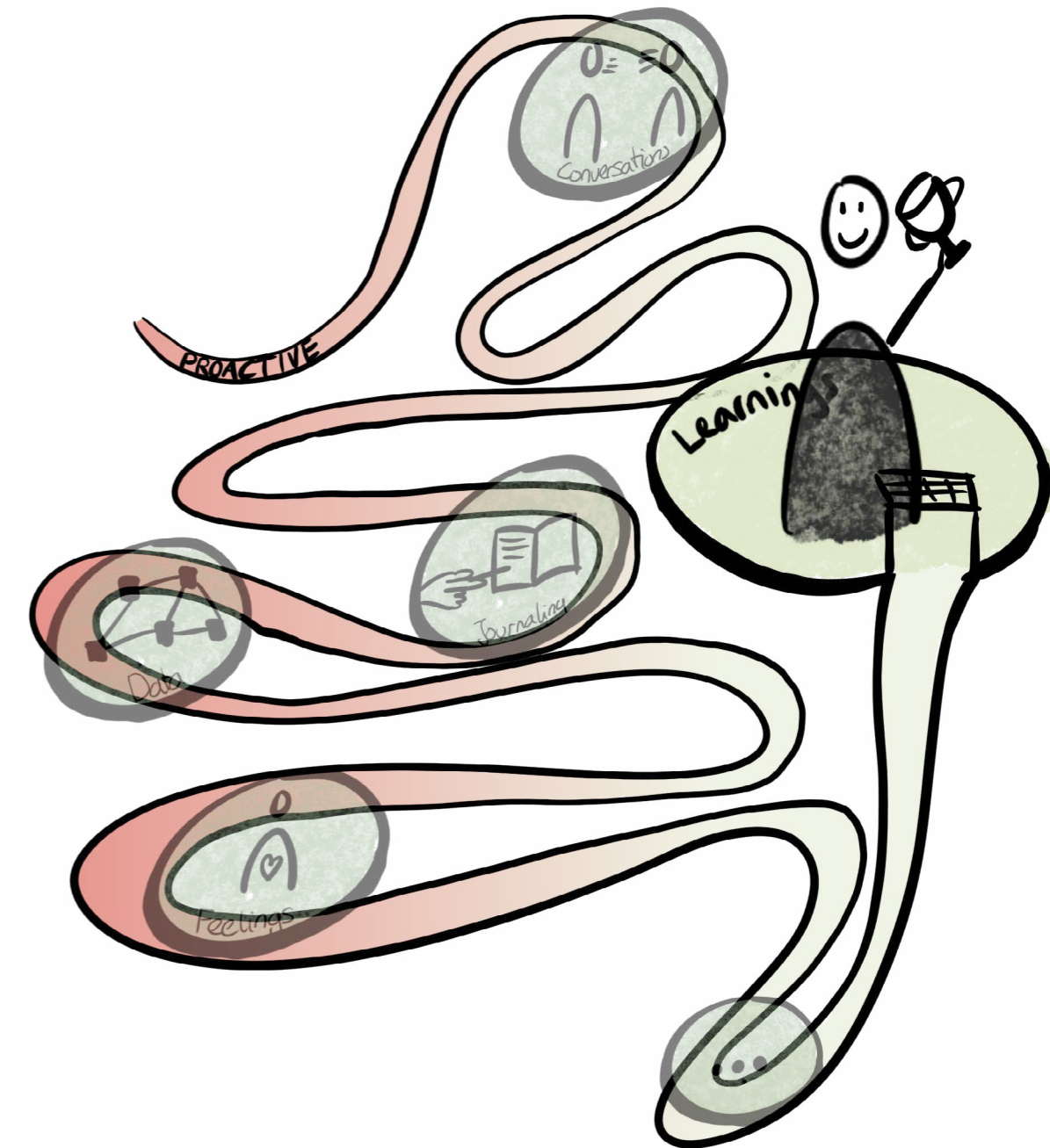


Fig. 27: People want their reflections to end on a positive

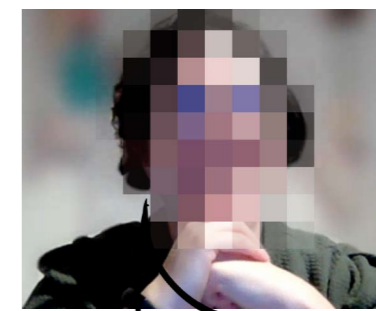
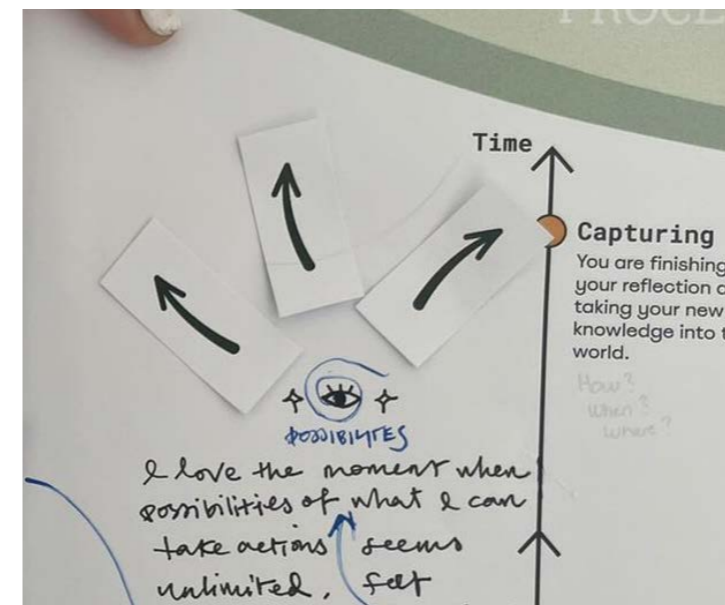
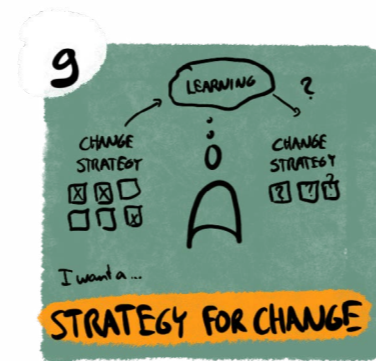
3.5 Capture

#9 PEOPLE WANT TO CONVERT LEARNINGS INTO PERSONALIZED STRATEGIES FOR CHANGE

In an ideal reflection where people gain new understanding about themselves and their behaviours, people want to convert them into something actionable that helps them reach their goals (see Figure 29). This action is usually (a commitment) to change or adapt the strategy that people currently use to reach their goal. When participants were asked in the interviews about the effects of reflections on their behaviour, they reported that reflections helped to “find the best strategies to reach my goals” (P4), “find out which strategy works and which one does not” (P6), “gaining new perspectives and seeing new ways to change” (P3), and “lead to [...] tactics to change” (P2).

Although people report that they are able to find new strategies for change after a reflection, many of them express the need for guidance on strategies that are tailored to themselves and their learnings. “I want to know what to do next after I have reflected” (P4). “I need advice to go from reflection to action” (P3). The process of coming up with strategies often looks like “a brainstorming session looking into ways to improve my behaviour” (P5), but many participants still “struggle to come up with strategies for change” (P8). Nakamura et al. (2021) have shown that people experience it as frustrating when they do not know how to act on their reflection learnings. The analysis of reflection concepts in literature also shows that only few concepts support people in this step.

There are however situations when people are happy with their reflections and learnings without feeling the urge to act on them. This is the case when people feel like the learnings are in line with the current path towards reaching their goal. They commit to sticking with the same strategy and are happily closing their reflections at this point.



“I want to find out which strategy works and which one does not.” (P6)

Fig. 28: One participant mentioning that (s)he wants to see many ways forward after a reflection

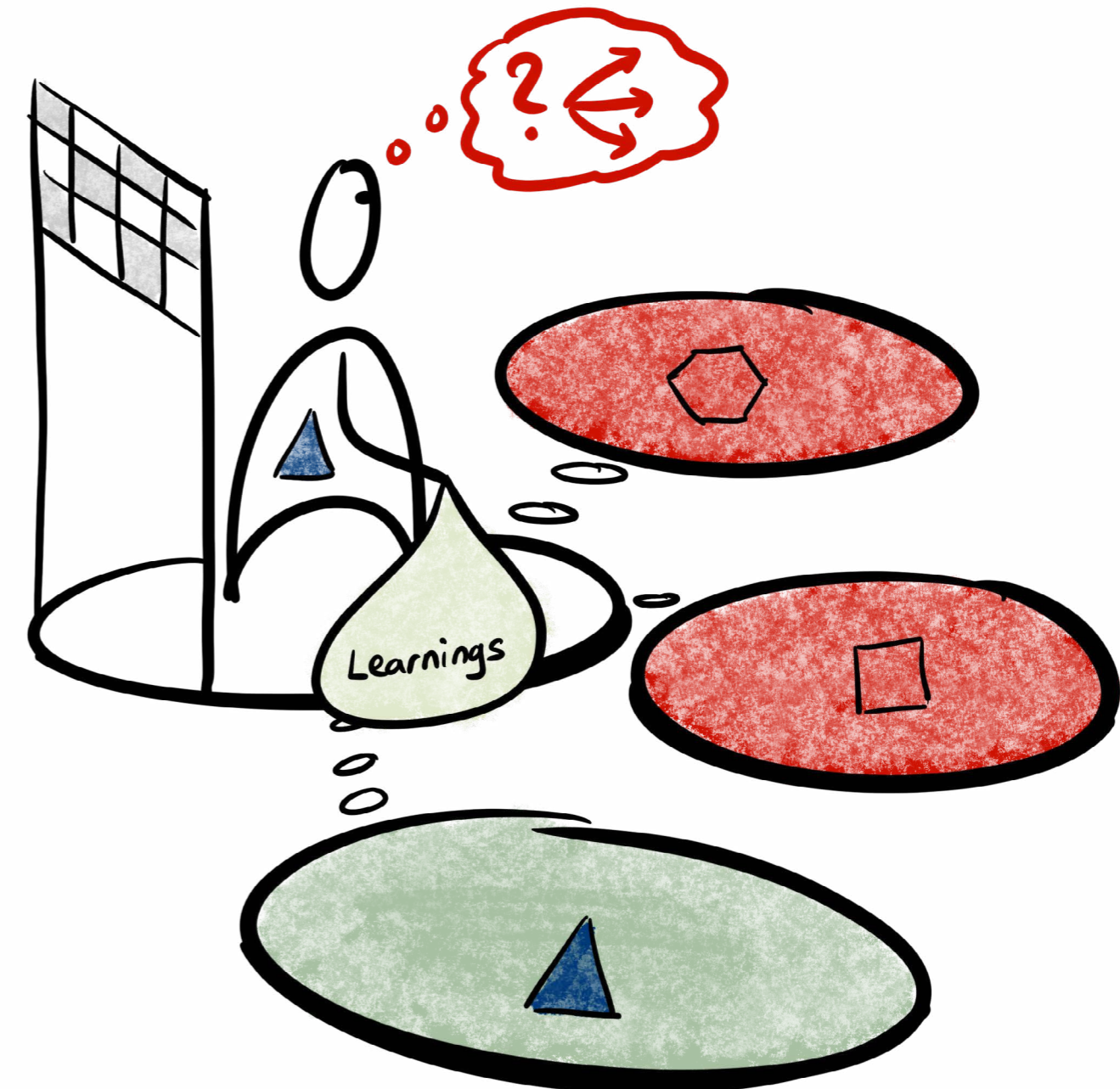


Fig. 29: People want the learnings to inform their next steps

3.6 Discussion

9 key reflection needs have been identified in people's process of reflecting on their health behaviors. The design concept presented in Chapter 6 will be set up to address these needs. While they align a lot with the literature on reflections, some nuances could be found. The process of reflecting is a very fuzzy one, and it has become clear that most reflections that people have are surface-level, defensive reflections that launch quick coping mechanisms and need fast solutions. It has become clear that due to people's everyday lives, proactive, deep reflections are rare because they need time, mental space, and the right trigger. While there are many triggers that start any mode of reflection, people want to be guided through more deep and insightful reflections that need deliberate engagement with time and space. If people are guided the right way through a variety of information (e.g. data, feelings, memories, senses) and are supported in making new connections and finding new perspectives, their reflections can lead to self-insight and to better understanding of their behavior change barriers and enablers. Currently, people help themselves through the reflection "support" phase with journals, digital applications, or through consulting other people. The guidance needs to further extend to the "capture" phase of a reflection, where people want to convert their new knowledge into their behavior change strategy to make it more successful and personalized.

Only by addressing the above needs can I support people to indulge in deep and insightful reflections on their behavior change, which is what this project aims to do. In the next chapter, we will complete the literature findings and user needs with the design knowledge needed to design a concept supporting people's reflections.

4.1 Introduction

The third phase, and fourth chapter, of the project focused on understanding the design mechanisms, principles, and features that facilitate reflection. This was done to create a design space that could guide the development of a reflection support concept.

Design mechanisms are meta-strategies that describe how concepts can be integrated into people's everyday lives to help them reflect. Examples of such strategies include supporting reflection through dialogue or creating the right environment. The design principles in our analysis represent high-level concepts that, if implemented, have been identified as leading to reflection. These principles have been clustered into top-level design principles that each incorporate more specific, strongly related principles (see Figure 30). Temporal perspective, comparison, data analysis, and mindfulness were identified as key design principles. As the final layer in the taxonomy, design features were identified that are used to address the aforementioned principles and mechanisms. They provide concrete ways in which systems can operate and interact with their users.

Before presenting the concepts in detail, it is important to understand the process through which I selected and analyzed these mechanisms and principles.

METHOD

To conduct a systematic review of the reflection concepts, relevant keywords, and phrases such as "reflection," "reflective practice," and "self-reflection" were identified and used to search for papers in databases such as Google Scholar and the ACM digital library. A set of inclusion and exclusion criteria was applied to select a final set of 18 papers on 27 concepts for the review. The inclusion criteria included papers that were published in peer-reviewed journals, were written in English, and focused specifically on the concept of reflection. The exclusion criteria included papers that were not relevant to our research question of how to design for reflection, such as those that focused on the theory of reflection and did not include a design concept. Papers that focused on other related but distinct concepts such as introspection or mindfulness were also excluded.

Once the final set of papers was identified, the process of coding and categorizing the information in these papers began. This involved reading each paper carefully and extracting key information from the concepts, such as whether they revolved around reflecting on a specific behavior or on life in general, how people interacted with the concept, whether they included intelligence, and what the embodiment looked and felt like. In some cases, design mechanisms, principles, and features were explicitly mentioned in the papers, while in other cases they could be concluded from the authors' descriptions of their concepts. The coding scheme of design mechanisms, principles, and features was used to organize the papers and their concepts.

Through this systematic review of the literature on reflection concepts, a design space with key elements for facilitating reflection was mapped. This information will be used in subsequent chapters of this thesis to create a design concept that supports people in reflecting on their health behaviors by addressing their needs.

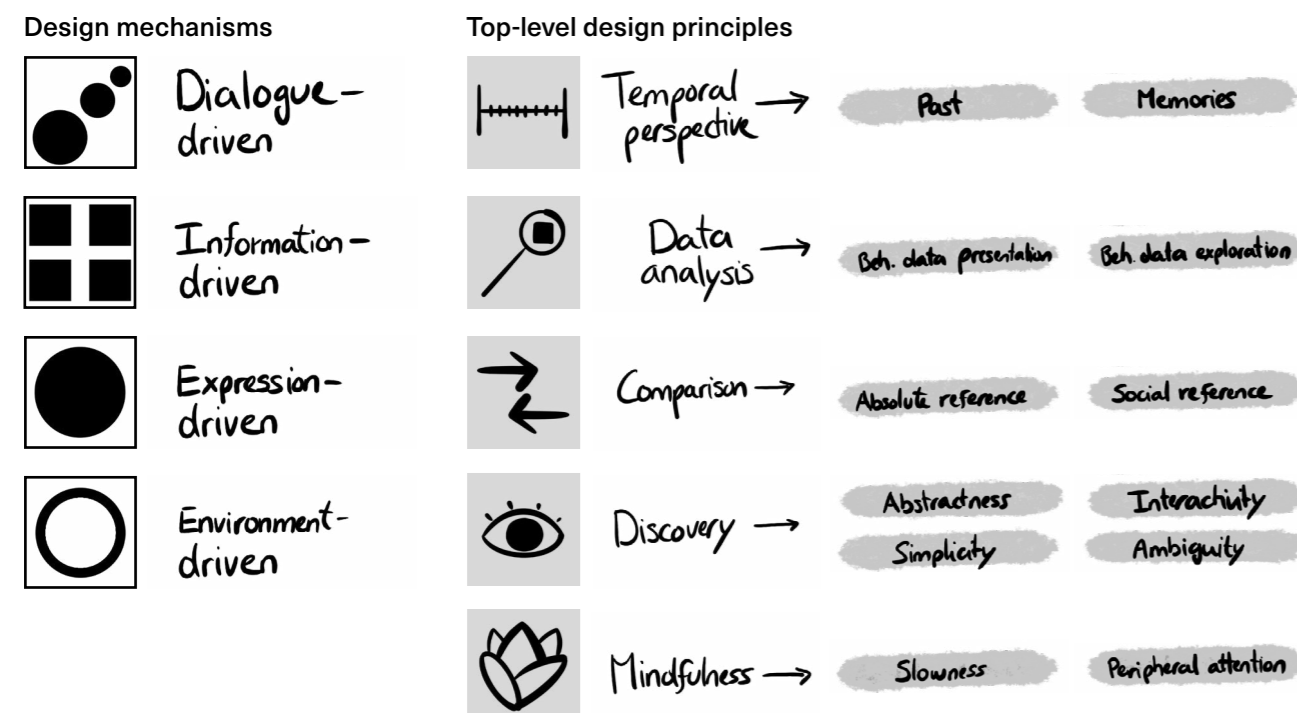


Fig. 30: Overview of the design mechanisms and principles

4.2 Concepts Presented

INTRODUCTION






In the following annotated portfolio, the 27 reflection concepts that have been assembled from literature, will be introduced through a short description. They are also annotated with their design mechanisms and principles, and whether they helped people to reflect on a specific behavior or on life in general. Please find the guide for reading the portfolio on the right page.

The concepts that have been analyzed are DataZen, MirrorMirror, Balance, OddOneOut, MixedEmotions, LifeTree, PeelAway, FragileWorries, PastScape, and Trail by Mols et al. (2016). Concepts from other authors are DearDiary (Mols & Markoupolus, 2012), Echo (Isaacs et al., 2013), Stoytellr (Landry, 2009), The lamp (Ghajargar et al., 2018), the conversational agent (Olafsson et al., 2019), Data Souvenirs (Aipperspach et al., 2008), Freed (Mendels et al., 2011), History Tablecloth (Gaver et al., 2006), Fit2plant, Eat2pic, Brush2music (Nakamura & Matsuda, 2021), Lovers box (Thieme et al., 2010), Memory Lane (Kalnikaité et al., 2011), Reflection Companion (Kocielnik et al., 2018), Reveal-it (Valkanova et al., 2013), SenseCam (Lindley et al., 2009), and Healthii (Andre et al., 2011).

It is important to note that most of these concepts have not been validated with users, but are based on design decisions and driven by literature insights on reflections. For most concepts, one can only assume that, if implemented in real life, they would actually help people to reflect (on their behavior). In general, as I have shown in Chapter 2, it is considered difficult to measure reflections themselves. Meaningful direct assessment of reflection can become intractably difficult (Sumion et al., 1996). Still, these concept can provide guidance and inspiration for the aim of this project, which is to design a system that helps people to reflect on their health behavior.

AN ANNOTATED PORTFOLIO

Design mechanisms

-  Dialogue-driven
-  Information-driven
-  Expression-driven
-  Environment-driven
-  Concepts supporting the reflection on a specific behavior

Design principles






-  Temporal Perspective
-  Data analysis
-  Comparison
-  Discovery
-  Mindfulness



Figure 31: The DataZen concept (Mols et al., 2016)

DataZen is a small zen-inspired garden used as an ambient display. Through vibration in its floor, patterns in the sand are created that are based on measurements of activity, stress and wellbeing (based on wearables).



Figure 32: The Balance concept (Mols et al., 2016)

Balance is a wooden balance that functions as a subtle display of the balance in your life as it stores your thoughts on its positive and negative sides. It shows weight distribution and acts as an abstract visualization and archive of thoughts.



Figure 33: The MirrorMirror concept (Mols et al., 2016)

MirrorMirror is a smart mirror that stimulates to look at our selves in a more reflective way through drawing outlines where people touch it.

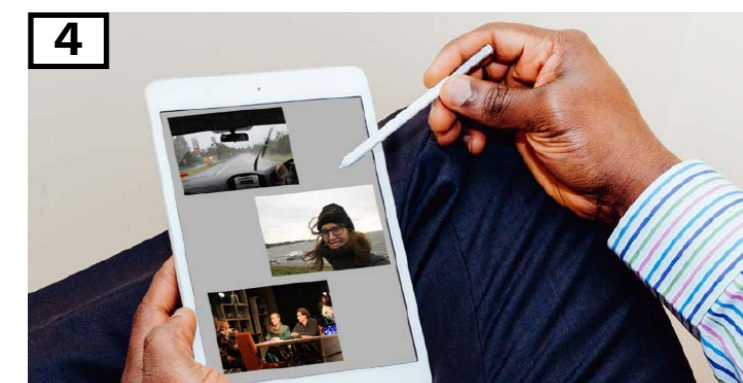


Figure 34: The OddOneOut concept (Mols et al., 2016)

OddOneOut stimulates reflections through looking at hidden similarities and differences between random photos from your personal past.



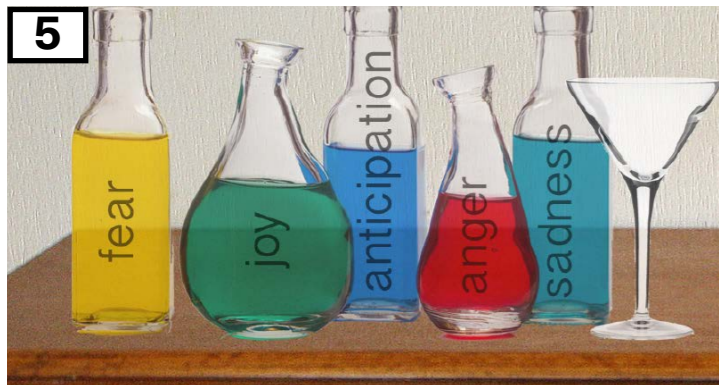


Figure 35: The MixedEmotions concept (Mols et al., 2016)

MixedEmotions encourages people to mix a drink out of bottles labelled with emotions, as a before-bed, relaxing ritual to reflect on daily experiences and emotions.

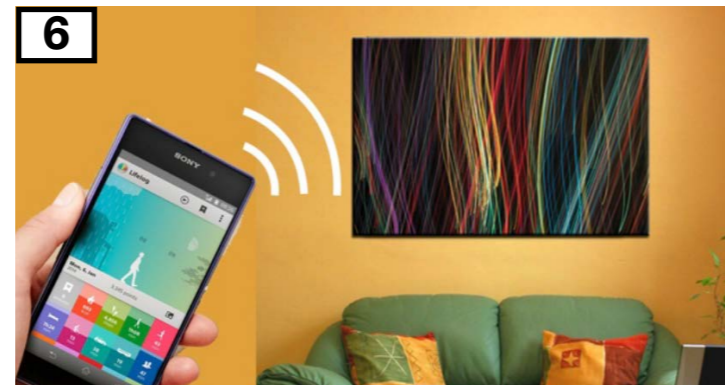


Figure 36: The LifeTree concept (Mols et al., 2016)

LifeTree visualizes activity data through an abstract interactive art piece. It is a peripheral trigger for exploring patterns of behavioural data and be surprised.



Figure 41: DearDiary concept (Mols & Markoupolus, 2012)

DearDiary is a more open, reflective version of a diary that stands in the room and triggers people to only write one word as a starting point for more in-detail reflection.

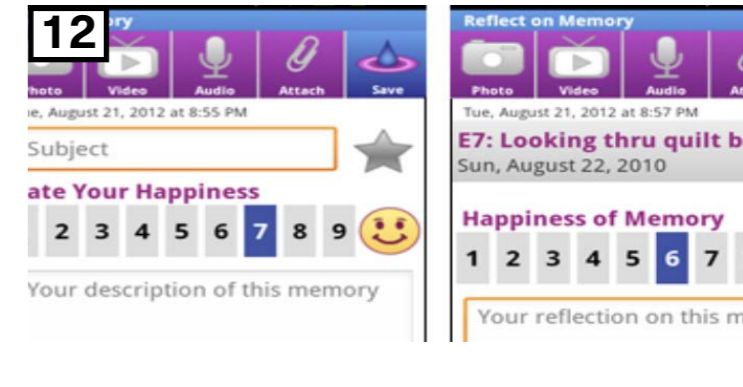


Figure 42: Echo concept (Isaacs et al., 2013)

Echo is a smartphone application that creates reflections through reminding users to input daily happiness ratings, titles, descriptions, and photos.

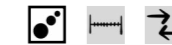


Figure 37: The PeelAway concept (Mols et al., 2016)

PeelAway explores underlying thought concepts and explanations through peeling off layers of thought to get to the core of problems and do a more critical reflection.



Figure 38: The FragileWorries concept (Mols et al., 2016)

FragileWorries helps to get rid of unwanted thoughts by writing them on ceramic and being able to break them. Shards can be saved as a reminder of past struggles.

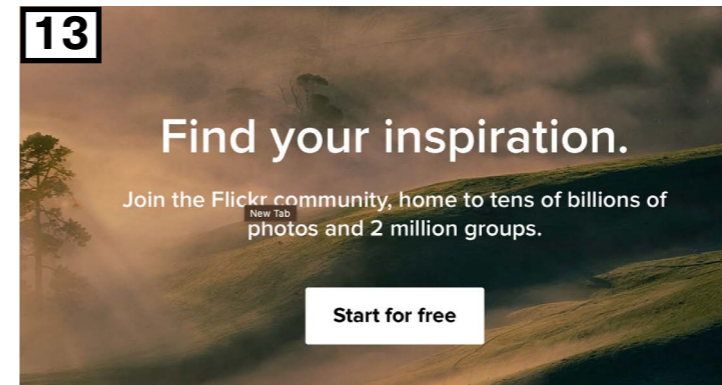


Figure 43: Storytellr concept (Landry, 2009)

Storytellr supports people in reflections on specific events by allowing them to upload pictures and helping them in creating complete stories out of them.



Figure 44: The lamp concept (Ghajargar et al., 2018)

The lamp is an interactive, modular object that emits light patterns based on a person's mobility data that is captured by wearables.

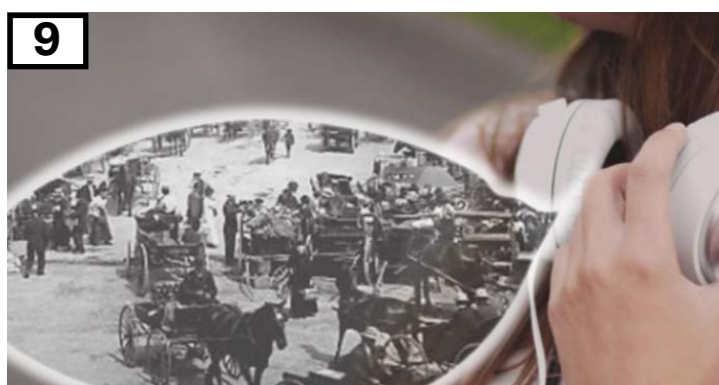


Figure 39: The PastScape concept (Mols et al., 2016)

PastScape stores sounds from the past and replays them when people are at the same location. Reflection is triggered through remembrance and new perspectives.

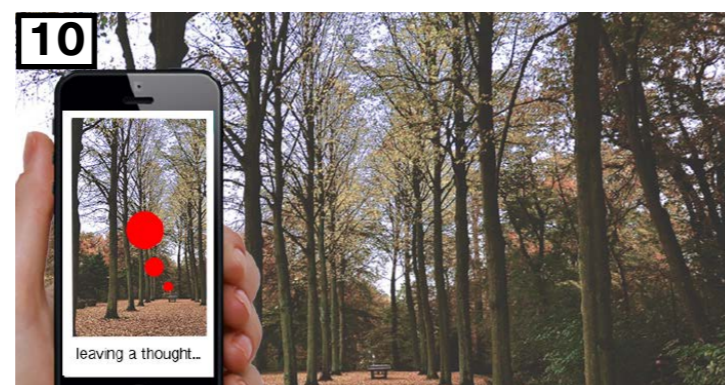
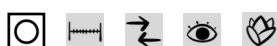


Figure 40: The Trail concept (Mols et al., 2016)

Trail allows people to connect thoughts to places in nature and return to them physically. It helps people to get away from everyday life activities and create a thought environment.



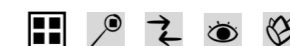
Figure 45: The Conversational Agent (Olafsson et al., 2019)

The Conversational Agent is a digital version of a counselling session, with an agent asking questions about people's behaviour through a screen, to encourage reflection.



Figure 46: Data Souvenirs concept (Aipperspach et al., 2008)

Data Souvenirs are physical-digital, interactive objects that look like books, and save and present information related to a specific behaviour captured by sensors.



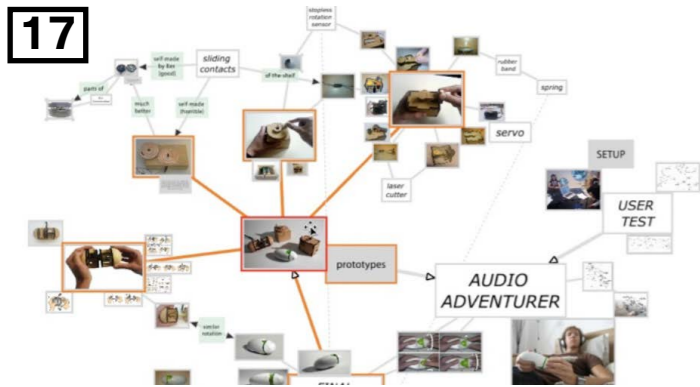


Figure 47: Freed concept (Mendels et al., 2011)

Freed is a software in which one can create a net of nodes (text, images, videos, links) in a digital canvas to ease documentation, exploration, communication, and reflection.



Figure 48: History TableCloth concept (Gaver et al., 2006)

The History Tablecloth is a flexible substrate screen-print that goes under objects and indicates the flow of objects in a home, such as when they have not moved for a while.

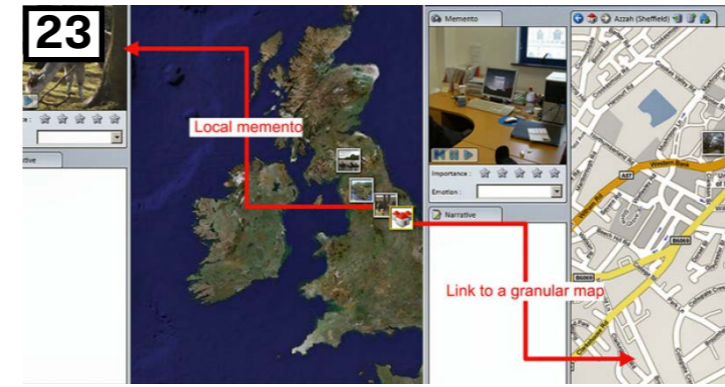


Figure 53: Memory Lane concept (Kalnikaite et al., 2011)

MemoryLane is a digital tool that encourages reflections through capturing, organizing and annotating memories related to people, places, and objects.



Figure 54: Reflection Companion concept (Kocielnik et al., 2018)

The Reflection Companion is a smartphone app connected to a Fitbit smart watch to reflect on behavioural exercise data through a chat conversation.



Figure 49: Fit2plant concept (Nakamura & Matsuda, 2021)

Fit2plant uses screen-based abstract visuals of a plant that grows with progress in physical activity measured by sensors, to encourage reflection on that behavior.



Figure 50: Eat2pic concept (Nakamura & Matsuda, 2021)

Eat2pic uses screen-based abstract visuals to indicate eating speed measured by sensors, to encourage reflection on their eating behavior.



Figure 55: Reveal-it concept (Valkanova et al., 2013)

Reveal-it is a public projection of the visualization of visitor's energy usage that provides a space for comparison and group reflection.



Figure 56: SenseCam concept (Randall et al., 2018)

SenseCam is an everyday wearable camera that takes pictures on regular occasions and alters them in a way that triggers reflection when looking back on them.



Figure 51: Brush2music concept (Nakamura & Matsuda, 2021)

Brush2music converts the brushing of teeth to musical patterns to guide and make people reflect on brushing speed and length through slow interactions.



Figure 52: Lovers Box concept (Thieme et al., 2010)

Lovers Box is a wooden box that allows the exchange of video messages between couples that they can then revisit and reflect upon together.

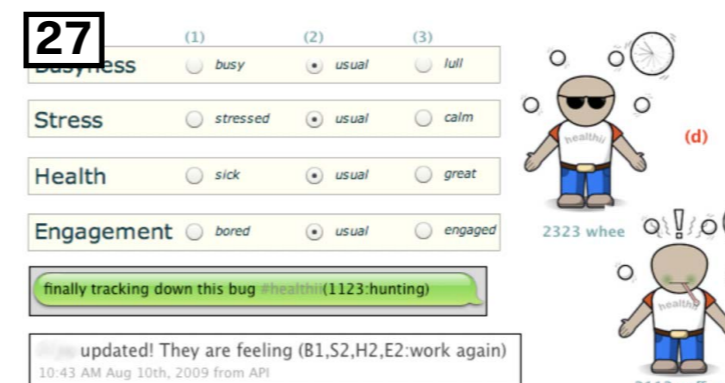


Figure 57: Healthii concept (Andre et al., 2011)

Healthii is a social media integration that defines predetermined categories of well-being to be reflected upon and filled out by users.



4.3 Design Mechanisms

The design mechanisms have been analysed through the framework by Mols et al., who have defined 4 possible design mechanisms (or strategies as they call it) for supporting reflections. **Reflection support concepts can be dialogue-driven, information-driven, expression-driven, or environment-driven.**

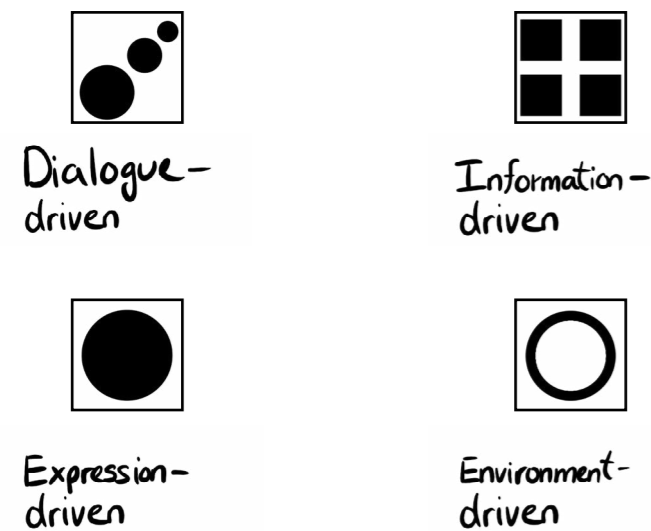
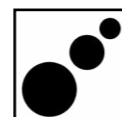


Fig. 58: 4 design mechanisms identified in the concepts

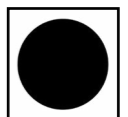
The first strategy for supporting reflections is through dialogue-driven reflection. This strategy uses verbalized dialogue through writing or speaking, such as the video conversations between partners in Lovers box (Thieme et al., 2010), the embodied agent that acts as a reflection partner (Olafsson et al., 2019), or the written dialogue with a smartphone application in the reflection companion (Kocielnik et al., 2018). Explicit prompts are used to encourage reflections, such as through notifications or conversation starters. This strategy focuses on reflecting with other people such as friends and family (Thieme et al., 2010; Landry, 2009), professionals such as therapists, or intelligent partners such as conversational agents or chatbots.



The second strategy is an information-driven reflection, which is best suited for reflecting on behaviour change according to Mols et al. (2016). Indeed, most of the analyzed concepts that support reflections on a specific behaviour can be classified to use an information-driven strategy. In accordance to the quantified self (QS) movement, many of these concepts present behavioural data as a trigger to get people to reflect. LifeTree show behavioural data in form of an abstract painting (Mols et al., 2016), Data Souvenirs give feedback when a behaviour has failed or been successful (Aipperspach et al., 2008), and Fit2plant visualize progress on physical activity through a digital plant on a display in people's room (Nakamura & Matsuda, 2021). This data is often presented back to people in a slightly altered way, such as to indicate ambiguity, invisibility, abstractness, or to trigger comparison. This strategy is especially helpful for people to discover information that they might have been unaware of.



Next up is the expression-driven strategy for supporting people to reflect. This strategy is less triggering, but it supports users in their need for expressing themselves in a reflection. These concepts can be guided, such as helping people to organize and annotate digital memories (Kalnikaite et al., 2011), organizing people's emotional states into different categories to be expressed on social media (Andre et al., 2011), or making people's thoughts more tangible (Mols et al., 2016). However, the most common examples for expression-driven reflection are unguided and include therapeutic writing or some other form of journaling (Mols & Markoupolus, 2012; Mols et al., 2022). Concepts also include both digital, as well as physical places to express themselves, and most common interactions for expression include writing and speaking.



The last strategy is to support environment-driven reflections. These are concepts that alter the environment in such a way as to create more space for reflections to occur. Many of these concepts try to reduce mental fatigue, extend people's perception of space and time, or encourage outdoor, natural settings. These elements draw from restorative environments (Kaplan and Kaplan), which have the ability to support reflective activities (Herzog et al., 1997). Mirrormirror (Mols et al., 2016), for example, encourages slow interaction and taking breaks by drawing shapes upon touch that vanish slowly afterwards. The lamp (Ghajargar et al., 2018) uses light to shape the atmosphere and get people to reflect. Brush2music (Nakamura & Mats., 2021) encourages slow interactions by playing music through brushing your teeth.



4.4 Design Principles

This analysis of high-level design principles that facilitate reflection, resembles the one that Bentvelzen et al. (2022) have done on concepts that use technology to help people reflect on everyday life. They have analysed over 50 papers that describe physical artefacts and another almost 50 smartphone applications in order to understand how reflections can be supported through technology. They conclude with the following high-level design resources that, if implemented, would lead to a reflection: Temporal perspective, conversation, comparison, and discovery. Each of these resources was divided into a sub-levels of design resources. We took these resources as a starting point for analysing the above concepts and have adapted them as follows (see Figure 59 for the final principles). Many of the design principles were also mentioned to trigger reflections by the study participants in Chapter 3.

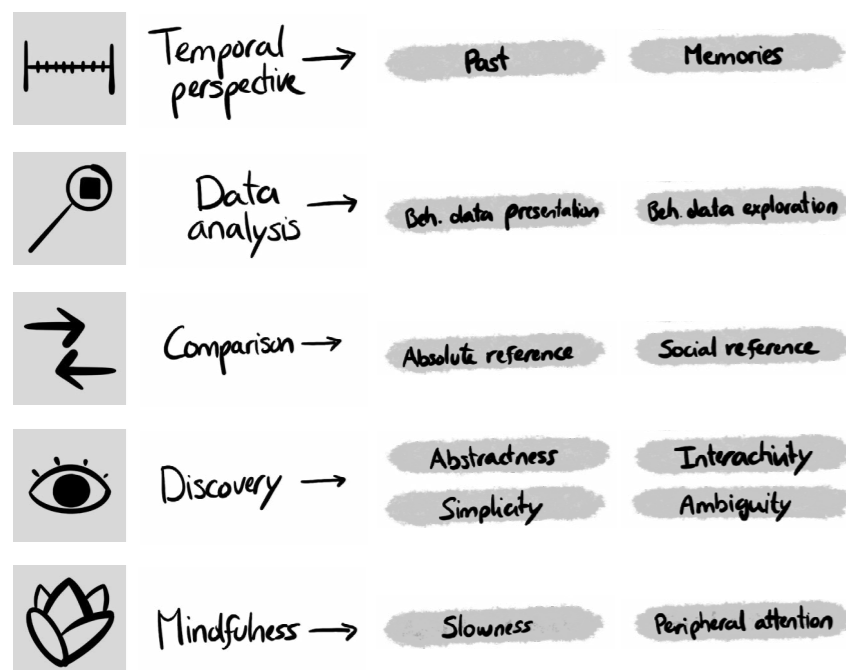


Fig. 59: Design principles with their top-level design principles

As a first over-arching design principle, similarly to Bentvelzen et al. (2022), we found **temporal perspective** the most widespread theme. Time was used a lot as a construct to offer a new perspective that yielded a reflection as result. Lindley et al. (2011) agree that time plays an important role and that longer timeframes increase reinterpretation in reflections. In this category, we identified two design resources: **past and memories**. Many artefacts use the past as a resource for

enhancing reflections. Such systems offer objective insights about past situations, such as the time an object was positioned at the same place (Gaver et al., 2006), or prompt to past photos that were taken by SenseCam (Lindley et al., 2009). Memories on the other hand, is related to a perspective of the past, while using a more subjective approach. Staudinger describes reflections as an analysis of one's life reconstruction through past memories (Staudinger, 2001). Concepts that use memories as a design principle trigger a reflection through making people remember memories of past events and experiences. The smartphone application Echo, for example, regularly prompts users to look back at previous journal entries where people attached photos and well-being information, and then asks users to rewrite comments on them. Lovers box (Thieme et al., 2010) is a box that saves video recordings of couples sent to each others when at distance, to be watched and reflected upon when couples are back together.

A second design principle that we introduce is **data analysis**, which is one of the principles most frequently used in concepts that encourage reflections on a specific behaviour. This data is often being provided by wearables that serve as activity trackers. Wearables and activity trackers in general have the capabilities to capture everyday life and thereby support remembrance, introspection (Byrne & Jones, 2009), and reflection. In this category, two underlying design principles were identified: **presentation, and exploration of data**. Many concept use the presentation of behavioural data as a trigger and support for reflection. These data streams often trigger a unique perspective and the defamiliarizing of everyday pattern which can lead to reflection (Gaver et al., 2007; Romero and Mateas, 2005). In the Reflection Companion (Kocielnik et al., 2018), a smartphone application presents physical activity data captured by a Fitbit with follow-up questions for reflection. Fit2plant (Nakamura & Matsuda, 2021) tracks posture-related data with sensors and converts it into the look of a digital plant on a screen. Reveal-it (Valkanova et al., 2013) create a projected visualization of data on energy usage that is manually input. Without really guiding or triggering users into a reflection, this approach often wrongly assumes that the presentation of behavioural data is sufficient for reflections to occur. The other data analysis principle that leads to reflections in the analysed concepts, was the exploration of behavioural data. Some concepts open up opportunities for users to engage and manipulate their data in meaningful ways to trigger reflection and create different perspectives on their information. Life Tree (Mols et al., 2022) allows users to manipulate the tracked data to see changes in the digital art. The lamp (Ghajargar et al., 2018) allows users to change the modular structure of the lamp to alter the light patterns, which were also influenced by behavioural data.

The next design principle was **comparison**, either through **absolute reference or social reference**. This resource lead to a reflection by users being able to compare themselves to an ideal self or to someone else. Data Souvenirs (Aipperspach et al., 2008) for example allowed users to input their goal and the physical-digital books would give feedback on the progress they make towards their goal. Thus they trigger people to compare themselves to their future ideal self



which can lead to a reflection. Echo (Isaacs et al., 2013) confronted people with ideal scores of happiness and well-being, which also triggered a reflection through comparison. Social reference is used as a design principle in Reveal-it (Valkanova et al., 2013), where users are shown a visualization of their data together with that of other people.

Another design principle that was identified in both this project as well as the analysis by Bentvelzen et al. (2022) was **discovery**. This resource is leading to a reflection by users discovering something new, unveiling new perspectives, or seeing something in an unexpected way. These concepts provide inspiration while keeping room for interpretation. The most wide-spread underlying design resources have found to be **abstractness, simplicity, interactivity, and ambiguity**. The ideal approach here is to give food for a good starting thought, but leave it open enough that questions remain. Concepts like Datazen (Mols et al., 2016), LifeTree (Mols et al., 2016), Eat2pic (Nakamura & Matsuda, 2021), and History Tablecloth (Gaver et al., 2006) all use behavioural data that is altered in an unusual way and converted into something else like a painting, light patterns, digital art, or projection. This principle relates to the reframing principle by Bentvelzen et al. (2022), often using data physicalization as a design pattern. Many concepts use simplicity in form, material, or interaction to enhance reflection; like using a 1-word diary (Mols & Markoupolus, 2012), a folded piece of paper in Peel Away (Mols et al., 2022), or play with simple light patterns in History Tablecloth (Gaver et al., 2006). Simplicity in material invites people to reflect (Hallnäs & Redström, 2001). Interactivity also leads to a reflection, such as in assembling memories in different ways in Storytellr (Landry, 2009) or in Freed (Mendels et al., 2011). Some concepts also deliberately put digital concepts in a physical box to enhance interactivity, such as closing and opening videos with a physical key in Lovers box (Thieme et al., 2010) or putting displays in a physical book (Aipperspach et al., 2008). Ambiguity has been found the last design resource, and is known for leading to a reflection (Gaver et al., 2003). Ambiguity is about a design creating room for various, often contrary ways of interpretation. The History Tablecloth (Gaver et al., 2006) for example indicates how long objects have been placed a certain way which can lead to people keeping them on the same spot for the patterns to unfold further, or people thinking that it might be time to place them elsewhere. Predicto predicts user activity and thereby leverages the unexpectedness of overestimation or underestimation to trigger users wanting to make sense of that information (Gouveia et al., 2015).

The last design principle that was identified was **mindfulness**. This principle is about leveraging an environment that supports reflections, as well as triggering reflections through a more natural and less intrusive way. In its subtlety, the designs evoke curiosity and thereby lead to reflections. It comes in two different underlying design principles: **slowness and peripheral attention**. Slowness is about accepting an invitation for reflection inherent in the design, and thereby leads to more time and increased presence. (Hallnäs & Redström, 2001). MirrorMirror (Mols et al., 2016) uses the slow interaction with the mirror by slowly fading touch contours to increase the perception of time and thereby make room for reflections.



Brush2music (Nakamura & Matsuda, 2021) increases the awareness of brushing the teeth by connecting it to the playing of music. Only by consciously changing speed and frequency do users realize the symphony of the music. Peripheral attention is used as a design resource to minimize distractions and leave people's attention as focused as possible on their thinking. PastScape (Mols et al., 2022) for example tries to trigger a reflection by only using subtle sounds that are played in certain locations for people wearing headphones.

The identified design principles align with many of those by Bentvelzen et al. (2022), with some subtle adjustments. There are certainly also some overlaps between the design principles, such as interactivity sometimes being a form of data exploration, or absolute comparison sometimes being a form of temporal perspective. Also, concepts often use many of these design principles, which can make it hard to determine what exactly leads to the reflection. These principles, however, provide a good starting point for creating a design space for reflections on behaviour change and will inform the design decisions in the next phase of the project.

4.5 Design Features

In contrast to the design mechanisms and high-level design principles, the design features are concrete ways in which the principles are implemented to stimulate reflections. The concepts vary significantly in terms of the design features that were used, but some connections between features and principles can be observed. Bentvelzen et al. (2022) also identified some design features (patterns) that strongly related to specific design principles.

Many concepts, especially those that use data analysis as a design principle, consist of **ambient displays or digital screens** as their medium to visualize and explore data. These concepts also often use data tracking through sensors or wearables. The Reflection Companion (Kocielnik et al., 2018) uses the smartphone as a screen to display behavioural information captured by a user's Fitbit. Fit2plant (Nakamura & Matsuda, 2021) uses a screen to show data of sensors that capture people's posture. LifeTree (Mols et al., 2016) uses a smart watch to track activity and show it through a visualization on a digital canvas.

A common design feature that many concepts used is to provide active **triggers** to get people to reflect. Triggers range from smartphone notifications (Kocielnik et al., 2018; Olafsson et al., 2019) to memory prompts (Lindley et al., 2009; Mols et al., 2016; Trail; Isaacs et al., 2013). Embedded questions or embedded meaning are another way that many concept try to get people to reflect. In these concepts, qualities of objects are used to trigger exploration or questioning, trying to make sense of the object's behaviour. This is often reflected through data or memory physicalization by emitting sound that are similar to places one has been in the past (Mols et al., 2016: PastScape), light that forms patterns according to a behaviour (Ghajargar et al., 2018; Gaver et al., 2006), or even music that unfolds with brushing teeth (Nakamura & Matsuda, 2021). Guided questions are also used as a way to engage people in deeper reflections (Olafsson et al., 2019; Mols et al., 2016: Peel Away; Kocielnik et al., 2018).

One of the most common design features is **physical or digital journaling**, which have been well-established reflection practices in counselling, psychotherapy, and have also become popular in people's everyday lives. Journaling is used as a way to foster remembrance, show different perspectives, or offload thinking. Journaling takes many different inputs in reflections and through different ways. Concepts vary in the breadth of things that they incite people to input- from their thoughts (Mols et al., 2016: multiple concepts; Isaacs et al., 2013; Thieme et al., 2010; Kocielnik et al., 2018), to photos (Lindley et al., 2009; Landry, 2009; Isaacs et al., 2013), and

videos (Thieme et al., 2010). DearDiary (Mols & Markoupolus, 2012) strips it down to journaling one word only. Both text and voice input are used as a means for people to input their thoughts.

Although the core of many concepts is often a **digital tool**, many concepts are wrapped into a **physical body**. This plays a lot into the design principle of mindfulness and interactivity. Indeed, the interactive engagement with physical objects can often enhance learning (Ghajargar et al., 2018). In Lover's box (Thieme et al., 2010), the physical box does not add to the functioning of the concept, which is the sending of video messages. However, it being wrapped into a physical box promotes a certain slowness and interactivity that enhances reflection. The same is true for Data Souvenirs (Aipperspach et al., 2008) that wrap digital screens into physical books so that they can be placed on book shelves without looking too different. At the same time, their core functions of showing behavioural goals are not being enhanced by the form of a book, yet it is an important design feature that supports reflection. Books in particular adhere to many of the conditions for a restorative environment (Aippersbach et al., 2011), as by the definition of Kaplan & Kaplan (1989).

4.6 Discussion

Over the last few sections, it has become clear that there are many paths that support systems can use to lead people into reflection. Artifacts can use dialogue to engage with users, utilize information and data as a means for reflection, they can promote the right reflection environments, or provide a platform for expression that guides the reflection. In terms of its functioning and embodiment, concepts can use design principles such as temporal perspective, data analysis, comparison, discovery, and mindfulness to get people to reflect. The most widespread design features in reflection concepts were the use of physical objects while integrating digital displays, working with different kinds of triggers, and incorporating journaling techniques.

Mapping the different concepts and their mechanisms, principles, and features onto the reflection process model by Mols et al. (2016) creates a design space for reflection. When contrasting the different mechanisms against the stages in the reflection process that these concepts support (see Figure 60), I realized that most concepts supporting the beginning of the process use information-driven, or environment-driven strategies, while concepts in later stages prefer dialogue-driven or expression-driven strategies. Information or everyday surroundings present good triggers for reflection, while in the “support” phase, people are mostly being supported by dialogue- and expression-driven concepts. When contrasting the design principles or features with the concepts and their respective positioning in the reflection process, no clear relationships could be identified. No principle or feature is specifically linked to any part of the process. In general, most concepts support the early stages of the process.

Although I could see a connection between the mechanisms and their positioning in the process, since many concepts have not been evaluated, this does not necessarily mean that different strategies are more successful in any part of the reflection process. Rather, I want to use this as a design space with ingredients to choose from based on the specific needs that people have demonstrated in the preceding chapter. I plan to use the design mechanisms as over-arching design approaches, the design principles to drive user-object interactions, and the design patterns to inform the embodiment. I want to use this space and the concepts as design inspiration for coming up with the first ideas and a more tailored concept in the end.

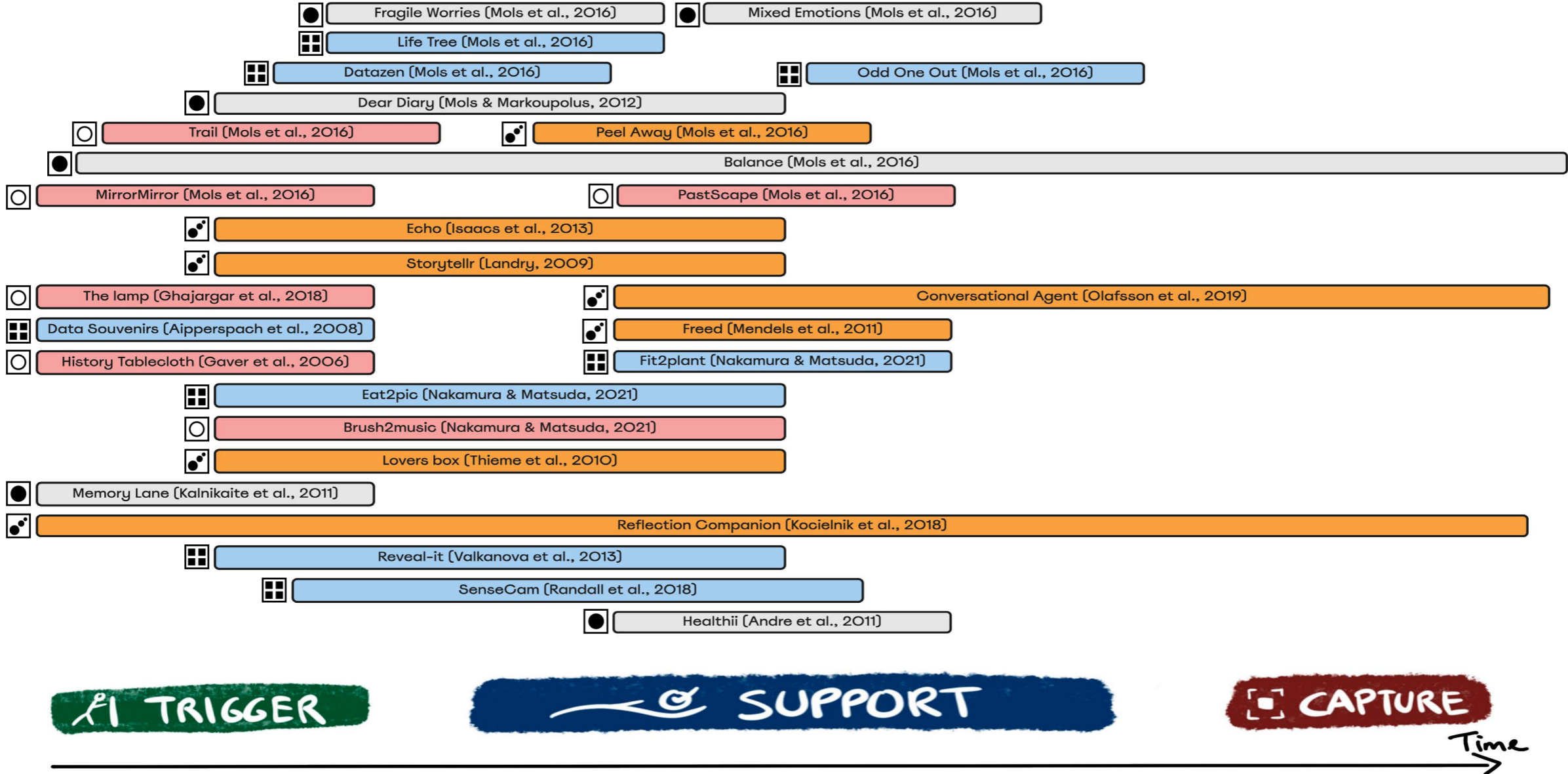


Fig. 60: The reflection concepts and the stages of reflection they support

Card to journal and be triggered by questions

Show behavioural info on object that is used when going outside.

Smart phone charger with ambient display to show behavioural info

Reflective 2nd nature object on commute routes (e.g. treadmill)

Show it trough art

Creating AI art out of behavioural data

Progress on goal shown through light patterns

App to help find explanations to behaviour (why-answers)

A search engine for answers on own behavior / questions during reflections (cc google)

Reflection thought box. Inputting journaling info and output is AI visualization

Card deck with reflection cards and ambient display

Pet like conversational reflection partner asking questions.

Thought box

Online course on how to reflect

Offloading thoughts to a box

intelligent phone block schedules

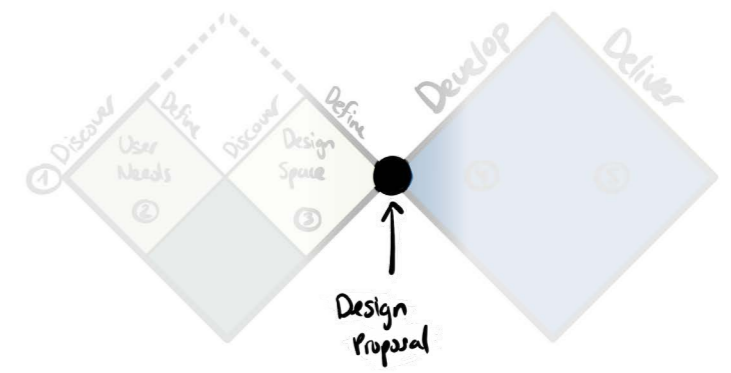
Shutdown button to turn off all connected devices and show reflection content

Extend people's impession of time

- Smart watch that sometimes goes much slower
- Smart glasses that show world is slow-mo
- Make people feel like on holiday

Turn off devices when good reflection environment is detected and show behavioural data

Case to hide distractive parts of a tech device.



05 Towards a Design Concept

This chapter bridges the discovery and the development phase of the project by bringing theory and practice together, as well as make design decisions driven by literature and user needs. It starts with the creation and testing of ideas, before it brings all the knowledge together into a design goal and design proposal.

5.1 Interaction & Embodiment Guidelines

AIM

Throughout the last chapters, the space for creating a design concept has been expanded immensely. To synthesize all the gathered knowledge and make the design decisions that are driven by users, I wanted to quickly gain some insights into the concept embodiment, material, and interaction. This also allowed to make user-driven decisions across the design space, with users that specifically sought to reflect on their health behavior change. It gave me an idea of the relationship between the user and a reflection concept that intends to use technology. Through the methods described in the next section, it was possible to identify directions for design decisions to make and thereby narrow down the design space and come up with a design goal.

METHODS

After doing extensive ideation sessions (see Appendix B for ideation material) with user needs in mind and inspired by the design space, rapid prototyping was used as a method for further inquiry. Quick prototypes of the most promising ideas were created, which ranged from physical objects to digital applications and storyboards. The tested prototypes were a physical credit card that showed behavioural data information (Figure 61), a key chain that indicated abstract forms of progress (Figure 62), a storyboard of a concept that used a smart watch to detect ideal reflection times and then show behavioral information, and an application that guided through various steps of prompting questions and instructing to journal (Figure 63). Physical objects were given to users to play around with over a day, while digital applications or storyboards were used in cognitive walkthrough sessions with users.

The participants of these walkthrough sessions were a subset of the participants from the first study. They included 4 people between the ages of 23 and 31, of whom 3 were women and 1 participant was a man. All of them were still engaged in their behavior change process, focusing on things like reducing industrial sugar

or becoming more mindful. Each session or day of experimenting concluded with an informal discussion around the following questions:

- How do people want to interact with a reflection support object?
- How should the object look and feel?
- How do people envision its help in the behavior change process?

These questions are derived from the main research questions of how to design for reflection and how to use smart objects to do so. In the next section, I will present the main conclusion in the form of design directions.



Fig. 61: The wallet card prototype

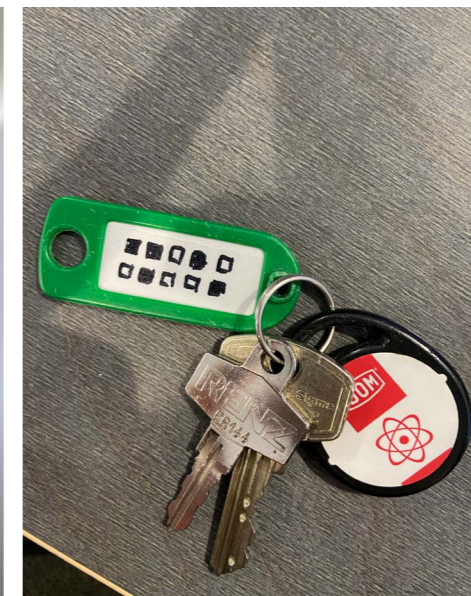


Fig. 62: The keychain prototype

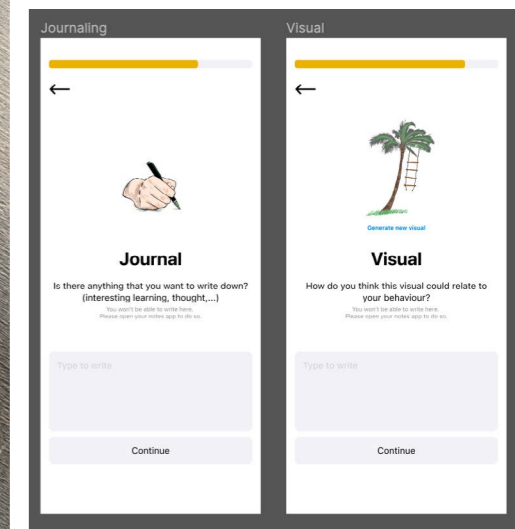


Fig. 63: Part of the app prototype

KEY FINDINGS

A first finding that came from the credit card prototype as well as the digital application, was that people like to input their thoughts by using voice. The participants using the credit card mentioned that it felt like making voice memos to friends, so it also did not feel weird publicly. The form factor being similar to that of a phone helped to make it feel normal, and almost intimate. The digital application was prototyped to use text as input for the journaling parts, but participants also mentioned that it would be easier to speak to the application. Participants described their thoughts as messy, and that there was too much of a threshold between thinking and typing. In the cognitive walkthrough sessions, 2 participants actively proposed the voice input as an interaction method they would prefer.



A second finding on the embodiment was that people enjoyed the tangibility of the keychain, but particularly that one of the card. In fact, the physical form of cards or books support many of the design guidelines of restorative environments, which are environments that support reflections. These guidelines include that objects should be portable, non-distractive, single-purposed, providing multiple perspectives, be tangible, and meaningful (Aippersbach et al., 2011). Participants valued the character of such objects portraying a form of slowness and non-connectivity, which mirrors many of the reflection qualities identified in literature and throughout this project.

The third and last finding revolved around the fact that reflections can be an intimate and sensitive topic to individuals. As the contextmapping study in Chapter 3 has already made clear, reflections can lead to overthinking and rumination. People can get stuck in their reflections, blaming themselves for past negative events and getting lost in self-doubt. When participants played around with the application, which prompts people to think about their behaviour and gives suggestions for explanations of past events, they highlighted the importance of careful wording. Depending on the context and on people's individual experiences and predispositions, suggestions could either be helpful or increase negative thoughts. For example, the explanation "Identifying your feelings can often lead to better understanding your past behaviours [...]" led one participant to think he or she was not good at identifying feelings which led to more negative thinking. I need to be very careful in the design concept and frame things positively whenever possible.



5.2 Bridging User Needs, Design Space, and Theory

INTRO

In the following sections, I will synthesize all the knowledge gathered so far into the different parts of the reflection process. Figure 64 shows all the different elements that make up the design space within the process. In the next sections, I aim to make connections between user needs and their potential for support by design mechanisms and principles, as well as by technology.

TRIGGER

People need to have mental space & time to engage in proactive reflections. This presence of time & space allows for deliberate attention and intentionality, characteristics that are echoed throughout this project, and can lead to reflection. Such an environment can be created through slow technology that is specifically designed to create time, space, and a non-distractive environment. The design principles around mindfulness and discovery could be best suited to address such needs, as they focus on simplicity, slowness, and carefully dealing with attention. No particular design mechanisms focus on creating time and space, although an information-driven reflection could go against the qualities of slowness and simplicity. Currently, participants mention that any type of commute, strolls in nature, or time alone at the beginning or end of days can be examples of such environments.

People need a trigger to reflect and are currently triggered through events, conversations, or objects. Anything that gets people started thinking about their behavior is a portal to reflections. We have seen that technology and its capabilities of capturing everyday lives provide a valuable trigger for remembrance, which is the first layer of reflection depth. This capturing of data and behaviors can also make triggers smart and integrate them into people's lives so that they appear in the best reflection situations. However, this triggering towards reflection somewhat contradicts the qualities of a reflective environment by actively taking hold of people's attention and trying to launch reflections through persuasion.

Participants in the contextmapping study have stated that the right environment, or thoughts coming up in that environment, can be sufficient and even beneficial for proactive reflections. This is backed up by literature on restorative environments, slow technology, and reflections in general. If I want to design more persuasive triggers, an information-driven mechanism could be used, and principles such as comparison or data analysis could be focused on.

People want to have proactive reflections, which are reflections that are driven by curiosity and a desire to learn. Such reflections are also often created by the right environment, and not after events have happened. Much of this need ties into the need of creating the right environment where mental space and time are provided. It also indicates curiosity as a means to explore thoughts, which can be supported by design principles of discovery or temporal perspective, focusing on simplicity and ambiguity. Technology can be of help in fostering curiosity through its capabilities of creating novel things.

SUPPORT

People need guidance to navigate their reflections from an initial trigger to their ideally gained learnings, a need that has also been identified by Fleck & Fitzpatrick (2010). In every reflection, people use different tools and methods to guide their reflection. From journals to talking with friends, many practices correspond to those of counseling. This guidance can thus be supported through the mechanism of a dialogue-driven reflection, rather than expression-driven reflection. The latter is a more open process that would amplify the fuzziness of the process. Any design principles can be used in the context of guidance.

People want to have positive reflections in which they stay away from criticizing and overthinking. The literature findings show that this has been much neglected in current research, and needs to be taken more seriously. Indeed, participants in the contextmapping study reported that most of their reflections involved self-doubt and frustration which led to such overthinking. This also relates to one of the design directions identified in the rapid prototyping, which is that reflections can be intimate and the wording of a reflection support concept needs to be designed carefully. Since people vary in their tendencies towards such defensive reflections, technology could help in personalizing a concept. The intimate character of a reflection could best be supported through a dialogue-driven or expression-driven concept. The design principle of comparison risks amplifying negativity.

People want to retrieve a lot of information related to their behaviors that help

them trigger new thoughts, make further connections, see new perspectives, and eventually learn. Participants currently consult their journals, feelings, digital applications, or other people to help them do so. Their objects or environments can however also be triggers to shift their perspective and think about things in a new way. The process of exploration is supported by writing things down or talking with other people. Voice input was stated as a promising way to journal. Especially tangible objects, like the reflection card, that adhere to the criteria of restorative environments, are found interesting to interact with. In Chapter 2, I have demonstrated that technology can be valuable not only for remembrance, but to show new perspectives. Through its computing capabilities, technology can identify patterns, find new relationships, and present information to users in various ways. This is arguably the place where technology can be of the most help. This phase is almost like an iterative process that restarts small, separate reflections. Participants' liking of voice as an interaction method suggests a focus on dialogue-driven reflections, and their preference for physical objects advocates for the design principle of discovery.

People do not want to be distracted in the process of reflecting, which means that the provided time and space need to be maintained until the individual closes the reflection. The appropriate design principles and mechanisms should be the same, while I want to highlight once more the importance of the introduced technology being non-distractive. It has become clear in past research that much of an individual's ubiquitous technology is counterproductive to the task of reflecting.

Ideally, at the end of a reflection, individuals have learned something new about themselves or their behavior. The odds of getting there are defined by the trigger, throughout the reflection process, and by people's attitudes. This need can not inform design principles or features, but the result that should be achieved by the support concept created in this project. Technology, through personalization and creating connections between information, can help to end reflections with an insight.

CAPTURE

People need to convert their reflection learnings into an adjustment for their behavior change strategy. After reflecting on their behavior change process, people expect to have identified barriers and enablers to their change process. They also hope to know how to adjust their strategy based on the new learnings. Again, the personalization & data capturing capabilities of technology could help to support that goal. Concepts from the literature that support the capturing of reflections seem to focus on dialogue-driven reflections through e.g. virtual assistants (Kocielnik et al., 2018). From the two main benefits of reflections on the behavior change process identified in chapter 2 (increasing motivation and personalizing the change strategy), I want to focus on helping people find the change strategy that they thrive on.

5.3 The Design Vision

Based on the summary of user needs and their connection to design principles and mechanisms, a design vision was developed that aligned with the desired characteristics of reflections. Additionally, interaction and embodiment principles were concluded from the synthesis of results. The interaction principles are going to drive the user-concept relationship, while the embodiment principles are going to drive the physicality, form, and materiality of the final concept. The design vision and the interaction and embodiment principles informed the development of the final design concept and its features.

Design vision

MY DESIGN VISION IS TO USE TECHNOLOGY
TO CREATE A DISTRACTION-FREE ENVIRONMENT
THAT SUPPORTS INDIVIDUALS TO REFLECT ON THEIR
HEALTH BEHAVIORS. THIS REFLECTION SUPPORTS
INDIVIDUALS IN IDENTIFYING BARRIERS & ENABLERS
TO FIND A FITTING STRATEGY FOR ACHIEVING
THEIR HEALTH GOALS.

Interaction principles

SLOWNESS, NON-DISTRACTION, INTENTIONALITY

Embodiment principles

SIMPLICITY, PORTABILITY, INTIMACY

5.4 A Design Proposal

The design vision and principles that have been defined in the previous section allow us to position the concept in the design space. This involves taking a position in the reflection process but also selecting design mechanisms and principles to focus on.

I want my concept to focus on the “support” and “capture” part of the process, while still creating the right reflection environment. The interaction principles of slowness, non-distraction, and intentionality contradict the introduction of persuasive triggers that force themselves into people’s attention. Rather, a subtle trigger can be integrated into peripheral attention, and thereafter the focus lies on supporting people in the reflections themselves, as well as informing their change strategy.

I want my concept to be environment-driven, adhering best to the interaction principles defined above. An environment-driven reflection uses elements of restorative environments which are all about slowness and a distraction-free space. I want to use this mechanism as it treats attention more deliberately and carefully. Thereby, it also strengthens the chance of people having the proactive reflections that they desire.

I want my concept to be dialogue-driven because of many reasons. First, it is best suited for the embodiment principle of intimacy. It is also the mechanism identified to give the most guidance while keeping people from overthinking. Lastly, it is a common approach in counseling and many participants already used a dialogue-driven method in their reflections, such as when they use journals or speak with friends and family.

In terms of the design principles, discovery and mindfulness correspond best to the desired goal of the design concept. Both of them are best suited to support slowness and keep people from being distracted. With the creation of this environment, they also support proactive reflections and non-intrusive triggers. Principles like interactivity, ambiguity, and abstractness can also lead to people seeing different perspectives on their behavior and thus enabling deeper kinds of reflections.

The way that I intend to use technology is by helping them not be distracted and identifying personal strategies for change. I aim to design with technology that fades into the background and aids to create a no-tech environment. Since

technology is often the reason why people are kept from reflecting in the first place, this is a particular challenge and opportunity. In a way, the technology introduced in the concept should reverse the negative consequences introduced by other technology.

Above decisions have been taken in favor of others because I believed that they best fitted the design vision, and the interaction and embodiment principles. For example, I believe that the presenting of data and an information-driven reflection would not fit the qualities of slowness and intentionality that are core to reflections. At this point in the process, decisions needed to be taken, but I acknowledge that different choices could have potentially led to other interesting concepts that might have been as effective in supporting reflections.

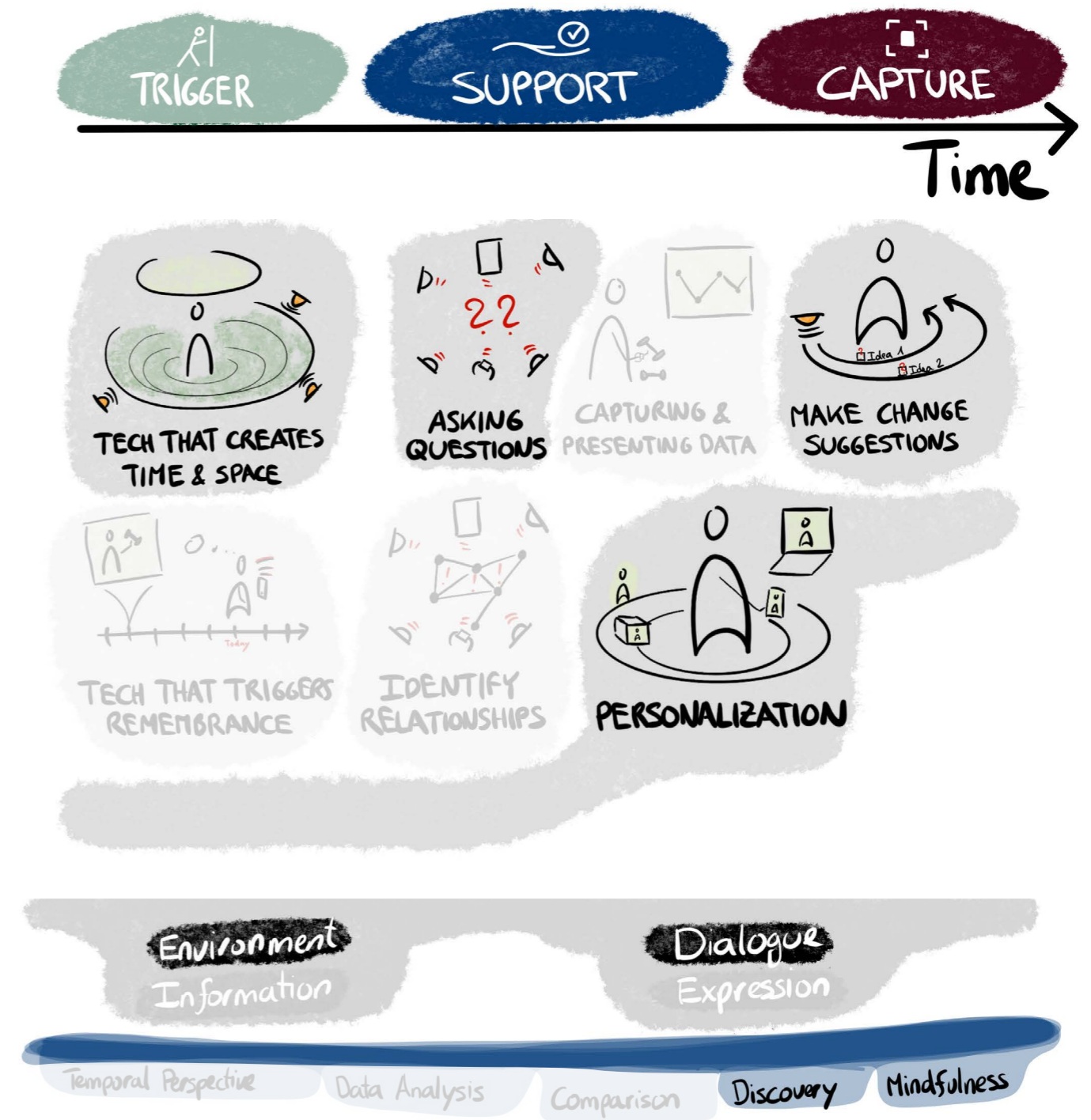
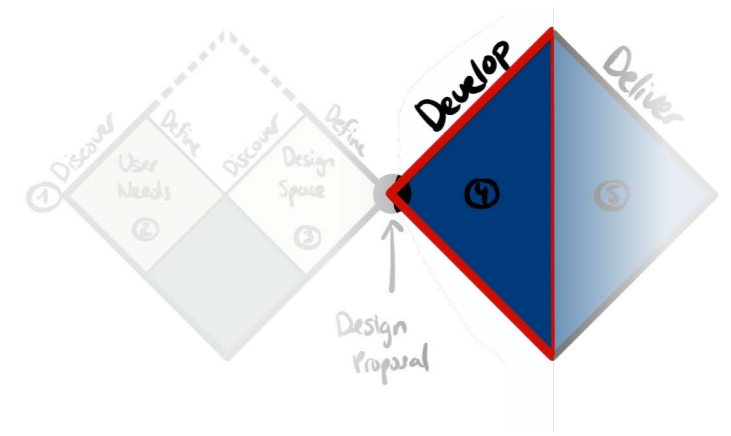
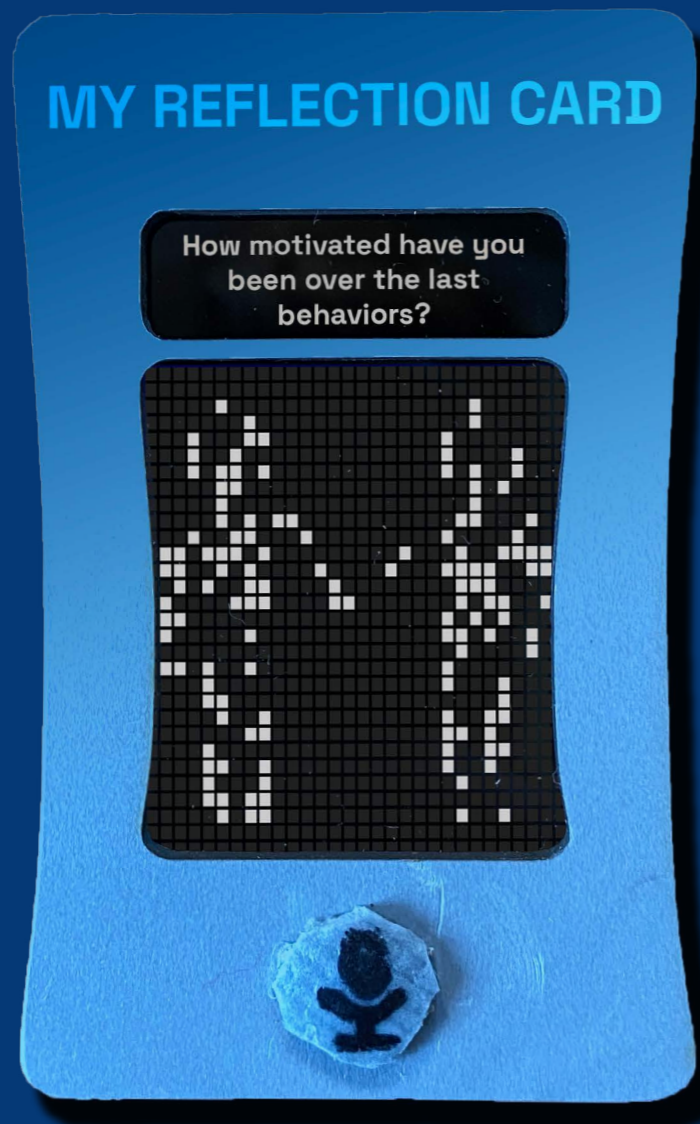


Fig. 64: Design proposal with respective focus areas on process, technology, mechanisms, and principles



06 Design Concept: The Reflection Card

This chapter introduces the reflection card concept that supports people's reflections as defined per the previous chapter. The concept will be presented in a summary, before diving into the separate components of the concept. These components are the scenario of use, the physicality of the card, its displays, and the back-end data architecture. The concept will then be evaluated before its final key features are presented and a reflection on the design process will be done. This chapter represents the last part of the double diamond process.

6.1 Concept Summary

The Reflection Card is a physical-digital product that includes a physical card and a digital app. The card has two displays and is attached magnetically to the back of phones. When users take the card off their phones, the phone switches to a no-distraction mode using NFC, and the displays light up. Questions about people's behaviors are prompted on one display, while the other shows an abstract drawing to trigger new perspectives. Users can reflect by speaking to the card, and the card uses AI to identify barriers and enablers to their current behavior change strategies. Each reflection ends with a small encouragement, task, or idea based on people's greatest barrier or enabler. The digital application shows how barriers and enablers evolve over time and it generates a personalized strategy for change after every few reflections.



Fig. 65: The reflection card

6.2 Concept Narrative

Sophie is an imaginary user of the reflection card concept. A few months ago, she decided that she wants to eat healthier by abstaining from industrial sugar. From time to time, however, she buys sugary items at the supermarket or eats unhealthy snacks that her roommate has bought. She is generally interested in how to change her behavior and decides to use the reflection card hoping to better reach her goal of becoming healthier. She also wants to gain some self-insights and discover what it is that gets her to "fail" on her strategy sometimes. For a general process, see Figure 66.

ONE INTERACTION

One early morning when Sophie stands on the platform waiting for her train to work, and kill the time by scrolling social media, she remembers the reflection card sitting in her peripheral attention at the back of her phone. She starts to think about her recent eating behavior and decides to pick up the card, hoping that it helps to increase the success of her behavior. She also thinks that it could be nice to indulge in that environment of focusing her attention deliberately on her thoughts. The phone switches into a no-distraction mode using NFC, and the display lights turn on, indicating that it is ready for Sophie to reflect.

When Sophie places her thumb on the reflection card, the upper screen asks a first general question about how her behavior was going recently, and the bottom screen evolves into a first random pattern of pixels. Sophie lifts the card and starts to answer the first question by speaking to the card: "I feel like I am fairly consistent with resisting the urge to buy sugary snacks, but when I was at the supermarket last time there were so many people... it was hectic and without really thinking about it... I bought some cookies". The voice recognition picks up the word "people" and associates it with the behavioral influence of social support. The bottom display visualization evolves into an abstract representation of people, to trigger her thinking more about it. She looks at the visualization and continues: "It might have been that the other people got me frustrated which led to making a bad decision. But when thinking about other people I must say that my roommate really helped

me to not eat them. He ate almost all of them himself. I was both happy and angry (laughs)." Sophie does not know what to say anymore, so she presses the button for another question.

This time, she is asked about a specific influence: "How confident are you to continue with positive behaviors?" She replies: "So I think that I am confident I can do it and resist the sugary urges, but sometimes I am tired and then it just happens. Or I am in a hurry and I can't make good decisions." Again, the drawing picks up the word "hurry" and portrays an abstract clock that makes her continue the reflection: "It also happens sometimes when I get stressed at work. Then I sometimes need a chocolate bar that helps me calm down and give me a little reward."

With the next iteration, the upper display shows an hypothesis that is based on Sophie's last reflections: "You have great knowledge of the benefits of not eating sugar!" Sophie replies: "That is true... I guess. I know that I feel better and more energized when I stick to good behaviors for a longer time."

With every answer that she finishes, the drawing can push her to think further, or she can press a button to change the upper question. This alternates between a question and a hypothesis that is always related to a specific behavioral influence. The hypothesis is built on the speaking that has already happened, or the trends identified over multiple reflections. In the background, the AI classifies the spoken thoughts of her current reflection into barriers and enablers of her behavior. This specific reflection shows great motivation and knowledge of the benefits, but some weaknesses her ability to make plans as well as her resource-availability of e.g. time.

When Sophie lifts her thumb off the card, she indicates that she wants to stop her reflection. Since this can happen accidentally, a countdown is first displayed that indicates the end of a reflection. If Sophie wants to continue with the same question, she can lay her finger back on the card. Sophie decides to end her reflection and the greatest barrier and enabler is identified based on this entire reflection. The card processes the information for a few seconds before it shows a small encouragement, insight, or task to Sophie. In this reflection, the card shows her: "Write down a time and day where you would ideally like to go to the supermarket." She is pushed to increase her planning and decide on a time where she has the resources to make good decisions. Sophie closes the reflection, puts the card back on her phone, and enters the train.

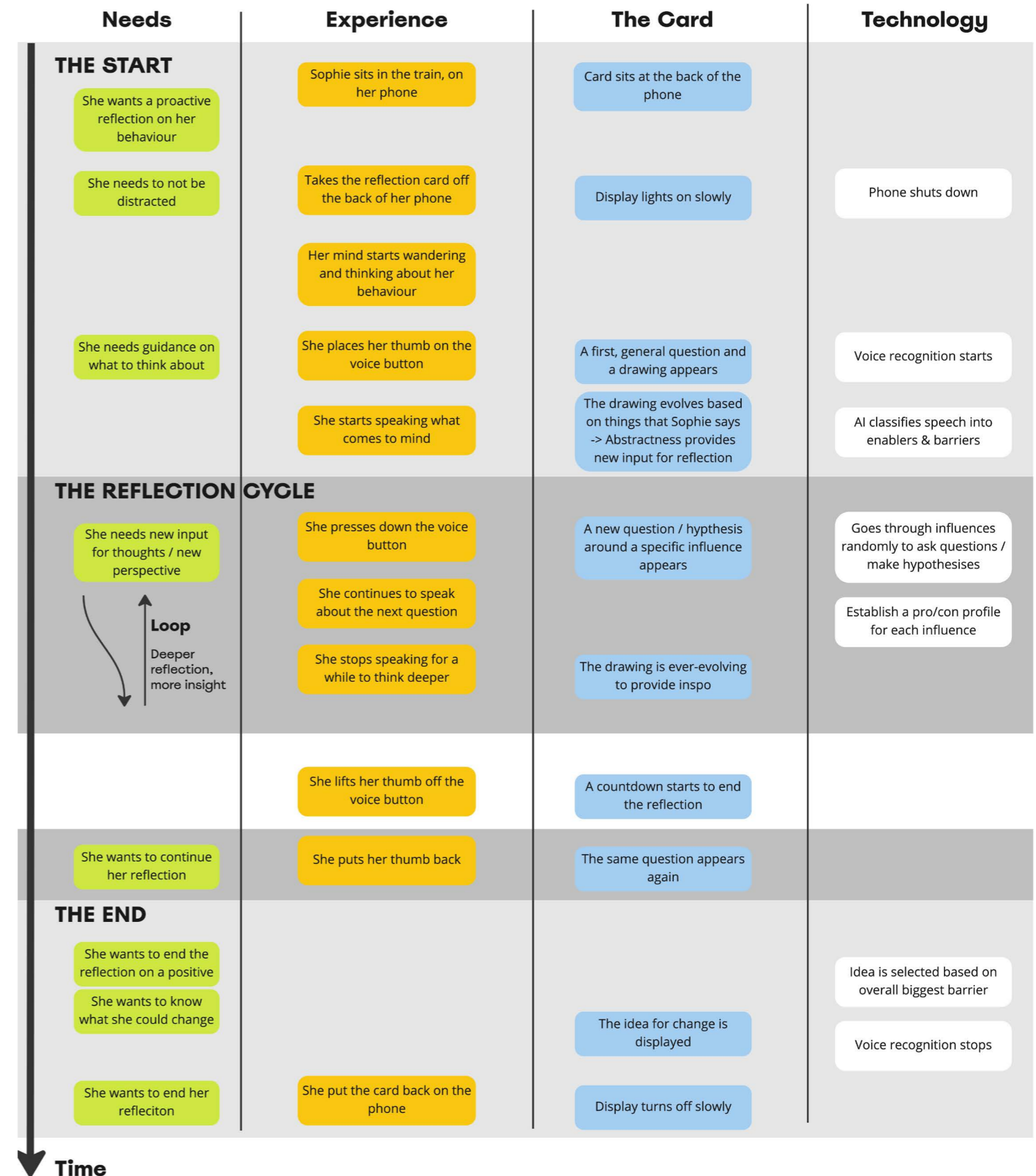


Fig. 66: User journey of one interaction with the reflection card

OVER MULTIPLE INTERACTIONS

Over the course of a week, Sophie reflects multiple times. With each reflection, the AI back-end system gets better at identifying barriers and enablers, and some trends are starting to appear. When opening the digital application, Sophie sees that the AI is almost ready to propose a new strategy to her that will help to accelerate her behavior change.

Sophie engages in another reflection whose questions and hypotheses are now informed by all the previous reflections and feel more personalized. While the current reflection informs most of the hypotheses and also the take-away at the end (since the behavioral influences can often change much from one instance to another), some insights about trends can also be given. After completing another reflection and visiting the digital application, Sophie can unlock the new strategy proposed by the AI, which is based on her behavioral barriers and enablers. It could say something like: "You demonstrate great motivation, but your behavior could improve if you have a clearer plan and more resources. Write down when you want to go to the supermarket each week so that you can make the best decisions. Try to avoid going to the supermarket or making decisions in times where you are stressed or tired." The wording needs to be carefully selected and always be positively framed.

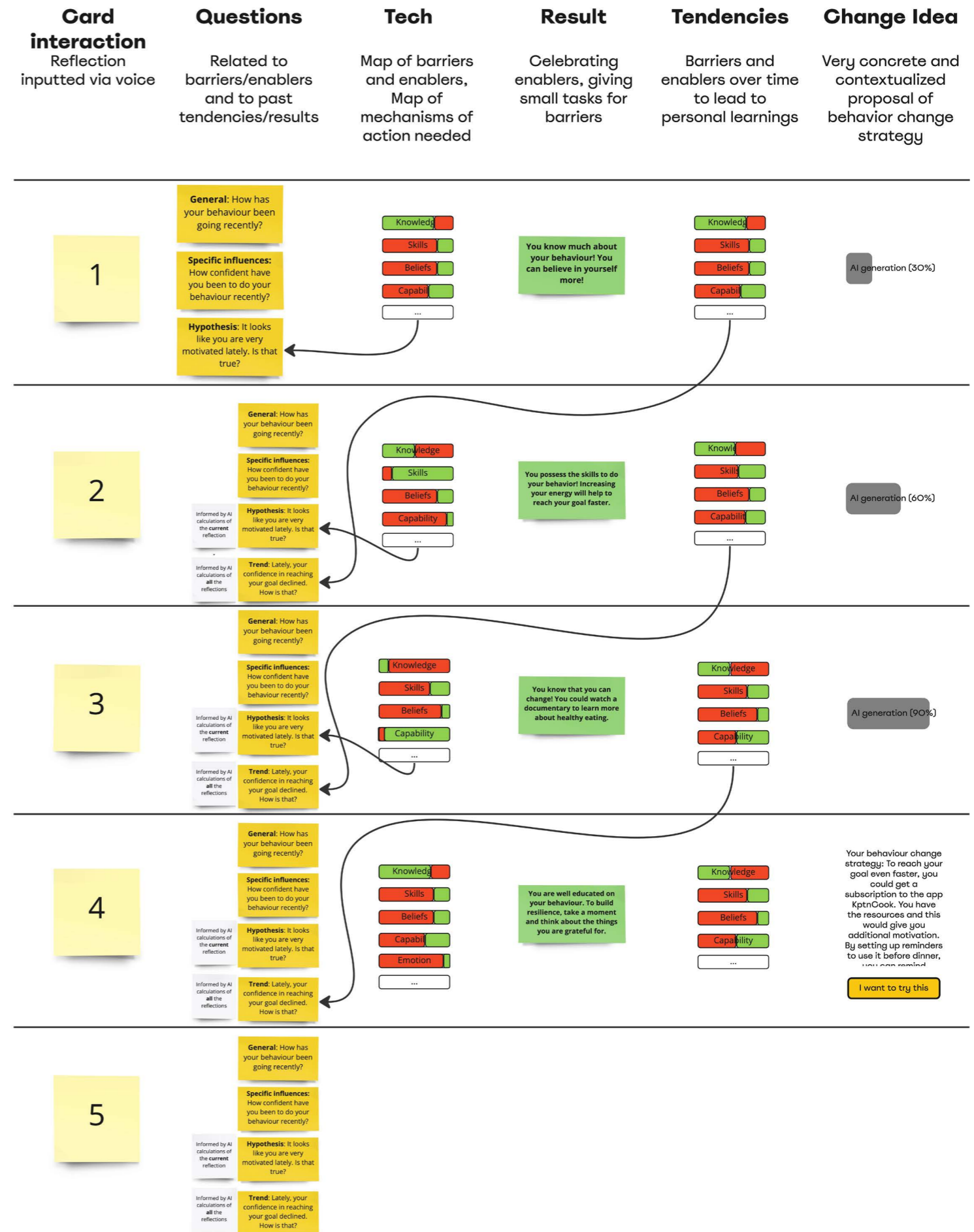


Fig. 67: Connections between multiple card interactions

6.3 Physicality

The reflection card is designed to embody the principles of simplicity, portability, and intimacy, as defined per the design vision. To achieve portability, it was made to be the size of a credit card but with added thickness and weight to improve its feel in the hand. The dimensions of the card are approximately 86 x 54 x 10mm, a threshold that was found not to increase the phone's footprint too much. The back of the card features a narrow indentation that magnetically connects to a strip that can be attached to the back of a phone. The card is made of soft plastic with round edges and a slight inward curvature to improve its grip and give it an anthropomorphic character. Thereby, it fits with the intimate character of reflections and makes it a more credible partner in the dialogue-driven reflection. A voice recognition button, wrapped in comfortable microfiber, is also included on the card for added functionality. It recognizes the touch of a finger to launch the reflection, but can also be pressed down to change the question on the card.

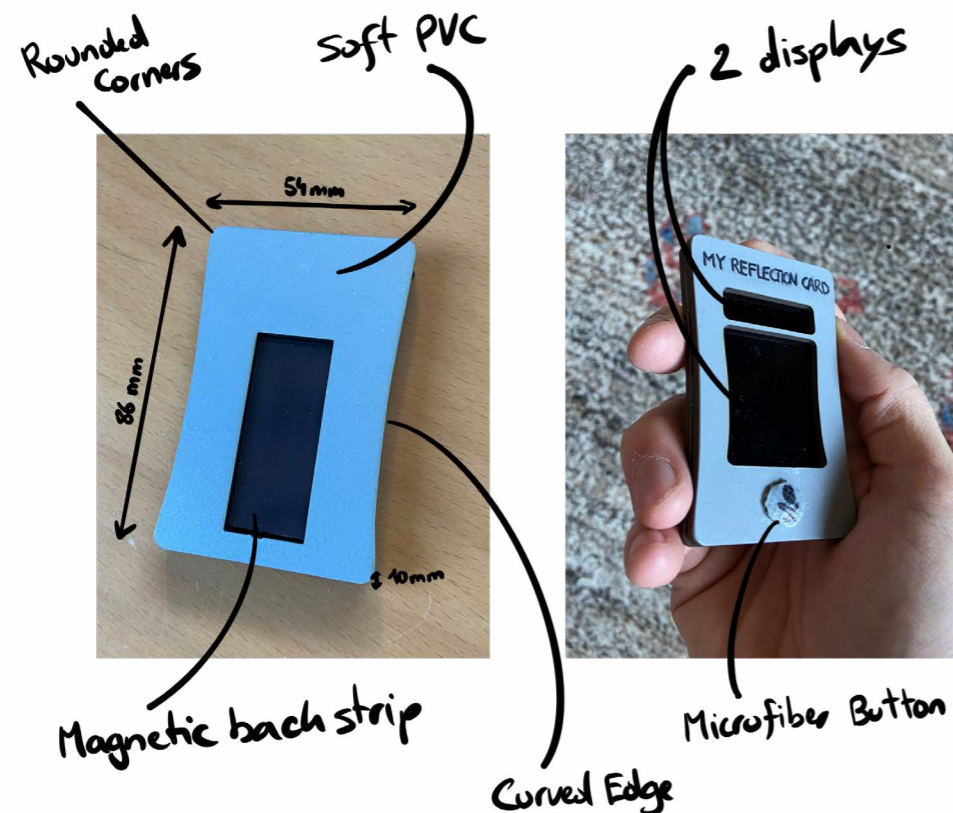


Fig. 68: Front and back of card, annotated with materials used

6.4 Card Displays

UPPER DISPLAY

The upper display of the reflection card is where the questions, and hypotheses, as well as other instructions are shown to its users. Whereas the bottom display is designed for inspiration, the upper display is what guides the users through their reflections. In alternation, the questions and hypotheses are displayed and roam around specific behavioral influences such as motivation, optimism, social support, or behavioral resources.

ART ANIMATION

Apart from the question or hypothesis on the upper display that people can change with the push of a button, the second display shows an abstract visualization made of a pixel matrix. The purpose of this display is to use the design principles of discovery such as abstraction and ambiguity as a means to encourage further thoughts and support people in creating connections.

When people start a reflection, all the pixels of the matrix are dimmed (Figure 68) and then slowly start to enable themselves in seemingly random patterns (Figure 69). As people speak to the reflection card, it picks up words that are related to specific behavioral influences. Words like "clock", "late", "hurry", etc. could all be related to the influence of not having enough time. When a user mentions such a word, a predefined pixel constellation that looks like a clock, is enabled and the pixels slowly evolve into that drawing. However, the pixels will always keep "moving around", so that the drawing is never clearly visible (see Figure 70 or 71). The visualization should stay open for interpretation while a connection to the reflection can be perceived. Whenever a new word related to a different influence is mentioned, the pixels slowly evolve into that new drawing. This process continues until the user decides to stop a reflection. When they do so, a small encouragement, insight, or task is displayed on the bottom screen until the users put the card back on the phone. To demonstrate the feasibility of AI coming up with such an idea, I have played around with ChatGPT (<https://chat.openai.com>) to generate examples

such as in Figure 72.

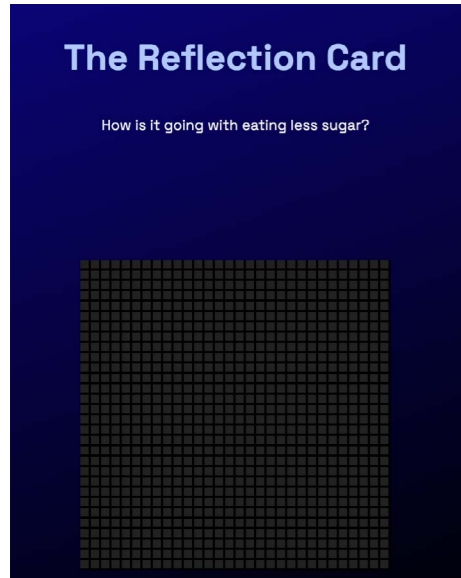


Fig. 68: Card Display with dimmed pixels

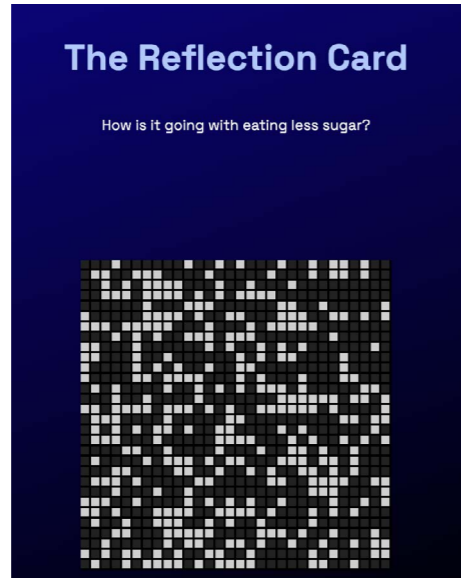


Fig. 69: Card Display with pixel matrix animation

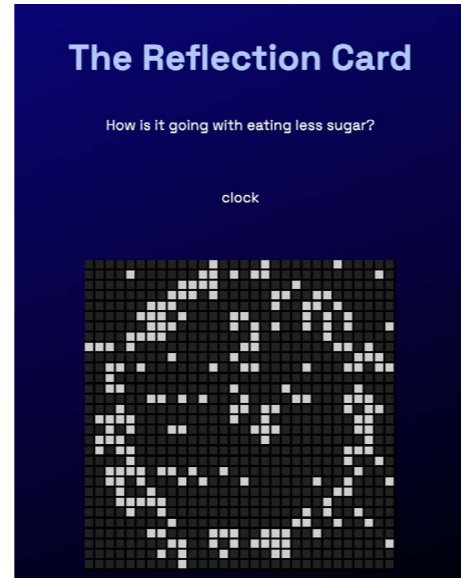


Fig. 70: Card Display moving towards the visualization of a clock

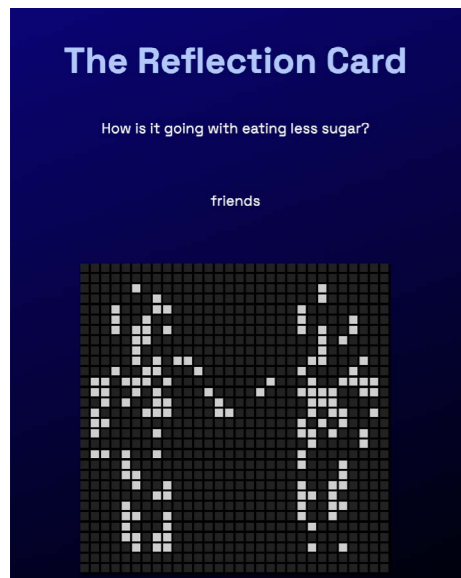


Fig. 71: Card Display moving towards the visualization of 2 people



Fig. 72: Screenshot of an AI conversation with ChatGPT

USABILITY

Although users' interactions with the card were kept as simple as possible, I still wanted to elevate usability as much as possible for the card to take away any mental burden and allow full focus on the reflection itself. Thereby, simplicity and intentionality could be guaranteed, and distractions avoided.

As soon as the card is taken off the phone, the display lights up to indicate that the card has been turned on and is ready for a reflection (see Figure 73). On the upper display, the instruction "Start your reflection by placing your finger on the button" is shown for users to know how they can start their reflection. To provide feedback that the card listens to the voice of their users, a sound wave animation is shown that reacts to the talking (see Figure 74). The animation starts and stops deflecting as users go back and forth between thinking and speaking. After users click the button to change the questions, the upper screen blinks to draw attention to the question and away from the drawing. As users lift their fingers, the upper screen turns into a countdown to indicate that the reflection ends soon (see Figure 75). This allows for some threshold time if people accidentally removed their finger. In the meantime, the bottom screen turns into a processing animation to show that the card generates a final takeaway based on the user's thoughts. The takeaway is then displayed together with an indication of how confident the AI is in that proposal. This gives users some transparency into the AI back-end and allows them to put the takeaways into perspective. When users finish their reflection and put the card back on the phone, the displays turn dark again.



Fig. 73: Display lights up when card is taken off the phone



Fig. 74: Sound wave animation when speaking

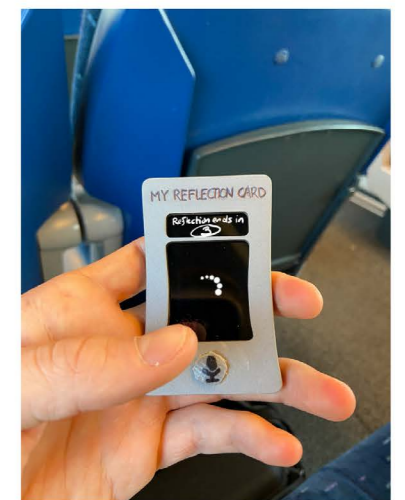


Fig. 75: Countdown animations when thumb is removed

6.5 AI Architecture

AI MODEL

Although the AI model has not been built, I want to demonstrate its feasibility and connect it to theory. The goal of the AI model is to derive current behavior change influences from an individual's reflection. The influences that the AI can use for classification are those of the Theoretical Domains (TDM) framework (Michie et al., 2005). These high-level behavioral influences include individuals' knowledge about their goals, their level of skills involved in the behavior, having a clear plan and goal in place, social influence in the behavior, and others (see Figure 76 for the full overview). These influences also link directly to the behavior change wheel or COM-B model by Michie et al. (2014) in which influences are divided into "capability", "opportunity", and "motivation". For each reflection, the thoughts that users express to the card are analyzed by the AI. Its words and sentences are classified into the high-level behavioral influences. Thereby, it identifies to what extent every influence is either a barrier or an enabler of the behavior in the current strategy that users pursue. A map is created in which the greatest barrier and enabler become evident and drive the reflection's final takeaway.

Reflection:
 I feel like I am fairly consistent with resisting the urge to buy sugary snacks but when I was at the supermarket last time there were so many people... it was hectic and without really thinking about it... I bought some cookies. It might have been that the other people got me frustrated which led to making a bad decision. But when thinking about other people I must say that my roommate really helped me to not eat them. He ate almost all of them himself. [...] So I think that I am confident can do it and resist the sugary urges, but sometimes I am tired and then it just happens.

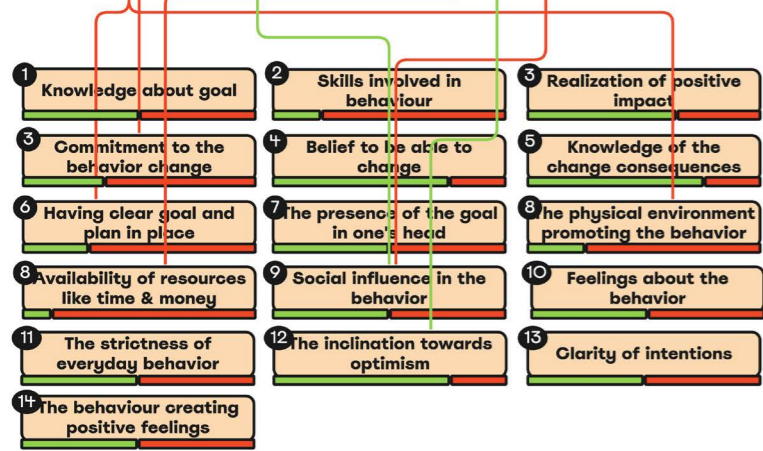


Fig. 76: Visualization of how the AI maps words and sentences to decide how much the behavior change influences by Michie et al. (2005) are barriers or enablers

TRAINING

The model needs to be pretrained before it is integrated into the reflection card concept. That allows immediate use of the concept and further personalized learning over time. In this generic pre-training, a diverse audience from different backgrounds and communities needs to be selected to cover as many experiences as possible. I imagine the training to happen by people telling stories about specific behavioral influences, like when they were socially influenced. This allows us to manually classify stories and influences, based on which the AI learns to classify future reflections.

When people start to use the reflection card, they can do additional pretraining with their personal stories. This happens in the digital application via a survey that is designed specifically for that purpose (see Figure 77). Users can thereby adjust the model to their experiences and it will need less time to give good takeaways and present personalized strategies. As users reflect with the card, the questions that are asked about specific influences, lead to a re-training of the model for better results.



Fig. 77: Question of the application survey to help train the model

BACK END ARCHITECTURE

The goal of the concept is that reflections can result in small takeaways, as well as a personalized behavior change strategy over time. To convert the voice input into such results, we followed an adapted process of Ojo et al. (2019) in their guide from theory to intervention: 1) Identify barriers and facilitators, 2) Identify intervention principles 3) Identify behavior change techniques 4) combine them into an intervention. See Figure 78 for a process overview.

The Theoretical Domains Framework is a useful method for systematically investigating influences on behavior change (Francis et al., 2012). Many studies across various disciplines and settings have used TDM to identify barriers and enablers to behaviors for the purpose of designing behavior change interventions (Tombor & Michie, 2017). Barriers and enablers directly link to evidence-based intervention principles, determined through the framework by Tombor & Michie (2017). For the behavior change techniques, I decided to go by the behavior change taxonomy V1 (Michie et al., 2013). These techniques can be connected to the TDM influences directly (Michie et al., 2008), or mediated by mechanisms of action (Carey et al., 2018). From the evidence-based principles that correspond to users' current greatest barrier, a quick tip or encouragement can be generated. To generate a personalized strategy, an individual's goal, the most urgent principle, and corresponding behavioral techniques are combined.

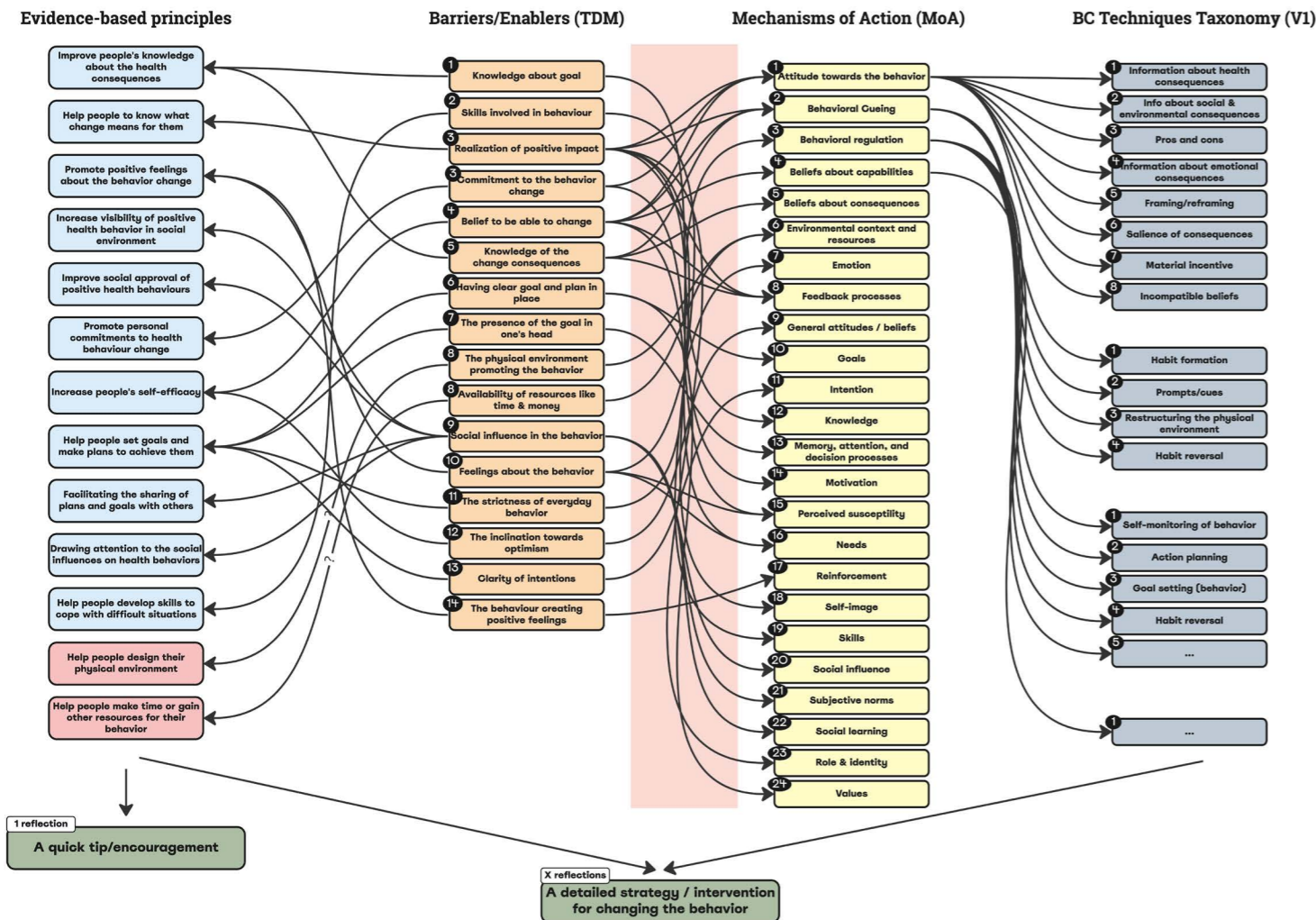


Fig. 78: AI back end: How barriers and enablers connect to principles and techniques to generate the reflection results

6.6 Digital Application

The reflection card digital application is an addition to the physical card that can be used optionally and no explicit triggers to visit that application are designed. It is the place where users can set initial parameters such as their goal and current strategy, and where they can train the AI model by answering questions about their behavior change barriers and enablers (see Figure 77). The main screen revolves around a dashboard in which users can see how their behavior change influences evolved over time, and revisit their reflection takeaways. This dashboard and seeing behavioral developments over time can lead to even more reflection and self-insight.

The most important feature of that platform, however, is that it shows how much the AI has developed toward proposing a new behavior change strategy (see Figure 79). A timeline is shown that projects the number of reflections that still need to occur before the AI has finished generating a new strategy for change, based on all previous reflections. Only when the AI has an understanding of barriers and enablers that surpasses a certain threshold, it can create a more personalized strategy that is informed by people's most dominant behavioral barriers and enablers. When it is finally generated and people visit the application, they can judge whether they want to adopt the new strategy going forward.

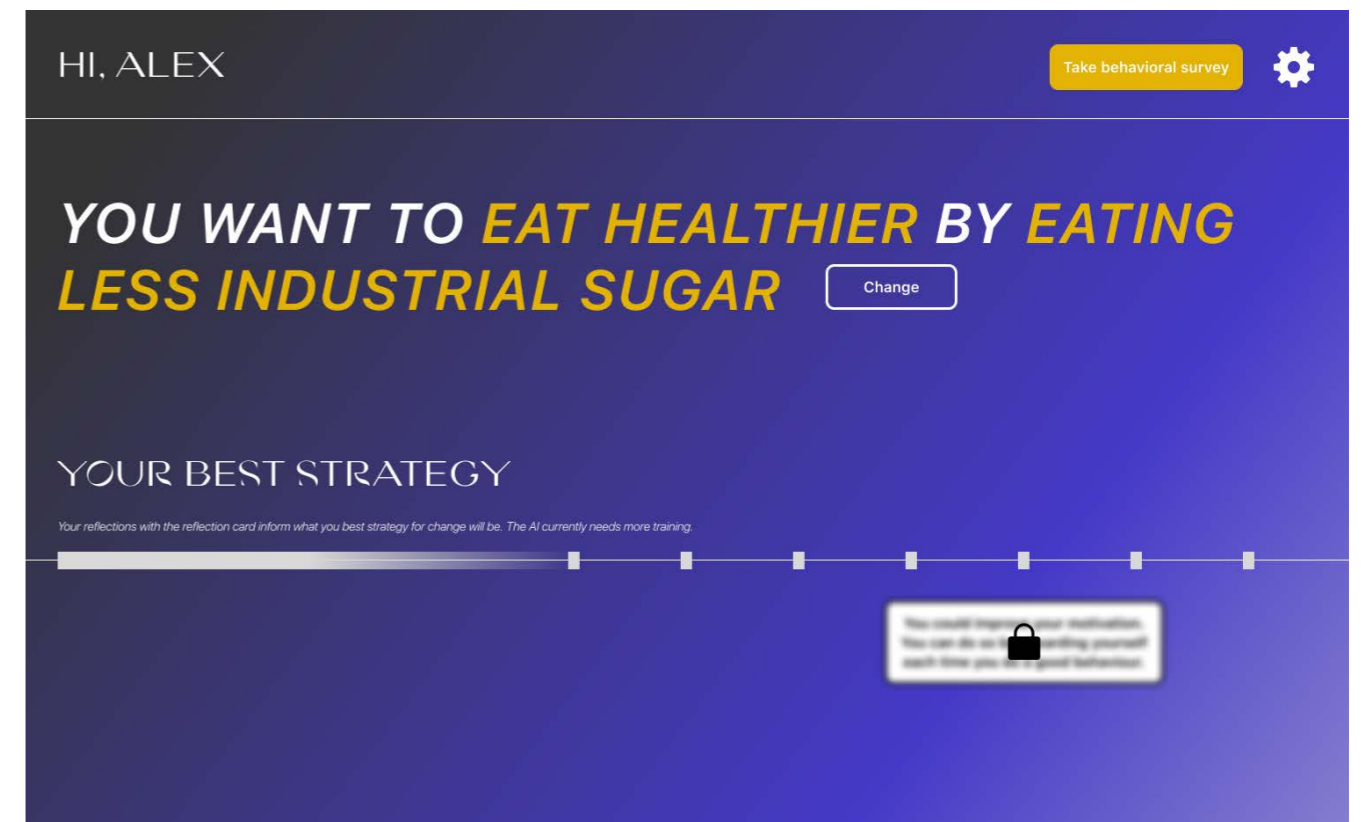


Fig. 79: Part of the application, showing progress towards the generated strategy

6.7 Key Concept Features

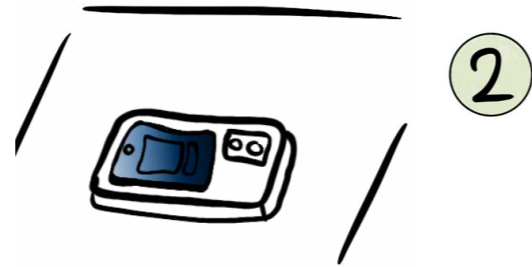
In this section, I want to present this concept's key features, how they address the reflection needs found in chapter 3, and how they relate to the design goal established in the previous chapter.

Card on the back of user's phone: The first key feature is the fact that the reflection card attaches magnetically to the back of people's phones. This brings the card into peripheral attention, being a non-persuasive trigger in moments where reflection environments can be given. The contextmapping study has shown that the best reflection environments are on commutes, at the beginning or at the end of days, which are also moments of high phone usage. Feeling the card while using the phone can make people think about their behavior in a non-distractive, intentional way that aligns with the design goal and the literature findings.

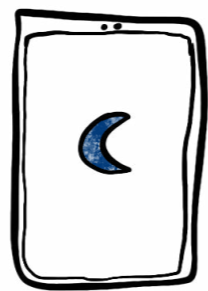
Shutdown of the phone: When people use the card, their phone shuts into "do not disturb", which allows them to fully focus on the reflection. Through technology and a simple interaction, time and space are created which increases the odds of a proactive reflection. People do not want to be distracted during their reflection, as this hinders them to develop new thoughts. This feature aligns with many of the user needs, as well as the design goal and interaction principles of slowness, non-distraction, and intentionality.

Prompting of questions: People need a clear starting point to reflect on and then be guided through the process. The card asking questions addresses these needs which align with standard counseling methods. Asking questions has also been used in many reflection concepts and it an established way technology can support deeper reflections. This also gives control over the positive language that is aimed for. In the study, people reported that asking questions helped them to also see different perspectives, provide further food for thought, and get to the core of an issue, all of which help to find barriers and enablers for an individual's health behavior.

The addressed user needs per feature, with their numbers as per Chapter 3 on page 47.



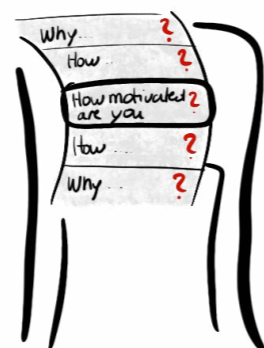
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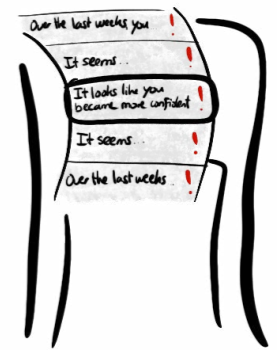
Prompting of hypotheses: Similarly to asking questions, hypotheses about one's behavior are a more provocative approach to triggering further thoughts and showing new perspectives. It is also a way for the AI to communicate with the user and help to learn about themselves by presenting what the AI has been learning so far. Thereby, hypotheses are also a way of making the learning of the card transparent and evident to users.

Abstract visualization, reacting to the reflection: The visual that is shown on the bottom card display leads to further reflection by adhering to many of the qualities of discovery. Discovery is a design principle defined in chapter 4 that is a focus of this concept. The abstract and simple nature of this drawing, combined with the ambiguity that comes from the reaction of the drawing to the reflection, leads to more thinking. Technology is particularly good at triggering reflections through showing data in an abstract way. It changes the perspective, fuels the quest for understanding, and leads to finding barriers and enablers.

Journaling through voice recognition: Using voice as a way to interact with a reflection concept has been proven valuable in chapter 5. It is an efficient way of expressing thoughts and it adheres to the intended intimate feeling of the concept. It supports the dialogue-driven nature of this reflection concept. Both in the literature and the contextmapping study, people report benefiting from conversations to gain self-understanding.

Concrete takeaway informed by barrier: After people's reflection, the card shows a concrete takeaway that is informed by the reflection. This can be a tip, encouragement, or quick action to act on the identified barrier. Having a concrete takeaway gives people a positive end to their reflection and it gives them guaranteed learning. This directly adheres to the design goal of supporting people to find barriers and enablers to their behavior and to help them successfully reach their health goals.

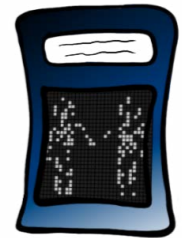
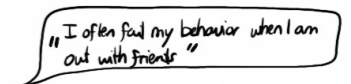
Generation of a behavior change strategy: After every few reflections, the AI generates a behavior change strategy that is tailored to the users based on their reflections. This gives people a personalized feel of the concept that adheres to intimacy. This feature is key because it directly helps people to find what fits them by proposing something by itself. Through the technology's personalization capabilities to adjust the behavioral strategy to individuals' barriers, enablers, and contexts, they can potentially be empowered to reach their health goals more successfully.



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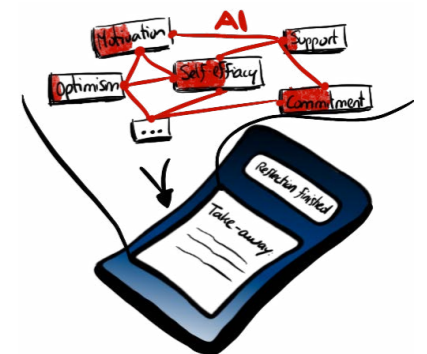
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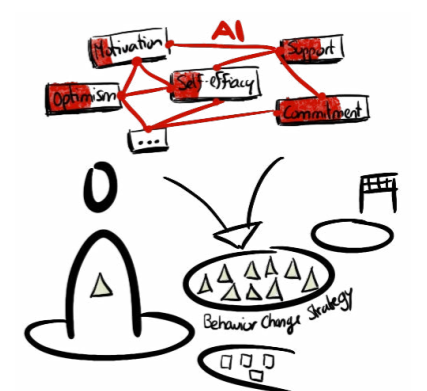
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6.9 The Road to the Concept

Although the key features and characteristics of the concept were driven by the design goal and principles, many small decisions needed to be made during the development process. This section is dedicated to reflecting on how these decisions were made. I will first present the methods that I used, before diving into some of the developments on the form and material, the card drawing, the triggers, and more.

METHODS

I used many different methods for making my design decisions, getting inspired, and informing myself. The presentation of my concept to people that did not fit the intended target group often gave some interesting insights that could still inform the design of the concept. Doing cognitive walk-through sessions especially helped to see if the concept was misaligned with people's everyday lives or how it performed on usability. Acting out the intended use with a preliminary prototype also helped to envision the interactions and allowed me to detail these further. Conversations with other experts in related fields helped to link the concept to models in theory. A conversation with an AI expert specifically informed the iterations on the back end of the concept. During the design process, I have also used AI as a means to gather design inspiration. For example, I used ChatGPT (<https://chat.openai.com>) to generate takeaways from barriers, principles, and techniques, so as to determine its capability to come up with such. I also used AI specifically to generate images for the card display and thereby experiment with different styles. Last but not least, I used drop-in design sessions where I sat in the TU Delft design faculty playing with materials, forms, and colors and would occasionally ask design students about their impressions. Most of these design methods were conducted to be inspired, and I still made final decisions based on the design goal and principles.

DEVELOPMENT PROCESSES

When I thought about how to trigger people, I initially thought about using lights or vibrations on the card to draw attention to it. However, it is very difficult, even with technology, to capture people's everyday lives and find the best reflection moments for such triggers. I definitely wanted to avoid that there would be an additional attention-grabbing object in people's lives, and adhere to the design goal and principles, so I decided the card itself in people's peripheral attention would be enough of a trigger. If people are more aggressively triggered, it also increases the chances of defensive reflections. This non-persuasiveness is a quality of this concept.

I set out to create an object that was with people in the moments where reflections were most probable. I initially planned to have the card sit in people's wallets, but when acting it out, I realized it would soon disappear between credit cards and food vouchers. The keychain was also not a good place, since people only used it briefly for very specific tasks. These were often short transition periods in which there was no time for reflection. The phone ended up being the object that people most often used in times when conditions for reflections were given.

After a paper card was paper, the next iteration was rectangular and made of polylactide (PLA). After the feedback I gathered at the university, I decided that I could do more effort to achieve the embodiment qualities. I wanted to make the card more intimate and feel better in the hand. That is how I came to decide on the rounded corners and the soft button. To increase intimacy, the one screen that the initial prototype had was converted into two separate screens and the card was slightly curved on the sides. The final card looks much less like a mini-phone and with the soft plastic, round curves, and microfiber button, it sits comfortably in people's hands. See Figure 80 for a full overview of the card iterations.



Fig. 80: Iterations of the concept and its material over time

The convergence towards the final character of the card visualization came through experimentation with AI image generation. To quickly gather an impression of different drawing styles combined with behavioral influences, I used Stable Diffusion and their Dream Studio (<https://beta.dreamstudio.ai>). You can see some example pictures of my most liked styles generated below, from "line art drawings" (Figure 81 & 82), "drawings in the style of Milton Glaser" (Figure 83), and "dot drawings" (Figure 84), to "pixel matrix". The visualizations needed to be abstract, which is why I initially liked the dot and line art drawings of behavioral influences. For example, I really liked what the AI-generated for "line art of motivation, minimalist, one line" (Figure 81). However, when I showed such drawings to people, they mentioned that it was too abstract to see the connection to their behavior. That is why I ended with a pixel matrix system, but on concrete words that are said during the reflection.

Overall, I see the main qualities of my concept in different things. First, I think that the focus on treating attention very carefully has led to many characteristics that encourage and support reflections. It has introduced a non-persuasiveness, and deliberateness that is core to reflections. I also see the balance of abstractness and concreteness as a quality because it is a thin line to walk, and both are necessary for people to successfully reflect. The visualizations provide the needed abstractness to trigger new thoughts, while the takeaways and strategies are clear and tangible reflection results. This leads me to the last main quality, which is the thoughtfulness that went into setting up the AI model and back-end system, as well as connecting it to theory. It has demonstrated that the connecting of technology and reflections can indeed lead to more successful health behavior change.

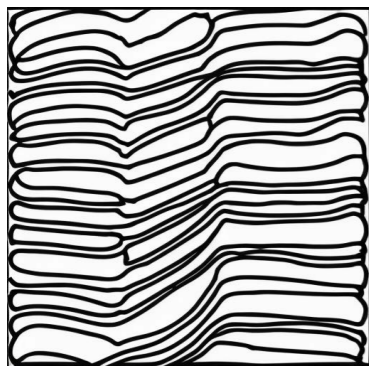


Fig. 81: AI art generation with prompt: line art of motivation, minimalist, one line

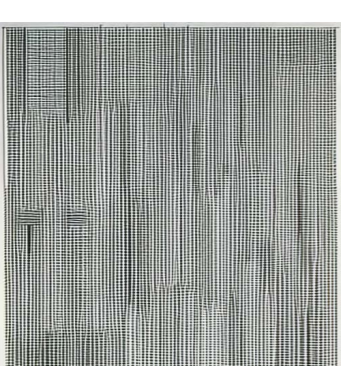


Fig. 82: AI art generation with prompt: line art of boredom, massimo vignelli, minimal



Fig. 83: AI art generation with prompt: A line art illustration of progress by Milton Glaser

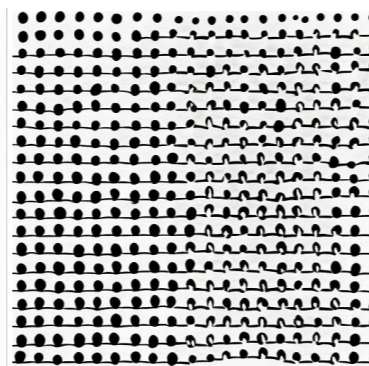
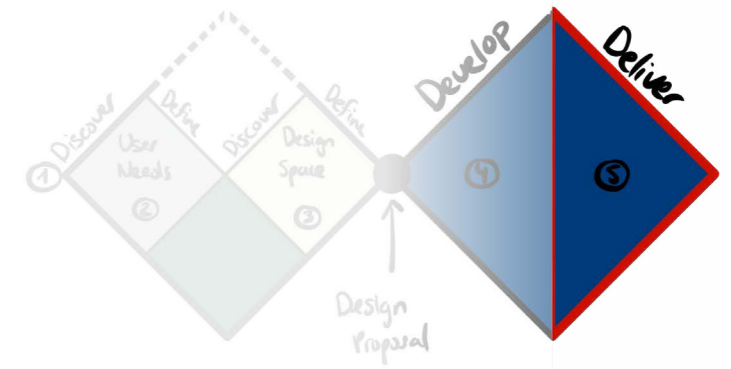


Fig. 84: AI art generation with prompt: dot illustration of confidence, small black dots, same size, black and white, sharp



07 Concept Evaluation

This chapter presents the insight of an evaluation study. It begins by detailing the setup and procedure of the evaluation of the design concept that was presented earlier. The conducted study aimed to gather feedback on various aspects of the concept, observe user interactions with the concept and physical prototype and explore the level of reflection elicited. As a result, the concept and its features were refined, resulting in a final iteration. The adaptations made are outlined and the final key features of the concept are presented in the conclusion of this chapter.

7.1 The Evaluation Study

INTRODUCTION

An evaluation study was set up and executed to investigate the following guiding questions:

1. How are the key concept features experienced by users?
2. What depth of reflection is reached when using the concept?
3. What do people perceive as the value of the concept (for their behavior change process)?

The first questions allowed to iterate on the key features of the concept so that they could be adapted to the feedback of users experiencing the reflection card. For each feature, a decision was taken on whether to keep, adjust, or remove it. Additional features could also be added based on the user's input and experience. Participant's feedback to the concept features also raised awareness of their more holistic worries and perceived benefits. The second and third question would inform the success of our design vision, which is about supporting individuals in reflecting on their health behaviors. With the third question, I also wanted to get some insights on the value that people attribute to the concept after using it.

Five participants who fit the project's target group (3 women and 2 men between the age of 23 and 29 who were currently in the midst of a health-related behavior change) were recruited and none of them had prior experience with the concept. The participants were engaged in various health behavior changes such as increasing exercise, returning to running, eating healthier and taking care of their mental health.

METHODS

The evaluation study consisted of three parts, each of which was related to one of the three research questions. The entire process was done with each participant separately at his or her home and took around 90 minutes. The reason for doing the study at people's homes was that it provided a non-distractive and familiar place that fitted the intimacy of the reflection process.

After participants consented to participate in the study, I gave them an overview of the concept and emphasized its intended goal of supporting reflections on the specific behavior they wanted to change. Then, the first section of the study was an open discussion of roughly 30 minutes where I presented each of the concept's key features and asked participants to project themselves using the concept and evaluate the feature against the concept's goal. For example, I explained that when taking the card off the back of their phones, the phone would switch into a "do not disturb" mode. I then asked people whether they think that this particular feature would support them in their reflections. For each feature, a cognitive walkthrough session was initiated and guided by follow-up questions. During this initial part, which aimed to address the primary guiding question, participants were able to interact with the physical prototype. The entire conversation was recorded for later review.

The second part of the study took another 30 minutes and was divided into two parts. Participants first used the prototype in an entire reflection process, and then filled out a questionnaire that assessed their depth of reflection. Before the study, I had asked participants about the behavior that they wanted to change and prepared the questions, hypotheses, and final takeaways of the card manually to fit their intended changes (see Figure 85 for the reflection questions of participant 1, or Appendix C for all the participant's prepared questions, hypotheses and takeaways). Since the physical card prototype did not include real displays and functionality, I programmed the card's displays as well as the reaction on voice recognition in JavaScript (<http://p5js.org/>). See Figure 86 for a wireframe of the card application or visit Appendix C to see more wireframes and parts of the code. However, since voice recognition only worked in English and it was important that participants (who were not native English speakers) reflected in their mother tongue, voice recognition was disabled in the study. Instead, the abstract visualizations were generated randomly. The procedure of this part went as follows: I left the room to leave people alone so that they could freely speak. A couple of minutes after I had left, I sent them a text message with the instructions to put their phone in "do not disturb", take the card from the back of their phone, and open a link to visit the digital prototype on their phone. I asked them to keep the physical card in their hand and imagine the phone screen being integrated into the card. The reflection then started and participants were guided through 4-6 prepared questions and hypotheses (see Figure 85) while random visualizations were shown on the bottom display. In the meantime, they were asked to reflect by speaking out loud, and the digital prototype gave feedback that it listened via a small animation. When participants received their takeaway and ended their reflection (which took 5-15 minutes), they messaged me and I entered the room again. After completing this entire interaction, participants were asked to fill out a survey that was inspired by Kember et al. (2000) to assess the depth of reflection. For each of the levels of reflection by Fleck & Fitzpatrick (2010) (Revisiting, Description, Exploring Relationships, Fundamental Change, and Wider Implications), three statements were designed and adapted to reflections specifically on behavior change. The statements were put in random order and could be answered on a 5-point scale from "Strongly Disagree" to "Strongly Agree".

Please see Appendix C for the full questionnaire.

The last part of the study followed immediately after participants interacted with the prototype and filled out the questionnaire. In another 30-minute discussion, participants reflected on their experience of using the physical card and the digital prototype. We followed up on their earlier feedback on the specific features and discussed how it felt to reflect with the help of the card. Participants were asked to reflect on the main value that they think the card provides, and whether/how they could think of incorporating the reflection card into their lives and their behavior change process.

Participant 1: Doing more sport

Q1: How is it going with doing more sport?"

Q2: "How was your motivation this past time?"

Q3: "It looks like you are confident in doing more sport going forward. Is that true?" (hypothesis)

Q4: "How have your friends played a role in your sports behaviours?"

Q5: "Has your environment hindered you to do more sports?"

Q6: "You seem to lack time for working out lately, is that true?" (hypothesis)

Takeaway: "Pick a sport that you never did before and try it out today or tomorrow."

Fig. 85: Prompts shown to participant 1 during the interaction

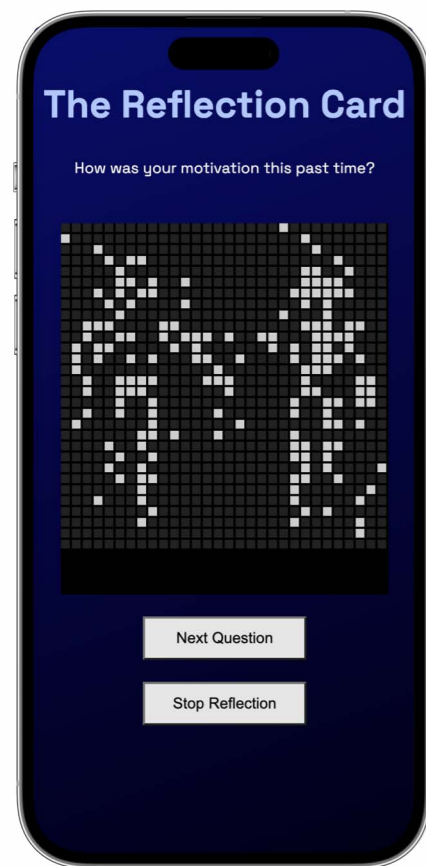


Fig. 86: Digital prototype of the reflection card



Fig. 87: Participant interacting with the physical card prototype

ANALYSIS

Prior to discussing the results of the evaluation study, I would like to outline the methodology used for analyzing the discussion and questionnaire data. Initially, I wrote down observations made during the discussions with participants and subsequently reviewed the voice recordings to identify key quotes that aligned with the guiding questions. These quotes were then organized and grouped into categories such as feedback on specific concept features and general remarks on the concept, using an online collaboration and design tool called Miro (<http://www.miro.com/>). Through a digital "on-the-wall" analysis, quotes were synthesized into main insights (see Figure 88). Additionally, I assigned scores ranging from "+" to "+++" to each individual feature based on the overall positivity of the feedback received. These scores, along with the main insights, were used to inform decisions about which features to keep, adjust, or remove.

When it comes to evaluating the questionnaire and measuring people's reflection depth, I calculated a score from 1 to 5 for each reflection level (being the average of the three statement ratings for each level). With 1 being the lowest score and 5 being the highest score, each value represented how much people's reflections involved thoughts at that level. These scores were then synthesized into line graphs that illustrated how people's reflections varied from the lowest level of reflection (revisiting) to the deepest level of reflection (wider implications). The combination of these graphs with the insights from the discussion in part three of the study allowed me to draw conclusions on participants' depth of reflection and the concept's success with regards to the design vision.



Fig. 88: On-the-wall analysis conducted in Miro

7.2 General Results

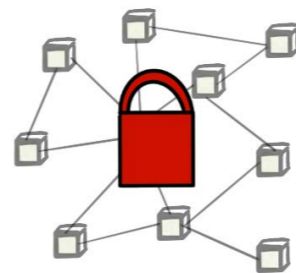
INTRODUCTION

In the following sections, I will present over-arching results that encompass the entire experience rather than the specific features. The latter will be presented in the upcoming subsection called “Concept Adjustments”. The upcoming sections are structured as follows: First I will go into the main concerns that participants expressed when I walked them through the features or after they experienced the concept. Before I draw conclusions about an individual’s depth of reflection when using the card, I will present the main benefits that participants connected to the experience of the prototype. Lastly, I will reflect on how the current version of the prototype adheres to the design vision that has been established in chapter 5.

CONCERNS

A prevalent concern among all participants was the requirement to provide extensive personal and intimate information to a device, which would subsequently learn highly private things about themselves. They were worried that their personal information would not be protected and that it would be used without their knowledge or consent by third parties. “You need to pay attention how far to take these because people will feel endangered in their privacy” (P4). Since they were also skeptical about the accuracy of the technology working in the back-end (“I am not sure how much I trust the AI with coming up with a correct strategy”, P2), they expressed doubts about the benefits outweighing these concerns. However, they acknowledged that if the technology would work as I mentioned, the benefits of learning about themselves, engaging in deep reflections, and supporting their behavior changes would outweigh the potential negative consequences. “Aside all the useless services that collect data, this could really be something that brings you forward”(P5). Still, the reflection card should treat user data with utmost care and make the protection of such sensitive data an absolute necessity.

The second concern was that the reflection card could become a tool that dictates how people should change their behaviors, rather than support them in doing so. “I want the tool to not dictate my life, but support it” (P4). Therefore, the tone of voice and the framing of things are very important. “The AI needs to own an ethical responsibility to not make people feel bad” (P2). “It is a narrow line between triggering new positive thoughts and be motivating, and evoking negative thoughts



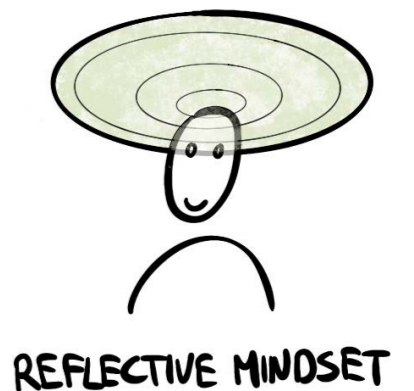
DATA PROTECTION

and be demotivating” (P1). What is important for people to feel supported rather than instructed is that the card output aligns with the user’s thoughts. This will build the necessary credibility and trust in the reflection card for it to be accepted as a partner in the behavior change process. “I would only take the hypothesis seriously if I gave such an answer to a question before” (P3). Participants want to feel like they are still driving their change process and earning the credits for their successes. It is therefore important that the reflection card is conscious about its use of language (“There is a threshold of how much provocation you can do before I would feel unwell”, P4), is transparent (“I think I would have wanted to know how the AI comes to this takeaway”, P2), and frames anything as a suggestion or idea rather than something the user must absolutely do (“I want to receive recommendations rather than instructions- the language of the tool is important”, P4).

CONCEPT VALUES

Participants praised and recognized several values in the reflection card. The first one was that the experience with the card put them in a reflective mindset that was rare and valuable to them. Although participants had a hard time describing what it felt like, participant 1 framed it like this: “I believe that today we do not occupy ourselves a lot with our own thoughts anymore, and this card really helps to do that. [...] I think that the interaction was nice and put you in a kind of reflective mental space.” “The card definitely helped to put me in a reflective mindset” (P4). “The main value is that it pushed me in a reflective mindset”(P5). Participant 2 also stated that she sees the benefit of the reflection card as “creating this reflection moment that is rare in everyday life”. The observation that this state of the mind is rare and valuable was echoed by participant 4: “Reflective moments are important in hectic everyday lives, and the card supports these moments”. This reflective interaction felt almost meditative, and many participants mentioned that the mental switch back to regular phone usage was a “hard cut”. “There is a great switch from a reflection to seeing all your notifications again” (P1). In the interview after the interaction, many participants kept thinking about their reflection and more self-insights sometimes came up. This made the strength of the previous reflective mental state evident.

Another main value, and perceived by participants to be a consequence of the reflective mindset, were the self-insights and personal learnings that the experience led to. “The card gives me more information about myself- almost like a second brain” (P4). Through the deep consideration of their own thoughts and experiences, the card helped participants to discover things about themselves and their behaviors. “It really made me think and search deeply for thoughts and explanations” (P5). It was stated to help uncover strengths and weaknesses (“It would be really great to develop a concept that shows your weaknesses”, P4; “I would love to see my strengths and weaknesses in a kind of report”, P3) and lead towards finding what fits oneself in the behavior change process. “I needed this reflection to come up with a plan to better change my behavior” (P3). The level of



personalization that is enabled through both one's own learning, as well as the learning of the card, was greatly valued. "It is great because it is so personalized and targeted to your specific behavior whereas you often only find general advice on the internet" (P2). "There are so many tips and tricks on the internet, but getting it tailor-made like this would be really great" (P1).

Lastly, participants valued the fact that the reflection card, in most of the experience, felt like a partner or coach to one's reflection and behavior change process. Through its tone of voice, the real-time reaction of the visualization, the interaction through voice, and the tips at the end, the interaction was positive and collaborative. "I see this tool as a thought partner, guiding you to think about your behavior" (P5). "I see added value in the tips at the end that feel almost like a coach" (P4). "The card is almost a partner that helps you through the routine of reflecting, also stay in the routine of your behavior" (P1). As we have seen in people's concerns, it is really important that the card keeps its character of being a reflection partner or coach vs. dictating people's lives.

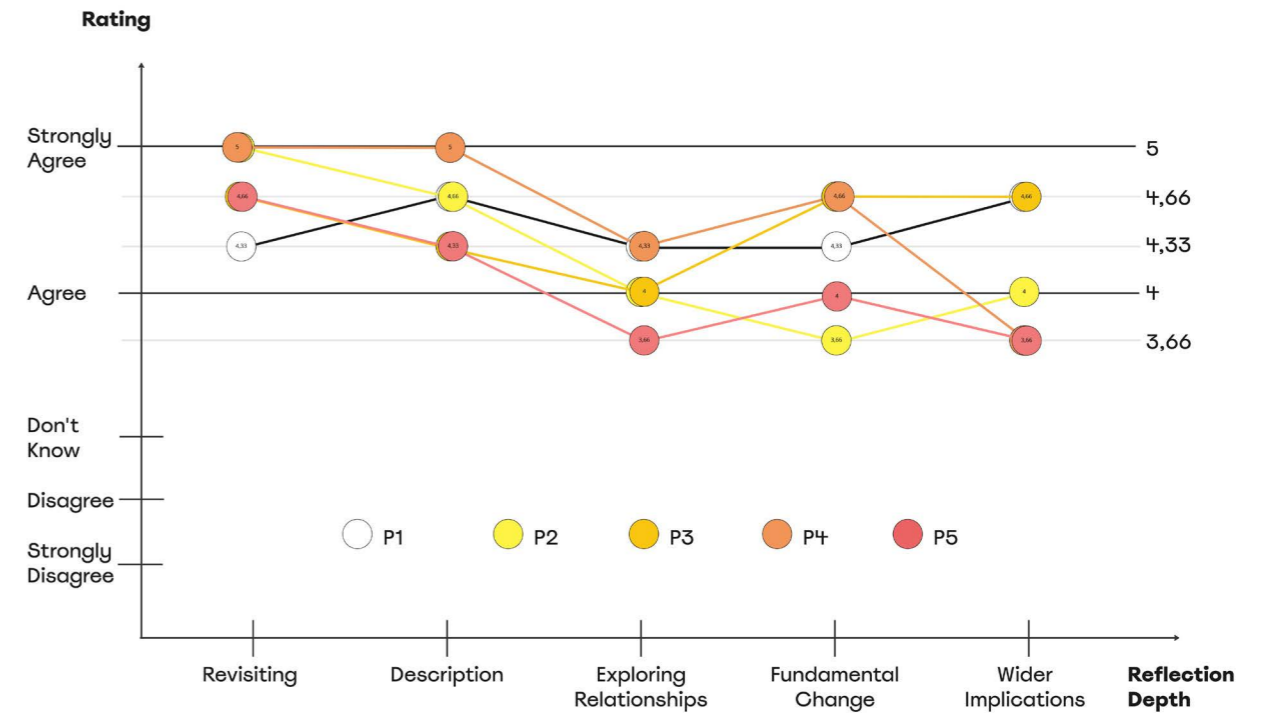


Fig. 89: Graphs showing people's rating per level of reflection depth

REFLECTION DEPTH

Participants have all engaged in reflections, as measured by Fleck & Fitzpatrick's levels of reflection (2010). As seen in Figure 89, all participants have experienced deep reflections that went as far as considering wider implications around their behaviors; being the deepest level of reflection. The measurements for each participant and level of reflection have averaged 3,66 or above. These self-reported measurements align much with the discussions in which the participants emphasized their complexity of thinking, different mental state, and the residual effect of reflecting even after some time had passed. Every participant agreed or strongly agreed to have thought about his or her behavior in a way that fits the levels of revisiting and description. The overall lowest scores have been given to the level of exploring relationships between different thoughts and experiences, although they are still high when considered in isolation.

Overall, there is a slight trend towards the downside when moving towards deeper reflection levels. This makes sense because Fleck & Fitzpatrick (2010) have argued that these levels build up on each others, meaning that people can't explore relationships if they have not thought descriptively about past experiences, for example. A point for a counterargument that can be observed in the evaluation study is that people thought about change more than they explored relationships, even though the former is considered a deeper level of reflection. However, this might be because the reflection has been specifically on behavior change.

DISCUSSION ON THE DESIGN VISION

My design vision with the reflection card concept has been to use technology to create a distraction-free environment that supports individuals to reflect on their health behaviors. This reflection should help them in identifying barriers and enablers to find their best strategy for achieving their health goals.








Although more effort could be made to suppress other kinds of distractions such as mental load, noise stimuli, visual distractions, and others, participants felt like their main source of distraction was eliminated with the "do not disturb" mode of their phones. "It helps to just stay with your reflective thoughts" (P2). As we have seen in the main concept values that people have identified, the reflective mindset and reflection process have been initiated and supported a lot. The fact that the card has helped to reflect specifically on their health behavior has also been recognized and appreciated: "There is a big difference in reflecting about life in general vs. on a specific behavior. [...] This specific thinking helped to stay structured and not go into overthinking and negative spirals" (P1). While participants did not frame them as barriers and enablers, but rather as strengths and weaknesses, they report that the reflection card helped them to find, or at least rediscover some of those during their experiences. "When I looked at the drawing with the people I remembered the fact that I need other people to get me motivated." (P1) "The interaction revealed that I was making excuses. [...] As I reflected I realized that I should make a concrete plan for exercising" (P3). "The card made me think about the last year and why I kind of lost my running habit" (P5). When it comes to finding a fitting strategy, the concept currently generates its own strategy that is tailored to individuals. Thus the success of this part of the design vision is largely dependent on the accuracy of the AI algorithms that were not developed as part of this project. Although participants reported that they would be equipped with new knowledge informing their change strategy, more interactions would be necessary to confirm this.

Concluding, the reflection card concept fulfills many of the criteria that were initiated with the design vision. Also, the upcoming section is diving into the participants' feedback on the concept's specific design features, and more changes will be made to the concept thereafter. This will hopefully shift the concept even closer to its intended design vision.

7.3 Concept Adjustments

INTRODUCTION

In this section, I will dive deeper into the feedback that participants gave on the concept's specific features that were introduced in chapter 6. For each of these features, a score of "+" to "+++" has also been synthesized based on the participants' feedback. Together with their insights from the discussion, a decision on whether to keep, adjust, or remove that feature will be made. Sometimes the change or removal of a feature led to the creation of a new feature. This was the case when the change or removal meant that a core user need got unfulfilled. Figure 90 shows an overview of all the features and the decisions took upon them. Next up, I will present the feedback and clarify the decisions in more detail.

Feature	Ratings	Decision	New Feature
 Card on the back of user's phone	P1: + P2: + P3: +++ P4: ++ P5: ++	 Remove	 Triggers through scheduled Beta Waves
 Shutdown of the phone	P1: +++ P2: +++ P3: +++ P4: +++ P5: +++	 Keep	
 Prompting of questions	P1: +++ P2: +++ P3: +++ P4: +++ P5: +++	 Keep	










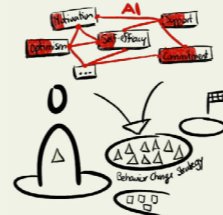

Feature	Ratings	Decision	New Feature
 Prompting of hypotheses	P1: ++ P2: ++ P3: ++ P4: + P5: ++	 Remove	
 Abstract visualization	P1: +++ P2: ++ P3: ++ P4: +++ P5: +++	 Keep	
 Journaling through voice recognition	P1: ++ P2: ++ P3: ++ P4: ++ P5: ++	 Keep	 Silent/Dumb mode
 Concrete takeaway	P1: +++ P2: +++ P3: +++ P4: +++ P5: ++	 Adjust	
 Behavior change strategy generation	P1: +++ P2: +++ P3: +++ P4: ++ P5: ++	 Adjust	

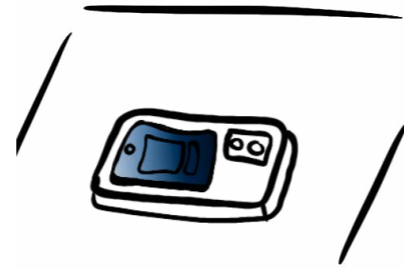
Fig. 90: Overview of all the features and the decisions taken on them. The final features are shown with a green background.

CARD ON THE BACK OF USER'S PHONE

Participants have appreciated the fact that this feature leads to having the card with them without giving it much thought, and also realized that this would be a non-intrusive trigger for reflecting. "From a practical perspective, it is great because you don't have one more thing to think about" (P2). "It is practical because it is something that always reminds you to use it" (P5). "The trigger can be useful in the beginning, but if it does not become a habit, the triggering characteristic fades" (P3). This feature is however primed with many things that people did not like. Over time, people fear that the card is not a trigger anymore. Also, participants did not like the fact that it thickens the phone even more. "If it would be a little thinner, it would be great" (P5). "If it was as thick, it would slightly bother me. Phones are already getting thicker" (P1). Some participants also expressed that the opposite of its intended effect could take place and that they were reminded of their phones at times when they wanted to reflect.

Ratings: P1 P2 P3 P4 P5

Decision: Remove

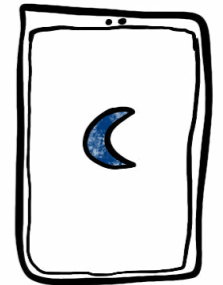


SHUTDOWN OF THE PHONE

All participants have uniformly supported this feature, as it helped them to disable their primary source of distraction. "This is certainly a great idea" (P2). "I am distracted a lot so this helps a lot" (P3). A focused state of mind was, once more, stated as essential by participants. "If I reflect and a notification would come in, this would throw me out of concept" (P3). "The thought process should not be interrupted because it is about staying in the flow. A phone notification would pull you out completely" (P5).

Ratings: P1 P2 P3 P4 P5

Decision: Keep

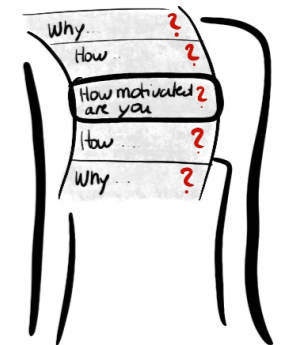


PROMPTING OF QUESTIONS

The prompting of questions by the card has been experienced entirely positive and as being supportive of reflections by all participants. Its benefits include that it stimulates novel thinking ("Questions can give a new perspective or make you realize something new", P1; "The different questions help to discover different thoughts and perspectives", P3; "Questions push you into thinking about new things and in a new way", P4), and it is a sign of genuine interest that builds credibility over time. "With such devices to help, they often pretend to know the problem and oversimplify things which is frustrating. Asking questions is great to help the device learn" (P3). Additionally, the fact that there is always a new question available helps to get unstuck and it keeps people from overthinking in their reflections. "Having someone ask questions helps to not get stuck" (P2). "If one is lost in a reflection, impulses such as questions can bring you further" (P5).

Ratings: P1 P2 P3 P4 P5

Decision: Keep



NEW FEATURE TRIGGERS THROUGH SCHEDULED BETA WAVES

Since the removal of this feature leads to people not being triggered to reflect anymore (which was one of their reflection needs), another triggering feature had to be introduced. After doing some research on unobtrusive triggers, I came to the idea of using sound and having users input their commutes and other ideal reflection times. In the app that comes with the card, users can now input the times in which they usually sit on a train or bus, take a walk, or other instances where they want to reflect. The card then creates beta waves, which are discreet sounds proven to stimulate focus (Abhang et al., 2016). Both the sound itself making the user aware of the card, and the stimulation of focus can lead to a reflection in which focus is essential. Participant 2 even expresses the connection of the concept to music: "I need a zen zone around myself where nothing is distractive. Maybe music would help with that".



PROMPTING OF HYPOTHESES

This feature has been particularly torn between benefits and concerns. The greatest insight has been that it depends a lot on the language used and the nuances of how hypotheses are framed. These nuances will determine whether hypotheses are positively or negatively provocative, leading to motivation or demotivation. "Depending on the hypothesis [...] it can be demotivating and too negatively revealing" (P1). "This could help to realize things in a more painful way" (P2). "Until a certain degree this would make sense" (P4). "It would be destructive feedback to frame the sentences like absolute truths" (P5). Related to one of the people's over-arching concerns, it is important that hypotheses are always framed as such and not as facts. To take the decision and remove them from the reflection process, I have also considered the comments by users saying that the thin line between positive and negative provocation would depend on people's character. The complexity in getting hypotheses right, and being conscious about keeping people from overthinking has resulted in this final decision. Also, no user needs have only been addressed by this feature, which is why it does not need to be replaced.

Ratings: ++ P1 ++ P2 ++ P3 + P4 ++ P5

Decision: **STOP**
Remove

"Depending on the hypothesis [...] it can be demotivating and too negatively revealing." (P1)



ABSTRACT VISUALIZATION, REACTING TO THE REFLECTION

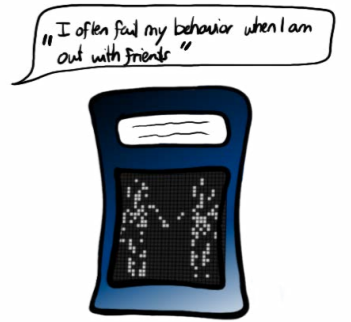
This is a feature that was really valued and appreciated by the participants. From the fact that it helped to trigger additional thinking in an unusual way, to being real-time feedback that it listened to, and understood, people's voice, the visualization supported the interaction. The abstract nature of the visualization "would push me in a new direction of thinking and explore that new thought area. [...] Abstraction does not give you a fixed frame of thinking, but it shows you a direction which you can explore for yourself" (P5). "This again gives new input [...] that pushes you into thinking deeper and differently" (P1). "Something visual might stay in your head differently than simple questions" (P3). "The visualization is also feedback that the device really listens and understands myself" (P5). Some participants also mentioned that the visualization was of a meditative character, fitting the reflection. "The visualization has something meditative, it does not distract but is still inspiring" (P4).

Ratings: +++ P1 ++ P2 ++ P3 +++ P4 +++ P5

Decision: Keep



"This would push me in a new direction of thinking and explore that new thought area" (P5)



JOURNALING THROUGH VOICE RECOGNITION

The feature of interacting with the card through voice recognition had clear benefits and downsides which most participants aligned on. On the one hand, they agreed that voice interactions, nowadays, are a natural and common way to interact with a device. "With all the voice messages that we do today, I think that the barrier to speaking with yourself has disappeared" (P1). "In general, I think that we are all relatively used to talking with our devices" (P2). Saying things out loud also helps to change one's perspective on said things. "[...] the talking out loud can put things in perspective" (P1). "It always gives a new perspective to say things out loud" (P3). One participant thought that journaling through voice would probably be most intuitive and sincere when compared to other interaction methods. However, all participants agreed that the nature of the interaction would restrict them from using the card in public spaces, as a reflection is too intimate to speak about in public. "When I am in a room with other people, I would not want to reflect out loud" (P3). "In a public space, I don't think that you want to talk about your habits [...] and more intimate things" (P4). "I would not do it on a bus in between lots of other passengers" (P5). Although the first study has shown that there are many ideal reflection moments when people are alone, some of them are in buses, trains, or other public spaces.

Ratings:

Decision: Keep



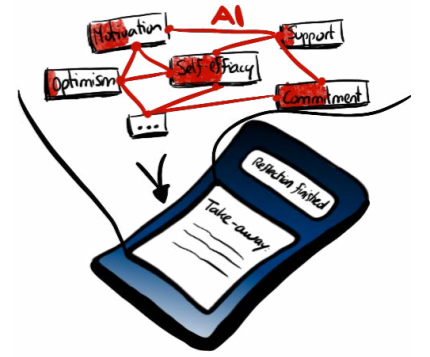
CONCRETE TAKEAWAY INFORMED BY BARRIER

The final takeaway has been primarily appreciated by participants, although some emphasises need to be made. It was important to participants that they had a clear end to their reflection, which would also act as a motivational factor to use the card in the first place. "I think that this conclusion is very important" (P4). "This take-away also pushes people to use the device in the first place." (P3). It felt great to not solely be responsible for creating that end, which could increase the odds of overthinking. "It helps to not be solely responsible in concluding your reflection and finding a way forward" (P2). This suggestion at the end was great to see a path forward amongst the ones created by oneself but needed to be aligned with one's own thinking. "It is important to show you a path you can take at the end. [...] Your reflection goes in one direction and therefore the tip needs to go into the same direction" (P5). As a consequence, it needed to be either very vague, framed as an idea, or the machine needed to acknowledge that it can't be completely sure.

Ratings:

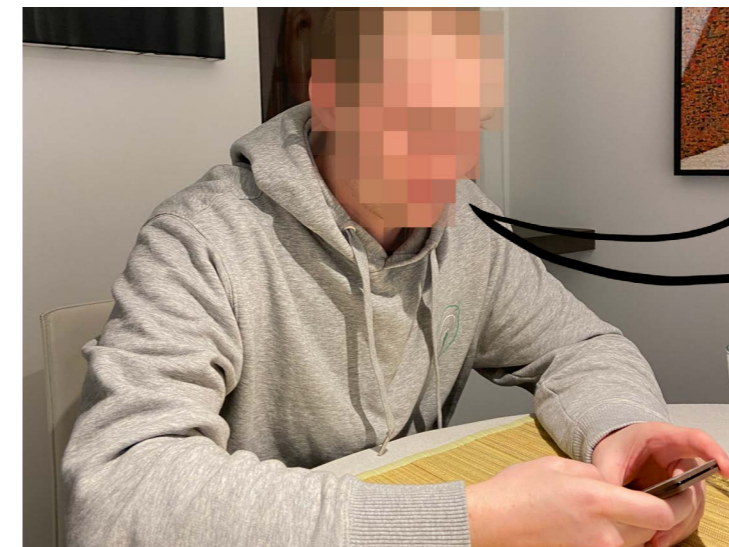
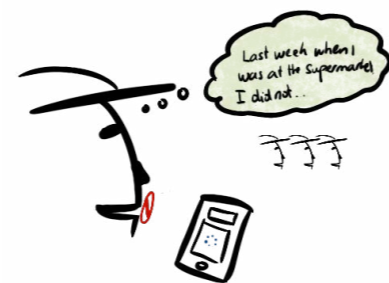
Decision: Adjust

Going forward, I want to structure the takeaways as follows: One encouragement (main strength/enabler), one insight (main weakness/barrier, framed positively), and one small idea for going forward. I also want to indicate the machine's confidence for each of these. Thereby, an emphasis is on the fact that there is always positive encouragement and that takeaways are framed as ideas rather than facts or to-dos.



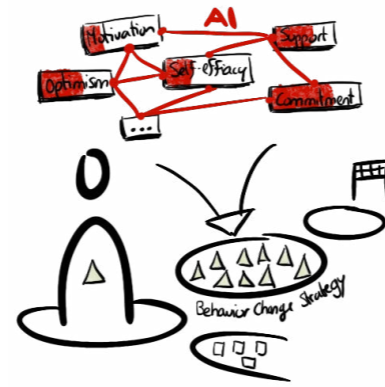
NEW FEATURE SILENT/DUMB MODE

With this feedback, I knew that I had to keep the voice interaction, but come up with an additional feature that worked in specific moments when other people were around: the silent mode, or dumb mode, was created. Whenever people do not want to talk, they can switch to this mode and use the card in a non-intelligent mode. In this mode, it only provides guiding questions and generates random visualizations. Users won't externalize their thoughts but only think by themselves. The tip at the end is based on things that the card has already learned previously. This interaction is not taken into consideration for any back-end learning that the reflection card concept supports. Still, it is a good backup that allows people to indulge in reflections in any kind of environment.



GENERATION OF A BEHAVIOR CHANGE STRATEGY

Although they all agreed that it would be extremely helpful in theory, participants were skeptical about the accuracy of such a personalized behavior change strategy generated by a machine. “I think that the idea is super useful if all these influences can be considered” (P5). “This would be really cool if it were possible” (P3). “I am not sure how much I trust the AI with coming up with a correct strategy” (P2). As mentioned in their concerns, participants also want the tool to support them, rather than dictate what they have to do. They want to feel like they contribute to coming up with a strategy and get credits themselves for a strategy that potentially works better. Therefore, they see the usefulness of this feature by providing additional ideas to the strategies they come up with themselves. “I think this can be really helpful for just getting ideas” (P2). Trust needs to be built into the system, and at the same time, it needs to downgrade its level of authority and its omniscient character.




Ratings: P1: +++ P2: +++ P3: +++ P4: ++ P5: ++

Decision:  Adjust

Without converting these into new key features, some slight adjustments will be done to the generation of a behavior change strategy. The goal of this is to increase user trust, acknowledge the imperfections of the machine, and support rather than dictate people’s behavior change process. The adjustments are that, instead of giving one strategy, the algorithms will provide different strategies with their levels of confidence. Thereby, the user understands that these strategies are ideas to support him or her and that he or she has the autonomy of deciding and driving the choice of strategy.

7.4 Final Key Features

In this section, the final key features are presented. It is important to note that these features are part of a concept that is not meant to be final, solve all issues perfectly, be the ultimate reflection support system, and improve a behavior change process considerably. Much rather, these features are part of a concept proposal that is as good as this project has achieved to become in its allocated time, but could certainly be improved further. The final key features are therefore describing the final iteration of this project’s concept, but not final in that they are the best they can be. I will present these features in synergy with the user’s reflection needs and an interaction narrative of a person called Sophie who started using the reflection card recently. Sophie has already been introduced in chapter 5 as an imaginary user who is trying to eat healthier by reducing her intake of industrial sugar.

 The addressed user needs per feature, with their numbers as per Chapter 3 on page 47.

1

People need mental space & time

2

People need a trigger

3

People want proactive reflections

4

People need guidance

5

People don’t want to overthink

6

People want to gain many different perspectives

7

People don’t want to be distracted

8

People want to end on a positive

9

People want to know how to change

One early morning when Sophie wakes up and has breakfast, the reflection card that lies next to her keys from the day before, starts to emit subtle sounds. At first, she did not really realize them, but then she remembers that she wanted to reflect once a week in the morning and scheduled such triggers in the app. Triggered by the sounds, she decides to combine her reflection with her morning walk to the train she needs to take to work. Knowing that she has recently paid less attention to her goal, she hopes that the reflection can lead to increased success in the future. The card triggered her to start thinking about her recent eating behavior, and the subtle sounds, which are beta waves, stimulate her brain to focus. Although it did not bother her, she walks to the card, turns the sound off, and puts the reflection card in her purse.

When she is ready to leave the house, she puts her phone and other items for work in her handbag with the reflection card. Once outside, she picks up the reflection card while taking a quiet path through the park which is on her way to the train. She has already started to think about her behavior. Now that she picked up the reflection card, her phone has switched into "do not disturb" mode using NFC, and the constant buzzing of her phone turns quiet. This allows her to stay focused on the thoughts around her behavior. The display lights turn on, indicating that the card is ready for Sophie to reflect.

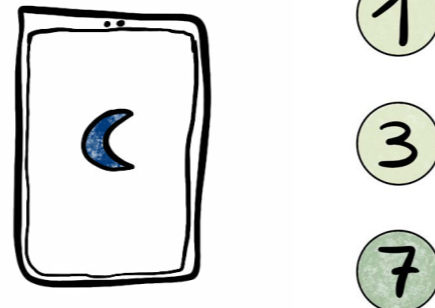
When Sophie places her thumb on the reflection card, the upper screen asks a first general question about how her behavior was going recently, and the bottom screen evolves into a first random pattern of pixels. Sophie lifts the card and starts to answer the first question by speaking to the card: "I feel like I am fairly consistent with resisting the urge to buy sugary snacks, but when I was at the supermarket last time there were so many people... it was hectic and without really thinking about it... I bought some cookies". The voice recognition picks up the word "people" and associates it with the behavioral influence of social support.

The bottom display visualization evolves into an abstract representation of people, to trigger her to think more about it. She looks at the visualization and continues: "It might have been that the other people got me frustrated which led to making a bad decision. But when thinking about other people I must say that my roommate really helped me to not eat them. He ate almost all of them himself. I was both happy and angry (laughs)." Sophie does not know what to say anymore, so she

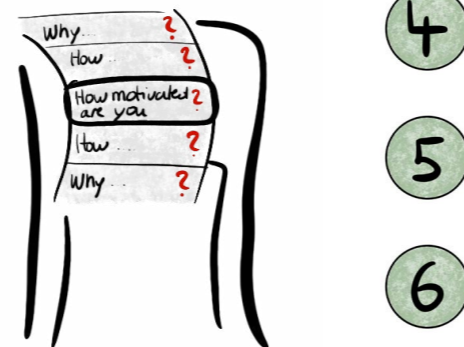
Triggers through scheduled Beta Waves



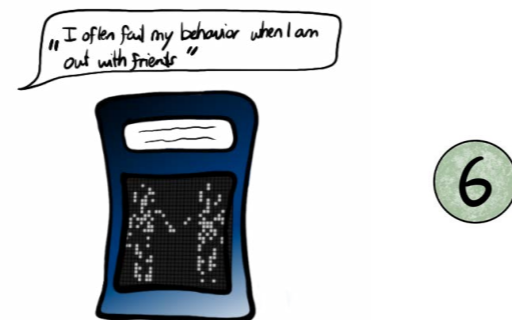
Shutdown of the Phone



Prompting of Questions



Abstract Visualization, Reacting to the Reflection



presses the button for another question. The questions really help to guide her reflection and be available as new input in times when she gets stuck.

This time, she is asked about a specific influence: "How confident are you to continue with positive behaviors?" She replies: "So I think that I am confident I can do it and resist the sugary urges, but sometimes I am tired and then it just happens. Or I am in a hurry and I can't make good decisions." Again, the drawing picks up the word "hurry" and portrays an abstract clock that makes her continue the reflection: "It also happens sometimes when I get stressed at work. Then I sometimes need a chocolate bar that helps me calm down and give me a little reward."

With every answer that she finishes, the drawing can push her to think further by reacting to Sophie's input, or she can press a button to change the question. In the background, the AI classifies the spoken thoughts of her current reflection into barriers and enablers of the current strategy. This specific reflection shows great motivation and knowledge of the benefits, but some weaknesses are her ability to make plans as well as her resource-availability of e.g. time. The classification happens on the basis of the Theoretical Domains Framework (TDM) by Francis et al. (2012).

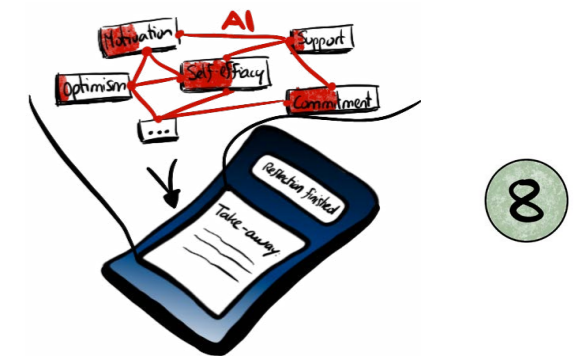
When Sophie lifts her thumb off the card, she indicates that she wants to stop her reflection. Since this can happen accidentally, a countdown is first displayed that indicates the end of a reflection. If Sophie wants to continue with the same question, she can lay her finger back on the card. Since Sophie is almost at the train station, she decides to end her reflection. In the background, the reflection card calculates the greatest barrier and enabler identified based on Sophie's entire reflection. The card processes the information for a few seconds before it shows an encouragement ("It seems like you are very motivated lately,..."), an insight ("...and by making better plans you could improve even more."), and an idea ("Write down a time and day when you would ideally like to go to the supermarket.") to Sophie. For each component of this final takeaway, the card shows its confidence in that statement. Sophie feels satisfied to close off her reflection like this and decides to execute the idea. Sophie puts the reflection card back in her handbag and enters the train.

On the train back home from work, Sophie starts to think

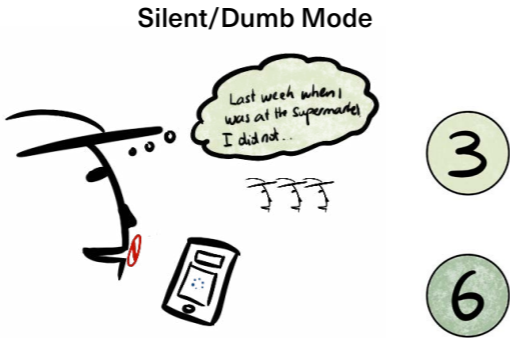
Journaling through Voice Recognition



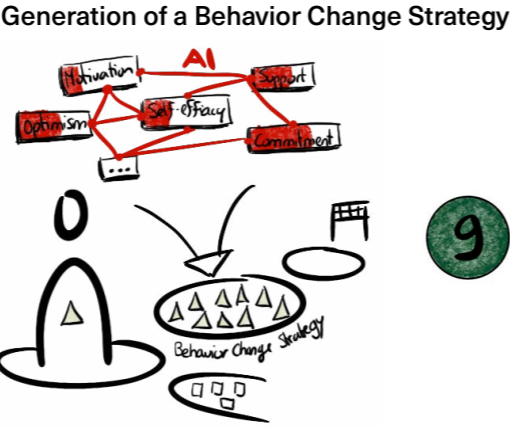
Concrete Takeaway informed by the Reflection



again about her morning reflection and feels like doing another one. However, the train is really crowded around this time and she does not want to speak publicly about the intimate thoughts related to her behavior. She decides to pick up the reflection card one more time but switches it into “Silent Mode” so that she does not have to speak out loud. In this mode, she only runs through a series of questions related to different behavioral influences while random visualizations are shown on the bottom display. It is enough for her to think about the questions quietly and gain self-insights from the changes in perspective and different stimuli provided by the questions. At the end of her reflection, a takeaway is shown that is informed by her last couple of reflections: “It seems like you have great social support, and learning about healthy eating would improve your behavior even more. You could watch this Youtube video about sugar production: *insert link*”.



Some weeks later, after she has reflected multiple times, Sophie visits the application where her behavioral strategy proposals have been unlocked. Across all the times that Sophie reflected, the AI has learned more and more about her tendencies and influences so that it turned capable of proposing entire strategies. These are grounded in the main identified barriers and behavioral techniques that are available in science. 3 different strategies are proposed to Sophie, with each one indicating the level of confidence with which the application predicts them. This allows Sophie to make her own decision on which one to adopt, or whether she wants to stay with her own idea. One of the proposed strategies goes as follows: “Hey Sophie, you have been very motivated in the last weeks. To make your behavior change even more successful, try the following: Write a message to the people closest to you making it clear that you want to not eat sugar. Each time that you are confronted with a choice of sugar/no sugar, reward yourself for the latter. Write down anything you really like and make that the reward. When you go to the supermarket, try to go there alone and in times when you are most energized, ideally after you ate. Each Sunday, make a plan of when you want to go and what to buy.” Sophie decides to give this strategy a try.





08 Discussion & Conclusion

This last chapter concludes the project by reviewing the initial aim of the project and contrasting it to its results. The first section discusses the contributions, strengths, and limitations of the project before the next section dives into identified opportunities for the future. Next, a conclusion is presented that summarizes the overarching results of this project. Finally, I reflect on the project as a whole and my position in it as a graduating designer and researcher.

8.1 Discussion

This project focused on helping people reflect on their health behavior, allowing them to make informed decisions on how to reach their goals. It was not about actively changing behaviors, but helping people reach insights to tailor their change process to their unique contexts and thus “find what fits”. This project sought to use intelligence to help people reflect and learn. Smart objects usually tell people what to do, but this project works to help people find out themselves if, and how, to adjust their change strategy. 4 questions mainly guided the process of research and design: 1) How do people reflect in their everyday lives? 2) How can people be supported to reflect on their behavior? 3) How can we design for reflection?, and 4) How can smart objects support a reflection process? This discussion will first dive into this project’s contributions before it explains some ethical concerns and limitations.

CONTRIBUTIONS

The contributions of this project include the identification and scientific connection between reflections and behavior change. Through literature research as well as multiple conducted studies, it has become evident that **reflections have the potential to support behavior change**. Although there are some papers and projects that include reflection as a contributing factor to behavior change, the work that solely focuses on the intersection of reflections and behavior change is rare but promising. This project emphasizes the connection between reflection and learning, as well as the importance of knowledge for a sustainable behavior change process.

At the same time as it creates an argument to focus on reflections on individuals’ health behaviors, this project displays the ever-growing absence of reflection in people’s everyday life. Considering that reflections are a worthwhile goal, this emphasizes that **reflection support is increasingly important**. Being only one of many insights from a contextmapping study, this project has identified an individual’s reflection process and 9 key needs to be supported throughout this process. They provide a comprehensive overview and can drive key interventions and support systems of how to help people engage in meaningful, deep reflections.

As a next contribution, this project has created a design space for reflection with key mechanisms, principles, and features that lead to reflection and support

individuals across the design process. This design space has also been completed with insights into how technology can help in specific parts of the process. It has made it clear that **there are many ways to design for reflections**. This design space can serve as a toolbox for creating concepts that support different parts of the reflection process.

Lastly, in a process of using different design methods such as cognitive walk-throughs, prototyping, co-design, and others, I was able to create a concept and a physical-digital prototype that supports people in reflecting on their health behaviors. This concept was a synthesis of people’s reflection needs, the decisions I made on the design space, and an evaluation session with 5 participants who used the first version of the concept. This concept and its prototype have also been connected to theory and were built to a high level of fidelity. **The concept has the potential to serve as a research artifact, be detailed into a final product, or serve as inspiration for other designers who seek to design for reflection.**

ETHICAL CONCERNS

There are a few ethical concerns that need to be raised awareness about. First, I want to recognize that the concept that has been developed as part of this project is another tool that, although developed with good intentions of supporting people to change health behaviors, **nudges people to do something they are not doing by themselves**. The term “support” might thus need to be used carefully, as it refers to assisting with an activity that people already engage in. However, people express a desire for having more positive reflections, but they are not doing so in their everyday lives. In this case, the nudging of people into that activity could potentially be considered as support.

Another concern that might arise is the reliance of people on such technology for engaging in reflection. Through repeated use of a concept such as the reflection card, **people’s skills to reflect by themselves might deteriorate**. This project has made a clear point about the importance of reflections in a behavior change process, and also in general. Thus, undermining an individual’s ability to engage in self-sustained reflections is contrary to the goal of this project. However, the knowledge created by this project and the use of the reflection card concept might as well equip people with the skills and information to increase her or his reflection abilities. It is not possible to draw final conclusions on this at the moment, but could potentially be observed over time. It is clear however that many tech tools in people’s everyday lives decrease people’s abilities to focus, engage in deep thought, or create time, much more than the reflection card concept.

A last ethical concern roams around the question of whether the goal of supporting people to reflect is worth **the capturing of so much of data**. To establish a full profile of people’s behavioral influences, it is essential to capture as much

related data as possible. Unfortunately, an increase in the amount of data often means more accurate algorithms, and thus better, and more personalized support. Again, the answer to this question is up to the user who is free to make his or her informed decision before a potential purchase of such a data-heavy tool.

STRENGTHS & LIMITATIONS

This project and its outcomes have their strengths and weaknesses, some of which are objective, while others are subjective. The first strength of this project is **its strong connection to theory**. An in-depth literature analysis was done and many decisions throughout this project are rooted in scientific insights. At the very least, choices were contrasted with their scientific background. Another strength of this project was **the diversity of methods and variety of activities** used to generate results. From literature research, contextmapping studies, design work, prototyping sessions, and much more, insights were gathered from many perspectives and by many means. A largely subjective strength of this project, but a big one for me personally, is that **the project withstood many modern design principles of technology which roam around efficiency and speed**. The careful treatment of attention, the deliberate choices of technology, and the explicit focus on inefficiency were principal to the success of this work.

When it comes to the strength of the project's content rather than its approach, the results from user studies are another strength because they proved to be particularly hard to get to. Any cognitive process is difficult for people to report, even more so when the process happens largely unconsciously. Even though participants had a hard time reflecting on their reflections, I was able to distill **meaningful insights and get to the core of their issues and needs**. Another strength of this project was its openness and the diversity of behaviors it addressed: I chose to focus both on the entire reflection process, and leave it open for people to reflect on any kind of health behavior change. The reflection card is a concept that remains **modular to reflections on any kind of behavior change and supports people in their entire reflection process**. Introducing a focus on any specific part of the reflection process would not have fulfilled all of the people's reflection needs and could thus have been considered incomplete. At the same time, both a focus on a specific behavior change, as well as a focus on a specific part of the process, would have allowed much more tailoring. A last strength of this project is the effect that the reflection concept had on its users. People were really enthusiastic about the kind of reflective mindset and rare moment for reflection that it introduced, as well as the learnings it helped them to uncover. The learnings emphasize **the potential of the concept to help people change behaviors**.

Before I present the opportunities for future work, I want to emphasize some of the limitations of this work. In terms of the content of this project, **reflections and personal contexts are highly individual and dynamic, the capturing of which is**

also limited in the reflection card concept. In fact, it might be that computers will never be able to fully capture a human's context. This limitation directly impacts the effectiveness of some aspects of the reflection card concept, such as the generation of a suitable strategy. This dependency is a limitation of this project that will improve as the technology becomes better at establishing a more complete understanding of people's lives. Not only does this include people's contexts, but also elements that are linked to their inner selves, such as character traits, values, and belief systems. While these also influence a behavior change process, it is hard to capture them and include them in a machine's calculations. In this project, some of the richness of people's individual experiences, contexts, and individual traits have been neglected in the establishment of the concept. This also applies to the development of insights from user studies, where the same **complexities have been oversimplified**. Although the results try to shine a light on individual tendencies, the resulting insights which have guided key decisions in the project probably lack nuances. This leads me to also acknowledge that the reflection card concept is certainly not the perfect way to address all issues, nor is it the most effective and usable in supporting people to reflect, that could have been created. Rather, it is a proposal of how to address this project's goal that is based on many decisions as well as my personal biases, belief systems, and preferences.

In terms of this project's activities, there are some limits in the executed studies as well as the lack of evaluation of the concept's long-term effects on the behavior change process. Both the contextmapping study as well as the evaluation study have been conducted with a **low number of participants with similar backgrounds** due to several constraints. Anytime results are driven by a low number of people, the evidence for these results is weakened. However, it has also enabled me to get a richer picture of these individuals and their experiences, which benefitted the project on the other hand. A last limitation of this project is that **the effect on behavior change was not tested**. Although participants in the evaluation sessions claimed that they could imagine the concept to help them change their health behaviors, there is no evidence for it. Such a long-term study would have exceeded the scope of this project.

8.2 Future Work

In the process of design and research that has been conducted over the last weeks and months, a few opportunities have crystallized that could benefit from further exploration. These are presented in no particular order, as possibilities for future work:

1) A better understanding of reflections

In the large literature research conducted on reflections and their connection to different scientific fields, I have realized that a clear definition of reflection is missing. In many papers on literature and design concepts, reflections are introduced without a clear connection to theory. Baumer et al. (2014) have come to a similar conclusion presuming that it was the result of a lack of deep engagement with the phenomenon of reflection. In the field of design, it might be interesting to do more research into how people experience reflections to drive a definition and foster shared understanding.

2) Shift the focus on the created design space

As I have mentioned before, the design space that I mapped out as part of this project can serve as a toolbox for creating more concepts that support reflections in different ways. By choosing from design mechanisms and principles, parts of the reflection process, and ways to use technology, new concepts can be designed. The design choices that I have made in chapter 5 are driven by the literature insights and user needs, but also by my personal biases and preferences. Shifting these choices to new ones make room for potentially different, and maybe better, reflection support.

3) Create the concept

Another possible opportunity is to detail the reflection card concept further, create a prototype of higher fidelity and finalize the algorithms that drive the concept. Thereby, the card could be converted into a final product. I have created a strong baseline with the physical and digital prototypes, but much more work would need to be done. I would suggest a designer working together with an AI expert to find the best possible implementation at the intersection of user needs and technical feasibility.

4) Test the concept over time

No matter if the concept is finalized or not, it would be interesting to test the reflection card concept with people over a longer period. Thus, it would be possible to make stronger conclusions about whether individuals use it, if it helps them to reflect, and if it supports their behavior change process. It might also be worthwhile to incorporate the concept into the ESE method for changing behavior; the method that is centered around helping individuals find what fits them in their change process (Fedlmeier, 2021). Thereby, conclusions could be drawn on whether reflecting with the help of such a concept leads to more informed choices in people's change processes and a more successful change in people's health.

8.3 Conclusion

This project set out to support people to reflect on their health behavior change and thus help them to find what fits their unique change process. Through various methods of research and design, framed by a double diamond design process, the connection between reflections, technology, and behavior change was explored. The conducted activities led to various insights from which one can conclude, in addition to those presented throughout the project, the following things:

Reflections are a promising means to help the behavior change process. They are a powerful way of gaining self-insights and identifying learnings about oneself. These learnings can then help to find what fits in an individual's behavior change process and thereby support the reaching of health goals. An extensive literature study as well as a user study have shown the positive effects of reflections on learning. Besides, technology has great potential to support the process of reviewing experiences to gain new understanding. While designers must pay attention to not have it detract from the reflective qualities of deliberateness, slowness, intentionality, and inefficiency, the literature research made it evident that technology can support the process in various ways.

There are many ways to design for reflection, and this project has only tapped into one of the possible directions. From the user study as well as the review of reflection concepts, it became clear that reflections can be designed for in many different ways, using technology in various ways, and addressing different parts of the process. The design space created as part of this project provides a starting point for designers to explore the many more routes that remain.

Lastly, **the benefits of reflections and their qualities extend beyond the field of behavior change.** Much of people's everyday lives are characterized by elements that are contrary to reflective qualities, such as efficiency and speed, and technology especially fuels these dynamics. There is no room left for slowing down and taking time to deal with one's thoughts. In the studies with participants, it has become evident that people desire more situations of reflective character. Designing for reflections using technology is a fresh approach that withstands the conformity of cultural and social dynamics, and provides meaningful value to people.

To conclude, this thesis makes a solid argument of why and unveils a space of how to support and design for reflections in a behavior change process. Through key literature insights, user reflection needs, a design space, and a design concept, this project can contribute to helping people change behaviors, increase personal flourishing, and tackle societal problems.

8.4 Reflecting on the Project

In this final chapter, I offer a reflection on the project and its position in the world, as well as on my academic goals. I finish this project's report with my personal learnings.

When I reflect on the content of this project, I am torn between pride and self-criticism. I am pleased with the approach that I took, the discomfort pushed through, the growth I have experienced, and the results that I created. There are 3 things in particular that I look back to with pride:

First, I think that I have gathered a large amount of knowledge on a topic that was fairly abstract and often felt like grasping for thin air. I believe that the insights gathered are deep, meaningful, and equipped with good context. Second, I am fond of the diversity of skills that I both managed to put into the project, as well as learned in the process. I have been able to create a rich and multi-faceted project through the combination of my design skills, my coding abilities, my previous research in behavior change, and my interests in psychology and ethical technology. At the same time, I have learned new skills in designing with AI, 3D modeling, and much more. Third, I am proud of the meta-approach with which I handled this project. We often realize that our goals are being hindered by today's ubiquitous nature of technology that values productivity and efficiency, and is in a constant battle for our attention. I believe that people have a central human need for inefficiency and that it is principal for complex thinking and meaningful engagement with others and the world. In a way, this concept has tried to thwart the technology developments primed by cultural and societal dynamics, using technology. I believe this to be an interesting and important design space to unwrap.

On the other hand, the perfectionist within me argues that I could have created a better job at combining knowledge and exploring even more ways to support people's reflections. In particular, I think that I took a very rationale-driven, science-based approach to the project, whereas sometimes a "designerly" approach would have been more beneficial. With my background in computer science and human-computer interaction, the design work of this project could have benefitted from more design experience outside of my internships and university projects. I think that more profound dealing with intuition and creativity would have improved the form, materiality, and interaction of the reflection card concept.

As I reflect on my academic ambitions, I believe that I have accomplished, or at least touched up all of them. I wanted to gain scientific knowledge about behavior

Reflections are a promising means to change behaviors

There are many ways to design for reflections

Reflections are meaningful beyond behavior change

change and psychology. Today I feel much better equipped to design for behavior change, and I have learned many things about how people think and behave. I also wanted to take an ethical approach toward designing with technology, which adheres to the meta-approach taken in this project. Next, I wanted to hone my prototyping skills in this project, as I lacked experience in building physical products. After engaging in paper prototyping, 3D printing, material assembly, laser cutting, and much more, I surely increased my knowledge of prototyping. Lastly, I wanted to learn and rightly apply the design methods that the curriculum at TU Delft taught. Through my double diamond process, the contextmapping study, literature research, co-design sessions, cognitive walkthroughs, wizard-of-oz prototyping, interviews, and others, I explored many design and research methods that proved fitting for the intended results.

In terms of personal learnings, there is one takeaway that is related to my self-criticism described above. A central skill of being a designer involves taking decisions. These decisions do not always need to root in research or other tangible evidence. Throughout this project, I learned that I needed to “own my designer” and make decisions based on my experience with the topic, design in general, and my intuition. It is common and can even be interesting that the outcome of a design project is influenced by the personality of the designer. Another personal learning is how I can help myself to get unstuck, which will inevitably occur during such projects. I do this by discussing matters with other people (designers and non-designers), or I read books that were related to the topic. Some book recommendations for this project include *Thinking, Fast and Slow* (Kahnemann, 2011), *How to Do Nothing* (Odell, 2019), and *The Distracted Mind* (Gazzaley & Rosen, 2016). Also, towards the end of the project, I started to use AI tools as a way to provide inspiration and open up new perspectives. A last personal learning was the need to become comfortable with discomfort. The simple realization that this was part of the process, and the confidence of there being an end to it, helped to deal with discomfort. There are inevitably going to be changes, setbacks, and times when you feel like nothing is working out and you are clueless about how to continue. In each new step of the project, I fell victim to the Dunning-Kruger effect, which means I got overly confident about the progress in the beginning, then I fell into a valley of despair, before I slowly perceived success again (see Figure 91). This up and down can feel like a rollercoaster, but you are eventually going to cross the finish line, so you might as well embrace the ride.

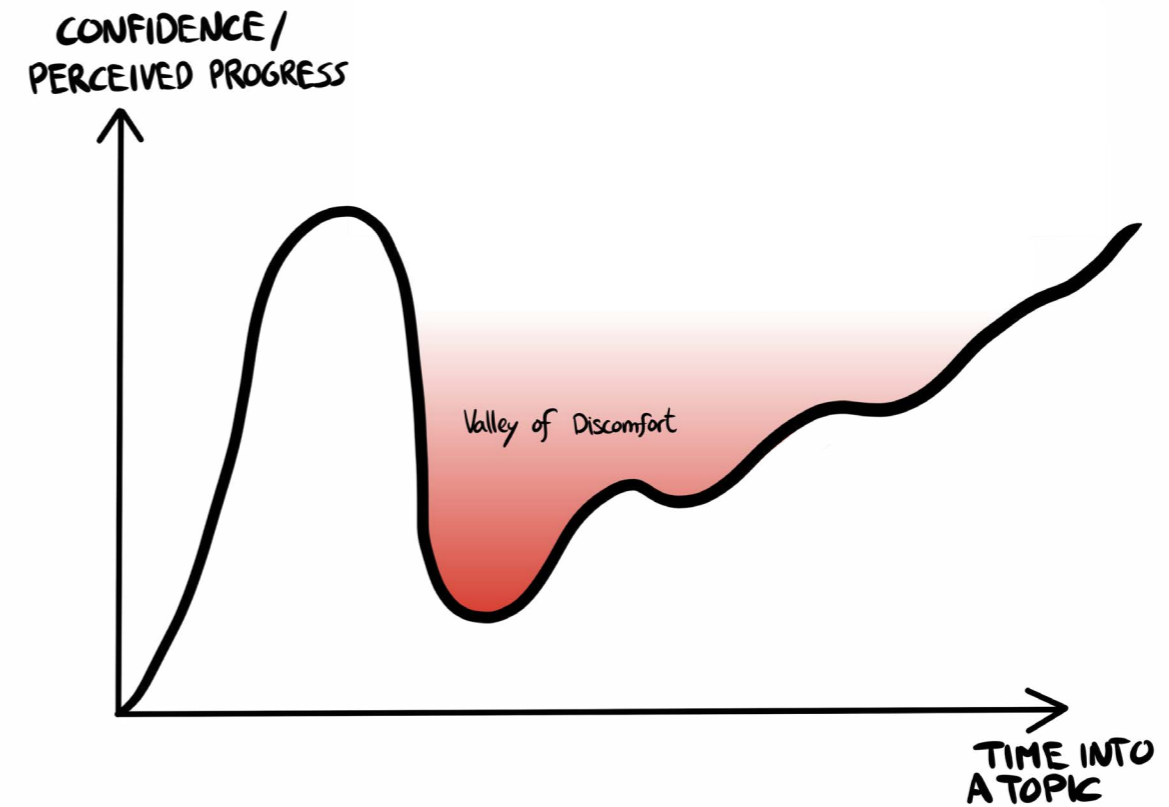


Fig. 91: Visualization of the Dunning-Kruger effect, with my moments of discomfort

09 References

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10 Appendix

Appendix A: Contexmapping Material

CONTEXTMAPING WORKBOOK

INTRODUCTION

Hello, and welcome to the study on reflections, where you will explore how you reflect in everyday life.

Reflections are “reviewing a series of previous experiences, [...] putting them together in such a way as to come to a better understanding or to gain some sort of insight.” (Baumer et al., 2014).

Before you start, please schedule a follow-up interview with me via this link: <https://neon.ly/vqAXj>. You can schedule the interview to be in 6-7 days from now, as you need 5 days to fill out this booklet.

Each day over the next 5 days, there is one exercise for you to do that takes about 10 min each. You should do one per day- no more no less. Please take a look at the exercises in the morning or on the day before, as some require activities throughout the day. This booklet is yours, so I'd encourage you to be creative; writing, drawing, annotating, glueing, including images etc. I hope and believe that you will learn about yourself in the process.

If there's something unclear, you can always contact me at P.A.M.Schroeder@student.tudelft.nl, or on Whatsapp at +352691697530.

Hi, my name is _____

 and I am a men/women/other who
 is _____ years old.

A new behaviour that I am recently
 trying to do is to (draw or write)

I do this because _____

I think that reflections can
 help to _____

Fig. 92: Workbook introduction exercise

DAY 1

What do I associate with reflections?

When you think of reflections in general, what comes to mind? Pick 5 words of the Day 1 material, and create 5 words on your own. Then, write down how you would define a reflection.



MINDMAP

My reflection definition


To me, a reflection is _____

Fig. 93: Workbook exercise day 1

DAY 2

My reflection helpers

Throughout this day, try to pay a little more attention to your environment as usual. Take 5 photographs of things (really anything!) that help you reflect on the behaviour that you are trying to change (mentioned in the intro), and 5 things that surely do not trigger such a reflection. Please send them to me via Whatsapp.



TRIGGERS

My reflection stimulators

After the left task, open day 2 material and attach the 3 things that make you reflect most, on this page (and shortly explain why it makes you reflect most).

Thing 1

Thing 2

Thing 3

Why? (1)

Why? (2)

Why? (3)

Fig. 94: Workbook exercise day 2

INTERVIEW GUIDE

The exercise of the workbook that is being referred to

Leading questions

Additional questions

Welcome	How did the exercises go?	This interview is about ...
Intro	Apart from this study, How often would you say you reflect on your behaviour?	
Ex. 2	What usually makes you reflect on your behaviour?	
Ex. 4	Where and when do such reflections on your behaviour mostly occur? Why?	Where and when would you ideally like to reflect?
Ex. 5	Can you take me through the process of you reflecting on your behaviour. What happens after being triggered?	What do you help yourself with to reflect?
Future	What is the hardest thing when you are trying to reflect?	What is the effect of the reflections on your behaviour?
		Why do you reflect? What are you hoping the effect to be?
	What could help you to reflect on your behaviour?	Thinking about smart devices- any ideas on how such could help?

Fig. 102: Interview guiding questions related to the workbook exercises

Appendix B: Ideation & Prototyping

SET OF IDEAS

Card to journal and be triggered by questions

Show behavioural info on object that is used when going outside.

Smart phone charger with ambient display to show behavioural info

Reflective 2nd nature object on commute routes (e.g. treadmill)

Show it trough art

What do the items/things/ places have in common?

Do you need to be triggered or self-initiate?

Creating AI art out of behavioural data

Progress on goal shown through light patterns

App to help find explanations to behaviour (why-answers)

A search engine for answers on our behavior / questions during reflections (cc. google)

Reflection thought box. Inputting journaling info and output is AI visualization

Card deck with reflection cards and ambient display

Pet like conversational reflection partner asking questions.

Online course on how to reflect

Thought box

Offloading thoughts to a box

intelligent phone block schedules

Shutdown button to turn off all connected devices and show reflection content

Turn off devices when good reflection environment is detected and show behavioural data

Extend people's perception of time

- Smart watch that sometimes goes much slower
- Smart glasses that show world is slow - no
- Make people feel like on holiday

Case to hide distracting parts of a tech device.

Fig. 103: Some of the ideas that were created

QUICK PROTOTYPES

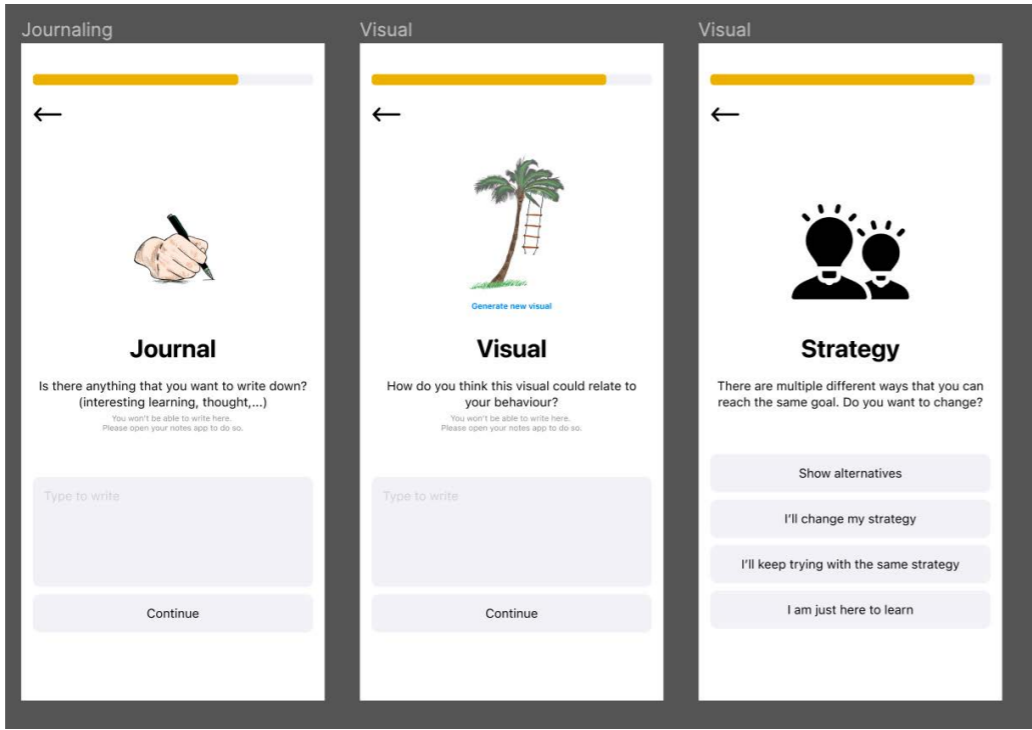
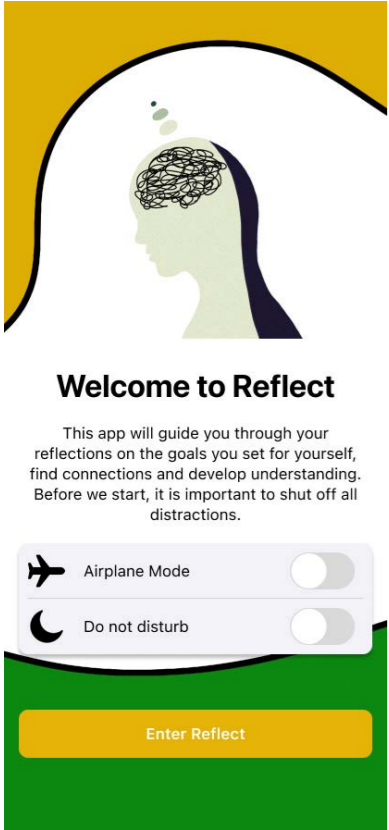


Fig. 104: Part of the app prototype

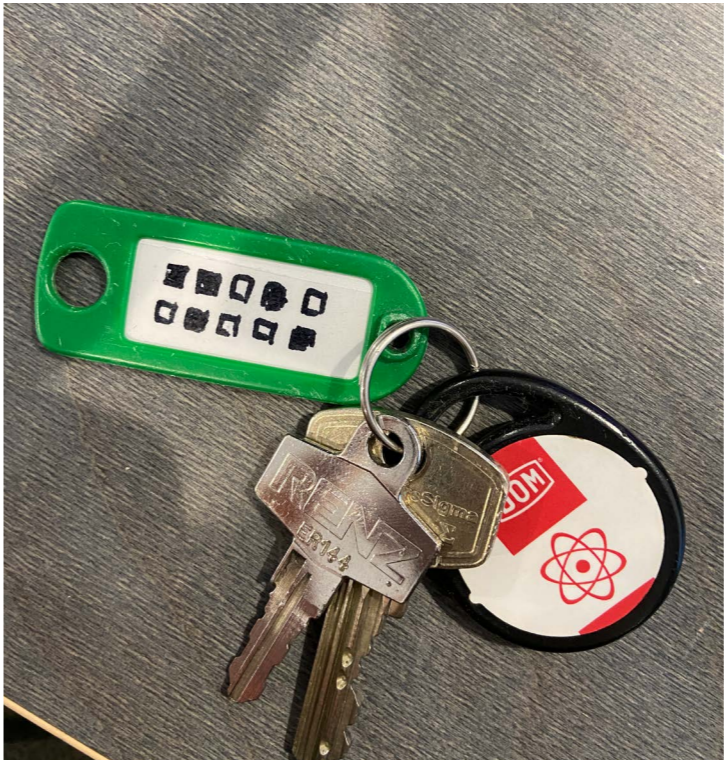


Fig. 106: The keychain prototype



Fig. 105: The wallet card prototype

Appendix C: Evaluation Material

EVALUATION PLAN

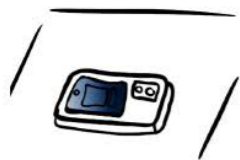
Concept evaluation plan

The concept and its key features will be evaluated in individual sessions with participants to answer the following 3 questions:

1. How are the key concept features experienced by users?
2. What depth of reflection is reached when using the concept?
3. What do people perceive as the concept's value (in the behavior change process)?

Concept key features

1. Card sitting on the back of user's phone



→ Non-persuasive, peripheral trigger in times where reflections could occur

2. Shutdown of the phone



→ Creation of non-distractive space, providing space and time (Fleck & Fitzpatrick, 2010), focus on thinking

3. Prompting of questions



→ Providing guidance, giving starting point, setting the right language, helping uncover barriers and enablers (counselling method)

4. Prompting of AI-informed hypotheses



→ Help people uncover things about themselves, showing new perspectives, transparent AI

5. Abstract visualization, reacting on the reflection



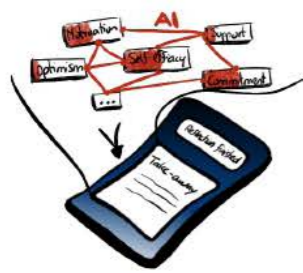
→ Providing ambiguity, abstractness, simplicity, leading to further reflection, triggers new thoughts, gives new perspective

6. Journaling through voice-recognition



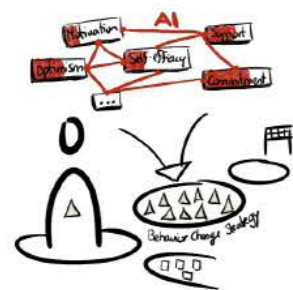
→ Fast way to output thoughts, intimate feel, allows immediate card reaction

7. Concrete take-away informed by barrier



→ Good feeling at the end, guaranteed learning, getting from reflection to action

8. Generation of a behavior change strategy



→ Personalized feeling, helping to find what fits, implementable thing boosting long-term behavior change

Recruiting

Conditions:

- 3-4 people

- In the target group of this project: 23-35 years old, working and/or studying, in the midst of trying to change a health behavior
- Speak English

Procedure

3 parts:

1. How are the key concept features experienced by users?
 - Experimental, generative role-play evaluation of main concept features
2. What depth of reflection is reached when using the concept?
 - One entire interaction and follow-up questionnaire
3. (How) do people see the concept's value in their behavior change process?
 - Informal discussion after parts (1) and (2)

1. Evaluating concept features

Duration: 30 min

Form: *Experimental role-play, discussion*

Material:

- Physical Card
- Display animation: <https://editor.p5js.org/philippeschroeder/full/UX8uPzT-K>
- Digital Application

Procedure:

1. Presenting the design vision/goal of the concept: "[...] to help people reflect on their behavior [...] find barriers and enablers [...]"
2. Walking through the concept, presenting feature by feature
3. For each feature:
 - a. Asking users to imagine the effect of the features on them
 - b. Asking users to evaluate the features against the intended goal

2. Evaluating the level of reflection

Duration: 30 min

Form: Prototype in use, paper survey

Material:

- Physical Card
- Display animation: <https://editor.p5js.org/philippeschroeder/full/UX8uPzT-K>

Procedure:

1. Prepare the prototype based on user's health goals
2. Reiterate the intended use of the prototype
3. Send the user on a walk with the prototype, should be using his/her phone
4. Send a message to users with the following instructions:
 - a. Take the card off your phone
 - b. Turn your phone into "do not disturb"
 - c. Start thinking about your health goal and open the following link: *insert p5 link*
5. Users should return after finishing their reflection
6. Users fill out the survey on reflection depth

Survey:

All questions are rated according to the following scheme:

How much do you agree with the following statements?

Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
----------------	-------	----------------------------	----------	-------------------

Please find the questionnaire below.

3. Evaluating the Value for Behavior Change

Duration: 30 min

Form: Informal discussion

Procedure:

A discussion on:

- Why did you give the answers in the questionnaire?
- What did you like/not like about the interaction?
- Where do you see the value of the concept?
- (How) do you think it can help you in your behavior change?

Summary

This document outlines a concept evaluation plan to evaluate key features of a concept, such as a physical card sitting on the back of a user's phone, prompting of questions, prompting of AI-informed hypotheses, abstract visualization, journaling through voice-recognition, and generation of a behavior change strategy. The evaluation plan includes individual sessions with participants to answer three questions, and the recruiting conditions and consent form are provided. The procedure includes an experimental role-play and discussion to evaluate concept features, and a prototype in use and paper survey to evaluate the level of reflection.

REFLECTION DEPTH SURVEY



Reflection questionnaire

Questionnaire is inspired by Kember et al. (2000) to measure reflection depth, adapted to the model of Fleck & Fitzpatrick (2010) and specified to behavior change:

Revisiting- No reflection

- (1) During the interaction, I thought more about my behavior than usual.
- (6) In my interaction with the card, I did not think much about anything. (n)
- (11) While using the card, I was thinking about my goal.

Description- Thinking about the past

- (2) During the interaction, I thought about past events, experiences, or behaviors.
- (7) The card made me think about the past.
- (12) I thought only about the moment itself when using the card. (n)

Exploring Relationships – Gaining understanding

- (3) During the interaction, searched to better understand myself and my behavior.
- (8) During my interaction, I thought about how different thoughts were related to each others.
- (13) While using the card, I tried to find new explanations for past events.

Fundamental Change

- (4) During the interaction, I questioned the way I was doing things in the past.
- (9) While using the card, I thought about better ways to reach my goal.
- (14) While using the card, I thought about what I could improve in my behavior.

Wider Implications – Taking context into account

(5) In my card interaction, I considered social issues and how they relate to my behavior.

(10) While using the card, I thought about how my goal is influenced by politics and culture.

(15) In my card interaction, I thought about the role of my context in my behavior.

P5 DIGITAL PROTOTYPE

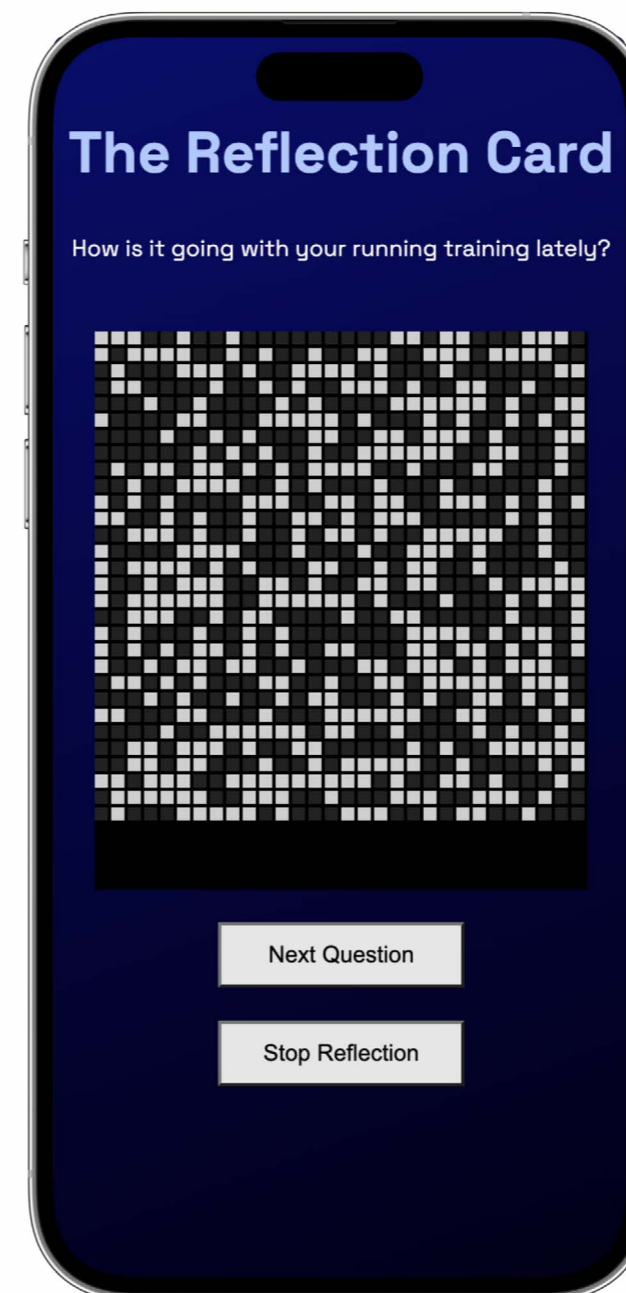


Fig. 107: Mockup of the start of a reflection

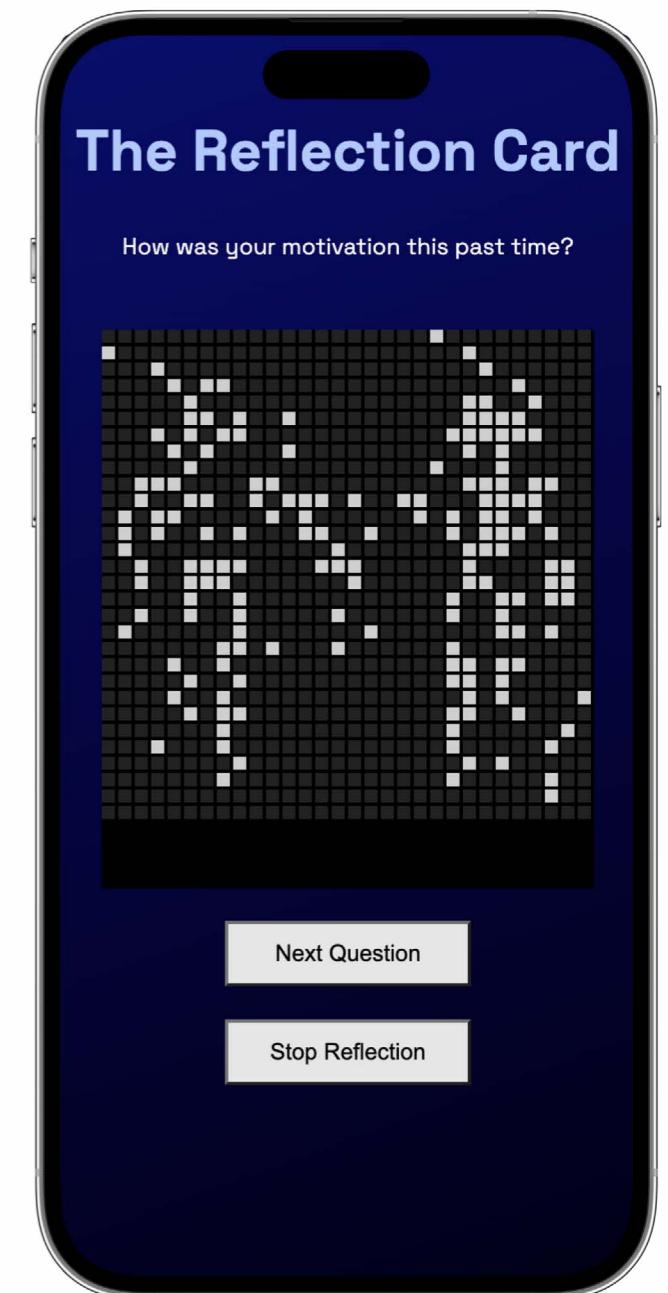


Fig. 108: Mockup of another question with a drawing evolving into two people

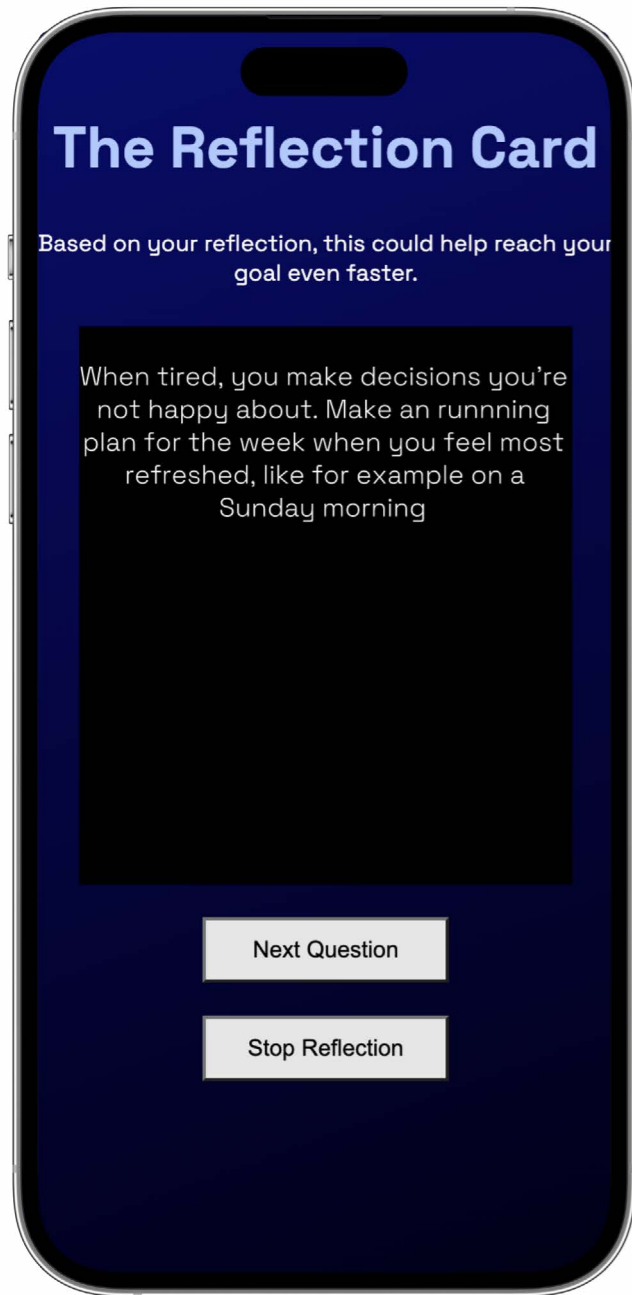


Fig. 109: Mockup of the final takeaway when people end their reflection



Fig. 110: Study participant talking to the reflection card

```

178 function renderPixels(){
179   let left = PADDING;
180   let top = PADDING;
181   let leftEnd = left + COLUMNS * CELL_SIZE;
182   for (let i = 0; i < pixelArray.length; i++) {
183     //change to .enabled to test a drawing, after enablePixels
184     funtion
185       fill(pixelArray[i].filled? COLORS[1] : COLORS[0]);
186       let size = CELL_SIZE - 2;
187       rect(left, top, size, size);
188       left += CELL_SIZE;
189       if (left === leftEnd) {
190         left = PADDING;
191         top += CELL_SIZE;
192       }
193     }
194   }
195   function enablePixels(image){
196     //empty the enabled pixels array
197     for (let i = 0; i < pixelArray.length; i++){
198       pixelArray[i].enabled = true;
199     }
200     for (let i= 0; i < image.length; i++){
201       pixelArray[i].enabled = image[i];
202     }
203     //create array of enabled pixels with map, saving the numbers
204   }
205 }
206 function drawClock(){
207   enablePixels(drawings.clock2);
208 }

```

Fig. 112: The pixel rendering part of the code, enabling pixels from a .json file where the drawings are saved as a true/false matrix



Fig. 111: The physical card prototype

CARD PROMPTS PER PARTICIPANT

Participant 1: Doing more sport

Q1: How is it going with doing more sport?"

Q2: "How was your motivation this past time?"

Q3: "It looks like you are confident in doing more sport going forward. Is that true?"
(hypothesis)

Q4: "How have your friends played a role in your sports behaviours?"

Q5: "Has your environment hindered you to do more sports?"

Q6: "You seem to lack time for working out lately, is that true?" (hypothesis)

Takeaway: "Pick a sport that you never did before and try it out today or tomorrow."

Participant 2: Being less on the phone

Q1: "How is it going with doing being less on your phone?"

Q2: "How was your motivation to resist your phone this past time?"

Q3: "It looks like you are confident in using your phone less going forward. Is that true?"
(hypothesis)

Q4: "How have your friends played a role in your phone behaviours?"

Q5: "Has your environment hindered you to be less on your phone?"

Q6: "You seem to lack energy sometimes for not using your phone, is that true?"
(hypothesis)

Takeaway: "On a piece of paper, write down the times you are not using your phone tomorrow."

Participant 3: Doing more sport

Q1: "How is your sport going lately?"

Q2: "How was your motivation this past time?"

Q3: "It looks like you are confident in doing more sport going forward. Is that true?"
(hypothesis)

Q4: "How have your friends played a role in your sports behaviours?"

Q5: "Has your environment hindered you to do more sports?"

Q6: "You seem to lack time for working out lately, is that true?" (hypothesis)

Takeaway: "When tired, you make decisions you're not happy about. Make an sports plan for the week when you feel most refreshed, like for example on a Sunday morning."

Participant 4: Taking care of his mental health

Q1: "How is it going with improving your mental health lately?"

Q2: "How was your motivation this past time?"

Q3: "It looks like you are confident in becoming more mentally healthy going forward. Is that true?" (hypothesis)

Q4: "How have your friends played a role in your the behaviors to improve your mental health?"

Q5: "What has been the impact of your environment on your mental health?"

Q6: "You seem to lack time for taking care of your mental health, is that true?"
(hypothesis)

Takeaway: "Write down the day, time, and activity you are committing to next to take care of your mental health."

Participant 5: Running more regularly

Q1: "How is it going with your running training lately?"

Q2: "How was your motivation this past time?"

Q3: "It looks like you are confident in running more often going forward. Is that true?"
(hypothesis)

Q4: "How have your friends played a role in your running training?"

Q5: "Has your environment hindered you to do more running?"

Q6: "You seem to lack time for running lately, is that true?" (hypothesis)

Takeaway: "Write down the day, time, and type of run you are committing to next."

Appendix D: Project Brief

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

! USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name Schroeder 5883
initials P.A.M. given name Philippe

Your master programme (only select the options that apply to you):

IDE master(s): IPD Dfi SPD

2nd non-IDE master: _____

individual programme: _____ (give date of approval)

honours programme: Honours Programme Master

specialisation / annotation: Medisign

Tech. in Sustainable Design

Entrepreneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair Dr. Jos Kraal dept. / section: HCD / AED

** mentor Dr. Ing. Marco Rozendaal dept. / section: HCD / HICD

2nd mentor _____

organisation: _____

city: _____ country: _____

comments
(optional)

⋮

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..



Second mentor only applies in case the assignment is hosted by an external organisation.



Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Dr. Jos Kraal date 29 - 08 - 2022 signature

How smart objects can support reflections in health behavior change project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 29 - 08 - 2022 07 - 02 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 21 EC **YES** all 1st year master courses passed

Of which, taking the conditional requirements into account, can be part of the exam programme 21 EC **NO** missing 1st year master courses are:

List of electives obtained before the third semester without approval of the BoE

name C. van der Bunt date 05 - 09 - 2022 signature
Digitally signed by C. van der Bunt Date: 2022.09.05 10:28:51 +02'00'

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: **APPROVED** **NOT APPROVED**

Procedure: **APPROVED** **NOT APPROVED**

comments

name Monique von Morgen date 06 - 09 - 2022 signature _____

space available for images / figures on next page

introduction (continued): space for images

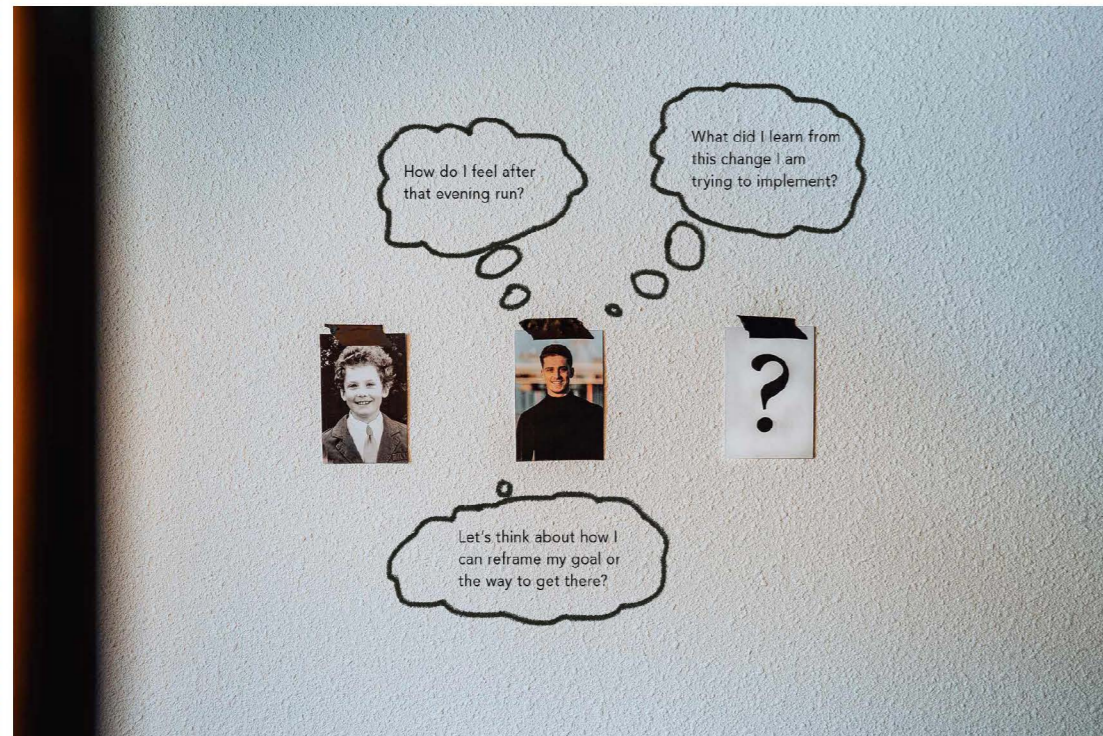


image / figure 1: Reflections are proven to help in a behavior change process



image / figure 2: Smart Objects have new sensing & interaction capabilities, creating more potential for reflections

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

This project has the goal of helping young adults create sustainable behavior changes in the context of health behaviors. It aims to do so, by creating (guidelines for) a product/service that triggers and supports people in reflections throughout their change process. The health behavior and the conceptualization of health is subject to individual's definitions and goals. It could be to become fitter by working out more or to support mental health by reading more books.

The intended effect is that people will have a better sense of progress and that they will gain personal learnings that help them find the best way to reach their health goals. In a first step, it will be explored how such reflections can fit most purposefully into the health behavior change process and people's contexts. Then, it will be explored how we can design smart objects that are able to support such reflections, and what the qualities of the product and the interaction with the user should feel like. After a research-through-design process, the findings will be converted into guidelines and into a final prototype that is validated by users.

The success of such a product will be measured against qualities of experience and interaction, determined by literature and throughout this project. It will also be measured on feelings of users' progress and their personal learnings, which are essential to the success of the reflection. While it would be interesting to test such a product/service against the sustainability of a behavior change in the long term, this would go beyond the scope of this project.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

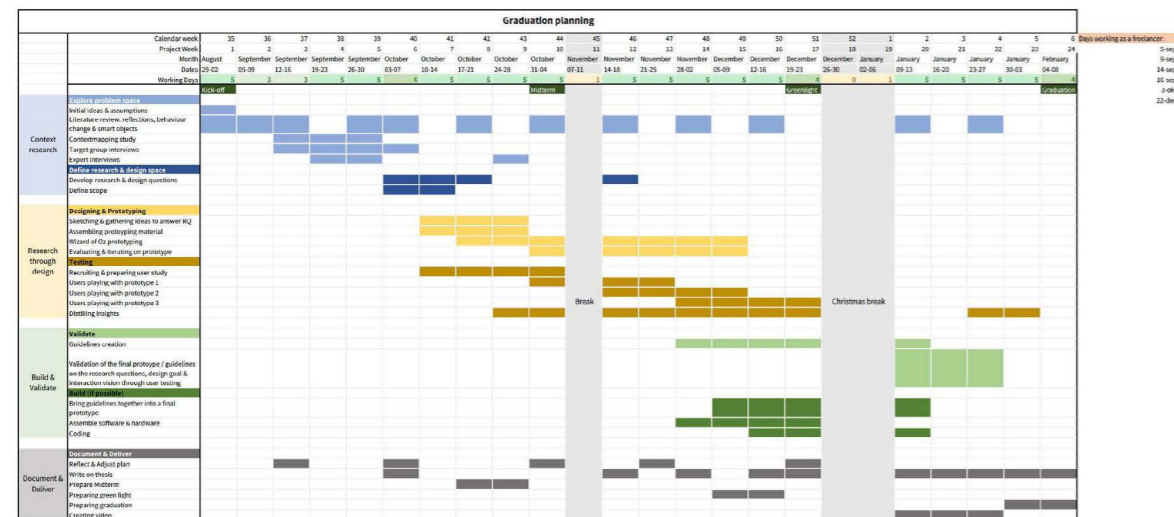
I will design and validate (guidelines for) a smart product/service at home that helps young adults reflect throughout their health behavior change process. These reflections will trigger a sense of progress and make people realize personal learning that will ultimately make their health behaviors more sustainable.

First, I will explore the concept of reflections and its role in the health behavior change process. Through primary and secondary research, I expect to be creating guidelines for reflections to successfully influence a behavior change process. These guidelines should be modular and include the type of reflection, its process, and content relative to people and their behavior change process. At the same time, I will be looking into ways that these qualities fit the interaction with smart objects, and how they can support the reflections. Through multiple iterations of prototypes that are tested with users, I expect to create a framework and final prototype for reflections supported by smart objects in health behavior change processes. The digital and/or physical form of the product, its materiality, shape, interactivity, media, and much more is going to be defined through a research-through-design approach. Strategies that are currently explored in literature roam around the creation of a human-object dialogue through voice or text (Thieme et al., 2011), the presentation of information through visual or textual digital media to promote comparison (Valkanova et al., 2013), ambiguity (Gaver, 2006), remembrance, or enable exploration (Kalnikaite & Whittaker, 2011). Another strategy is to allow users to express themselves towards smart objects that process and display information that is fed to them through any type of interaction, such as speaking, kneading, drawing, or through gestures. This could result in smart forms of diaries, sensing devices such as wearables, a smart mirror, reflection application, interactive digital painting, speakers helping to remember past experiences, and others (Mols et al., 2016). An interesting new direction also lies in slow technology; technology that is inherently designed to promote reflection (Hallnäs & Redström, 2001).

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 29 - 8 - 2022 7 - 2 - 2023 end date



The project will be divided into four parts: Context research, Research-through-design, Build, and Document. While the first three phases build up on each other, I will document the process and gather insights throughout the entire project.

The context research phase revolves around a context-mapping study and interviews with the target group to broadly explore the concepts and their contexts in real-life environments. In the research-through-design phase, research questions on the final concept that have emerged from the first phase, will be explored through the creation of prototypes. They will be given to users in their health behavior change process in an effort to discover materiality, interactivity, and more on how a final concept can support reflections. To evaluate an effect on behavior change for which a longer timeframe is necessary, prototypes will be tested for up to 4 weeks. This will however depend on the exact research question and the goal of the prototype. In the Build & Validate phase, I will create a framework for a smart, supportive reflection tool out of all the insights from the previous parts as well as literature findings. If possible, a final prototype will be created. The guidelines and/or final prototype will then be tested against criteria that are established in phases 1 and 2. Finally, a report on the entire project will be created and it will be presented at the graduation on the 7th of February (tbc).

I will work 5 days a week for most weeks but work as a freelancer on selected dates. This will help me financially, but I believe it will also help me creatively to focus on other work from time to time. In November, I also want to take a week off the project to focus on redesigning my website and reading new books. The 100 working days are distributed over 24 weeks (holidays included).

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, Stick to no more than five ambitions.

Over the last years, I discovered that I personally find a lot of success and happiness from being able to change my behaviors easily. That is why I became curious about the ins and outs of behavior change, the techniques, and the psychology behind it. At the same time, the design education at IDE regularly emphasizes the importance of psychology when designing for users.

As a next step, I want to help other people find the same kind of fulfillment, happiness, and success. I believe that being able to change one's behavior is the path to becoming your ideal future self. At the same time, having a solid understanding of behavioral science helps to become a better designer. Being able to change one's behavior can also contribute to societies being able to solve complex problems easier. I believe that if people were better supported in changing their behaviors, we would be much further in solving problems like climate change, misinformation, or poverty.

At the same time, I have always been fascinated by the possibilities of technology. Recently, however, I have also become more aware of their harms and far-reaching impacts on people and societies. That is why I am very interested in "humane technology", technology ethics, and how we can design technology that fits meaningfully and purposefully into people's lives.

Both of these interests are combined in this master's project, which I am really happy about. I want to help other people change their behaviors, and contribute to the design of ethical technology. This project allows me to learn about both of these directions and the design practice simultaneously. Having a background in HCI and thinking about pursuing a career in design, I need to build on the design process & methodology knowledge that I gained throughout my studies. In summary, I have the following ambitions:

- Gain scientific knowledge about behavior change & psychology
- Pioneer ethical approaches when designing with technology
- Hone my prototyping skills
- Learn to apply the right design methods

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Appendix E: Ethics Application

CONSENT FORM

Consent form:

Contextmapping study to explore reflections on health behavior

You are being invited to participate in a study around reflections on your health behaviors in everyday life. This study is coordinated by Philippe Schroeder from the TU Delft.

The purpose of this research study is to explore how people reflect on their health behavior and how they can be supported in their reflections. The different activities in the study will take you approximately 2 to 3 hours, including daily 10-minute exercises, an interview of 30 minutes and a workshop of 1.5 hour. The data will be used for creating prototypes and will be included in a graduation thesis report. In a first part, you will be handed a booklet with exercises to do throughout a week. These will roam around your experiences with reflections, the process, and its contexts. You will be creating material as part of the study that is given back to the researcher after the week has passed. In the interview, we will dive deeper on how, when, and where you reflect to understand how you might be supported and ultimately become more successful in leading a healthy lifestyle. In the workshop, we will try to identify barriers and facilitators for reflection, and explore prototyping for reflection.

The material created throughout the study will be saved for review, but it will be de-identified shortly after the study. The interview will be recorded for review, but the recording will be deleted after the project (February 2023). This data will be safely stored on a hard drive for the rest of the project and beyond. To the best of our ability your answers in this study, as well as material provided will remain confidential. When using quotes, pictures, or results of other exercises, we will provide an alternative name, blur your face and try to remove any connection from yourself and the results provided.

Your participation in this study is entirely voluntary **and you can stop it at any time**. You are free to omit any questions as well as have parts of your results be removed from analysis.

Thank you!

Philippe Schroeder

Email: P.A.M.Schroeder@student.tudelft.nl

Date: 08/09/22

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated 08/09/22 or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	<input type="checkbox"/>	<input type="checkbox"/>
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	<input type="checkbox"/>	<input type="checkbox"/>
3. I understand that taking part in the study involves: doing short exercises on my reflections individually, having an interview with the researcher, and taking part in a workshop.	<input type="checkbox"/>	<input type="checkbox"/>
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
4. I understand that taking part in the study involves collecting specific personally identifiable information (PII) such as my name, age, and gender, and associated personally identifiable research data (PIRD) such as my thoughts and replies to questions. I understand that this information will be anonymized as soon as possible.	<input type="checkbox"/>	<input type="checkbox"/>
5. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: Anonymisation of the data through blurring faces, changing names, limiting access to the research team, and keeping data on an external hard drive and/or the cloud.	<input type="checkbox"/>	<input type="checkbox"/>
6. I understand that personal information collected about me that can identify me, such as my name and my photographs will not be shared beyond the study team.	<input type="checkbox"/>	<input type="checkbox"/>
7. I understand that the (identifiable) personal data I provide will be destroyed at latest after the project on February 15 th 2023.	<input type="checkbox"/>	<input type="checkbox"/>
8. I understand that participating in face-to-face meetings might pose a risk to a covid infection. However, I will use the pre-cautions provided by the researchers to limit the risk of infection (hand sanitizer, face masks, social distancing).	<input type="checkbox"/>	<input type="checkbox"/>
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
9. I understand that after the research study the de-identified information I provide will be used for creating a project report, video, and publication.	<input type="checkbox"/>	<input type="checkbox"/>
10. I agree that my responses, views or other input can be quoted anonymously in research outputs.	<input type="checkbox"/>	<input type="checkbox"/>
11. I provide permission to the research team to reuse and publish works that I have created under copyright law. Such could be thoughts, images, text, or any other material created in the scope of this study.	<input type="checkbox"/>	<input type="checkbox"/>
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
12. I give permission for the de-identified quotes, pictures, and other data that I provide to be archived on a hard drive of the researcher so it can be used for future research and learning.	<input type="checkbox"/>	<input type="checkbox"/>

HREC CHECKLIST

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

Signatures

Name of participant [printed]

Signature

Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Researcher name [printed]

Signature

Date

Study contact details for further information:

Philippe Schroeder

P.A.M.Schroeder@student.tudelft.nl

+352691697530

IMPORTANT NOTES ON PREPARING THIS CHECKLIST

1. An HREC application should be submitted for every research study that involves human participants (as Research Subjects) carried out by TU Delft researchers
2. Your HREC application should be submitted and approved **before** potential participants are approached to take part in your study
3. All submissions from Master's Students for their research thesis need approval from the relevant Responsible Researcher
4. The Responsible Researcher must indicate their approval of the completeness and quality of the submission by signing and dating this form OR by providing approval to the corresponding researcher via email (included as a PDF with the full HREC submission)
5. There are various aspects of human research compliance which fall outside of the remit of the HREC, but which must be in place to obtain HREC approval. These often require input from internal or external experts such as [Faculty Data Stewards](#), [Faculty HSE advisors](#), the [TU Delft Privacy Team](#) or external [Medical research partners](#).
6. You can find detailed guidance on completing your HREC application [here](#)
7. Please note that incomplete submissions (whether in terms of documentation or the information provided therein) will be returned for completion **prior to any assessment**
8. If you have any feedback on any aspect of the HREC approval tools and/or process you can leave your comments [here](#)

I. Applicant Information

PROJECT TITLE:	How smart objects can support reflections in health behavior change
Research period: <i>Over what period of time will this specific part of the research take place</i>	29/08/22-07/02/23
Faculty:	Industrial Design Engineering (IDE)
Department:	Applied Ergonomics and Design (AED)
Type of the research project: <i>(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)</i>	Master's
Funder of research: <i>(EU, NWO, TUD, other – in which case please elaborate)</i>	Self-funded
Name of Corresponding Researcher: <i>(If different from the Responsible Researcher)</i>	Philippe Schroeder
E-mail Corresponding Researcher: <i>(If different from the Responsible Researcher)</i>	P.A.M.Schroeder@student.tudelft.nl
Position of Corresponding Researcher: <i>(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)</i>	Master student
Name of Responsible Researcher: <i>Note: all student work must have a named Responsible Researcher to approve, sign and submit this application</i>	Jos Kraal
E-mail of Responsible Researcher: <i>Please ensure that an institutional email address (no Gmail, Yahoo, etc.) is used for all project documentation/ communications including Informed Consent materials</i>	J.J.Kraal@tudelft.nl
Position of Responsible Researcher : <i>(PhD, PostDoc, Associate/ Assistant/ Full Professor)</i>	Assistant professor

II. Research Overview

NOTE: You can find more guidance on completing this checklist [here](#)

a) Please summarise your research very briefly (100-200 words)

What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbreviations)

Over the period of 5 months, we will be doing interviews, a contextmapping session, and research through design by having participants use prototypes. In an attempt to help people change their health behaviour towards their desired goals, people of age 25-35 will be considered in half-hour interviews to talk about their relationship with reflections, health behavior and smart objects. In a context-mapping session of about 2 hours, participants will do short reflection exercises. In the research-through-design phase, participants will be given prototypes to test throughout multiple weeks to help them reflect on their behaviour change process.

b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

Add your text here – (please avoid jargon and abbreviations)

-

c) **If your application is a simple extension of, or amendment to,** an existing approved HREC submission, you can simply submit an [HREC Amendment Form](#) as a submission through LabServant.

III. Risk Assessment and Mitigation Plan

NOTE: You can find more guidance on completing this checklist [here](#)

Please complete the following table in full for all points to which your answer is “yes”. Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of **Personally Identifiable Information (PII)** and/or **Personally Identifiable Research Data (PIRD)** which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alignment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that **you're much more likely to need to resubmit your application if you neglect to identify potential risks**, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

ISSUE	If YES please complete the Risk Assessment and Mitigation Plan columns below.		Please provide the relevant reference #	
	Yes	No	DMP	ICF
A: Partners and collaboration 1. Will the research be carried out in collaboration with additional organisational partners such as: <ul style="list-style-type: none"> One or more collaborating research and/or commercial organisations Either a research, or a work experience internship provider¹ ¹ If yes, please include the graduation agreement in this application		x		
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? <i>If yes please provide a copy of the signed DTA/DPA</i>		x		
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? <i>If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below</i>		x		
B: Location				

If YES please complete the Risk Assessment and Mitigation Plan columns below.				Please provide the relevant reference #		
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!	MITIGATION PLAN – what mitigating steps will you take? Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.	DMP	ICF
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?	x		The research will take place in the Netherlands, in Luxembourg, or online. Possible risks include: - Mental strain of online meetings - Participants feeling left out in hybrid meetings	- Creating regular breaks in online sessions - Creating separate sessions for online and onsite participants		
5. Will the research take place in a country or countries outside the EU?		x				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		x				
C: Participants						
7. Will the study involve participants who may be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes).		x				
8. Will the study involve participants who may be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		x				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? <i>It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).</i>		x				
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?		x				
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups		x				
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a		x				

If YES please complete the Risk Assessment and Mitigation Plan columns below.				Please provide the relevant reference #		
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!	MITIGATION PLAN – what mitigating steps will you take? Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.	DMP	ICF
community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)						
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third party data-gathering service, such as a survey platform?		x				
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		x				
E: Subject Matter <i>Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.</i>						
15. Will your research involve any of the following: • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and <i>In Vitro Diagnostic Medical Devices</i> Research		x				
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? <i>If yes see here to determine whether medical ethical approval is required</i>		x				
17. Will blood or tissue samples be obtained from participants? <i>If yes see here to determine whether medical ethical approval is required</i>		x				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		x				
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) <i>Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.</i>	x		- It can involve discussion of personal behavioral data - It can involve recitation of past memories or other intimate information	- All data will be safely stored on an external hard drive or in the cloud - Participants' information will be made unidentifiable in any public report by changing names and not showing faces		
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)		x				
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? <i>If yes please attach the advice/ approval from the Privacy Team to this application</i>		x				
22. Does your research investigate causes or areas of conflict?		x				

If YES please complete the Risk Assessment and Mitigation Plan columns below.				Please provide the relevant reference #		
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!	MITIGATION PLAN – what mitigating steps will you take? Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.	DMP	ICF
<i>If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.</i>						
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences <i>If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.</i>	x					
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		x				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		x				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?	x		- Participants might be made aware of the incongruity between their goals and their actual behaviour	- This incongruity is necessary for behavior change so it will not be mitigated, but participants will have the option to opt out of the study at any time		
27. Will the experiment involve the use of devices that are not 'CE' certified? <i>Only, if 'yes': continue with the following questions:</i>	x		- Prototypes could not be safe in electronics, environment or health	- Instructions on how to use (and not use) the prototype(s) will be prepared - Prototypes will be tested by the researchers first - Prototypes will be returned to the researchers after the study		
• Was the device built in-house?	x					
• Was it inspected by a safety expert at TU Delft? <i>If yes, please provide a signed device report</i>		x				
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? <i>If yes, please provide records of the inspection</i>		x				
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	x		- Covid infection	- Hand sanitizer will be arranged - People are free to use masks		
29. Will your research involve either:	x		- There might be the use of datasets that are used in ML models	- Proper documentation of data sets and models will be provided		

If YES please complete the Risk Assessment and Mitigation Plan columns below.				Please provide the relevant reference #		
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!	MITIGATION PLAN – what mitigating steps will you take? Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.	DMP	ICF
a) "big data", combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants and/or b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?						
G: Data Processing and Privacy						
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)	x		- The stealing of personal information	- Data will be securely stored on a hard drive and/or the cloud - Data that is not relevant for further research will be deleted after the project		
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and what other Personal Research Data (including personal or professional views) will you be collecting?	x		- Videos, pictures, gender, age, health goals, behavioral information, tracking data, and sensory information will be collected throughout the project	- Data will be securely stored on a hard drive and/or the cloud - Data that is not relevant for further research will be deleted after the project		
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		x				
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	x		- Published in the TU Delft repository - Presented at a graduation ceremony	- All participants will be made unidentifiable in any public report or presentation, through e.g. blurring faces and changing names		
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?	x		- Findings on prototypes might be archived	- The connection between participants and their data will be eliminated as much as possible		

H: More on Informed Consent and Data Management

NOTE: You can find guidance and templates for preparing your Informed Consent materials [here](#)

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments [here](#)

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)

Signature of Corresponding Researcher: Philippe Schroeder

Date: 08/09/22

Name of Responsible Researcher (print)

Signature (or upload consent by mail) Responsible Researcher:

Date:

V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

Please also attach any of the following, if relevant to your research:

Document or approval	Contact/s
Full Research Ethics Application	After the assessment of your initial application HREC will let you know if and when you need to submit additional information
Signed, valid Device Report	Your Faculty HSE advisor
Ethics approval from an external Medical Committee	TU Delft Policy Advisor, Medical (Devices) Research
Ethics approval from an external Research Ethics Committee	Please append, if possible, with your submission
Approved Data Transfer or Data Processing Agreement	Your Faculty Data Steward and/or TU Delft Privacy Team
Approved Graduation Agreement	Your Master's thesis supervisor
Data Processing Impact Assessment (DPIA)	TU Delft Privacy Team
Other specific requirement	Please reference/explain in your checklist and append with your submission

DATA MANAGEMENT PLAN

Plan Overview

A Data Management Plan created using DMPonline

Title: How smart objects can support reflections in a health behavior change process

Creator: Philippe Schroeder

Affiliation: Delft University of Technology

Template: TU Delft Data Management Plan template (2021)

Project abstract:

In this project, we will design and validate (guidelines for) a smart product/service that helps young adults aged 23-35 in higher education, to reflect on their health behavior change process. These reflections will trigger a sense of progress and make people realize personal learning that will ultimately make their health behaviors more sustainable.

In semi-structured interviews, we will first gain more general knowledge on reflections and behavior change, before a context-mapping workshop of 2 hours will help us gain deeper insights into the context of reflections and their occurrence in behavior change. Finally, in a research-through-design process, users can test prototypes to help us answer important questions on interactivity, materiality, and positioning in users' lives of a smart object that supports reflection.

ID: 106625

Start date: 29-08-2022

End date: 07-02-2023

Last modified: 16-09-2022

How smart objects can support reflections in a health behavior change process

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

Faculty data steward: Love, Jeff

Note: This project is very similar to other graduation projects performed in the past years, with a similar data management plan. Therefore, our plan is based on an earlier DMplan that was developed in cooperation with Jeff

2. Date of consultation with support staff.

2022-09-08

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Videos	.mp4	Captured with phone camera during contextmapping sessions, by participants in their everyday life, or by screen recording in online sessions.	For analysis and documentation of the interviews, contextmapping session, and use of prototypes	Laptop + OneDrive	My supervisory team and myself
Photos	.jpg	Captured with camera during contextmapping session or by participants themselves	For analysis and documentation of the interviews, contextmapping session, and use of prototypes	Laptop + OneDrive	My supervisory team and myself
Gender, Age, Name	Written	Asked at recruiting or during interviews	To personalise session material (but will be anonymized later)	Laptop + OneDrive	My supervisory team and myself

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- README file or other documentation explaining how data is organised

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- OneDrive

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, ask your [Faculty Data Steward](#) for advice. You can also check with the [privacy website](#) or contact the privacy team: privacy-tud@tudelft.nl

- Yes

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your [Faculty Data Steward](#) for advice.

- No, I will not work with any confidential or classified data/code

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your [Faculty Contract Manager](#) when answering this question. If this is not the case, you can use the example below.

Data information will be owned by the TU Delft.

10. Which personal data will you process? Tick all that apply

- Signed consent forms
- Photographs, video materials, performance appraisals or student results
- Gender, date of birth and/or age
- Email addresses and/or other addresses for digital communication
- Names and addresses

11. Please list the categories of data subjects

People aged 23-35 in higher education. They should be working and/or studying.

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

All study participants will be asked for their written consent for taking part in the study and for data processing before the start of the given study.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform [Data Protection Impact Assessment \(DPIA\)](#). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).

If two or more of the options listed below apply, you will have to [complete the DPIA](#). Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.

If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.

If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Anonymised or aggregated data will be shared with others

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

I will not share data of participants who do not give consent for data sharing.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- All other non-personal data (and code) produced in the project

29. How will you share research data (and code), including the one mentioned in question 22?

- I will upload the data to another data repository (please provide details below)

TU Delft educational repository

31. When will the data (or code) be shared?

- As soon as corresponding results (papers, theses, reports) are published

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, the only institution involved

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

My supervisors Jos Kraal (J.J.Kraal@tudelft.nl) and Marco Rozendaal (M.C.Rozendaal@tudelft.nl)

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

I will handle all data management

REVISION FORM

Delft University of Technology
HUMAN RESEARCH ETHICS
REVISIONS TEMPLATE
(Version: January 2022)

This revisions template should be used to address queries raised by the Human Research Ethics Committee (HREC) in an ongoing ethics approval and uploaded into your live submission.

If you have any questions about your applying for HREC approval which are not dealt with on the [Research Ethics webpages](#), please contact HREC@tudelft.nl

I. Response to HREC queries:

Query 1:

HREC Query	Please reflect upon the amount of data that is being collected for this research and the risks of re-identification for participants. Also think about taking precautions to anonymize data as soon as possible.
Response	Some of the data we collect are personally identifiable information, which is necessary for the project. However, we will remove and de-identify this data as soon as possible (use participation code instead of participant name, hide faces in images), and make sure no participants can be re-identified from the published data.

Query 2:

HREC Query	Further specify the nature of the devices that you are planning to utilize and include HSE approval and/or advise.
Response	In the project, we will explore how participants reflect on health behavior using low fidelity and paper prototypes (think of a small booklet, a diary, text message-based reminders, a cardboard item for on your desk). These prototypes will help us gather data on when/how/why people reflect. Interactions with these prototypes will deliver very limited risk to our participants. In case we will develop prototypes from material with sharp edges, working electronics or other materials that pose a risk to our participants, we will reach out to the HSE advisor.

Query 3:

HREC Query	Further clarify the mental discomforts that participants might experience (as mentioned in the informed consent form).
Response	The risk of mental discomfort for our participant is expected to be very small (if any). We will ask participants to reflect on their own health behavior throughout the project, and reflection could lead to overthinking. Although overthinking can be perceived as mental discomfort, we do expect the risk and harm of overthinking very small (if any). It was included in checklist/informed consent in an earlier version, but took it out later after a discussion with the team. However, we forgot to take it out of the informed consent. In the updated version, we have removed this sentence from the form.

Query 4:

HREC Query	Include possible covid risks in the informed consent form.
Response	We have added information regarding possible risk of covid infection to the informed consent form

Query 5:

HREC Query	We advise a precautionary approach on the publication of interview transcripts
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Response	Transcripts of the interviews won't be added to the final thesis, and will therefore not be included in the publication.
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II. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)

Signature of Corresponding Researcher:

Date:

Name of Responsible Researcher (print)

Signature (or upload consent by mail) Responsible Researcher: Philippe Schroeder

Date: 29.09.22