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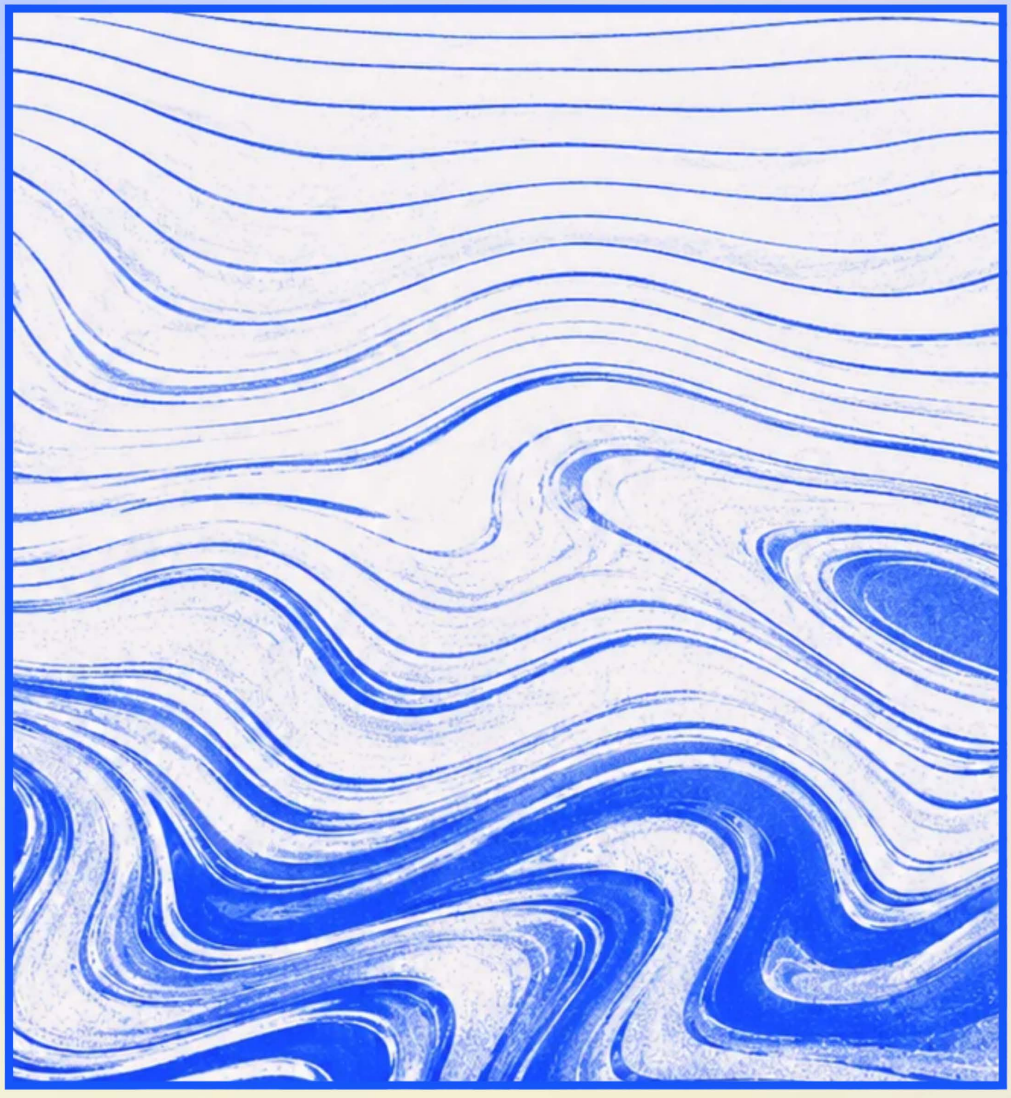
Supporting Adolescents in Navigating Health Behavior Change



Timothy Andrew Houtman

Supporting Adolescents in Navigating Health Behavior Change

Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus,
Prof.dr.ir. H. Bijl,
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by

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Key words: health behavior change, adolescent health, design, personalization, self-tailoring, self-experimentation, serious games
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Waarom moet alles optimaal? Hoezo moet alles efficiënt?

Je bent een mens en geen machine, een mens is niet consistent

Continu, concurrent, het loopt anders dan gepland

Ben je dat na al die tijd nog steeds niet gewend?

- *Sef (lieve monsters)*

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Summary

Adolescence is the developmental period between childhood and adulthood, from the early teens to the early twenties. Healthy lifestyle behaviors established during adolescence, such as regular physical activity, balanced nutrition, and adequate sleep, influence both immediate and long-term health and wellbeing. Yet changing and maintaining these behaviors is difficult for many adolescents. Interventions aimed at adolescent health behavior tend to show short-term and heterogeneous effects. One reason is a mismatch between these interventions and the developmental characteristics of adolescence, such as shifting interests and motivations, new social roles, and growing autonomy.

In this dissertation, I investigate how serious games, and health behavior change interventions more broadly, can be designed to be more developmentally sensitive and to support sustainable healthy lifestyle change in adolescents. To do so, I focus on personalization, which is increasingly used to improve the fit between an intervention and the person it is meant to support, and thereby its effectiveness. However, personalization is usually done top-down, where the intervention is tailored on the adolescent's behalf, which removes the agency and autonomy that adolescents increasingly want to exercise. I therefore investigate self-tailoring, in which adolescents adapt an intervention to themselves, and self-experimentation, in which they try out their approach in daily life and learn from experience what works for them.

My approach combines behavioral science and human-centered design. In Chapter 2, I discuss the strengths of both fields and how integrating their principles leads to a complementary approach to designing for sustainable, long-term health behavior change. In Chapter 3, I examine the barriers and facilitators adolescents experience around maintaining physical activity, using interviews and a card-sorting task based on Q-methodology with thirty adolescents. This yielded five facilitator profiles and four barrier profiles. The facilitator profiles ranged from the immediate experience of the activity, such as enjoyment and social belonging, to more future-oriented profiles centered on personal development. The barrier profiles ranged from internal sources, such as low motivation and energy, through the balancing of school and other obligations, to environmental obstacles. The profiles were not fixed: 70% of participants reported that their facilitators had changed over time, and 57% reported changes in their barriers.

These findings show that adolescents differ in what facilitates and hinders them in maintaining healthy behaviors such as physical activity, and that these factors change over time. This suggests that interventions benefit from personalization

that fits the specific facilitators and barriers adolescents encounter in their daily lives, with room to adapt the approach as their situation changes. With this in mind, I developed *Mapping of Me* together with adolescents in a participatory design process. Mapping of Me is a three-week hybrid journaling game in which adolescents work in pairs on a self-chosen health goal. Across two cycles of self-experimentation, they plan, try out, and reflect on self-enactable strategies.

Chapters 4 and 5 describe the design process, including two Research through Design activities that shaped the underlying mechanisms. In the first, seven adolescents constructed, applied, and reflected on their own strategies for a self-chosen health goal over three weeks. With only a few simple prompts, they arrived at their own strategies and revised their approach based on experience, but they also expressed a need for an overview of strategy options. In the second, I therefore developed a strategy menu of 29 self-enactable strategies, drawn from existing behavior change techniques and from strategies participants had generated themselves. The strategies are organized into six categories: Action (such as starting small), Space (such as removing temptations), Time (such as time blocking), Mindset (such as treating every day as a reset), Social (such as doing it together), and Symbols (such as visual reminders). Adolescents select and combine strategies as building blocks for their own approach and decide whether to use them before, during, or after their activity. I tested the menu with twenty adolescents. Each participant assembled a unique combination of strategies, which suggests that adolescents choose strategies based on personal fit. The strategy menu was then built into Mapping of Me.

Chapter 6 presents the evaluation of Mapping of Me with thirty-six adolescents, examining which strategies they developed, whether they still used them one month later, and what insights they gained about their own behavior change. Every strategy on offer was selected at least once, and the same strategy was rated as highly effective by one participant and as ineffective by another, which suggests that the value of a strategy depends largely on personal fit. Mindset strategies were the most popular, but were rated as less effective than Action, Space, and Time strategies. Participants mostly used their strategies before and during their chosen activity, to make it easier to get started or to keep going. At follow-up, 27 of the 34 respondents (79%) reported still using at least one strategy, either for their goal or in other areas of their lives, such as studying. Experimenting helped them learn which strategies fitted their context, what motivated them, how to set realistic goals, and which problems lay behind their goals. Some of these problems only became visible once they tried out their approach in practice.

Together, these studies show how behavioral science insights can be applied with a human-centered design approach to health behavior change interventions for adolescents. They also show that adolescents can construct and adapt their own approach to a healthy lifestyle when an intervention gives them the room and support to do so. The dissertation thereby contributes design knowledge about how serious games, and health behavior change interventions more broadly, can be designed for adolescents. Its central contribution is a design rationale and design principles for self-tailoring and self-experimentation in health behavior change interventions. Interventions built on these can be more personalized and developmentally sensitive, because adolescents shape their own approach and try out what works for them in their daily lives. This gives them a more active role and more autonomy in their own behavior change, and helps them build self-knowledge. This may lead to interventions that not only help adolescents change their behavior now, but also equip them to shape a healthy lifestyle in the future.

Samenvatting

De adolescentie is de ontwikkelingsfase tussen de kindertijd en volwassenheid, van de vroege tienerjaren tot begin twintig. Gezonde leefstijlgedrag zoals bewegen, gezond eten en voldoende slapen, dat zich in deze periode wortelt is bevorderend voor de gezondheid en het welzijn van adolescenten, nu en voor later. Toch is het voor veel adolescenten lastig om hun gezonde leefstijl te adopteren en die vol te houden. Gezonde leefstijlinterventies voor adolescenten hebben vaak een kortdurend en uiteenlopende resultaten. Een van de verklaringen is dat deze interventies onvoldoende aansluiten bij de kenmerken van adolescenten: hun interesses en motivaties veranderen, ze experimenteren met nieuwe sociale rollen en hebben steeds meer autonomie om hun leven zelf in te richten.

In dit proefschrift onderzoek ik hoe *serious games*, en gezonde leefstijlinterventies in bredere zin, beter kunnen aansluiten bij de deze kenmerken en adolescenten kunnen ondersteunen voor een meer duurzame gezonde leefstijl. Binnen dit onderwerp richt ik me op personalisatie: hoe gezonde leefstijlinterventies beter aan kunnen sluiten bij de behoeftes van de persoon, om zo de werking en effecten van de interventie te verbeteren. Vaak gebeurt personalisatie van bovenaf, waarbij de interventie voor de persoon op maat wordt gemaakt. Bij adolescenten neemt dit mogelijk juist de autonomie en eigen regie weg waar zij in deze levensfase juist behoefte aan hebben. Daarom onderzoek ik in dit proefschrift *self-tailoring*, waarbij adolescenten de interventie voor zichzelf op maat maken, en *self-experimentation*, waarbij ze hun zelfgemaakte aanpak uitproberen in het dagelijks leven om te ontdekken of het voor hen werkt.

In dit onderzoek combineer ik gedragswetenschappen en mensgericht ontwerp. In hoofdstuk 2 bespreek ik de eigenschappen van beide disciplines en hoe ze elkaar kunnen versterken bij het ontwerpen voor duurzame gezonde gedragsverandering. In hoofdstuk 3 onderzoek ik welke bevorderende en belemmerende factoren adolescenten ervaren bij het volhouden van beweeggedrag. Daarvoor interviewde ik dertig adolescenten aan de hand van een sorteertaak op basis van Q-methodologie. De analyse resulteerde in vijf profielen van bevorderende factoren en vier profielen van belemmerende factoren. De profielen van bevorderende factoren varieerden van de directe beleving van het bewegen, zoals plezier en ergens bij horen, tot persoonlijke ontwikkeling op de langere termijn. De profielen van belemmerende factoren varieerden van interne oorzaken, zoals gebrek aan motivatie en energie, via drukte door school en andere verplichtingen, tot obstakels in de omgeving. Bovendien, waren deze factoren dynamisch: 70% van de deelnemers gaf aan dat hun bevorderende factoren in de

loop van de tijd waren veranderd, en 57% zei dat over hun belemmerende factoren.

Deze bevindingen laten zien dat adolescenten verschillen in wat hen helpt en belemmert bij het volhouden van gezonde leefstijlgedrag zoals bewegen, en dat dit in de loop van de tijd verandert. Dit suggereert dat leefstijlinterventies baat hebben bij personalisatie die aansluit bij de specifieke bevorderende en belemmerende factoren die adolescenten in hun dagelijks leven tegenkomen. Daarbij moet er ook ruimte zijn om de aanpak aan te passen wanneer hun situatie verandert. Vanuit dit uitgangspunt ontwikkelde ik via een participatieve aanpak samen met adolescenten Mapping of Me, een hybride serious game waarin twee spelers als team samen werken aan een persoonlijk zelfgekozen gezondheidsdoel. In twee cycli van self-experimentation kiezen ze gedragsstrategieën, proberen ze deze uit en reflecteren ze over wat voor hen werkte.

In de hoofdstukken 4 en 5 beschrijf ik het ontwerpproces van Mapping of Me, waarin twee Research through Design-activiteiten de basis legden voor de onderliggende mechanismen. In de eerste activiteit bedachten zeven adolescenten hun eigen strategieën voor een zelfgekozen gezondheidsdoel, probeerden ze die drie weken lang uit en reflecteerden ze erop. Met alleen een paar eenvoudige vragen als houvast kwamen ze zelf tot strategieën, en op basis van hun ervaringen stelden ze hun aanpak bij. Tegelijk gaven ze aan behoefte te hebben aan mogelijke strategieën om uit te kiezen. Voor de tweede activiteit ontwikkelde ik daarom een strategiemenu: 29 strategieën die adolescenten zelf kunnen uitvoeren, gebaseerd op bestaande gedragsveranderingstechnieken en op strategieën die deelnemers zelf hadden bedacht. De strategieën zijn verdeeld over zes categorieën: Actie (zoals klein beginnen), Ruimte (zoals verleidingen weghalen), Tijd (zoals vaste tijd inplannen), Mindset (zoals elke dag als een nieuwe start zien), Sociaal (zoals het samen doen) en Symbolen (zoals visuele herinneringen). Adolescenten kiezen strategieën als bouwstenen voor hun eigen aanpak en bepalen zelf of ze die vóór, tijdens of na hun activiteit inzetten. Ik testte dit menu met twintig adolescenten. Elke deelnemer stelde een unieke combinatie samen, wat erop wijst dat adolescenten strategieën kiezen op wat persoonlijk bij hen past. Het strategiemenu is vervolgens verwerkt in Mapping of Me.

In hoofdstuk 6 evalueer ik met zesendertig adolescenten welke strategieën zij met Mapping of Me ontwikkelden, of ze die een maand later nog gebruikten en welke inzichten ze opdeden over hun eigen gedragsverandering. Elke strategie uit het menu werd minstens één keer gekozen, en dezelfde strategie werd door de ene deelnemer als zeer effectief en door de andere als weinig effectief beoordeeld. Dit wijst erop dat de waarde van een strategie vooral afhangt van hoe goed die bij

iemand past. Mindsetstrategieën waren het populairst, maar werden als minder effectief beoordeeld dan strategieën gericht op concrete acties, de omgeving en planning in de tijd. Deelnemers zetten hun strategieën vooral in vóór en tijdens de zelfgekozen activiteit, zodat het makkelijker werd om te beginnen of het gedrag makkelijker vol te houden. Bij de nameting gaven 27 van de 34 respondenten (79%) aan dat ze nog minstens één strategie gebruikten, voor hun doel of op andere gebieden in hun leven, zoals studeren. Door te experimenteren ontdekten deelnemers welke strategieën bij hun situatie pasten, wat hen motiveerde, hoe ze haalbare doelen konden stellen en welke uitdagingen er achter hun doelen schuilgingen. Deze uitdagingen werden pas zichtbaar toen ze hun aanpak in de praktijk uitprobeerden.

Samen laten deze studies zien hoe gedragswetenschappelijke inzichten kunnen worden toegepast met een mensgerichte ontwerpaanpak voor gezonde leefstijlinterventies voor adolescenten. De resultaten laten zien hoe adolescenten ondersteund kunnen worden in het zelf samenstellen en bijstellen van hun gedragsstrategieën, als een interventie hen daar de ruimte en ondersteuning voor biedt. Daarmee levert dit proefschrift ontwerpkennis op over hoe serious games, en gezonde leefstijlinterventies in het algemeen, voor adolescenten ontworpen kunnen worden. De belangrijkste bijdrage is een ontwerprationale en ontwerpprincipes self-tailoring en self-experimentation. Interventies die hierop gebaseerd zijn, kunnen beter aansluiten bij het dagelijks leven van adolescenten, omdat zij hun aanpak zelf vormgeven en uitproberen wat voor hen werkt. Zo krijgen ze een actievere rol en meer eigen regie, wat past bij hun ontwikkelingsfase, en leren ze zichzelf beter kennen. Dit kan leiden tot interventies die adolescenten niet alleen helpen hun gedrag nu te veranderen, maar hen ook zelfkennis en handvatten geven om hun gezonde leefstijl in de toekomst zelf vorm te geven.

Positionality statement

This dissertation is shaped by my prior experiences, both personal and academic. Health and wellbeing have been a through line in my life and work. While I originally aimed to study medicine, the Dutch lottery admission system put me on a different path, and I am glad it did. I still ended up studying biology in different forms, but during my bachelor's I was also introduced to the social and behavioral sciences. Even though my research interests still revolved around health and wellbeing, these disciplines offered new lenses through which I could study them. It was during this time of my life that I became interested in how mind, body and environment interact and shape each other. Part of this interest stems from my own challenges living with a chronic condition for which healthy lifestyle changes are the best available option for managing symptoms. Because of this, I had to learn, through lots of, often frustrating, trial and error with diet, physical activity and ways to manage stress, how to change and maintain my own lifestyle behaviors.

When I saw the opening for this PhD position, it felt like a great match with my personal and academic interests, and with my ambitions after finishing my master's program. I had recently completed a research master's in behavioral science at Radboud University, where I was trained mostly in quantitative research design, methods and analysis, and I was looking for a place to apply these skills. Although my training there had made me a better researcher, I still felt that the kind of knowledge I learned to produce there, such as my published master's thesis about gut microbiota, contributed only to a niche scientific understanding whose societal impact was unclear to me. Where I had learned to study whether a phenomenon is in line with theory or not, I was more interested in what happens when theory meets reality. The step of translating the gained insights into societal benefit was often left to others, such as policy makers or health care practitioners. I wanted to be part of that step, of how scientific knowledge can be translated into benefits for people's everyday lives.

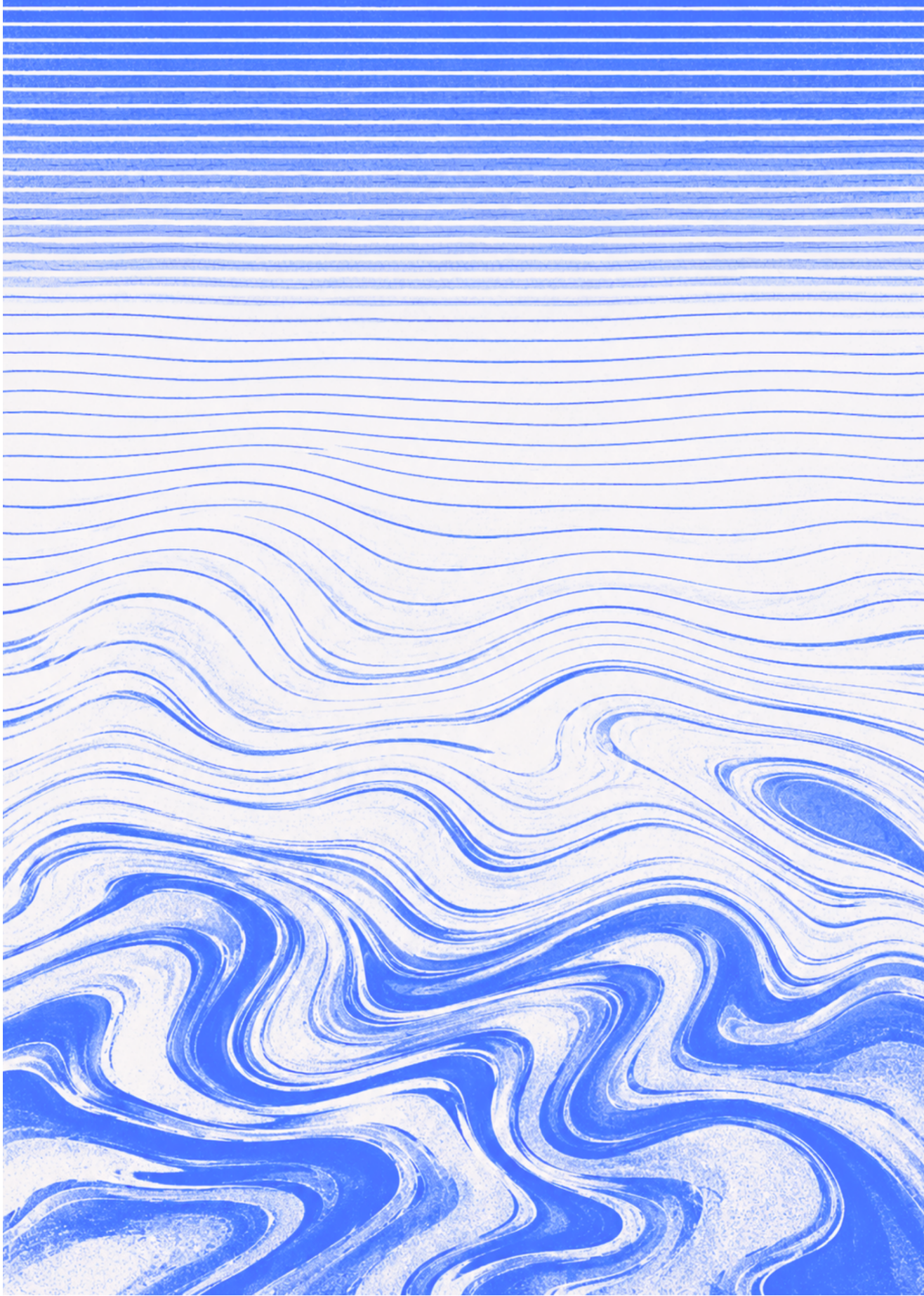
This was one of my main motivations for coming to the faculty of Industrial Design Engineering at TU Delft, and to work on how scientific knowledge can be translated into tangible products, systems and services that improve people's lives. Even though I was interested in design, I did not know what design research entailed. Adapting to this new territory was challenging at times. For instance, behavioral science has much clearer standards for what counts as a high-quality execution of a method, whereas in design, methods are not checklists with well-defined steps and they require more intuition and sensitivity in adapting them to the specific challenge and context at hand. I also had little to no experience with

qualitative methods or participatory approaches, or with managing stakeholders and incorporating their, at times conflicting, needs and perspectives. Much of what is reported in this dissertation reflects my own journey into design, and my attempts to combine my background in behavioral science with new ways of working.

Overall, my PhD years at TU Delft have been a greatly enriched my thinking and skillset, and my way of working has changed for good. I have gained a new perspective on how research can be approached and how problems can be solved, and more confidence in navigating complex and ambiguous topics. One of my main lessons us that some things are only understood through doing because we cannot think our way out of (some) problems. We have to *make* the futures we imagine, and design offers ways of making them tangible. This is where theory meets reality, and where the real challenge of translating scientific knowledge into societal benefit lies.

I am still unsure whether my work has lived up to the ambitions I had when I started this PhD. For now, its insights remain in these pages and in online databases, waiting to be taken up and turned into real world change. In addition, this work looks at behavior change at the level of the individual and does not examine or question the structures and conditions around the individual. Healthy lifestyles are not just an individual's problem to solve but also calls for a collective effort to address these wider factors to create conditions that attract healthy behaviors. The approaches I explore here can help people navigate those conditions, but they do not change them.

Still, in some sense I have found what I was looking for. I have come one step closer to bridging scientific understanding and practical application. My search for good design to support health and wellbeing continues.



Chapter 1. Introduction

Adolescence is a formative period of life. It marks the transition from childhood to adulthood, a period in which a person increasingly takes on responsibility for their own decisions and direction in life. This growing self-direction extends to healthy lifestyle behaviors: as adolescents gain more autonomy, they take on a larger role in deciding how active they are, what they eat, and how they balance these choices against the competing demands of school, peers, and leisure.

How adolescents learn to make healthy lifestyle choices can have far-reaching public health potential. The behaviors established during this life stage, such as regular physical activity, balanced nutrition, and adequate sleep, contribute not only to immediate physical and psychological functioning but also to long-term health outcomes and quality of life (Franklin et al., 2023; Hautekiet et al., 2022), furthermore, they frequently persist into adulthood (Craigie et al., 2011; Hayes et al., 2019). Adolescence therefore represents an important window in which healthy lifestyle patterns can be supported, with benefits that extend well beyond this life stage. Despite well-documented benefits, a large proportion of adolescents worldwide do not meet recommended health guidelines. Adolescents tend to be insufficiently physically active (Guthold et al., 2020), increasingly sedentary (Kontostoli et al., 2021), and experience difficulties maintaining healthy dietary patterns (Neufeld et al., 2022). In the Netherlands, fewer than half of adolescents achieve the recommended sixty minutes of moderate-to-vigorous physical activity per day (Centraal Bureau voor de Statistiek, 2025). These behavioral patterns influence not only physical wellbeing but also mental wellbeing (Zhang et al., 2022) and academic performance (Wilhite et al., 2023). While the need for adolescent health behavior change interventions (HBCIs) is widely recognized, their effectiveness remains variable. Despite considerable effort in their development, HBCIs tend to demonstrate heterogeneous and generally moderate effectiveness for adolescents (Baumann et al., 2022; de Sousa et al., 2022), with limited sustained impact over the longer term (Champion et al., 2019). Engagement of adolescents with such interventions is often cited as an issue influencing the outcomes (Jacob et al., 2021; Rose et al., 2017; Yeager et al., 2018).

Serious games, which are games designed for a primary purpose other than entertainment, such as education, training, or health promotion (Michael & Chen, 2005), are a promising avenue for promoting healthy behavior. By embedding health content within interactive game contexts, they offer a format that can help engage adolescents in healthy lifestyle behaviors (Mancone et al., 2024), and a growing body of work shows that they can improve adolescents' health knowledge and attitudes toward health behaviors (Ancona et al., 2024; Hammady & Arnab, 2022).

Shifts in knowledge and attitude, however, are not always sufficient to produce health behavior change in practice (Conner & Norman, 2022). Although increased knowledge and more favorable attitudes can raise intentions to change behavior, intentions do not reliably translate into action. This intention-behavior gap is substantial and well documented; meta-analyses suggest that nearly half of those who intend to be physically active do not act on that intention, a pattern also found among adolescents (Haider et al., 2024; Rhodes et al., 2022). There is growing recognition that serious games for health behavior change need to be designed more explicitly around the behavioral mechanisms that can help bridge intention and action (Andrew et al., 2023; Hammady & Arnab, 2022). This dissertation investigates how serious games can be designed to enable adolescent healthy lifestyle behaviors. The next section examines adolescence as a developmental period, approaches that have been used to support health behavior change in this group, and how design might help bridge the intention-behavior gap.

1.1 How to design for adolescent health behavior change?

Changing health behavior is particularly demanding during adolescence. Adolescence marks a period of rapid physical, cognitive, and social change (Viner et al., 2012). The exact definition varies across disciplines; this dissertation defines adolescence as the developmental period between childhood and adulthood, roughly spanning ages 12 to the early twenties (Crone & Dahl, 2012). During this time, adolescents undergo puberty, become increasingly influenced by peers, experiment with new social roles, and develop greater autonomy (Crone & Dahl, 2012; Patton et al., 2016), all of which bear significantly on their healthy lifestyle behaviors.

Adolescence is often approached as a period of health risk. The adolescent brain undergoes substantial reorganization that heightens sensation-seeking and peer sensitivity while executive control systems are still maturing (Crone & Dahl, 2012). At the same time, environments have grown increasingly obesogenic with high accessibility of processed and energy dense food (Jackson et al., 2020; Verde et al., 2024) and digital media competes for attention and time that might otherwise be spent in movement or rest (Bozzola et al., 2022). Making healthy lifestyle decisions in this kind of choice environment is especially challenging during adolescence, when the capacity to navigate one's surroundings and make deliberate, value-aligned decisions is still developing (Crone & Dahl, 2012).

Adolescent health has often been viewed through a risk-reduction lens: physical inactivity or poor diet is treated as a risk factor for future disease, and the adolescent as a site of such risk factors to be corrected (Kimiecik et al., 2020). This

framing has shaped how interventions are designed; many foreground health itself and the prevention of future disease, and adopt a top-down approach that supplies facts, issues guidelines, and prescribes behaviors (Kimiecik et al., 2020). Yet this approach may be illfitted with this developmental stage as adolescents increasingly experience adults' efforts to direct their behavior as a threat to their autonomy and emerging sense of agency (Yeager et al., 2018).

Adolescence is also not only a period of risk. It is equally a period of learning and exploration: learning to make one's own choices, forming personal values, and learning from experience what does and does not work for oneself (Blakemore & Mills, 2014; Dahl et al., 2018). An alternative to the risk-reduction approach to adolescent health behavior change is a person-based, development-oriented perspective (Kimiecik et al., 2020). This perspective begins with the person rather than the target behavior and treats adolescents not as a set of deficits to be corrected but as agents with developing values and a capacity for positive development.

From this perspective, the problem is not that adolescents do not value health, but that they also value other things, such as connecting with friends, gaining peer acceptance, and having fun (Martins et al., 2021; Strömmer et al., 2021). Designing healthy lifestyle support for this group therefore means acknowledging and incorporating adolescents' own developing values rather than imposing expert-defined, distant health rationales (Strömmer et al., 2020; Yeager et al., 2018). The question shifts from how to change adolescents' health behavior to how adolescents can be supported in navigating competing motivations, interests, and demands around healthy lifestyle behaviors as they develop over time.

Navigating these competing demands is not only about aligning more with personal motivations, but also about providing ways for adolescents to act on healthy lifestyle intentions. Within interventions, this is typically supported through behavior change techniques (BCTs) such as action planning, prompts and cues, and self-monitoring (Mair et al., 2023; Michie et al., 2013). Interventions are usually built around a fixed set of BCTs, selected by the designer based on what is assumed to work for a given target group. What works for one person, however, may not work for the whole group. Research on a large healthy lifestyle intervention shows that adolescents tend to engage with only a subset of the techniques offered, seemingly those they find personally fitting and actionable (Hankonen et al., 2017; Palsola et al., 2020). A technique that helps one adolescent, such as seeking social support, may be unavailable or ineffective for another with different preferences and life circumstances (Hankonen, 2021). A

standard, one-size-fits-all set of BCTs may therefore not fit adolescents well, as they prefer enacting behavioral change in different ways.

Taken together, designing for adolescent health behavior change means being sensitive to adolescents' developing values and growing desire for autonomy, and recognizing that behavior change techniques do not work the same way for everyone. This suggests a different role for design: rather than selecting techniques on adolescents' behalf to reach predetermined goals, design can empower adolescents to choose their own goals and strategies, and to discover for themselves what fits and works. In the context of a serious game, this means moving away from a fixed path of strategies or techniques, toward creating the conditions in which adolescents can formulate their own goals and approaches to health behavior change.

One approach that could facilitate this process is self-experimentation, in which individuals systematically try out, evaluate, and adapt strategies in their own daily lives to discover what works for them (Lee et al., 2017; Phatak, 2019). Its aim is not to produce generalizable knowledge but a form of self-knowledge which is specific to the individual, about how to approach one's own behavior change (Choe et al., 2014). Trying out different strategies in real life can help generate insights into how health behaviors fit an adolescent's own preferences and circumstances, making them a more active agent in tailoring their behavioral change. This idea of self-tailoring intervention elements to oneself fits the characteristics of this life stage, marked by exploration and a heightened need for autonomy (Kimiecik et al., 2020; Yeager et al., 2018). As a result, health behavior strategies can become more closely aligned with adolescents' own personal preferences, values, and life circumstances, which can help bridge the intention-behavior gap.

1.2 Research aim and questions

The main aim guiding this dissertation is to generate knowledge about how serious games, and health behavior change interventions more broadly, can be designed to support adolescents in changing and maintaining healthy lifestyle behaviors. The focus is on supporting adolescents' own capacity to regulate healthy lifestyle behaviors. Although environment-changing approaches for healthier choices are promising, they fall outside the scope of this dissertation.

Three research questions address this aim. The first investigates the barriers and facilitators adolescents experience around maintaining healthy lifestyle behaviors, within the specific domain of physical activity. The second concerns how

adolescents can be more closely involved in personalizing their own behavior change. The third examines what strategies and insights adolescents develop through a self-experimentation serious game designed, Mapping of Me, developed during this PhD project.

RQ1: What barriers and facilitators do adolescents experience around maintaining physical activity?

RQ2: How can adolescents be supported in constructing and adapting their own health behavior strategies?

RQ3: What strategies and insights for health behavior change do adolescents develop through a self-experimentation serious game, Mapping of Me?

1.3 Research approach

This dissertation sits at the intersection of behavioral science and human-centered design, drawing on the strengths of each (Schmidt, 2020). The two fields approach behavior change through different modes of inquiry. Behavioral science works in a largely analytic and inductive manner: it identifies regularities in human behavior through controlled study, abstracts these into theories and principles, and applies them to inform interventions. Its strength lies in this accumulated body of evidence and in the rigor with which interventions can be specified and tested. Human-centered design works in a more generative and abductive manner: rather than applying established principles to a defined problem, it begins by surfacing the situated needs and circumstances of those it designs for and uses these to frame the problem and to propose what an intervention could be. Its strength lies in this attention to context and in its capacity to construct, rather than select, new directions.

These strengths can also complement their weaknesses. Behavioral science offers principles that hold across individuals, but its findings are often decontextualized, derived under conditions removed from the everyday settings in which behavior actually unfolds (Schmidt, 2020). Human-centered design attends more closely to context but has a less strong theoretical and evidence-based foundation when designing interventions. Drawing on both therefore allows the work of this dissertation to be informed by what is already known about behavior change while remaining responsive to the situated realities of the adolescents it designs with.

From behavioral science, this dissertation draws the theories and principles of health behavior change set out above, and the body of intervention work that has been built on them. From human-centered design, it draws an approach to

inquiry. Within that approach, it uses participatory methods, including context mapping, to surface adolescents' own experiences and circumstances, and research through design to generate knowledge by designing, testing, and reflecting on an actual intervention.

1.4 Project context

This PhD project was conducted as part of a larger project called Enduring Rewards funded by the Dutch Research Council (NWO), involving a consortium of TU Delft, Erasmus University Medical Center, the municipality of Rotterdam, and &RANJ serious gaming company (grant file number: 403.19.246). Throughout the project, multiple stakeholders were involved including secondary school and university students, teachers, high schools, sport providers, researchers, social designers, and representatives from public health institutions.

The original ambition was to extend Lekker Fit!, a well-established health promotion initiative for primary school children in Rotterdam, into secondary schools (Smit et al., 2025). A previous pilot of Lekker Fit! in secondary schools had been discontinued, in part because materials had been translated relatively directly from the primary school context without adequately accounting for the different developmental needs, motivations, and life circumstances of adolescents. The project aimed to take a fundamentally different approach: building a secondary school intervention program from the ground up, grounded in adolescents' own perspectives and experiences, through a participatory design process. The original research plan was to take an existing serious game of &RANJ and tailor it towards adolescents' needs through a participatory design process. Over the course of the project, this ambition of tailoring an intervention to adolescents developed into a more specific focus on self-experimentation as a mechanism through which adolescents could tailor their own approaches to health behavior change.

In practice, the project encountered significant structural barriers that shaped what was ultimately possible. A national government guideline advising secondary schools to keep mobile phones out of the classroom from January 2024 onward (Ministerie van Algemene Zaken, 2023) affected the originally planned digital intervention components and the logistical demands of sustaining participatory work with secondary schools post-covid proved difficult to meet within the constraints of a single PhD project. As a result, the final evaluation of Mapping of Me was conducted with university students rather than secondary school students, and the ambition of embedding the intervention within Lekker Fit! schools was not realized. These constraints are relevant not only as contextual background to this research, they also point to more systemic factors that shape

the design and implementation of health behavior change interventions in educational settings, which I reflect on in section 7.5 in the discussion.

1.5 Structure of this dissertation

Chapter 2 introduces the theory underlying this dissertation. One of its central aims is to design for healthy lifestyle behaviors that are not only changed but maintained over the longer term, and this chapter reviews the theoretical principles concerning the maintenance of health behavior change. It also examines how a human-centered design approach can contribute to interventions with more sustainable effects. In doing so, the chapter treats behavioral science and human-centered design as complementary disciplines for developing health behavior change interventions.

Chapter 3 mainly addresses RQ1: What barriers and facilitators do adolescents experience around maintaining physical activity? It investigates how Dutch adolescents experience and perceive the barriers and facilitators surrounding their long-term physical activity, using Q-methodology to characterize these experiences and how they change over time.

Chapters 4 and 5 together address RQ2: How can interventions be designed to support adolescents in constructing and adapting their own health behavior strategies? Chapter 4 documents the participatory design process of the serious game Mapping of Me, in which adolescents, design researchers, and game designers took part in ideation sessions, workshops, and prototype testing to iteratively develop the game concept. Chapter 5 focusses on two research through design activities within the design process: workshops in which adolescents constructed, applied, and reflected on their own behavior change strategies for a self-chosen goal, and the development of a strategy menu to support adolescents in self-tailoring behavior change strategies.

Chapter 6 addresses RQ3: What strategies and insights for health behavior change do adolescents develop through a self-experimentation serious game, Mapping of Me? It reports an evaluation of Mapping of Me with thirty-six participants over three weeks, with a one-month follow-up, examining the strategies participants generated and the insights they developed through self-directed experimentation.

Chapter 7 synthesizes the findings, reflects on the theoretical and design contributions of the dissertation, and addresses its limitations and directions for future research and practice.

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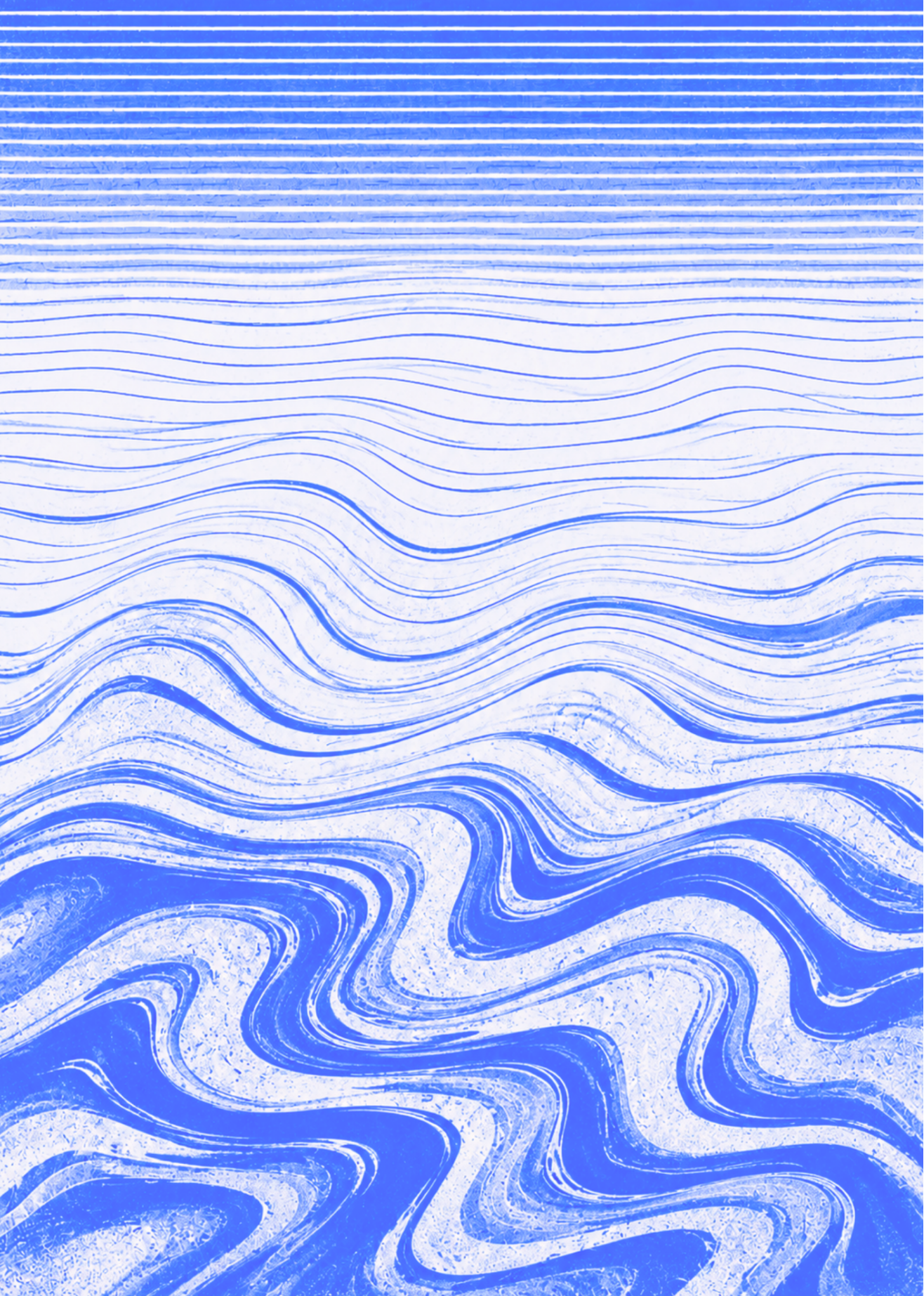


Chapter 2. Designing interventions for maintenance of health behavior change:Insights from health psychology and human-centered design

This chapter has been submitted as:
de Buisonjé, D. R., Houtman, T. A., Hondmann, S. M., Janssen, V., Sleeswijk Visser, F., Evers, A., & Visch, V. *Designing interventions for maintenance of health behavior change: Insights from health psychology and human-centered design*.

Abstract
Health behavior change interventions show a consistent pattern: behavior improves while the intervention runs and declines toward baseline once it ends, a trajectory described as the triangular relapse pattern. Decades of theory have clarified why maintenance is difficult, yet interventions that reliably support it remain rare. We argue that part of the difficulty is disciplinary. Health psychology has become precise about what an intervention must achieve for change to last, while saying relatively little about how to design something people will keep using under the messy conditions of everyday life. Human-centered design has methods for exactly that, but is rarely brought into contact with maintenance theory. This article analyzes what each field contributes and where the two meet. From health psychology we distill three key considerations for maintenance. Motivation is dynamic: regulation that begins as externally prompted must become more autonomous if behavior is to persist. Automaticity develops as behavior is repeated in stable contexts, reducing the need for deliberate effort. And moment-to-moment affective experiences during behavior enactment matter in their own right, since behaviors that feel good while they are performed are more likely to be repeated. From human-centered design we identify three practices that speak to these considerations. Understanding people's lived experiences through empathic inquiry surfaces the tacit and latent needs that interviews and questionnaires miss. Agile designing lets an intervention change as its user changes, whether the design adapts or the user customizes it. And designing affective experiences attends not only to what an intervention targets, but to how taking part in it feels. We illustrate the practical utility of this approach by applying it to the Gecombineerde Leefstijlinterventie, a two-year, government-approved Dutch lifestyle program that fewer than half of participants complete. In published participant accounts, relapse is experienced as shame and mental fatigue rather than as behavioral lapse alone. We conclude that health psychology and human-centered design hold complementary rather than competing strengths, and we encourage researchers and practitioners in both fields to seek the collaboration needed to bring them together in support of long-term health behavior change.

2.1 Introduction

Healthy lifestyle behaviors, such as physical activity, balanced nutrition, and adequate sleep, have a significant impact on our wellbeing. Not only can they directly improve physical and mental health, but they also help prevent and manage non-communicable diseases (NCDs), which pose a substantial burden on healthcare systems worldwide (World Health Organization, 2024). Although people often recognize the benefits of a healthy lifestyle and intend to adopt health-promoting behaviors, transforming these intentions into sustainable behaviors is considerably more difficult (Rhodes and Sui, 2021; Sheeran and Webb, 2016). In response, policymakers, scientists, and companies are investing significant effort into designing, implementing, and evaluating interventions that foster behavior change (Albarracín et al., 2024). These health behavior change interventions (HBCIs) are typically guided by psychological theory and aim to support individuals, groups, or populations in adopting healthier behaviors (Michie et al., 2011). HBCIs can be successful at initiating behavioral changes (Hutchesson et al., 2015), but often struggle to help people sustain these changes long-term (Lv et al., 2017; Romeo et al., 2019). Research consistently shows that after initial success, people fall back into old behavioral patterns (Kwasnicka et al., 2016). Wood and Neal (2016) have labeled this the *triangular relapse pattern:* a typical behavioral pattern in which an initial improvement during the intervention period is followed by a decline toward baseline once the intervention ends. This pattern has been observed in various domains including weight loss (Volpp et al., 2008), gym attendance (Charness and Gneezy, 2009), smoking cessation (Volpp et al., 2009), and physical activity (King et al., 2014). The challenge of maintaining long-term change remains one of the biggest obstacles in health promotion (Kwasnicka et al., 2016; Sheeran and Webb, 2016).

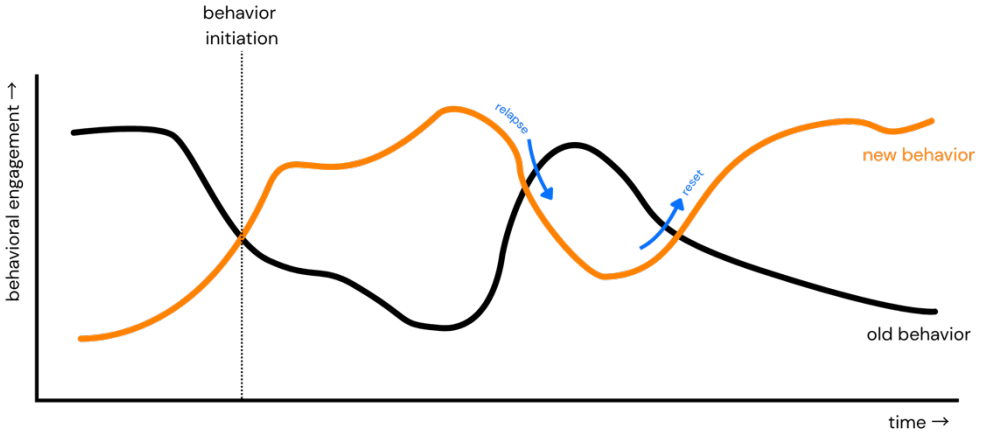
This paper aims to contribute to the design of interventions for maintenance of health behavior change. First, we examine the foundational theories of behavior change maintenance in health psychology and the constructs they rest on. We highlight three key considerations that should be prioritized when designing for lasting behavior change: *motivation*, *automaticity*, and *experience*. However, behavioral change interventions solely grounded in theory can fail to account for the dynamic and messy real-life contexts that extend far beyond the structured conditions assumed in most psychological interventions (Kwasnicka et al., 2016). Current approaches in health psychology lack the tools needed to navigate the complexity of long-term maintenance of change. Recent theorizing places increasing emphasis on maintenance, while acknowledging that the open question is how maintenance concepts can be operationalized in the ecological contexts where behavior actually takes place (Rhodes and Sui, 2021; Becker and Veling,

2026). This is where Human-Centered Design (HCD) comes into play. Where Health Psychology seeks to isolate and measure the mechanisms through which interventions produce their effects, HCD focuses on creating interventions that align with people's needs, desires and experiences in context. Although HCD is increasingly applied in health research, differences in methods, terminology, and evaluation standards create tensions between the two fields (Bazzano et al., 2017; Göttgens and Oertelt-Prigione, 2021). We will explore how HCD practices can complement psychological theory in the development of health behavior change maintenance interventions. Then, we illustrate the practical utility of this approach by showing how HCD insights can enhance an existing intervention. We do this by looking at the Gecombineerde Leefstijlinterventie (GLI in Dutch), a government-approved lifestyle program in the Netherlands which targets long-term weight loss maintenance.

2.2 Theory overview: maintenance of health behavior change

When a new behavior is introduced, it often replaces an existing one (Figure 2.1). Initially, engagement with the new behavior increases while the old behavior diminishes. However, over time, relapses may occur, leading to a temporary return to the old behavior (Wood and Neal, 2016). In these moments, intentional resets may be necessary to re-engage with the desired behavior and move toward a state of long-term maintenance. Maintaining a behavior change requires navigating these fluctuations and reinforcing the capacities that support stability over time (Kwasnicka et al., 2016). For example, when someone decides to replace their habit of watching TV on the couch after work with going for a 30-minute walk, they initially succeed and feel energized. After a few weeks, a busy workday or bad weather may cause them to skip the walk and fall back into the couch routine. Recognizing this slip, they intentionally reset and recommit, for instance by inviting a friend to join that can help to re-establish the new walking habit and gradually stabilize it as part of their routine.

Figure 2.1. Temporal perspective on initiating and maintaining new behaviors (Figure adapted from Kwasnicka et al., 2016)



Health psychology has long studied the processes involved in behavioral change. Decades of research and intervention design have contributed to developing theoretical models that describe behavior change processes and their underlying determinants. One influential framework is the COM-B model (Michie et al., 2011) which emphasizes the interplay between capability, opportunity, and motivation for changing behaviors. Motivation provides behavior with energy and direction (Reeve, 2008), but motivation alone is not enough. According to the COM-B model, behavior is also influenced by a person's psychological and physical capabilities (e.g. skills), and the opportunities afforded by the environment. Despite the added value of this and other frameworks, many interventions still have only short-term impact on behavior change (Rhodes et al., 2022; Sheeran and Webb, 2016; Wood and Neal, 2016; Żurawski and Bartosiewicz, 2026). In response, researchers are increasingly recognizing the importance of understanding the distinct determinants involved in the maintenance phase, as these may differ substantially from those required for initiation (Rhodes and Sui, 2021). Following Kwasnicka et al. (2016, p. 280), we define maintenance of behavior change as "the continuous performance of a behavior following an initial intentional change at a level that significantly differs from the baseline performance in the intended direction".

While some researchers propose time-based cut-offs to distinguish between initiation and maintenance phases, such cut-offs are often behavior-specific and may vary between individuals. Therefore, we adopt a more dynamic perspective. Building on Rhodes and Sui (2021), we approach maintenance as a process characterized by a shift in the underlying mechanisms that guide behavior. This

view underscores that the behavioral mechanisms driving the initiation of a (new) behavior are distinct from those involved in the maintenance of behavior. This is reflected by Kwasnicka and colleagues (2016), who show that the initial stages of behavioral change are characterized by deliberate intentions and outcome expectations. This inference is supported by theories like the Transtheoretical Model of Change (Prochaska and DiClemente, 1983), the Health Action Process Approach (Schwarzer, 1992), and Social Cognitive Theory (Bandura, 1986). To illustrate, the TTM (Prochaska and DiClemente, 1983) conceptualizes behavior change as progressing through a series of stages: precontemplation, contemplation, preparation, action, and maintenance. Each stage reflects different types of motivation and readiness for change, suggesting that interventions are more effective when tailored to an individual's current stage. The HAPA (Schwarzer, 1992) formalizes this distinction more explicitly by separating behavior change into a motivational phase and a volitional phase. In the motivational phase, intentions are formed through risk perception, outcome expectations, and self-efficacy. These are considered conscious, evaluative processes that are often prompted by external input. In the volitional phase, the challenge shifts from wanting to change to actually enacting change, which depends more on planning and self-regulatory capacity. Taken together, these theories suggest that the early stages of behavior change are characterized by deliberate, often externally prompted processes, but they say less about what sustains behavior once initial motivation fades. In contrast, the maintenance of health behavior change depends on different processes. Self-Determination Theory (Ryan and Deci, 2000) suggests that behaviors sustained over time tend to be more autonomously motivated (i.e., driven by personal value, enjoyment, or identity rather than external pressure). As behavior is repeated over time in stable contexts, it may become increasingly habitual, reducing the reliance on conscious deliberation, as is also suggested by learning and habit theories (Gardner, 2015; Verplanken and Aarts, 1999).

While the theories discussed so far describe the broader regulatory shift from initiation to maintenance, the upward spiral theory of lifestyle change (Van Cappellen et al., 2018) focuses on the moment-to-moment experience of behavior. It argues that positive affective responses during a healthy behavior (such as enjoyment) create self-reinforcing cycles. These cycles entail that positive experiences build personal resources and broaden motivation, which in turn increase the likelihood of repeating the behavior. Maintenance, in this view, is not only a matter of shifting regulatory processes over time, but also of accumulating positive experiences that build momentum for continued engagement with the behavior. From this overview of theories, we distill three key considerations which are particularly useful when designing interventions for long term

maintenance of health behavior change. First, we discuss the roles of different types of motivation (e.g., extrinsic versus intrinsic). Second, we explore how behaviors become automatic and habitual over time. Thirdly, we consider how positive moment-to-moment affective experiences during behavior enactment can build the momentum for lasting behavioral change. We will address these three key considerations in more detail in the next sections.

2.2.1 Dynamic motivation

Most theories of human behavior propose a direct link between motivation and behavior (Conner and Norman, 2015), making it a key concept when one aims to change behavior. Self-Determination Theory (SDT) distinguishes between extrinsic motivation (e.g., performing a behavior to achieve external outcomes or rewards) and intrinsic motivation (e.g., engaging in a behavior because it is inherently enjoyable or interesting) (Deci et al., 1999). SDT posits that behaviors which inherently satisfy basic psychological needs (autonomy, competence, and relatedness) are more likely to be intrinsically motivated and sustained over time (Ntoumanis et al., 2021; Ryan and Deci, 2000). For this reason, SDT has become a widely used framework for designing health behavior change interventions (Ntoumanis et al., 2021; Teixeira et al., 2020). However, extrinsic motivation can still play an important role in the design of such interventions. Research on financial incentives, for example, shows that these external motivators can effectively help initiate behavior change (Giles et al., 2014; Mitchell et al., 2020). In theory, once initiated, repeated engagement and positive experiences may facilitate internalization, leading to more autonomous forms of motivation over time (Ryan and Deci, 2000). Yet, empirical evidence supporting this theoretical trajectory is scarce. Meta-analyses across different health behaviors generally conclude that evidence for maintaining behavior change after incentives are removed is limited at best (Giles et al., 2014; Mantzari et al., 2015; Mitchell et al., 2020). A recent meta-analysis focused specifically on weight loss makes the pattern concrete. Across 29 trials, financial incentives produced a small but reliable effect on weight loss while they were in place (SMD = 0.18), and no detectable effect once they were withdrawn (SMD = 0.03, ns; Hondmann et al., 2026). It is also worth noting that only about half of the included trials reported any post-incentive data at all, which is itself an illustration of how thinly the maintenance phase is studied even for an intervention type that is otherwise well researched.

A concern often raised in motivation research is whether extrinsic motivators might undermine intrinsic motivation, a phenomenon referred to as "crowding out" (Promberger and Marteau, 2013). The idea of crowding out is largely based

on classic studies, such as Deci and colleagues' work on puzzles and drawings (1999). These studies showed that when individuals were offered external rewards for activities, they already found intrinsically enjoyable, their intrinsic motivation decreased. However, these findings are less applicable to health behavior change, where behaviors such as exercising or making dietary changes require substantial effort and self-control, are not always immediately enjoyable, and are therefore unlikely to be driven by intrinsic motivation at the outset (Promberger and Marteau, 2013). In line with this, research has shown no evidence of crowding out in health interventions (e.g., Leahey et al., 2017; Ledgerwood and Petry, 2006). Instead, extrinsic and intrinsic motivations might best be viewed as independent and additive drivers of behavior. In a meta-analysis spanning four decades of research into school, work, and physical performance, Cerasoli and colleagues (2014) concluded that extrinsic incentives and intrinsic motivation are not inherently antagonistic. While incentives tied directly to performance sometimes reduce intrinsic motivation, they can complement intrinsic motivation by addressing different aspects of behavior. For instance, extrinsic motivators often predict the quantity of performance, while intrinsic motivation is a stronger predictor of the quality of performance (Cerasoli et al., 2014). Indeed, other evidence suggests that both extrinsic and intrinsic motivations play important, complementary roles in health behavior change. For example, Geller et al. (2018) found that individuals who successfully maintained physical activity for over a decade reported higher levels of both intrinsic and extrinsic motivation than those who were not regularly active. In another study, Buckworth et al. (2007) demonstrated that intrinsic motivation is a strong predictor of long-term maintenance, while extrinsic motivators are important for fostering initial engagement. It is important to recognize that some health behaviors may never be fully intrinsically motivated. For example, eating high caloric foods and preserving energy by remaining sedentary have been deeply hardwired through human evolution (Lieberman et al., 2021). Becoming physically active and reducing calorie intake might thus never be as enjoyable as their opposites.

To conclude, instead of viewing intrinsic and extrinsic motivation as opposing forces, the theory outlined above suggests they can work together, and may even operate synergistically, to support sustained health behavior change. While intrinsic motivation is important for long-term maintenance, it typically needs to develop over time. Early in the behavior change process, regulation is often more externally driven, and extrinsic incentives can be effective in initiating behavior change. Over time, as positive experiences accumulate and the behavior becomes more personally meaningful, intrinsic motivation can take on a greater role in sustaining change.

2.2.2 Automaticity

A critique of focusing on motivation is its heavy focus on conscious decision-making, overlooking the unconscious processes, habits, and contextual cues that significantly influence behavior change (Resnicow and Vaughan, 2006). Behavioral learning theories, including classical conditioning, operant conditioning, and social learning theory, provide insight into how behaviors are learned and sustained over time. Pavlov's Classical conditioning, for example, explains behavior as a response to learned associations between environmental cues and stimuli. Repeated pairings can lead individuals to develop automatic responses to specific triggers. Building on this, B.F. Skinner's operant conditioning emphasizes the role of consequences: behaviors followed by rewards are more likely to be repeated, while those followed by punishment are less likely to occur (Akpan, 2020). Social Learning Theory adds to these theories by examining the role of the social context. More specifically, that people learn from observing and modeling others (Rumjaun and Narod, 2020). These theories also form the basis for theories that describe how habits develop.

Habits are behaviors which are automatically triggered in the presence of specific cues, enabling behaviors to be performed with minimal cognitive effort (Lally et al., 2010). For example, seeing the television and couch after a long workday might automatically trigger someone to lie down and turn on the television. Habit theory builds on the principles of reinforcement by emphasizing the formation of learned context-response associations. Positive reinforcement (e.g., rewards) or negative reinforcement (e.g., removing adverse conditions) of a behavior increases the likelihood of a behavior being repeated (Wood and Neal, 2016). The complexity of a behavior also influences the time required for it to become habitual. Simple behaviors, such as drinking water daily, may become automatic relatively quickly, whereas complex behaviors, like regular exercise, take longer to establish (Saunders and More, 2025). Reinforcement schedules also play an important role: immediate and certain rewards (e.g. a monetary incentive) are particularly effective for initiating behavior change, while escalating reinforcement schedules, where magnitude increases with successive target behaviors, tend to produce stronger and more sustained outcomes than fixed schedules (Rash, 2023). Ultimately, repeated reinforcements can change behaviors from deliberate actions to automated responses or habits. Interventions designed to support habit formation focus on key strategies such as promoting repetition in consistent contexts, leveraging rewards, fostering consistency (e.g., streaks), and addressing the role of triggers and cues (Lally and Gardner, 2013). Taken together, considering learning theories and automaticity complements the

earlier focus on motivation by addressing what happens after motivation sparks initial behavioral change. Whereas extrinsic motivation can help initiate behavior, long-term maintenance often relies on the transition from intentional effort to automatic execution. Designing for maintenance therefore requires not only supporting shifts in motivation, but also creating the (repeating) conditions under which behavior can become habitual.

2.2.3 Moment-to-moment affective experiences

In the previous sections we have seen how different types of motivations can be complementary, and how initial extrinsic motivation may change over time into intrinsic motivation or habits. Thus far we have focused on longer time scale transitions of weeks and months, but now we will zoom in on the momentary experiences that play a role in the process of sustainable behavior change. The moment-to-moment affective experiences during the performance of a new health behavior are crucial to understanding maintenance. Behaviors which are experienced as negative in the moment are less likely to be maintained in the long run (Rothman, 2000). For example, when someone is ashamed by the body sweat caused by initial attempts to be more physically active, this momentary experience might deter the person from following through. Moment-to-moment experiences are closely tied to affective evaluations of behavior, and these evaluations in turn generate motivation to continue or discontinue the behavior (Van Cappellen et al., 2018). For instance, short-term rewarding experiences, such as a sense of flow, positive emotions, and engagement (Schüler and Brunner, 2009), can support the development of intrinsic motivation, which is important for the long-term maintenance of health behaviors (Petosa and Holtz, 2013). The upward spiral theory of lifestyle change provides a framework for understanding how positive experiences contribute to long-term adherence to health behaviors (Van Cappellen et al., 2018). This theory emphasizes the role of affective processes. Positive affect experienced during health behaviors increases the incentive salience of cues associated with those behaviors, implicitly guiding attention and decisions to repeat them (Fredrickson, 2001; Van Cappellen et al., 2018). For example, enjoying a Zumba class makes its cues (e.g. the specific music or workout clothes) grab attention and feel rewarding, increasing the likelihood of going for another class. Furthermore, positive affect builds vantage resources such as optimism, social connections, and self-efficacy. These resources, in turn, make it easier to continue engaging in healthy behaviors, creating a reinforcing upward cycle of wellbeing and sustained change (Van Cappellen et al., 2018).

A recently proposed model arrives at this same conclusion from a different tradition. The Value and Experience-based Model of Behavior Change (VEM-BC; Becker and Veling, 2026) adopts a value-based decision-making perspective, in

which behavior follows from an integration of tangible, social, and self-related value. Its central addition is experiential: how a behavior feels while it is being performed feeds back into the value assigned to that behavior the next time it is considered. Habits are treated as a separate branch, in which repeated behavior comes to bypass value computation altogether, so experience offers a route to durability alongside habit formation rather than a competing one. This also gives an account of why intervention effects fade: someone paid to walk 10,000 steps a day may hit the target for three months, and if each walk is experienced as a chore, the value of walking falls with every repetition, so that by the time the payments stop it is worth less to them than it was before they started. The model is more specific still about which part of an experience does this work. It assumes that value updating follows the peak-end rule: what people remember of an episode, and therefore whether they repeat it, is set by its most intense moment and by how it ended rather than by its average (Becker and Veling, 2026). In the example above, that would make the last few minutes of the walk more consequential than the hour as a whole. For designers this is a usefully narrow instruction, directing attention to the peaks and the endings of an interaction rather than to its overall pleasantness.

To leverage these insights, interventions should aim to foster positive affective experiences during behavior change. Such experiences can help attune nonconscious processes toward the target behavior and build vantage resources that sustain change over time (Van Cappellen et al., 2018). This enables people to positively engage with the behavior change process (Yardley et al., 2016). In developing effective interventions attention should be paid not only to what behavioral mechanisms are targeted, but also to how they are experienced. Interactions that feel positive, meaningful, and enjoyable, especially during peaks and endings, will foster upward spirals of behavior change.

2.2.4 Limitations of psychological approaches when designing for maintenance

While the theories outlined above are valuable for explaining underlying behavioral mechanisms, HBCIs still struggle to support long-term maintenance in daily practice. Psychological theory excels at describing, isolating, and measuring behavioral components, but offers less guidance on how to actually design interventions that are used and support a long-lasting behavioral change. Because behavioral science favors narrowly framed problems that fit experimental methods such as randomized controlled trials, problem definitions are often shaped more by what methodological standards allow than by the widely diverging realities of everyday life. Yet, alignment with everyday life conditions is

what effective long-term uptake actually requires (Schmidt, 2020). Researchers themselves acknowledge that practical, user-focused solutions can outperform purely theoretical ones (Baumeister and Finkel, 2010). A further limitation is the assumption, embedded in many intervention-development frameworks, that interventions can be decomposed into discrete ingredients that will recombine smoothly in new settings. Taxonomies such as the Behavior Change Technique Taxonomy (BCTT; Michie et al., 2013) and frameworks such as Intervention Mapping (IM; Bartholomew Eldredge et al., 2016) list potent techniques (e.g., prompts, action planning, self-monitoring) yet provide little direction on implementing them in ways that are emotionally engaging, context-sensitive, and sustainable in the long term. As Chin and Chow (2023) observe, the BCTT specifies *what* to include but not *how* to deliver it so that it resonates with users. Heino and colleagues (2021) similarly argue that decomposition cannot capture the evolving, interconnected conditions under which real-world maintenance unfolds. The authors of the VEM-BC name this gap themselves. Having set out their model, they conclude that what remains is to work out how its different elements can be operationalized "in the moment," so that the model becomes suitable for behavior in the ecological contexts where it occurs (Becker and Veling, 2026, p. 13). Specifying what an intervention should achieve is not the same as knowing how to build one that achieves it. To address these limitations, intervention development must shift from static, component-driven planning toward approaches that foreground the usage context and design solutions people will engage with in the long term.

2.3 The added value of human-centered design

HCD is an integrative approach that starts and ends the design process with the people that actually use the design. HCD's emphasis on understanding people's needs and contexts through iterative, participatory processes (Göttgens and Oertelt-Prigione, 2021) can help situate theory-driven interventions in the realities of how people actually live. We argue that HCD is particularly effective in translating behavioral insights into effective intervention design in at least three ways:

Understanding people's lived experiences – empathically exploring everyday motivations, beliefs, and experiences to know which are present, and could be tapped into with an intervention

Iterative improvement – using rapid test–refine cycles to continuously be able to align interventions with the dynamic, uncertain nature of behavior change maintenance

Designing affective experiences – shaping positive, engaging interactions that support intrinsic motivation and build momentum for maintaining change

2.3.1 Understanding people's lived experiences

Human-Centered Design (HCD) begins with a deliberate effort to understand people in their everyday context. What they value, how they behave, what challenges they face, and when something fits best in their everyday routines. Whereas traditional behavioral science tends to start from theory-driven hypotheses, design research begins from the contexts and experiences of people, offering a more generative approach to framing problems that is not predefined by theoretical constructs (Schmidt, 2020). By treating people as experts on their own lives, HCD complements theory-driven hypothesizing with empathic inquiry rooted in lived experience (Sleeswijk Visser et al., 2005). Designers use empathic and generative methods such as context mapping, cultural probes, co-creation workshops, and ethnography to surface tacit and latent needs that are usually harder to capture through interviews or questionnaires (Drouet et al., 2024; Sleeswijk Visser et al., 2005). These methods give participants tools to express their thoughts, feelings, aspirations, and experiences, allowing them to articulate what is difficult to put into words. Insights generated through such generative methods therefore broaden the framing of a problem by exposing overlooked or under-appreciated influences on behavior. Starting from peoples lived realities (rather than from problems predefined by experts who may have very different lives and perspectives) and involving end-users early on, enables tailoring health behavior-change interventions to a better understanding of people's experiences in context. Beyond involving end-users, HCD brings together diverse stakeholders (including communities, practitioners, scientists, and developers) whose different perspectives can challenge and reframe initial assumptions about the problem (Sanders and Stappers, 2008). This interdisciplinary collaboration can lead to more integrated solutions, while the inclusive process itself may foster a sense of ownership among stakeholders that supports adoption and long-term impact.

2.3.2 Iterative improvement

HCD uses iterative, rapid development cycles to create prototypes that people can interact with and respond to. Design teams begin with low-fidelity prototypes and artifacts (paper sketches, storyboards, mock conversations, or simple digital click-throughs) to obtain early reactions from the target group and gather rapid feedback that guides subsequent iterations (O'Cathain et al., 2019). This approach can be understood as piloting early and often: by identifying problems and

refining solutions through multiple rapid cycles during the development phase, interventions are better informed before they enter resource intensive randomized controlled trials (O'Cathain et al., 2019). In traditional theory-driven intervention development, such feedback often arrives later in the process, after substantial resources have already been committed.

Because behavior change maintenance in real-life contexts is dynamic and messy, outcomes are difficult to predict. As described in the theory section, habit formation and motivation are processes that unfold gradually. Over time, behaviors must become at least partially intrinsically motivated or automated to be sustained. Because this process is long and nonlinear, it is in the interest of better intervention design to adapt to these dynamics. Early prototypes provide a window into how a behavior might unfold in actual use and how motivations, habits, and context shift over time. This naturalistic insight helps us discover sooner how an intervention may fit into people's everyday routines. Schraefel and Hekler (2020) call this process tuning: adapting an intervention so that it becomes "in tune" with existing behaviors and with the constantly adapting processes (e.g. motivational dynamics) that underpin them. Designers are particularly skilled at mapping user journeys, identifying moments of friction or challenge, and allowing designs to adapt accordingly. Designs can thus change together with the changing user to ensure an optimal fit. Such changes in the design might be made by a) the design itself, such as an intervention that is able to adapt the level of challenges presented to the user based on measured user skills, b) by the user, such as a design that the user can customize by (re)setting preferred challenge levels, or by a combination of adaptation and customization. This makes the design (continuously) responsive to change, something that traditional behavior change interventions often lack. In sum, by starting small, learning quickly, and adapting continuously, design can keep interventions agile, context-sensitive, and aligned with the messy, nonlinear paths of real-world behavior change.

2.3.3 Designing affective experiences

Momentary positive experiences with a health behavior (intervention) markedly increase the odds of repeating it, helping people push through challenges and sustain change (Petosa and Holtz, 2013; Schüler and Brunner, 2009). Following Desmet and Hekkert's (2007) framework, we define intervention experience as all affective responses in human-intervention interaction. In health behavior change interventions, this experience consists of three components: aesthetic experience (sensory pleasure like sight or touch), experience of meaning (symbolic or personal associations), and emotional experience (feelings evoked by the product's function or relational meaning). These dimensions jointly influence how

users engage with and adopt such interventions. Yet in the design of health behavior change interventions, components are typically specified in terms of their target mechanism (e.g., reinforcement, self-monitoring, goal-setting) (Michie et al., 2013) with little attention to how they are experienced by participants. Recent theorizing makes that omission harder to justify: in value-based accounts such as the VEM-BC, what a participant experiences while performing a behavior is itself part of the mechanism rather than a by-product of it (Becker and Veling, 2026). HCD is well-suited to exploring and designing for these affective experiences, using iterative processes to shape each interaction so that it is not only mechanistically sound but also aesthetically pleasing, meaningful, and emotionally engaging. This can help spark the positive affect that drives upward spirals and, ultimately, durable behavior change (Van Cappellen et al., 2018).

2.4 Current state of the Gecombineerde Leefstijlinterventie (GLI)

The Gecombineerde Leefstijlinterventie (GLI) programs in the Netherlands are government-approved interventions for adults with overweight or obesity, focusing on sustainable lifestyle changes rather than short-term weight loss (Berendsen et al., 2011; Duijzer et al., 2014; Gannamani et al., 2024). Referred by General Practitioners, participants follow a two-year program consisting of a treatment phase (9 months) and a maintenance phase (15 months), with eight group sessions and seven hours of individual coaching (Gannamani et al., 2024). A multidisciplinary team of lifestyle coaches, dietitians, and physiotherapists delivers the program (Berendsen et al., 2011). During the treatment phase, the program emphasizes motivation, education, and skill-building. Participants learn about nutrition, physical activity, and behavior change strategies, with frequent group meetings and individual consultations helping them set realistic goals and build confidence. Coaches provide close guidance to encourage adherence. As the program progresses into the maintenance phase, support becomes less intensive but remains consistent. Participants transition from weekly to monthly sessions, focusing on self-monitoring, overcoming obstacles, and relapse prevention (Duijzer et al., 2014).

2.4.1 Inspecting the GLI through a psychological lens

The GLI addresses different types of motivation by starting with extrinsically guided support through coaches and structured group sessions, and gradually shifting toward more autonomous forms of motivation. Participants are supported in setting personal goals, building self-efficacy, and gaining confidence to maintain behavior independently over time. The program also supports automaticity by encouraging participants to build routines around healthy eating, physical activity,

and self-monitoring. Through repeated behaviors and ongoing coaching, participants are given tools and strategies to integrate new habits into daily life. The group-based format and coaching structure can also foster positive affective experiences: group sessions provide social connection, while early successes generate feelings of pride and increased energy. Yet, despite its effectiveness, dropout remains an issue. In 2020, 48% of participants completed the program, with 26% dropping out in year one and 35% of the remaining participants quitting in year two (Gannamani et al., 2024; Oosterhoff et al., 2023).

2.4.2 Lived experiences of GLI participants

Understanding the lived experiences of GLI participants provides valuable insight into the struggles they face in sustaining their progress. To make these experiences concrete, we draw on two episodes of the Dutch Leefstijl Lab podcast (Hermans, 2025a, 2025b), a public series in which people speak about their experience with weight management. One of the authors was familiar with the series and selected these two episodes for their relevance to the present analysis. The series addresses weight management broadly, including pharmacological treatment, and both speakers combine medication with lifestyle change. Quotations were transcribed and translated from Dutch by the authors and were selected to illustrate recurring themes rather than to establish how common they are. This is an illustrative case rather than a systematic qualitative analysis; its purpose is to make visible the kind of experiential detail that a human-centered design process would set out to gather deliberately. Two former participants, whom we refer to here as Participant A and Participant B, shared their personal journeys in episodes of the Dutch Leefstijl Lab podcast (Hermans, 2025a, 2025b), revealing the emotional highs and lows that define life after GLI. For both, the initial period with the GLI brings a sense of empowerment and regained control over their lives. Participant A reflects on the joy of being able to do everyday activities again: “I could finally do things I hadn’t been able to do for years… walking with my children, going to the swimming pool” (Episode #81). This reclaiming of a ‘normal life’ is a powerful intrinsic motivator, reinforcing why they began their journey in the first place. Similarly, the physical transformation is often exhilarating: “A whole new world opened up for me… I was on cloud nine when I fit into a size 40 pair of pants again” (Episode #81). Yet, despite these victories, many participants experience a ‘revolving door’ problem, struggling to maintain their progress and feeling trapped in an exhausting cycle of weight regain and renewed effort. This struggle is both physical and emotional. Participant B describes an ongoing challenge: “I feel like I’m becoming the best version of myself physically, but at the same time, I’m having an incredibly hard time… and that really weighs on me” (Episode #80). Even with persistent effort: “I

still exercise six times a week, I absolutely watch my diet… but it still feels incredibly difficult to maintain my weight" (Episode #80), the pressure remains. Many participants find themselves mentally consumed by their weight and food choices: "It feels like a constant noise in my head… purely about food" (Episode #80). The ongoing strain leads to frustration, exhaustion, and, for some, a sense of inadequacy despite their hard work. When weight regain occurs, many feel shame and reluctance to seek help again. Participant A shares how demoralizing it feels to return to the GLI: "It feels like being sent back to school as a little child… as if they need to tell me all over again how to do it" (Episode #81). The stigma around repeated attempts to lose weight creates a psychological barrier to seeking continued support. Participant A also explains the tension between needing help and fearing judgment: "You don't want to hear 'You're doing it wrong,' so you feel ashamed to go back to the doctor" (Episode #81). This highlights a crucial gap in the GLI's design; after the program ends, participants are often left to navigate their health journey alone, without the long-term support needed to prevent relapse.

2.4.3 Improving the GLI through an HCD lens

By applying an HCD lens to the lived experiences of GLI participants reported above, we can identify directions for further improvement. Below, we outline three areas where an HCD approach could enhance the GLI.

2.4.3.1 Understanding people's lived experiences

Participants A and B feel alone and ashamed after relapse. They report mental fatigue and fear of returning to GLI ("It feels like being sent back to school…"). Their experience after relapse is marked by emotional burden, not just behavioral lapse. Rather than treating relapse as a deviation from a linear path toward maintenance, an HCD approach would begin by understanding what relapse actually feels like for participants through methods such as reflective diaries, experience sampling, or participatory interviews. These insights could then inform the design of support that normalizes and destigmatizes relapse as part of the process and signals to participants that their personal journey is valid and improving, even when messy. Crucially, this means designing with people who have experienced relapse, rather than for them based on assumptions about what they need. Including testimonials from participants who have experienced relapse would normalize relapse and support sustained engagement with the GLI. Whether it does so should be visible in two places: the proportion of participants who return to the program after weight regain, and the shame participants report at the point of return.

2.4.3.2 Iterative improvement

Participants A and B describe the maintenance of weight loss as mentally exhausting and emotionally taxing, even when they continue to put in significant effort. Feelings of frustration, pressure, and inadequacy can accumulate, especially when weight fluctuates despite healthy behaviors. Rather than delivering a static program format, the GLI could develop small modules that help participants navigate these recurring obstacles. These "Reset Modules" could focus on managing emotional fatigue, reframing temporary setbacks, or reactivating motivation when progress plateaus. The modules might take the form of brief peer-led check-ins, personalized prompts for reflection, or light-touch digital interventions that provide reassurance and perspective. The modules can be presented by the GLI based on monitoring (in this way the GLI adapts to the user) or the modules can be chosen by participant (in this way the user customizes the GLI). In both ways, or in a combination, the GLI aligns to the changing user. Whether the modules do so effectively should be visible in dropout during the second year of the program, which in 2020 affected 35% of participants who completed the first year (Oosterhoff et al., 2023).

2.4.3.3 Designing affective experiences

Participants A and B vividly remember their early wins but report difficulty sustaining joy and motivation on the long run ("It still feels incredibly difficult..."). Emotional rewards fade faster than behavioral habits build. We should thus explore how positive experiences can become an integral part of the intervention rather than something that happens incidentally. This could mean designing moments of celebration into the program. For example, by setting personal rewards, sharing milestones with loved ones, or creating rituals around achievements. The aim is not to instruct participants to feel motivated, but to design the conditions in which joy and pride emerge structurally and naturally: through moments that make progress feel real and personally meaningful markers of change. By co-designing these moments with participants, in advance and during the GLI, the program can tap into what actually feels rewarding to them, rather than relying on generic encouragement. Whether such designed moments do sustain positive affect can be established through experience sampling across the two-year trajectory, which is precisely the kind of in-the-moment measurement that Becker and Veling (2026) identify as the field's next methodological.

2.5 Discussion

Long term maintenance of health behavior changes remains understudied and is rarely achieved in health interventions. Health psychology helps our understanding of maintenance of health behavior change through testing and refining theoretical models. Our analysis of behavior change theory identified three requirements for maintenance: there are different types of motivation (e.g., extrinsic versus intrinsic), which change over time (e.g., initially extrinsic eventually intrinsic), and that positive moment-to-moment experiences during behavior enactment are essential for long-term maintenance. Relevant psychological theories struggle to design interventions for long term maintenance in real-life conditions because they mostly aim for initiation of change while maintenance requires different resources and make linear inferences that do not account for the complexity and messiness of daily contextual influences. HCD can help address some of these gaps by understanding people's experiences in context first. Furthermore, through agile designing and experimenting early and often with emotional and meaningful moment-to-moment experiences, HCD can help generate more contextually and experientially fitting interventions. In this way, HCD can surface tacit knowledge and experiences that are difficult to access through more structured research methods alone.

Despite these advantages, HCD has limitations: it is not strongly grounded in theoretical underpinnings like health psychology. Its emphasis on qualitative and contextual insights may also not always align with research psychology's emphasis on generalizable effects. Where the dominant discourse in psychology is about fully understanding a phenomenon, the discourse in design is more about what works in practice. However, by combining theory and methods from both disciplines, we can develop interventions that are not only evidence-based but also practical, engaging, and fitting for long-term impact. Three specific limitations limit what our current analysis can rightfully claim. First, our selection of theories is necessarily partial: we have foregrounded motivation, automaticity, and affective experience because they recur across accounts of maintenance, but other determinants (e.g., social and physical environment, socioeconomic constraint, and the pharmacological options) receive little attention here. Second, our illustration rests on a single intervention in a single country and on two publicly available participant accounts. Therefore, it demonstrates what the combined lens can surface, not how often the issues it surfaces occur. Third, and most consequentially, the approach itself is untested. We have argued that combining health psychology and human-centered design yields interventions better suited to maintenance. However, establishing that it does would require comparing interventions developed with and without design involvement on long-term

behavioral outcomes. That comparison is, in our view, the most useful study to run next.

Finally, the present article highlights only a selection of key insights, brought forward by an author team that included both health psychologists and designers. By applying these insights as a lens on an existing intervention, we hope to have illustrated some of the potential of combining perspectives from both fields. Our contribution is an initial exploration of how health psychology and HCD can complement each other when it comes to designing interventions for maintenance of health behavior change. To build on this interdisciplinary approach, we encourage health psychologists and human-centered designers to seek collaboration, combining their complementary strengths to better understand and support long-term health behavior change.

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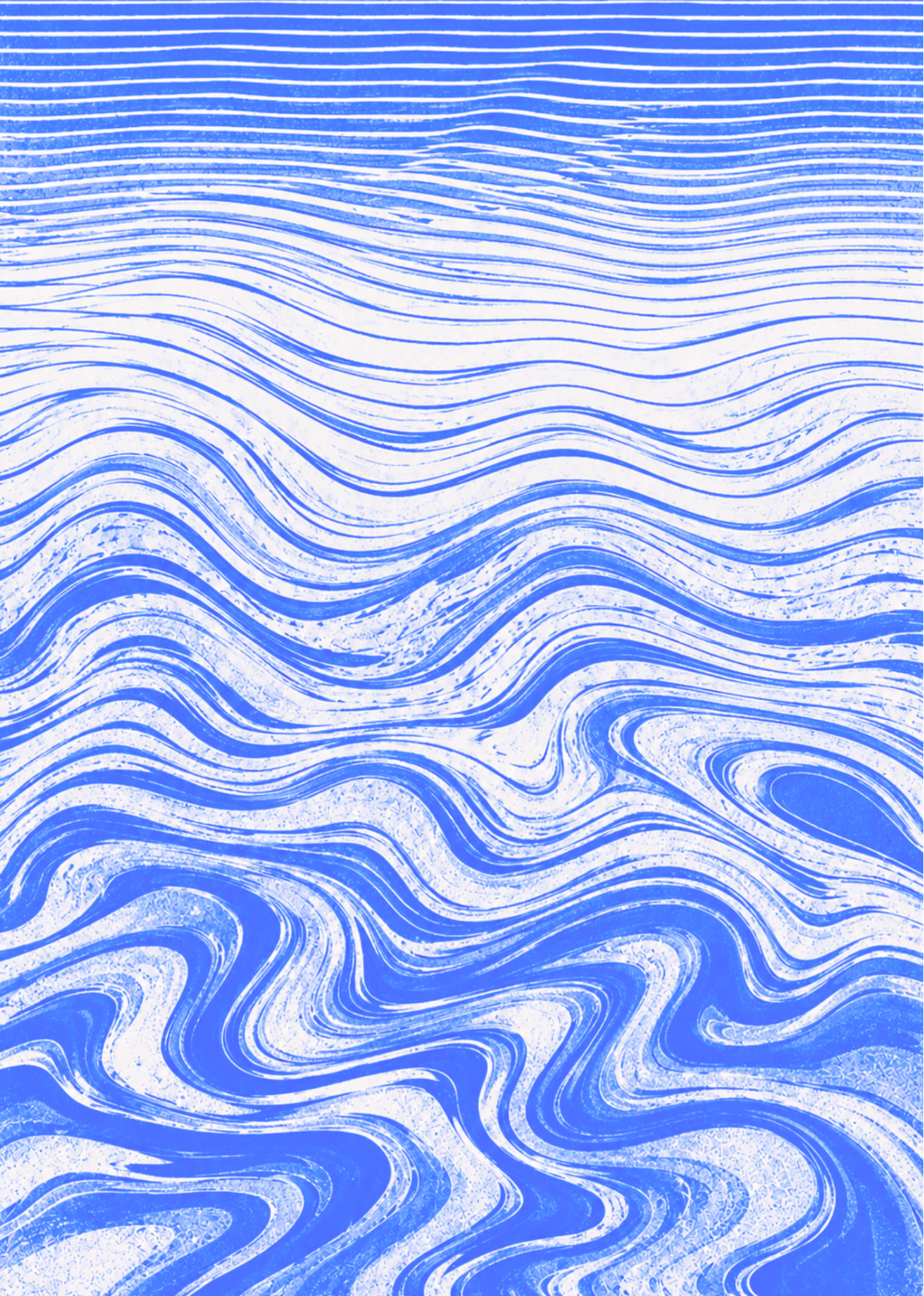

Chapter 3. Dynamics and diversity in adolescents' experienced barriers and facilitators for physical activity maintenance

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Abstract

Despite the well-documented health benefits of physical activity (PA), over 80% of adolescents worldwide fail to meet recommended daily levels. This study identified experienced barriers and facilitators for PA maintenance among Dutch adolescents, examine how they form barrier and facilitator profiles, and explore how barriers and facilitators evolve over time. First, we conducted 21 interviews with adolescents (13-16 years) to uncover relevant barriers and facilitators. Then, we developed and applied a card sorting task based on Q methodology, and examined barrier and facilitator configurations with 30 adolescents (aged 13–18 years) who had maintained a physical activity for ≥2 years, followed by interviews. Factor analysis revealed five facilitator profiles: *Mental and physical health benefits*, *A way to be myself around others*, *Pursuing health goals*, *Developing confidence and strength*, and *Developing along my own path*. Four barrier profiles emerged: *Low motivation and energy*, *Not a good fit for me*, *Balancing act*, and *Proximity, possibility and perception*. Facilitator profiles ranged from immediate characteristics of the activity. such as enjoyment, social connection, and mental wellbeing, to more future-oriented drivers such as autonomy and self-development. Barriers profiles varied from predominantly internal (e.g., low motivation) to external (e.g., distance, weather) or mixed influences linking life demands to reduced personal resources. Across participants, enjoyment was the most consistent facilitator, but perceived influences often shifted with age, from immediate, activity-based facilitators more related to competence and relatedness to motivations tied to autonomy, identity and coping with growing responsibilities characteristic of this life stage. These results highlight the diversity and dynamic nature of barriers and facilitators in adolescent PA maintenance. Tailoring PA promotion programs to adolescents' evolving motivations and constraints may increase their effectiveness, supporting sustained active lifestyles into adulthood.

3.1 Introduction

Despite well documented physical and psychological benefits, such as cardiovascular health and stress regulation (Mahindru et al., 2023; Posadzki et al., 2020), over 80% of adolescents worldwide fail to meet daily PA recommendations (Guthold et al., 2020). Specifically, 77.6% of boys and 84.7% of girls aged 11 to 17 are insufficiently active, and activity levels often drop further as they transition into adulthood (Corder et al., 2019; Farooq et al., 2020; Guthold et al., 2020; Hayes et al., 2019). Although many interventions can increase PA levels during the intervention period these short-term gains typically erode within six to twelve months (Al-Khudairy et al., 2017; Stice et al., 2006; Yeager et al., 2018; Yuksel et al., 2020), highlighting the need to understand what enables and hinders long-term maintenance of healthy behaviors in adolescence.

Current PA promotion programs tend to emphasize intervention outcomes, often focusing on risk-reduction metrics such as BMI improvement and minutes of moderate-to-vigorous activity (Kimiecik et al., 2020). Although these evidence- and theory-based interventions (e.g., using behavior change techniques) can produce short-term PA increases, a key limitation is the intervention design tends to be static and is not adapted to the rapid physical, psychological and social changes that characterize this life stage.

A person-based, developmental approach offers an alternative by treating adolescents as active agents whose goals and constraints can change over time. Drawing from self-determination theory (Deci & Ryan, 2000) and developmental science, the person-based, developmental approach considers adolescents' subjective experiences and values as well as how their motives and barriers shift throughout their development (Kimiecik et al., 2020). As adolescents explore new social roles and identities, their motivations and social surroundings change and become increasingly diverse. Given the strong links between intrinsic motivation, identity congruence, and long-term PA maintenance (Kwasnicka et al., 2016; Rhodes, 2021), interventions that incorporate adolescents' own experiences are more likely to foster sustainable health behavior change. Accordingly, this paper has two aims: (1) to identify profiles of experienced barriers and facilitators for PA maintenance amongst adolescents and (2) to examine how experienced barriers and facilitators are perceived to change over time.

Facilitators are factors that enable or motivate a behavior, whereas barriers are factors that obstruct or demotivate it. Prior research has identified a wide array of PA facilitators and barriers including individual, social, and environmental factors (Martins et al., 2015). For example, adolescents often cite enjoyment and social

support as primary reasons for participation, while lack of time, low motivation, or access often prevent PA participation (Martins et al., 2015, 2021).

However, barriers and facilitators are not isolated but interact within each adolescent's life. Yet most research treats barriers and facilitators as general characteristics of adolescents, aggregated across large groups (e.g., all adolescents) (Martins et al., 2015, 2021) or simple subgroups (e.g., by gender) (Duffey et al., 2021; Knowles et al., 2014) thereby obscuring the unique configurations that drive individual PA. Because motivation and experience around PA are made up from multiple connected personal and contextual influences (Agans & Lerner, 2021), PA behavior may be better understood as profiles of barriers and facilitators. These combinations create a more holistic picture than single indicators alone. Moreover, facilitators can reinforce one another but also compete with other life motivations. For example, Strömmer and colleagues (Strömmer et al., 2021) show that while adolescents tend to value their health, their motivations for engaging in health behavior, like PA, can be at odds with their growing desires for autonomy or social belonging. This finding highlights the importance of recognizing how barriers and facilitators are connected and how they sometimes compete with each other in shaping adolescents' PA experiences.

Barriers and facilitators for PA not only interact within an individual's life but also evolve over time. Especially during adolescence, a developmental period marked with major life changes in which their goals and priorities can shift (Crone & Dahl, 2012). For example, adolescents often experience shifts in motivation and attitudes towards PA during key transitions such moving from primary to secondary school (Gavin et al., 2016; Knowles et al., 2014). As they gain new experiences, they explore different interests, form new peer groups, and exercise increasing autonomy in their decision making , all of which shapes their active lifestyle trajectories (Agans & Lerner, 2021).

Theoretical perspectives also suggest that the motives and capacities driving early PA engagement differ from those needed to maintain PA (Rhodes, 2021). These initial facilitators must change and adapt over time to support long-term PA maintenance. Research on adolescent PA adherence shows that a passion for the activity, perceived positive outcomes, identity alignment with the activity, and continued support from friends and parents are key determinants for sustained PA engagement (Agans & Lerner, 2021; Fernández-Prieto et al., 2019; Gavin et al., 2016; Knowles et al., 2014). These findings aligns with behavior maintenance theories, which emphasize intrinsic motivation, identity, and habit formation (built through repeated practice in stable contexts), as essential for long-term

health behavior maintenance (Kwasnicka et al., 2016). However, these facilitators of PA maintenance may not be present in the early phases of PA engagement and need to be cultivated over time. Even among adolescent PA "maintainers", the barriers and facilitators are expected to shift over time both because of the changes associated with this developmental period and also the facilitators of PA maintenance differ from those of earlier PA engagement. Understanding these dynamics can inform how interventions can support adolescents' changing barriers and facilitators.

This paper examines adolescents' experienced barriers and facilitators for PA maintenance with two aims. The first aim is to examine profiles of experienced barriers and facilitators associated with PA maintenance and how these vary across adolescents. The second aim is to investigate how PA barriers and facilitators are perceived to change during adolescence. By examining these profiles and perceived dynamics, we will gain richer insights into adolescents' experiences with PA maintenance. These findings can support the design of interventions that resonate with young people's own perspectives and aim to promote sustained PA engagement.

3.2 Methods

We employed a mixed methods approach over two main phases to gain a rich understanding of adolescents' experienced barriers and facilitators of PA maintenance. In phase 1, we conducted semi-structured interviews to explore adolescents' perceptions and views on barriers and facilitators of PA. In phase 2, we translated these insights into a card sorting activity based on Q methodology to gain insights into personal profiles of barriers and facilitators and how they can change over time.

Q methodology combines quantitative and qualitative techniques to investigate the range of possible perspectives on a topic (Exel & Graaf, 2005; Stephenson, 1936). Its purpose is to uncover subjectivity by identifying the extent to which perspectives are shared or differ across people. In a Q-sort, participants rank a structured set of items, which forces prioritization and trade-offs rather than evaluating each item in isolation. These ranked configurations are then analyzed using by-person factor analysis to shared profiles of participants , which are then interpreted qualitatively using participants' explanations from interviews.

This approach is well suited to our aim of understanding adolescent experience as configurations of interrelated influences rather than isolated barriers or

facilitators. Because participants rank the items themselves and confirm they reflect their experiences, the resulting profiles offer a holistic view of how multiple influences shape PA maintenance experiences according to adolescents. The combination of the quantitative structure with qualitative insights enables the systematic identification and interpretation of shared patterns in our sample.

3.2.1 Ethics

Ethical approval for the study was obtained from the Human Research Ethics Committee of Delft University of Technology (submission number 1790). Permission was granted by four secondary schools in the Rotterdam area, the Netherlands to approach their student on school premises. After approval from a designated school staff member, a digital information letter was sent to parents and guardians at least one week before approaching participants. The letter outlined the study and explained that their child might be approached on school premises. On the day of data collection, researchers approached students during free periods (breaks, mentor classes, or after school), explained the study verbally, and obtained written informed consent. Each participant received a physical follow-up letter to their parents confirming their participation and reminding the parents about the study and the right to withdraw their child. Participants were also given a €5 cinema voucher for their participation. Only non-identifying demographic data (age and gender) was recorded. The consent procedure was developed in collaboration with the legal department of Delft University of Technology.

3.2.2 Recruitment

The data collection for phase 1 took place in October 2021 the data collection on phase 2 took place the second half of 2022. With approval from the school, the first author and a research assistant (acknowledgement) visited each school. In phase 1, we invited any student interested in sharing their views on health and PA, in phase 2, we approached students who had engaged in a specific physical activity for at least two years. Students were approached during gap hours, breaks, after school, or, when arranged, during mentor class sessions with permission of the teacher.

3.2.3 Phase 1: Exploratory interviews

To identify barriers and facilitators relevant to our local target group, we conducted interviews with 21 adolescents aged 13 – 16 (M_{age} = 14.2). During the interviews, we used generative methods to elicit personal experiences around health behavior (Sleeswijk Visser, 2009). We used objects and visuals (Appendix 2A) were used to engage participants and prompt discussion about what an active lifestyle means to them. For example, we presented illustrated characters and asked participants to indicate which they perceived as the most and least fit. We also asked them to rank various objects (e.g., a ball for exercise, a toy bed for sleep, fruit for food) according to their importance for the participants' fitness. These objects and images, selected by the researchers, were intended to evoke different dimensions of health (exercise, diet, sleep, etc.). Furthermore, we asked participants the barriers and facilitators they have faced when trying to change or maintain their health behavior. Their choices and statements were written down and the interviews lasted approximately 30 minutes.

3.2.4 Phase 2: Card sorting

Based on the insights of the interviews we developed a card sorting activity based on Q methodology. Following this method, we asked participants to rank a series of statement cards, called a Q-set, about the topic according to their personal views. This ranking process, called Q-sorting, allowed us to understand the subjective viewpoints of the participants. Consequently, participants were interviewed about their Q-sorts. The Q-sorts were then used to perform a by-person factor analysis revealing shared perspectives on the topic (Watts & Stenner, 2012).

Step 1. Q-set development

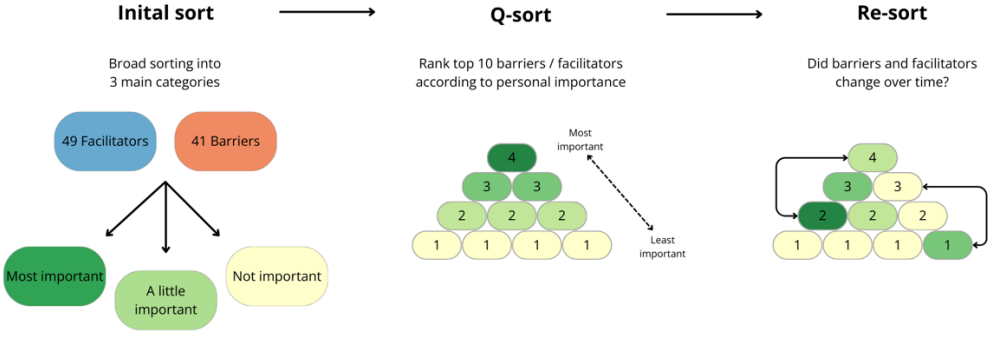
Based on the exploratory interviews, two Q-sets were developed: one for barriers and one for facilitators. The interview results were analyzed using the barrier and facilitator themes identified by Martins and colleagues as a guide (Martins et al., 2021), which resulted in 41 barriers and 49 facilitators. The two lists were reviewed within the research team and the redundancy between statements was reduced by removing ones with overlapping themes, resulting in two balanced Q-sets. The two sets consisted of 31 barriers and 36 facilitators (Appendix 2B).

Step 2. Q-sorting

Q-sorting was conducted with 30 adolescents aged 13 – 18 (M_{age} = 15.1, 16 male). Each Q-sorting lasted approximately 30 minutes and consisted of asking each participant to:

1. select a physical activity that they had maintained for at least two years and are still doing currently.
2. respond to the facilitator Q-set statements, which were shown one by one, and to categorize the statements as 'not important', 'a little important' or 'very important' for maintaining their physical activity.
3. select the top 10 from the 'very important' stack and sort them in the ranking structure based on personal importance (Figure 3.1).
4. explain each sorting choice they made and how they played a role in their PA maintenance.
5. reflect on any changes in their facilitators over time, and if applicable, re-sort them in line with their experiences from two years ago
6. explain how and why their facilitators had changed over time.
7. repeat steps 2-6 with the Q-set about PA barriers.

Figure 3.1. Research protocol during Q-sorting.



Step 3. Analyses

Using the data obtained in step 3, we investigated the descriptive statistics to identify the most important barriers and facilitators based on cumulative ranked scores for all adolescents in our sample. Adolescents had maintained a variety of PA activities (Appendix 2C).

We then conducted a by-person factor analysis (PCA involving varimax rotation) of the facilitator and barrier Q-sorts using the *qmethod* package in R (version: 1.3.1093) (RStudio Team, 2023; Zabala, 2014). The number of factors was determined using visual inspection of the screeplot, the Eigen-value criteria > 1, and at least 3 participants per factor which are commonly used criteria for this method (Watts & Stenner, 2012). Next, we developed weighted average z-score tables for displaying the ideal Q-sort and focused our interpretation of the factors, which we will also call profiles, on the statements ranked +2 or above, as determined by these tables (Appendix 2D).

Perceived changes over time were examined by calculating the change in rank order of each barrier and facilitator for participants who indicated a change. These rank order changes were summed for each barrier and facilitator to identify the influences that shifted most between participants' past and current PA experiences.

The profiles and largest retrospective shifts were analyzed and interpreted qualitatively, utilizing participants' explanations and anecdotes about their choices, and guided by the themes described by Martins. Participant quotes were visually organized on statement cards within the relevant profiles and for the largest barriers and facilitators changes. Throughout the analysis, researchers stayed closely aligned with participants' own words to ensure a faithful representation of their experiences.

3.3 Results

3.3.1 Descriptive statistics

Table 3.1 presents the overall highest scoring facilitators and barriers of the group based on rank scores. Results suggest that having fun was the most important facilitator. The most important barriers were related to having other responsibilities or too little time or more related to personal factors such as having too much on one's mind and too little energy.

Table 3.1. The total scores of most important barriers and facilitators in our sample, n = 30.

Facilitators	Type	Total ranked score (out of possible 120)
Having fun	Activity	60
Clearing the mind	Individual	36
Being able to be yourself	Individual	33
Wanting to maintain something	Life	29
Barriers		
Other responsibilities	Life	45
Too little energy	Individual	44
Too little time	Life	41
Having too much on one's mind	Individual	38

3.3.2 Factor analysis

3.3.2.1 *Facilitator profiles*

Two to seven factors were considered, and a five-factor solution was selected based on our criteria as described in the methods section. The final five factors included 20 (out of 30) participants and explained 53.7% of the total variance each representing a distinct profiles (see Figure 3.2).

Profile A – "Mental and physical health benefits"

These adolescents placed significant value on the mental and physical advantages of engaging in physical activity, while emphasizing the importance of enjoying these activities with others. For these individuals, participation in physical activity served as a coping mechanism for managing stress and energy, enabling them to clear their mind.

Profile B – "A way to be myself around others"

This factor of adolescent girls placed great value on authenticity, fun, and self-expression in their engagement with PA. Participants emphasized the significance of being able to be your authentic self when doing physical activities in social groups, which significantly to their enjoyment of the experiences.

Profile C – "Pursuing health goals"

These adolescents were driven by goal achievement, such as earning diplomas and acquiring specific skills, and maintaining their physical fitness for their future wellbeing. They seek to grow personally through facing challenges while also working on their overall health and wellbeing. Overall, they regarded their PA as a fundamental component of a well-balanced lifestyle.

Profile D – "Developing confidence and strength"

These adolescents accentuated the significance of personal growth and self-identity, while also recognizing the positive impact of physical activity on their overall wellbeing. A central aspect was the value placed on the importance of expressing their true selves openly, even in public settings. Personal development held considerable importance, with individuals finding joy in their own transformative journeys and progress.

Profile E – "Developing along my own path"

The adolescent boys in this profile emphasized developing themselves in terms of progressing in their chosen activity, but also extending beyond skill improvement to enhance their abilities in handling other life situations. This individuals in this profile places great importance on autonomy, valuing the freedom to make their own choices, for example of their preferred activity or club. Enjoyment was also a significant influence with participants also recognizing it as playing an essential role in both performance and personal development.

3.3.2.2 *Barrier profiles*

Three to five factors were considered, and the four-factor solution was selected based on our criteria. The four factors included 27 participants and explained 53% of the total variance each representing a distinct profile (see Figure 3.3).

Profile A – "Low motivation and energy"

Adolescents here expressed difficulties such as feeling physically and mentally unwell, which hindered their motivation for PA. Additionally, lack of time and the burden of other obligations like school and work occupied their minds, further impeding their enthusiasm to participate in physical activities.

Profile B – "Not a good fit for me"

These adolescents struggled most with the at times physical and emotional unsafe environment where their PA would take place. Time constraints posed a significant challenge for this group, as they strived to balance their school commitments with engaging in physical activities. The compatibility of the activity with their preferences was also crucial, as it boosted their enjoyment and motivation to participate regularly. Financial burdens of the activity also played a role, arising from, for example, regular contributions and the cost of necessary equipment.

Profile C – "Balancing act"

These adolescents attributed their challenges to multiple competing responsibilities particularly involving schoolwork and part-time jobs, which often take sometimes take priority over engaging in physical activities. Falling out of their exercise routine was a recurring occurrence among this group, and they sometimes struggle to get back on track after moments of laziness. Distractions, such as mobile phones or other leisure activities, also interfered with their physical activity plans.

Profile D – "Proximity, possibility and perception"

These adolescents encountered challenges in surmounting environmental barriers, particularly concerning distance and adverse weather conditions, which hindered their engagement in physical activities, especially when they were preoccupied or uncomfortable. Moreover, the combination of other commitments, such as school obligations, further impeded their ability to engage in physical activities. Feelings of physical discomfort exacerbate their reluctance to participate, as they were concerned about their performance level and the fear of scrutiny from others.

Figure 3.2. Identified facilitator profiles for physical activity maintenance.

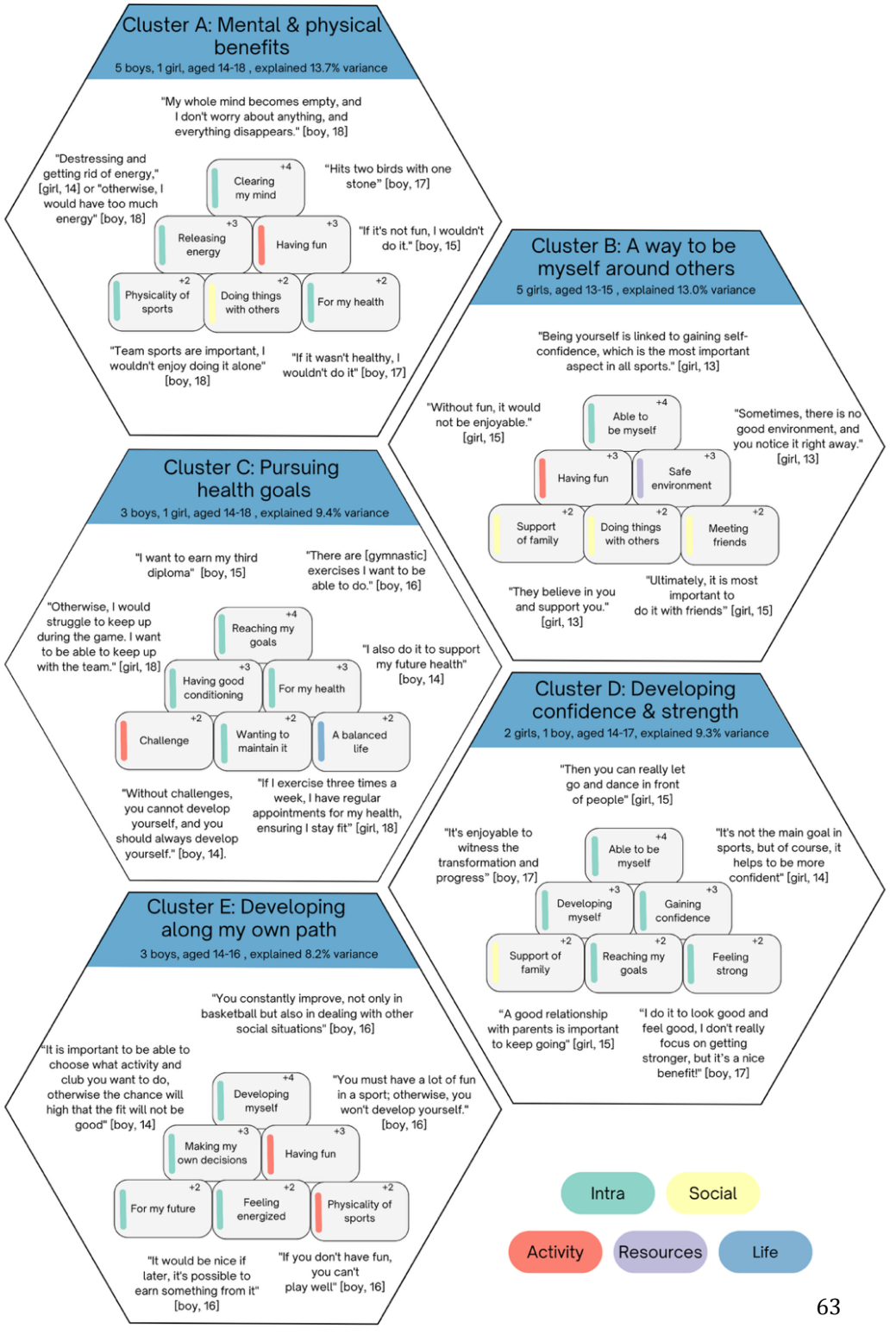
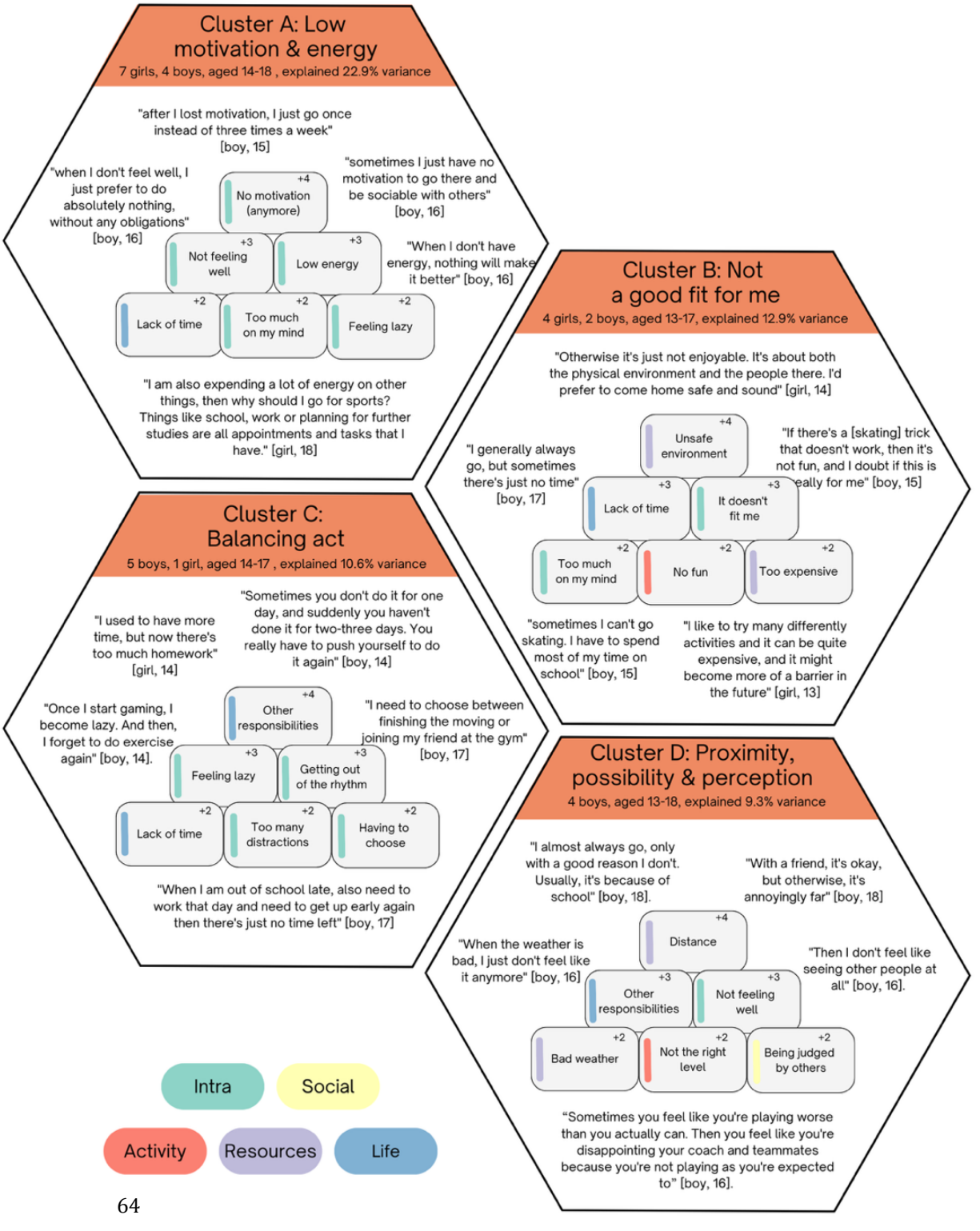


Figure 3.3. Identified barrier profiles for physical activity maintenance.



3.3.3 Perceived changes over time

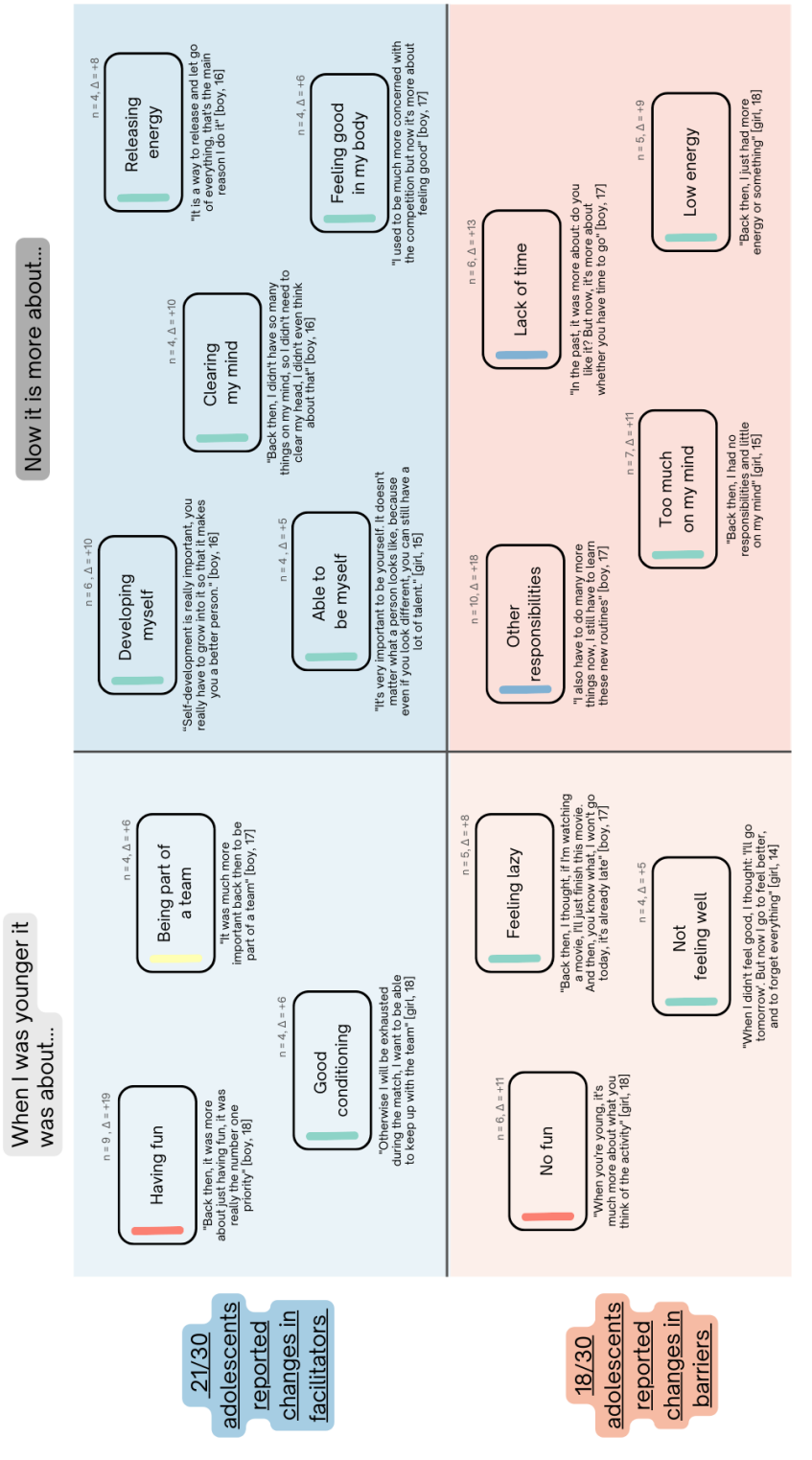
After the initial sorting of the cards, participants were asked whether and how their barriers and facilitators for the same activity had changed compared to two years earlier. 21 out of 30 (70%) adolescents indicated that their facilitators had changed over time (13 male, 8 female, ages 13 – 18). 17 out of 30 (56.7%) indicated changes in their barriers (10 male, 7 female, ages 13 – 18). The most notable shifts, which were shared by at least four participants, are shown in Figure 3.4.

Participants who reported changes in either barriers or facilitators were slightly older on average (15.3 years) than to non-changers (14.3 years). The age range for changers was also slightly wider (ages 13–18) compared to non-changers (ages 13–16). who reported changes in both barriers and facilitators were the oldest on average (15.7, n = 14), compared to those reporting changes only in facilitators (15.1 years, n = 7) or only in barriers (14.0 years, n = 3). These patterns suggest that older participants were more likely to report changes in their perceived barriers and facilitators.

In the past, enjoyment stood out as a primary motivator for engaging in PA for the participants. Additionally, having a good physical conditioning and being a part of a team and were important facilitators in the past. In contrast, present facilitators were more self-directed, including both the ability to be true to themselves and to pursue their self-development. Moreover, PA has turned into a mechanism that can regulate both mental and physical well being such as mental clarity and energy levels.

Past barriers centered more on the activity itself or adolescents' physical and mental states, with the prospect of not enjoying the activity as the primary barrier for PA engagement. In addition, feelings of personal discomfort and moments of laziness were common obstacles. In contrast, present barriers predominantly revolved around external factors and obligations. Adolescents now grapple with balancing responsibilities, which contributes to feelings of mental overload and a perceived depletion of time and energy from doing other tasks.

Figure 3.4. The largest perceived shifts in barriers and facilitators for physical activity maintenance between past and present experiences. Δ indicates change in ranked score.



3.4 Discussion

This study employed a mixed methods approach combining interviews and card sorting based on Q-methodology to study how adolescent experience their PA maintenance. For our first research aim, we identified barrier and facilitators profiles which represent different adolescent perspectives on PA maintenance. For our second research aim, we identified how barriers and facilitators for PA were perceived to change over time.

3.4.1 Barrier & facilitator profiles

Factor analysis on the card sorting task resulted in five facilitator and four barrier factors, showing that adolescents' experienced barriers and facilitators to PA maintenance are not uniform but can be grouped into distinct profiles. Profile A ("Mental and physical health benefits") and B ("A way to be myself around others") were grounded in the direct, immediate characteristics of the activity. Profile A emphasized fun and direct physical and mental health outcomes, while B, the most distinct factor and composed exclusively of girls, highlighted the importance of social context and support. In contrast, profiles C, D, and E were more goal-driven and future-oriented. Profile C prioritized health goals and performance milestones, D emphasized developing strength and confidence, and E combined forward-looking self-development with enjoyment. However, our factor solution did not capture all variation, as ten participants did not fit any facilitator factor, indicating additional unrepresented perspectives exist beyond these profiles.

The barrier profiles showed less overlap than the facilitator profiles, making them more distinct. They differed in the degree to which they emphasized internal versus external influences. Profile A was positioned firmly at the internal end of the spectrum, focusing almost exclusively on barriers such as low motivation, limited energy, or feelings of laziness. At the opposite end, profile D centered almost entirely on environmental obstacles unrelated to the activity's content (e.g., weather, travel distance). Profiles B and C combined internal and external barriers. Profile C connected external life demands to depleted internal resources, while Profile B emphasized the fit between the activity and the individual (e.g., questioning whether the activity feels right or safe).

Together, these findings indicate that adolescents' PA maintenance experiences are shaped by multiple influences and can be grouped into distinct profiles. This is consistent with prior work showing that youth construct their own meanings, values, and perceptions around health behaviors, and that these subjective

configurations shape maintenance. (Agans & Lerner, 2021; Strömmer et al., 2021) However, the profiles we identified are unlikely to represent the full spectrum of adolescent experiences. The explained variance of the factor solutions was relatively low (below 60%), and could be explained by other contributors to maintenance, such as self-regulation skills, habit strength, and environmental resources (Kwasnicka et al., 2016), were only indirectly captured in our card set. Although most profiles emphasize intrapersonal influences, adolescents' accounts also point to external demands from the environment, showing the interaction between context individual characteristics.

3.4.2 Changes over time

Our results show that adolescents perceived both barriers and facilitators for PA to change over time. In the past, facilitators were more tied to the direct characteristics of the activity (e.g. team atmosphere, having fun, and feeling physically capable). Over time, these changed towards more "higher order" goals related to self-development and self-expression, for example, gaining benefits beyond the context of the activity and becoming who they want to be. This change suggests that earlier PA engagement depends more on immediate, experiential qualities, whereas current engagement (among our sample of PA maintainers for at least two years) is supported by motives more aligned with identity and self-directed goal pursuit. Viewed through a self-determination theory lens, earlier motivation appeared to be connect more to relatedness and competence needs (e.g., connection in a team setting and feeling capable), whereas current facilitators increasingly reflect autonomy (developing myself, able to be myself). Furthermore, adolescents also seem to develop a broader conception of wellbeing (energy balance, feeling good, clearing my mind), suggesting that their understanding of what PA affords now also includes psychological and self-regulatory benefits, not just physical ones.

Barriers followed a complementary pattern. Earlier in adolescence, obstacles tended to be more internal and immediate (e.g. boredom, low mood, or not feeling well). In contrast, present barriers were more often due to new external demands, driven by increasing responsibilities from school, work and family, and consequently by reduced available time or energy for PA. This shift reflects a broader life context in which adolescents constrained not only by internal factors such as low motivation or boredom, but also by the need to juggle multiple demands from their surroundings.

The changes in barriers and facilitators echo findings from other studies and align with developmental psychology theories.(Agans & Lerner, 2021; Gavin et al.,

2016; Knowles et al., 2014) Adolescence is a period of identity exploration and formation, occurring alongside new academic, familial, and social responsibilities and interests (Hazen et al., 2008; van Doeselaar et al., 2020). These transitions require continual reprioritization and trade-offs in how limited time and cognitive resources are allocated. Our sample of maintainers appears to counteract these life demands by drawing increasingly on motivation grounded in autonomy and positive outcomes, which can contribute to their sustained engagement. Notably, while most participants reported changes, some reported no change in their barriers (n=12) or facilitators (n=9), indicating that these shifts are not universal. Participants who reported changes over time were one year older on average, suggesting that such shifts may become more likely as adolescents progress along their developmental pathways. However, the age ranges of changers and non-changers overlapped substantially (ages 13–16 vs. 13–18), indicating that age alone does not fully explain these differences. Moreover, across the sample, "having fun" remained the most consistent facilitator, underscoring that immediate enjoyment continues to be a core motivator for PA, even as other motives evolve.

The primary strength of this research is the investigation of subjective perspectives and experiences of adolescents around maintained PA. Our findings have several implications for promoting sustained physical activity from a person-based developmental perspective. First, interventions should treat adolescents as evolving agents, not static targets. Priorities, motivations, and constraints change over time, and simply adding "more" activity without acknowledging competing demands can increase friction rather than support engagement. Second, because enjoyment remains a core driver, especially earlier in PA engagement, PA should be framed not merely as a health imperative but primarily as an intrinsically enjoyable experience, a point often secondary in health promotion programs. Third, PA interventions must be adaptive and reflective. Although the immediate experiences of the physical activity are most important, for maintained PA, other goals also become important such as self-development, regulating energy balance, and feeling like you can be yourself. These more future-oriented influences should be given space to develop within PA interventions and actively encouraged, for example by embedding periodic reflection opportunities to reassess how PA also contributes to other goals. As several participants commented: *'I knew all these things already, but it is good to get an overview of it like this.'* Health promoting programs could provide adolescents with tools to create an overview of their barriers and facilitators can help guide autonomous decision-making as their needs evolve with shifting life contexts, supporting them in renegotiating how PA fits alongside growing responsibilities and changing identities.

This study is not without limitations. First, the study took place in a Dutch adolescent population in an urban area of the Netherlands, which comes with culture-specific considerations at both contextual and developmental levels. The Netherlands is a high-income country with relatively good access to PA opportunities, but most adolescents don't meet the recommended amount of PA (RIVM, 2025). Furthermore, none of the researchers were adolescents, so the selection of the stimuli used during interviews, the creation of the card set, and the interpretation of interviews necessarily reflect adult perspectives. Our assumptions and consequent study design decisions may have shaped participants' responses and may not fully capture how adolescents themselves conceptualize PA. These points make the generalizability of these research harder to other contexts. Future research could involve adolescents as co-researchers and by conducting similar studies in different cultural contexts. Second, we are unable to link our findings to actual PA data of our participants (e.g., accelerometer measures or activity logs). While engaging in one physical activity for at least two years was an inclusion criteria of the study, but we did not measure actual PA levels during the data collection. Consequently, we cannot determine how perceived changes in barriers and facilitators relate to actual PA engagement or predict long-term adherence. Future research could integrate objective PA data with experiential insights to examine how subjective experiences interact with measured activity levels. Third, we compared changes across a wide age range (13–18 years). Within this range, developmental stages differ substantially in cognitive, social, and physical ways. Future studies could focus on narrower age ranges to clarify how developmental transitions influence PA maintenance profiles.

3.5 Conclusion

This study provides valuable insights into adolescents' PA maintenance experiences by identifying distinct profiles of barriers and facilitators and showing how these can change over time. It highlights that adolescents' experiences are diverse and dynamic, with differences linked to internal versus external influences and to immediate versus more distal characteristics of PA. By capturing these patterns, our research deepens understanding of lived experience around PA maintenance in adolescence. These findings point to new directions for designing tailored, person-based interventions that account for developmental changes and support sustainable PA among adolescents.

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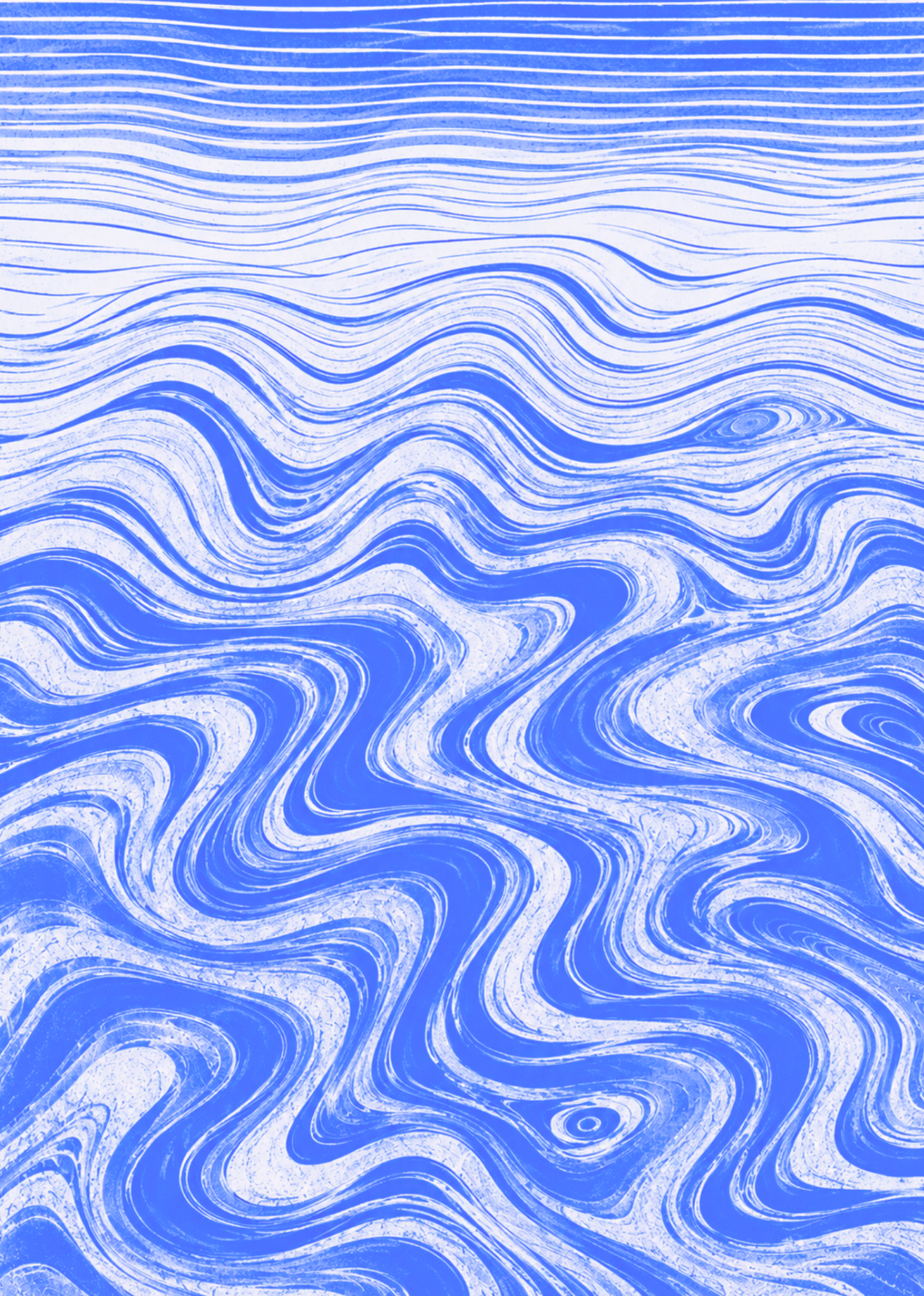


Chapter 4. Design and development of Mapping of Me

4.1 Introduction

This chapter documents the design process of Mapping of Me (MoM), a three-week hybrid journaling game in which adolescents work in pairs to pursue a personal health goal across two cycles of self-experimentation. Its aim is to support adolescents in discovering and experimenting with health behavior strategies that fit into their own lives.

The design process built on the two preceding chapters. In Chapter 2, my co-authors and I distilled three key theoretical considerations from health psychology when designing interventions to support maintenance of health behavior change: dynamic motivation, automaticity, and moment-to-moment experiences. These considerations describe what an intervention should target, but say relatively little about how it can be designed. We therefore argued that human-centered design (HCD) can complement them through three practices: understanding people's lived experiences, iterative prototyping, and designing affective experiences. Chapter 3 took a first step toward better understanding adolescents' lived experiences with health behaviors like physical activity. The barriers and facilitators adolescents experienced were diverse and person-specific, and most participants reported that these had changed over time. These findings suggested that an intervention should support adolescents in navigating changing motivations and barriers around health behavior.

In this chapter, I describe the design research activities through which I translated these insights into a serious game. Of the three HCD practices from Chapter 2, the chapter is primarily an account of using iterative prototyping to develop MoM. The process was informed by Research through Design (Stappers & Giaccardi, 2017), in which designing prototypes is itself a way of generating knowledge. Many decisions about how MoM would work could not be derived from theory in advance but came out of building, testing, and adjusting prototypes with adolescents, designers, and fellow researchers.

Two decisions shaped the design process from an early stage. First, the project proposal had set out to develop a serious game. Serious games are games designed for a purpose beyond entertainment, such as learning or behavior change. Serious games are usually built around some transfer effect or learning goal that should carry over from the game into players' lives (Siriaraya et al., 2018). Designing MoM therefore required defining the transfer effect the game should aim for. The second decision followed from this: I chose to explore self-experimentation as the approach to health behavior change. Self-experimentation

involves individuals systematically testing behavioral changes on themselves to determine what works for their own health, typically through an iterative cycle of selecting a change, trying it out in daily life, and reflecting on whether it worked before adjusting or replacing it (Fedlmeier et al., 2022; Karkar et al., 2016). This approach matches the diverse and changing barriers and facilitators reported in Chapter 3. It also positions adolescents as active agents in the behavior change process instead of recipients of a predetermined approach, which fits with the developmental need for autonomy.

The design process differed from what was originally intended. The project initially set out to adapt Joynme (n.d.), an existing mobile-based serious game developed by &RANJ. When mobile phones were restricted in Dutch secondary school classrooms following national government guidance (Ministerie van Algemene Zaken, 2023), the project pivoted to developing a new serious game concept that relied less on mobile phones. MoM is the result of that pivot.

4.2 Chapter overview

The design process took place between January 2024 and February 2025 and was carried out in collaboration with the serious gaming company &RANJ. The chapter proceeds chronologically through eight design research activities, from the game jam (Section 4.3), in which the first game mechanics were generat, to the final prototype (Section 4.10). Each activity is introduced briefly and then documented using the same structure (Figure 4.1):

Input: the materials that informed the activity
Who: the people involved
Question: the question the activity set out to answer
Outcome: the insights, design decisions, or artifacts produced

Figure 4.1. Structure used to document each design activity.

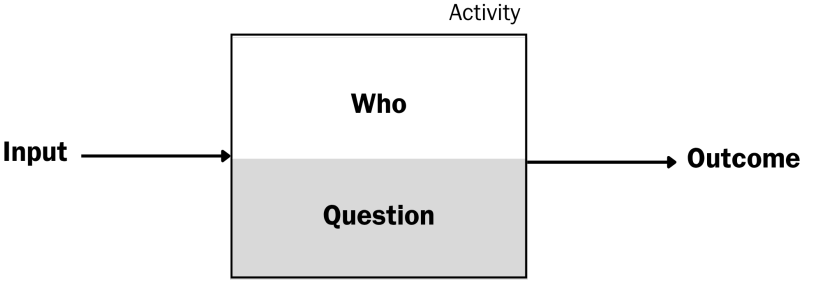


Figure 4.2 gives an overview of the activities and their main outcomes. Two activities, the self-experimentation workshops (Section 4.4) and the strategy menu development (Section 4.8), are also reported in full in Chapter 5.

Figure 4.2. Overview of the design activities leading to Mapping of Me

SECTION	ACTIVITY	WITH WHO	PURPOSE
4.3	**Game jam**	Two &RANJ designers, two researchers from IDE	Generate game mechanics that could engage adolescents in self-experimentation
4.4	**Self-experimentation workshops** Chapter 5, Study 1	Seven first-year bachelor IDE students	Understand how adolescents construct, apply, and reflect on strategies
4.5	**Goal-setting and reflection prototypes**	Six design researchers in health from IDE	Develop ways to guide participants through self-experimentation that support autonomy
4.6	**First integrated booklet**	Twelve design researchers from IDE	Test how the mechanics function when combined into a single prototype
4.7	**Full cycle prototype**	Eight first-year bachelor IDE students, in pairs	Explore how progress tracked in daily life can be carried into the in-person sessions
4.8	**Strategy menu development** Chapter 5, Study 2	Supervisors; tested with 20 first-year bachelor IDE students	Develop a structured set of strategies from which adolescents can construct their own approach
4.9	**Full concept**	Designers from &RANJ	Integrate the outcomes of the preceding activities into one game concept
4.10	**Final prototype**	Designers and programmers from &RANJ	Realize the complete intervention as a working prototype
Ch. 6	**Evaluation of the final prototype**	36 adolescent participants	

4.3 Game jam

The first design activity was a game jam to generate game mechanics that could support self-experimentation. The session was structured around three “how might we” questions: how might we help adolescents maintain a behavioral experiment for two weeks, create social incentives, and build personal health rituals (Figure 4.3). For each question, participants generated ideas using Crazy 8s (Pip Decks, n.d.), an ideation method in which each participant draws eight ideas in eight minutes to encourage quantity over refinement. After the idea generation rounds, participants voted on ideas, combined promising concepts, and ranked the resulting directions together.

Input: Guiding "how might we" questions, and barrier and facilitator profiles from Chapter 3 used as supporting material during the session.

Who: Two &RANJ designers and two researchers from IDE, in an online session using Miro

Question: What game mechanics could engage adolescents in self-experimentation?

Outcome: The session produced three clusters of game mechanics.

Figure 4.3 "How might we" questions



- Social accountability: relay systems in which players pass a task on to one another, voting on consequences when someone does not follow through, and time-limited check-ins.
- Strategy collection: players assemble strategy elements into a personalized toolbox.
- Daily check-in system: checking in entered players into a lottery with the chance of a reward.

Of these, the idea of strategies as building blocks that could be collected and modified was discussed most extensively, and it became a central principle of MoM.

4.4 Self-experimentation workshops

The game jam produced candidate game mechanics, but it was still unclear what adolescents would experience when trying to enact change through self-experimentation. To explore this, I organized two workshops separated by three weeks in which first year bachelor students from the faculty of Industrial Design Engineering (IDE) at TU Delft created personal health goals and tried out their approach in daily life. In workshop 1, participants used worksheets to design their strategies; a digital check-in then prompted them to reassess their goals and strategies; and in workshop 2, participants annotated motivational timelines of their experiments. The workshops are reported in more detail in Chapter 5 (Study 1).

Input: Paper-based reflection worksheets for defining, choosing, and reflecting on strategies, informed by Fedlmeier et al. (2022).

Who: Seven first-year bachelor IDE students.

Question: How do adolescents construct, apply, and reflect on strategies?

Outcome:

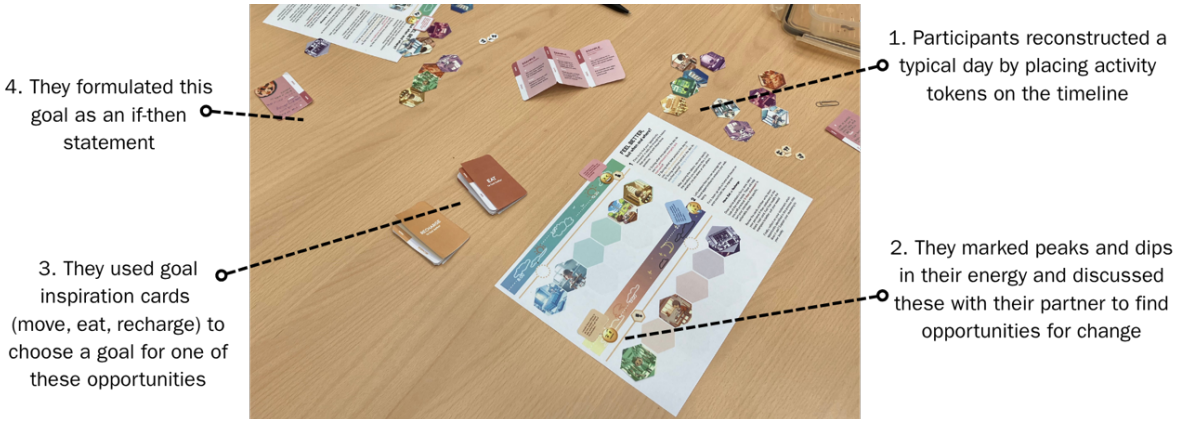
- Participants generated strategies that reflected established behavior change techniques without instruction, indicating that the intervention could offer rather than prescribe strategies
- Goals were revised at the check-in with increased specificity (e.g., "establish a morning routine" became "wake at 07:45 without snoozing"), suggesting that structured reflection can scaffold the development of self-knowledge
- Motivational timelines peaked after the first workshop, dipped in the weeks that followed, and recovered at the check-in, where participants revisited their goals. MoM's repeated sessions were designed around these moments of revisiting and resetting goals and strategies.
- Participants expressed a need for explicit strategy options, which motivated the strategy menu (Section 4.8)

4.5 Goal-setting and reflection prototypes

With self-experimentation as the approach and strategy collection as a central mechanic, the next step was to work out how participants could be guided through these processes. For a series of workshops, I designed two paper prototypes with the help of master student Keyue Bao. The first focused on how to set a goal that fits into daily life, and the second on how to reflect on a goal and revise it.

The first prototype was a context mapping exercise (Figure 4.4). Working in pairs, participants mapped out a typical day using tokens and marked the peaks and dips in their energy to identify opportunities for change. Based on these opportunities, they formulated a specific goal as an if-then statement. Inspiration cards with example goals in three domains (move, eat, and recharge) helped them think along; participants could choose one of these examples or formulate their own goal. They then tried out their goal in daily life and tracked their progress.

Figure 4.4. Context mapping and goal-setting prototype in use.



The second prototype supported reflection and revision. While trying out their goal as a self-experiment, participants filled in a short daily survey recording how the day had gone and how they felt about it (Figure 4.5). In an in-person session, they reflected on their data in pairs and discussed how to adjust their approach. To structure this revision, the prototype used a menu metaphor: the goal activity itself was the main course, starters were strategies to use before it, sides were strategies that made it more palatable while doing it, and desserts were ways to reward oneself afterwards (Figure 4.6).

Input: Paper-based prototypes for context mapping, goal setting, and reflecting on tracking data

Who: Six design researchers in health from IDE.

Question: How can participants be guided through self-experimentation in a way that supports autonomy?

Outcome: These prototypes formed the basis of MoM's self-experimentation cycle. They structured the user journey into three phases: setting up the experiment, carrying it out, and reflecting and adjusting. They also led to three design decisions.

Figure 4.5. One participant's experiment tracking data.

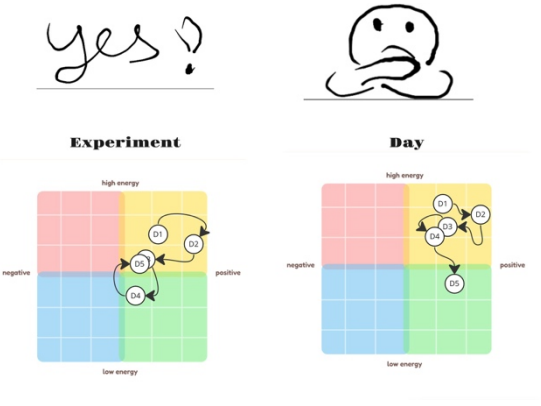


Figure 4.6. Paper prototype worksheet of the menu approach.



First, goals and approaches would be defined in pairs, so that each participant had a sparring partner. Second, goal setting would start from analyzing one's own day to find opportunities for change. It would focus on approach goals, that is, behaviors to adopt in the move, eat, and recharge domains, formulated as if-then statements that connect the desired behavior to an existing routine. Third, reflection would go beyond logging whether a goal was completed. Visual materials and emotion labels would help participants make sense of their experiences, and these insights would be made concrete by placing strategies before, during, or after the goal activity.

4.6 First integrated booklet

To see whether the features could be combined into one self-experimentation cycle, I brought goal setting, tracking, and strategy revision together in a first integrated self-experimentation booklet. The booklet tested whether the exercises flowed into one another and whether the concept as a whole was understandable. It also introduced the name Mapping of Me and its narrative for the first time: players meet at basecamp by the campfire and set out on an expedition to find out what fits them. The booklet was tested in two sessions. In the first, design researchers worked through the goal-setting exercises in pairs and then tried out their goal for a week. Four of them returned for the second session, in which they reflected on their self-experiment by telling "stories" around the campfire (Figure 4.7). Dixit cards, illustrated cards from a storytelling board game, served as supporting materials.

Input: First integrated self-experimentation booklet combining goal setting, tracking, and strategy revision.

Who: Twelve design researchers from IDE.

Question: How do the mechanics function when combined into a single prototype?

Outcome: The test showed that the features could be combined into one booklet, and several elements worked well. The interactive elements, such as tokens, and the narrative framing invited participants to engage with the exercises and lowered the threshold for shared reflection. The transitions between exercises, however, needed more scaffolding, and the exercises needed to build on each other more clearly. Participants were also left to come up with their own ways of tracking their progress and checking in with each other. The next prototype therefore focused on structuring how participants tracked their progress and held each other accountable between sessions, and on how the resulting data could be used in the in-person sessions.

Figure 4.7. Second session of the booklet test: participants used Dixit cards to tell "stories" of their self-experiment by the campfire.

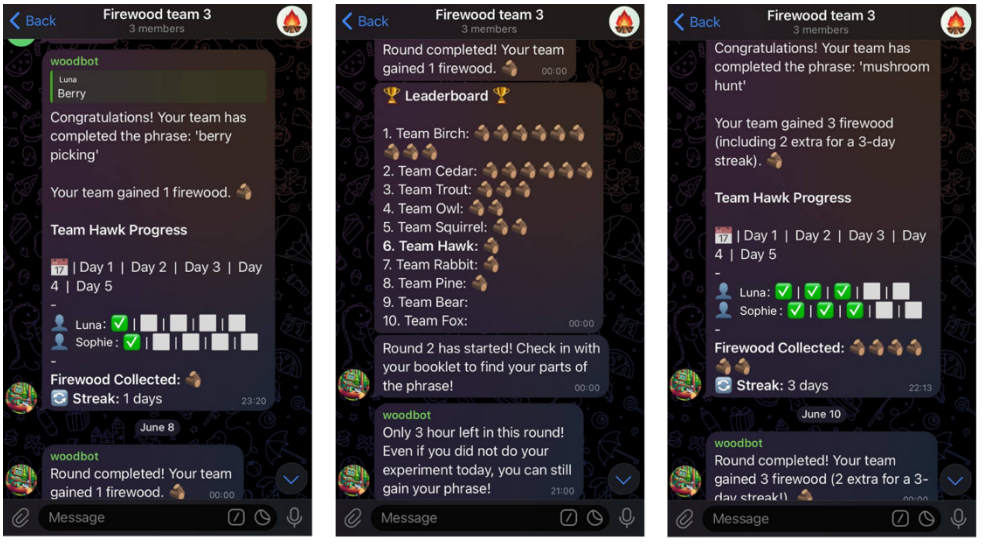


4.7 Full cycle prototype

To address the gaps found in the booklet test, I combined a revised booklet with a companion application in Telegram. We tested this full self-experimentation cycle with first-year bachelor IDE students. Pairs completed the booklet activities together, worked on their goals independently for a week, and then returned for a second session.

Each pair was added to a Telegram group chat with a game bot. For each day that players tracked their goal progress in the booklet, each of them received one half of a two-word phrase, a daily word puzzle. If both players typed their word in the group chat within the same day, the pair earned wood, an in-game resource for their campfire (Figure 4.8). Because neither player could earn the reward alone, this created mutual accountability. The chat also contained simulated teams to add a sense of competition. At the next in-person session, the wood each pair had collected was returned as wood token stickers, which they used in the session exercises.

Figure 4.8. The Telegram group chat with the game bot and the daily word puzzle.



Partners each post their word in the group chat to complete the phrase and earn firewood

Teams compete with each other on a leaderboard of collected firewood

Checking in on several days in a row builds a streak that earns extra firewood

Input: A prototype of the full self-experimentation cycle, consisting of a physical booklet with tokens and stickers and a companion application in Telegram.

Who: Eight first-year bachelor IDE students working in pairs.

Question: How can progress tracked in daily life be carried into the in-person sessions?

Outcome: Returning tracked progress as physical stickers connected daily life to the in-person sessions: the wood stickers carried what pairs had tracked into the session exercises, which supported a hybrid physical and digital format for the final prototype. The paired format and the social mechanics also appeared to keep participants engaged between sessions. Two elements needed revision. The word puzzle was engaging, but it was only indirectly linked to self-experimentation, since earning wood did not depend on what participants learned about their goal. The daily interaction was also too fragmented: participants journaled in the physical booklet and then switched to Telegram to share their word, which they sometimes found cumbersome, and the bot did not always work as intended.

Figure 4.9. Full cycle prototype test (second workshop).



4.8 Strategy menu development

Participants in the self-experimentation workshops (Section 4.4) and the full cycle prototype test (Section 4.7) had asked for explicit strategy options, and the strategy collection mechanic needed a set of strategies that players could collect. To address both, I developed an à la carte strategy menu: a structured set of strategies from which adolescents could select and combine their own approach. We started from 214 strategies and reduced this set by clustering strategies that worked in similar ways. We then evaluated the remaining strategies against four design requirements:

- **Versatility**: Applicable across different goal types
- **Approach-oriented**: Focused on adopting new behaviors rather than avoiding existing behaviors
- **Modularity**: Strategies that can be combined as building blocks used towards the same goal
- **Self-enactable**: Can be used independently by the user

Input: Strategies from three sources: participant-generated strategies from the self-experimentation workshops (Section 4.4), the Compendium of Self-Enactable Techniques (Knittle et al., 2020), and Atomic Habits (Clear, 2018) with its accompanying resources.

Who: I compiled an initial set of strategies, which my supervisors and I then reviewed together. The menu was tested with 20 first-year bachelor IDE students.

Question: How can a structured set of strategies support adolescents in constructing their own behavior change approaches?

Outcome: The result was a strategy menu of 29 strategies in six categories (Action, Space, Time, Mindset, Social, and Symbols; Table 4.1), each of which could be placed before, during, or after the goal activity. In the test, 27 of the 29 strategies were selected at least once, and every participant chose a unique combination drawn from at least three categories. Ratings for the same strategy varied widely between participants, suggesting that perceived effectiveness depends on personal fit. Some patterns did emerge by domain: move goals were often paired with Time and Social strategies and eat goals with Space and Symbols strategies.

Table 4.1. Strategies included in the menu organized into six categories.

 **Space:** Environmental design	 **Time:** Scheduling and transitions	 **Action:** Breaking up or adjusting actions	 **Symbols:** Visual cues and celebrations	 **Social:** Accountability and support	 **Mindset:** Mental reframing
Make it easy	Time blocking	Stack habits	Celebrate your success	Do it together	Every day is a reset
Remove temptations	Time pressure	Start small	Visualize streaks	Tell it somebody	Every obstacle has two sides
Add obstacles	Use transitions	Break up actions	Visual memory	Find like-minded people	Enjoy the moment
Setting the stage		Track behavior	Make it stylish	Public commitment	Visualize pride
		Make it more fun			Positive perspective
		Add challenge			Anticipate regret
		2-in-1 actions			Mental rehearsal

4.9 Full concept

The preceding activities had produced a set of mechanics, interaction patterns, and a strategy menu. To bring these together into one game concept, I worked with serious game designers from &RANJ in three steps: refining the core gameplay loop, designing the overarching user journey, and developing the visual identity. To get a better sense of what players would go through, I made a journey map of multiple sessions and periods of self-experimentation.(Figure 4.10).

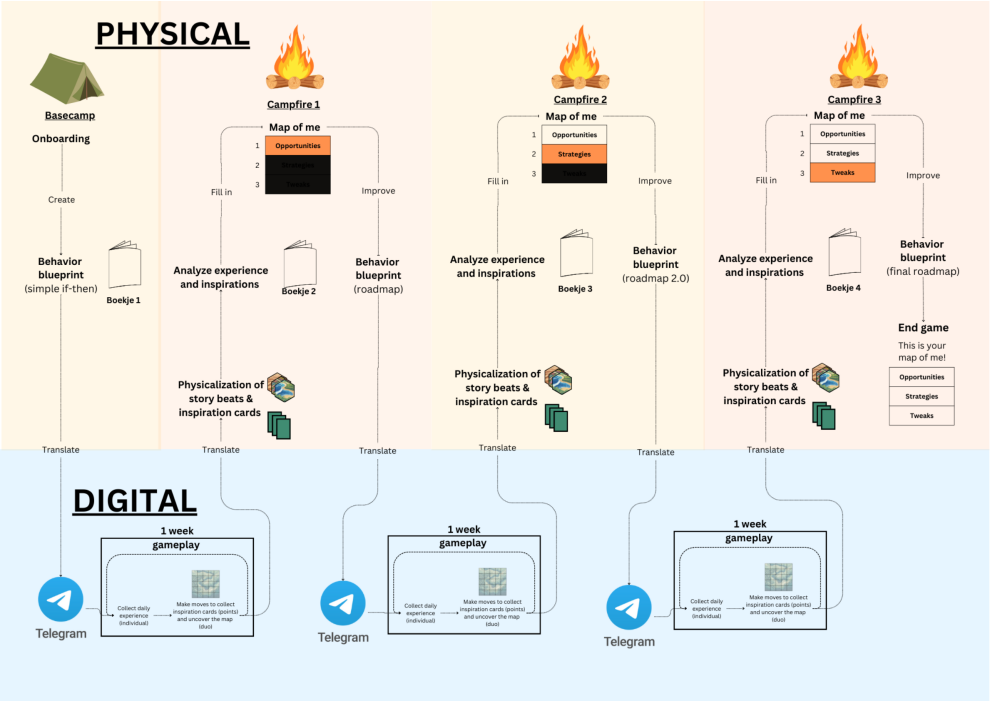
Input: The outcomes of all preceding activities: the game mechanics from the game jam, the insights from the self-experimentation workshops, the goal-setting and reflection features, the booklet and full cycle prototype tests, and the strategy menu (Sections 4.3 to 4.8).

Who: I, in collaboration with designers from &RANJ.

Question: How can the outcomes of the preceding activities be integrated into one game concept?

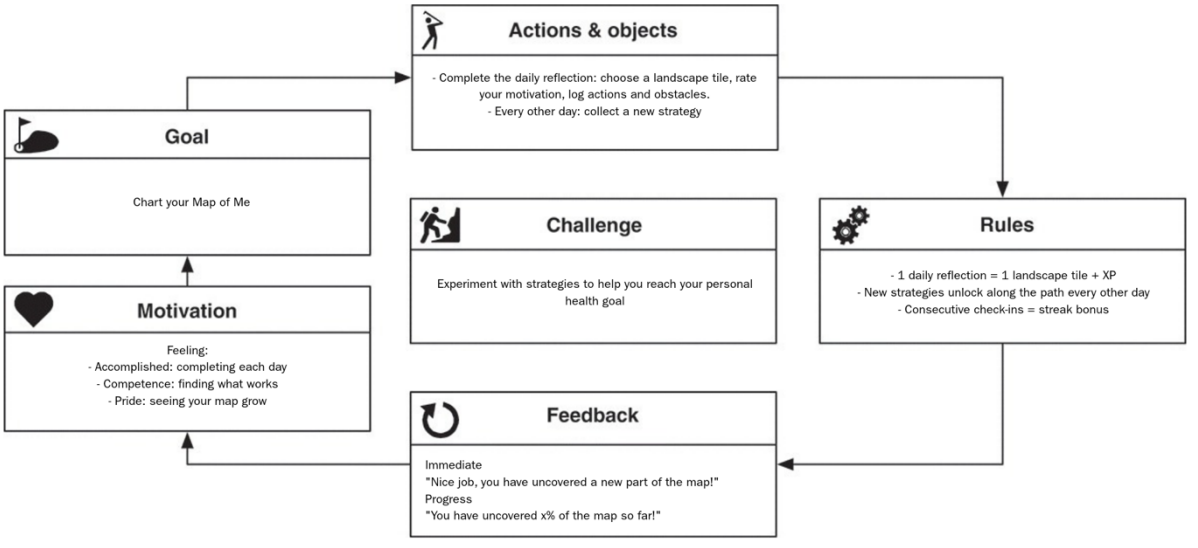
Outcome: The integration resulted in a user journey map of the full intervention, with one outcome for each of the three step

Figure 4.10. Concept hybrid user journey map.



The core gameplay loop. The intrinsic skill atom lens (Deterding, 2015) was used to define the core gameplay loop (Figure 4.11). The daily check-in became the core of the digital game: players open a new tile and journal about their day. Strategies from the menu are also collected through this loop, so all but one of the 29 strategies were included in the game. The strategy *track behavior* was left out, because tracking was already part of the daily check-in.

Figure 4.11. Intrinsic skill atom used during ideation of the daily journaling landscape tile mechanic in Mapping of Me.



A hybrid user journey. The game alternates between in-person sessions and periods of self-experimentation in daily life. Physical booklets for the paired sessions provide a way to define and revise goals and strategies, while the digital application supports tracking and strategy collection in between. Personalized stickers printed from the tracking data connect the two, carrying each player's experiences back into the in-person sessions as tangible materials for the exercises.

A visual identity built on the expedition narrative. The game frames behavior change as a series of expeditions in which players map their daily landscape, returning to basecamp between expeditions to reflect and prepare. The visual design uses imagery from nature and cartography to present this process as exploration (Figure 4.12).

Figure 4.12. Visual style of Mapping of Me: booklets, landscape stickers, and strategy stickers.



4.10 Final prototype

In the final activity, I developed the content and structure of the game into a working prototype in collaboration with &RANJ, who delivered the final designs of the physical materials and the web application.

Input: The journey map, strategy menu, interaction patterns, and expedition narrative.

Who: I, together with designers and programmers from &RANJ.

Question: What should the complete intervention look like in its realized form?

Outcome: The final MoM prototype is a three-week hybrid journaling game. It combines three in-person sessions, each with a booklet and stickers (Figure 4.12), with two expeditions in the digital application, during which players track their self-experiment and discover new strategies. Below, I describe its structure and its main game elements.

Structure. Pairs meet for three one-hour in-person sessions, each with its own booklet. In Session 1, players choose a health goal (move, eat, or recharge), map out their day to find opportunities, and formulate their goal as an if-then statement, which they try out during a one-week expedition. In Session 2, pairs review the expedition and revise their strategy plan for a second, two-week expedition. In Session 3, they identify the strategies that worked best and consolidate them into a final strategy plan. Sessions 2 and 3 thereby offer

moments to (re)set goals and strategies, building on the fresh start effect observed in the self-experimentation workshops (Section 4.4).

Narrative framing. Each self-experiment is an expedition into an uncharted personal landscape. Each session is a return to basecamp, where players step back to plan and review.

Discovering landscapes and strategies. Each daily check-in in the web application asks players to make sense of their day and decide what to try next (Figure 4.13):

- Players open a new tile on their map board and choose a landscape type that characterizes their day (e.g., mountains for a challenging day, meadows for an easy one).
- They write a brief reflection, record whether they used their planned strategy, and note what to do differently tomorrow.
- Every other day, a falling star presents strategies from the strategy menu, from which players pick one to add to their backpack (Figure 4.14).

Figure 4.13. Screen walkthrough of the daily reflection in the Mapping of Me app.



A glowing tile on the map shows that the daily reflection is ready

Participants describe their day by choosing the landscape that fits it best

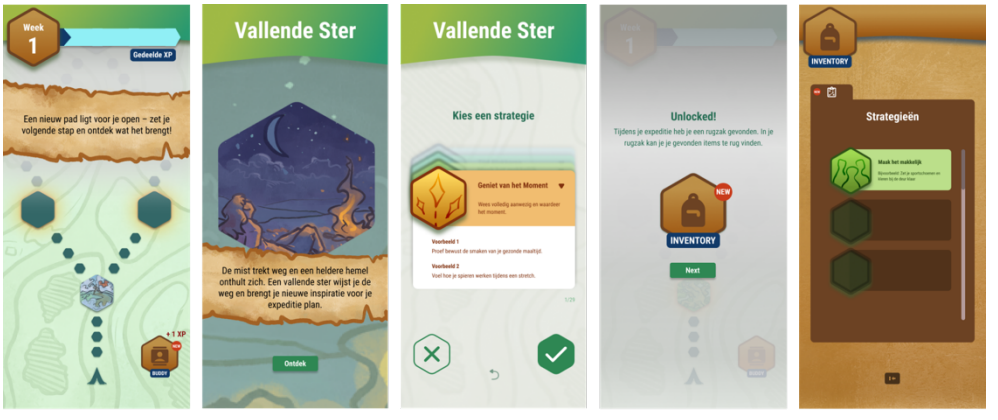
They rate motivation and select the actions they took and the obstacles they faced

The chosen landscape is unlocked as a new piece of terrain

The landscape is placed on the map

The in-game goal is to collect five landscapes in the first expedition and ten in the second. Because this goal is tied to checking in rather than to attaining the goal, a difficult day still adds to the map.

Figure 4.14. Screen walkthrough of strategy collecting in the Mapping of Me app.



Every other day, a new path opens on the map

A falling star brings inspiration for a new strategy

Players swipe through strategies from the strategy menu and choose one

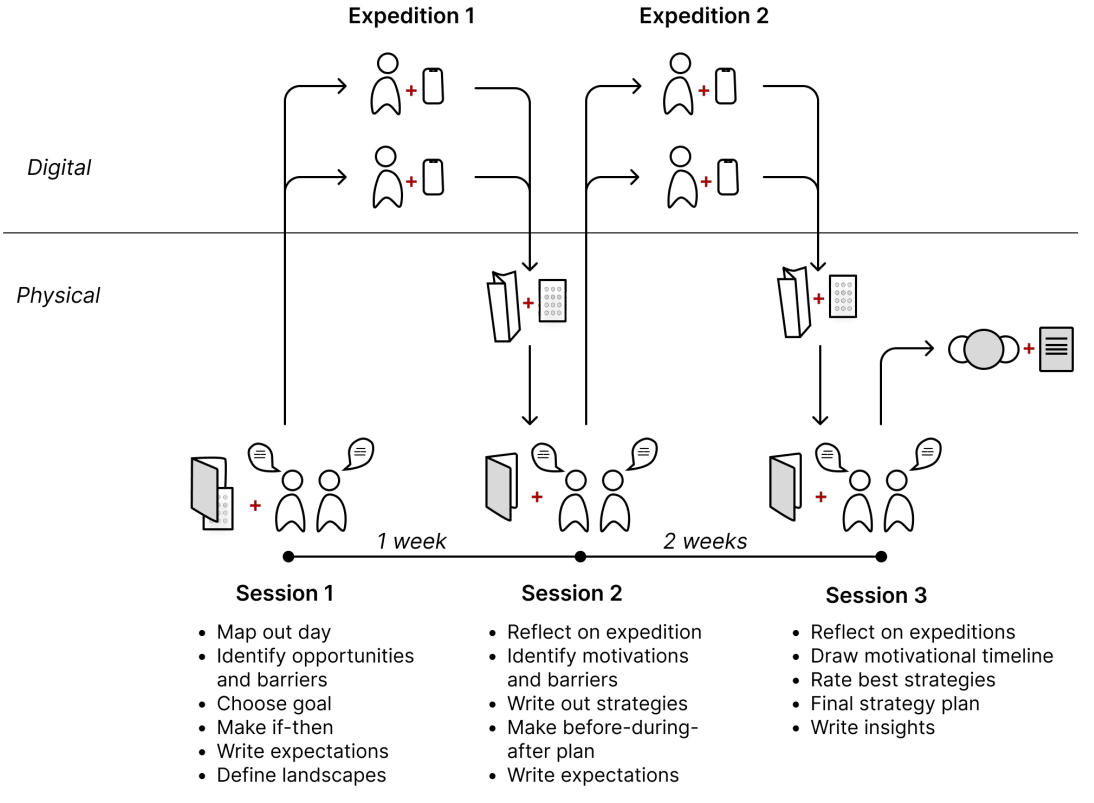
The first strategy unlocks the backpack

Collected strategies are stored in the backpack and shown during the daily check-in

Personalized interactive physical materials. Before Sessions 2 and 3, the landscapes and strategies each player collected digitally are returned as stickers and as a foldable map of the expedition, the Map of Me. Pairs use these to compare their expeditions and to place strategy stickers before, during, or after the goal activity, which makes strategy planning tangible and offers a playful alternative to writing.

Figure 4.15 shows the final user journey. The evaluation of this prototype with 36 adolescent participants is reported in Chapter 6.

Figure 4.15. Final user journey of Mapping of Me (credits to Dieuwertje den Besten).



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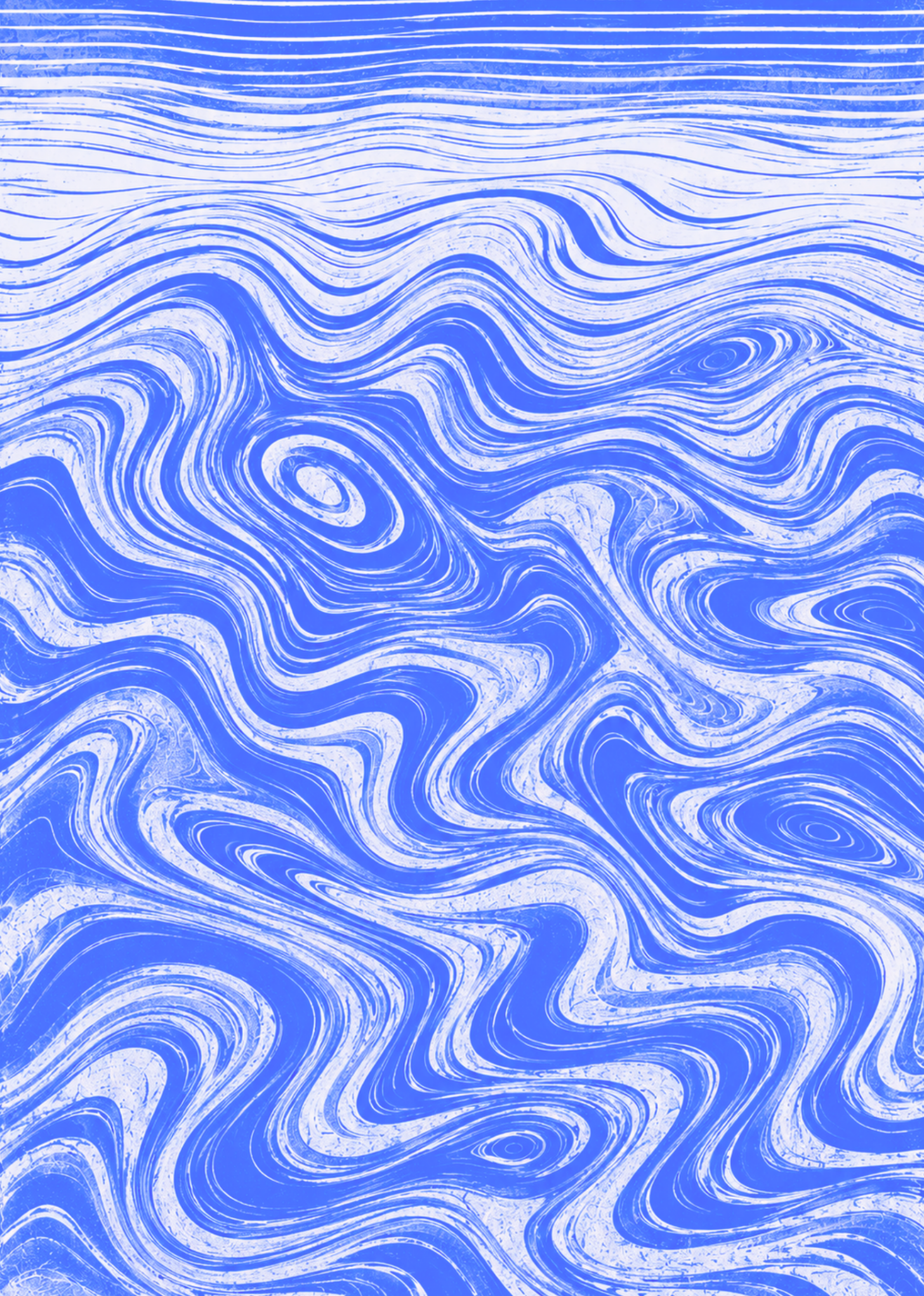

Chapter 5. Designing for self-tailoring in adolescent health behavior change

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Abstract
Digital behavior change tools increasingly use system-driven tailoring to guide users toward healthier choices. While well-intentioned, such approaches may undermine autonomous behavior change by removing users from decision-making processes and limiting opportunities to develop self-knowledge: a practical understanding of what works for oneself that can help regulate current and future behaviors. This is particularly consequential for adolescents, who are developing personal autonomy at a time when the health behaviors they establish can have long-term consequences. We propose that self-tailoring can enhance autonomy by actively involving users in constructing and adapting approaches to their own contexts. Through two studies, we investigated how adolescents can be supported in constructing their own behavior change strategies. Study 1 shows that adolescents are capable of self-tailoring and that doing so can build self-knowledge through experience. Study 2 shows how a strategy menu at moments of goal (re)setting can scaffold self-knowledge to inform behavioral choices.

5.1. Introduction

Digital behavior change technologies promise to transform how people manage their health. Health applications have become ubiquitous, with millions using apps for everything from step counting to meal planning. These technologies increasingly employ tailoring to provide a personalized experience by adjusting content, features, and interface of interventions to improve fit with user needs and increase effectiveness and engagement (Lustria et al., 2013).

The dominant approach in digital behavior change interventions (DBCIs) has been system-driven tailoring (Rivera-Romero et al., 2023), where interventions automatically adapt based on predefined rules and algorithms that process user data (Kreuter & Skinner, 2000). Health experts design the intervention logic using behavior change techniques (BCTs), which the system then adjusts algorithmically according to user demographics, personality traits, goal types, or ongoing usage patterns (Klooster et al., 2024). For example, a step counter might send a notification that a daily goal has not yet been reached, prompting the user to take action based on the system's real-time monitoring.

However, this technological sophistication in system-driven tailoring may undermine autonomous and effective behavior change. By processing user data and automatically presenting adapted content, algorithmic systems place users outside the decision-making loop, creating a separation between the user (as data source) and the system (as decision-maker). Just-in-time interventions, for instance, deliver motivational messages at moments when users are deemed the most "receptive" (Nahum-Shani et al., 2018).

This creates two problems. First, it concentrates ethical responsibility with designers to determine what constitutes "desired" behavior change and whether interventions align with users' self-interests and values (Jun et al., 2018). Second, while system-driven tailoring intentionally reduces cognitive load to lower barriers to action (Nahum-Shani et al., 2018), users outsource their decision-making to algorithms that detect patterns and suggest interpretations on their behalf. By handling this interpretive work, and with it the choices about what to do and when, system-driven tailoring risks producing cognitive offloading. This limits the opportunity for users to develop self-knowledge: a practical, personal understanding of what works for oneself in one's own context, built through engagement with behavior rather than received from an external system (Heyen, 2020).

This tension between convenience and capacity building is reflected in how engagement is conceptualized in DBCI research. Researchers in digital health distinguish between micro-engagement (engagement with the tool itself: clicks, time spent in-app) and macro-engagement (engagement with actual behavior change process) (Villegas Mejía et al., 2024; Yardley et al., 2016). This distinction raises questions about how technology should support health behavior change. Should health behavior change technologies be designed for continuous use, or to stimulate independent regulation of health behaviors? While system-driven tailoring excels at creating convenient user experiences, it can undermine users' autonomy and active engagement in the behavior change process itself.

This concern is particularly acute for adolescents. It is a period of rapid physical, cognitive, and social change, during which young people are developing personal autonomy and taking greater responsibility over their own choices (Dahl et al., 2018). The behaviors they establish during this period often last into adulthood and have long-term consequences for their wellbeing and disease risk (Campbell et al., 2020). Because their motivations and barriers around health behavior are diverse and shifting (Houtman et al., 2025), adolescence is a window of opportunity to supporting young people in learning to navigate health decisions and accumulating experiences from which self-knowledge can grow. If adolescents come to rely on digital tools to manage their health decisions during this time, it can come at the cost of developing the capacities they will need beyond adolescence to regulate their own behaviors autonomously.

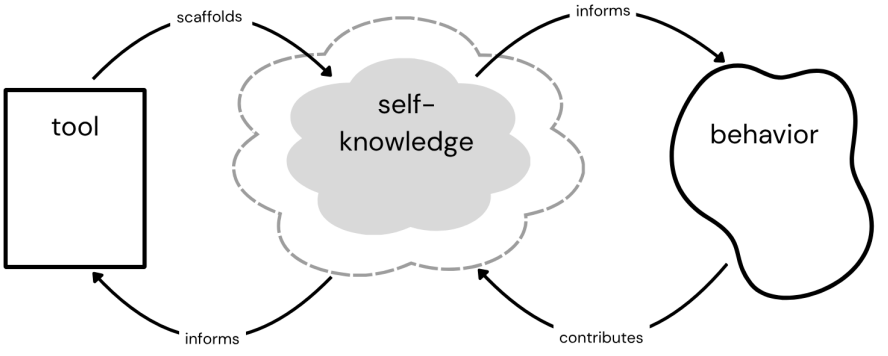
In order to move beyond engagement with the screen toward engagement with behavior change itself, behavior change tools must account for users' personal context and adopt a transfer of learning rationale (Villegas Mejía et al., 2024). While passive sensing data can capture behavioral frequencies and environmental context such as step count and GPS location (Nahum-Shani et al., 2018), it reduces understanding of the self to individual tracked parameters and does not capture the subjective experiences and personal meanings through which people actually construct an understanding of their own behavior (Krippendorff, 2005; Rapp & Tirassa, 2017). When people come to rely too heavily on these numeric accounts, they risk displacing their own felt sense of their behavior with an externalized, numeric one (Nichols, 2017). Rather than leaving users dependent on external systems to define their behavior for them, tools could instead be designed to help people recognize what works for them and why. Over time, this kind of engagement with one's own decisions can build personal heuristics that help users navigate their health behavior across changing circumstances (Schraefel et al., 2021).

By increasing self-tailoring, behavior change tools can support users to construct their behavioral actions rather than simply receiving them, deciding for themselves what strategies to pursue and how to enact them. While many DBCIs offer ways to tailor the user experience, users still have minimal influence over the underlying behavioral mechanisms applied (Hankonen, 2021; Klooster et al., 2024). Designers select BCTs deemed suitable for a given behavior or target group (Fiedler et al., 2020), yet BCTs such as reminders, action planning, and social accountability are broad concepts that leave significant room in how they are designed and enacted (Farhat-ul-Ain et al., 2025). Research with adolescents, for example, shows that participants use only a subset of offered BCTs (Hankonen et al., 2015), suggesting that they already select those strategies that seem most useful and relevant to them.

Rather than pre-formulating BCTs further, behavior change tools can offer strategies in actionable and digestible forms that users can choose and adapt for themselves (Hankonen, 2021). This is a form of delegation of design, in which the act of designing is distributed to the user (Krippendorff, 2005). In doing so, interventions do not become prescriptions but invite users to draw on their own self-knowledge to contextualize and enact strategies, making and learning from their own decisions over time.

As illustrated in Figure 5.1, we conceptualize self-tailoring as a cycle in which the tool and behavior are connected through the user's developing self-knowledge. Rather than prompting behavior directly, the tool scaffolds self-knowledge, supporting users in making sense of their own experiences and choices. That self-knowledge then informs how users choose to act. Enacting those choices contributes to self-knowledge over time through experiences, which in turn informs how users continue to engage with the tool.

Figure 5.1. Self-tailoring as a cycle of tool, self-knowledge, and behavior



This paper explores how self-tailoring can work in practice with adolescents. While digital interfaces typically aim to minimize cognitive effort (Mejtoft et al., 2019), the effortful sense-making that self-tailoring requires is where its value lies. This cognitive involvement serves as a form of positive friction (Chen & Schmidt, 2024) that, when applied at the right moment in the behavior change process, can foster intentional engagement through which self-knowledge can develop to support autonomous health behavior change. We conducted two studies with adolescents, developing prototypes that investigate how adolescents construct, apply and reflect on behavior change strategies, examining how self-tailoring can be designed.

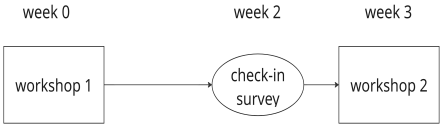
5.2 Method

Using a Research through Design (RtD) approach (Stappers & Giaccardi, 2017), we iteratively developed and tested two prototypes to support adolescents in self-tailoring various aspects of a healthy lifestyle behavior goal. The studies were conducted as sequential phases: Study 1 was exploratory, aimed at understanding how adolescents construct, apply and reflect on their own behavior change strategies; Study 2 was generative, translating those insights into a concrete design artifact and examining how a strategy menu could support user constructed strategies. In both studies we recruited first-year bachelor students, whose transitional life stage and new academic environment provided a naturalistic setting for studying how adolescents develop and revise personal behavior change strategies amid real competing demands.

Study 1 involved two workshops in which participants reflected on a self-chosen health behavior goal, generated possible strategies, and configured their own approach. An online check-in between sessions gave participants the opportunity to revisit and revise their strategies based on early experience.

Study 2 built on the findings of Study 1 by developing a strategy menu, which was explored with a new cohort to examine how a structured set of options could support user constructed health behavior strategies. Table 5.1 outlines the research questions and characteristics of the two studies.

Table 5.1. Studies overview.

	Study 1	**Study 2**
Research question	How do adolescents construct, apply and reflect on their behavior change strategies?	How can adolescents be supported in constructing their own health behavior change strategies using a menu?
Prototype	We developed two workshops in which we provided paper based reflection tools with prompts to guide users to defining, choosing and reflect on strategies for a personal health goal.	We developed a menu with behavior change strategies as selectable "building blocks" that participants could combine to construct personalized approaches to help structure health behavior change
Duration & Structure	Two 60-minute workshops over three weeks and a check-in survey 	Single 15-minute session in which participants used the strategy menu to construct their behavioral strategies.

Participants	7 first-year bachelor industrial design engineering students (7 female age 18-20)	20 first year industrial design engineering students (14 male, 6 female, age 18-19)
Recruitment	Recruited via posters and messages in student whatsapp groups. New Year's resolutions. Participants received a free healthy lunch during the workshops. January 2024	Recruited via participants at the end of a lecture. With participation, participants could win one of two 5 euro voucher via a lottery. October 2024
Data & analysis	Qualitative content analysis of reflection worksheets, check-in questionnaire responses, workshop audio recordings, and field notes to identify patterns in adolescent behavior change processes and opportunities for positive friction.	Quantitative analysis of strategy selection patterns and ratings which we supplement with participant generated examples of strategies and fieldnotes

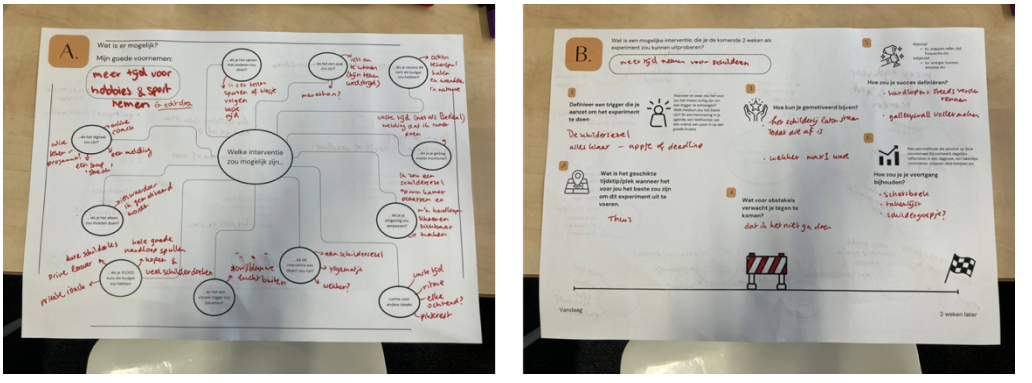
5.3 Study 1

5.3.1 Process

Participants with New Year's intentions completed a three-week intervention comprising two in-person workshops with an online check-in at the midpoint inspired by the set-up by (Fedlmeier et al., 2022).

Workshop 1 (Week 0): Participants used two worksheets (Figure 5.2) to design personal behavior change experiments. The first worksheet prompted divergent thinking to generate potential strategies (e.g. what would it look like if it were social, what would it look like if it were a game?); the second facilitated convergent thinking to concretize one strategy by defining goals, action steps (trigger, time, place), motivation approaches, anticipated obstacles, success criteria, and progress measurement. Participants then implemented their self-designed strategy for two weeks.

Figure 5.2. Worksheets for workshop 1. Left prompted thinking of diverging option and right prompted to make the goal and strategy concrete.



Online Check-in (Week 2): Participants assessed their experiment's progress, identified useful elements, determined next steps (stop, adapt, enhance, maintain), and optionally redesigned their experiment for another week.

Workshop 2 (Week 3): Participants drew and annotated motivational timelines of their three-week experience with their goal and discussed their self-tailoring process.

5.3.2 Results

Diverse Personal Goals and Strategies

During workshop 1, participants selected individual health behavior goals that clustered around two main themes:

1. **Daily structure** (5 participants): establishing morning routines, waking up earlier, creating scheduled study blocks, or achieving work-leisure balance
2. **Specific health behaviors** (2 participants): reducing sugar intake or increasing exercise and creative hobbies

Despite goal differences, participants defined similar sets of behavior change strategies for their two-week experiment, as shown in Table 5.2.

Table 5.2. Strategies employed by participants.

Strategy Type	Description	Examples
Reminders	Self-prompts for goals and strategies	Handwritten notes in planners, sticky notes, timed smartphone notifications
Social Accountability	Peer-based support systems	Group chats for progress updates, regular peer check-ins
Planning Strategies	Task organization and time management	Drafting task lists, scheduling specific time slots for activities
Environmental Design	Physical space arrangement to reduce barriers	Pre-arranging spaces for easier behavior initiation
Anticipating Benefits	Cognitive projection of positive outcomes	Imagining post-exercise energy, self-rewards for completion, penalties for non-adherence

At the week 2 check-in survey, all participants wanted to keep trying at their goals. Six out of seven participants indicated that they wanted to revise their goals and strategies. These revisions generally increased the goals' specificity, detail, and accountability, shifting them from broad intentions to more concrete, actionable commitments.

The following are some examples from revised goals made during the check-in:

- "Establish a morning routine" → "Wake at 07:45 without snoozing"
- "Be late less often" → "Not forget plans and be late less often"
- "Better balance between work and leisure" → "Plan more clearly and stick to my planning"

Strategies were also adapted. Four of the seven participants shifted toward time-blocking approaches, assigning more dedicated timeslots to activities to "make sure they follow through". Planning tools were switched from analogue (e.g., handwritten planners, sticky notes) to digital ones, to make them more easily accessible. This was in particularly common among participants aiming to improve their daily structure. Others still maintained a combination of the previously mentioned strategies, such as social accountability, loss aversion, adding obstacles and timed reminders.

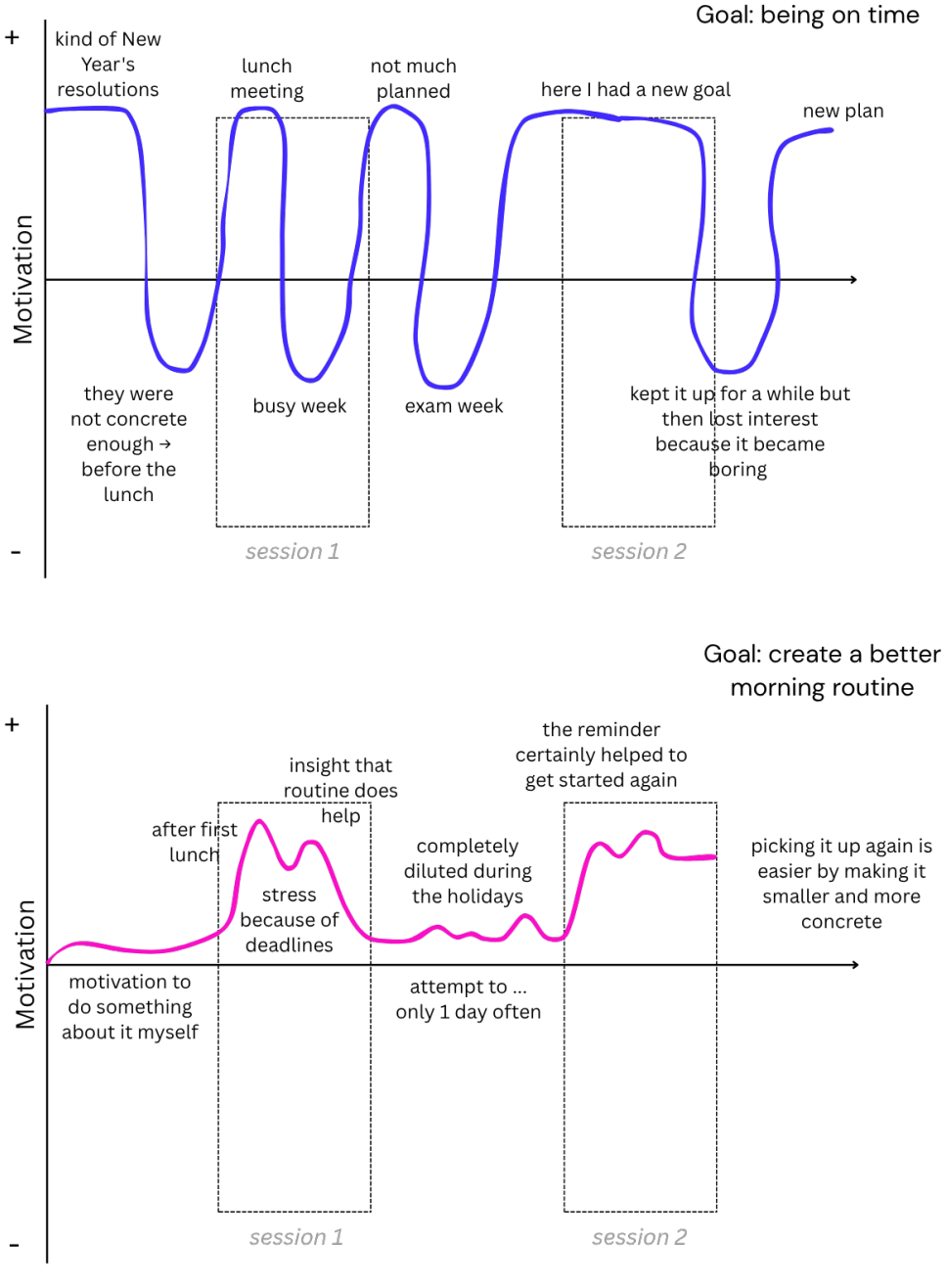
Motivation Fluctuations and Reset Moments

Motivational timelines created during workshop 2 (Figure 5.3) showed consistent patterns across all participants. Motivation peaked immediately after the first workshop, when participants started implementing their initial experiments, then

declined over the following two weeks, sometimes rapidly, sometimes more gradually. Around the time of the check-in survey, which prompted participants to revisit and reset their goals, their motivation levels rose again. Participants explicitly mentioned that these structured moments of reflection helped them regain focus, even when external circumstances had derailed their initial efforts. One participant explained: "The survey made me realize I hadn't completely forgotten about my goal, I just needed a reminder to get back on track" Despite being able to self-tailor the new iteration of their goals and strategies, participants expressed a need for having explicit options to choose from when planning their behavior change strategies.

A common theme that emerged was that the decline in motivation coincided with the examination period following the first session. Although students had initially been motivated to "get their lives in order" before exams, motivation decreased as both the initial enthusiasm faded and academic pressures intensified. The subsequent holiday period further disrupted routines, as students relaxed and temporarily abandoned their goals.

Figure 5.3. Annotated motivational timelines participants made during workshop



5.3.3 Insights study 1

Study 1 demonstrated adolescents' capacity for self-tailoring. Participants employed diverse strategies such as planning aids, social accountability, environmental design, and motivational tactics, many aligning with evidence-based BCTs, suggesting they already possess knowledge about behavior change principles.

Participants also learned from experience. During the two-week period, they faced obstacles from changing routines and academic pressures. However, the online check-in had a "fresh start" effect, prompting recommitment to the goal. This pattern suggests motivation fluctuations stemmed from contextual factors rather than loss of interest.

The design elements supported self-tailoring through expanding awareness and by creating focus (Chen & Schmidt, 2024).

Expanding awareness:

- Workshop 1's exploration worksheet prompted participants to diverge in what kinds of strategies they could adopt
- Check-in survey created moments to reflect on experiences and reconsider intentions
- Motivational timeline facilitated reflection on previous attempts, identifying obstacles and patterns
- Workshops provided dedicated time, creating deliberate slowness for reflection

Creating focus:

- Workshop 1's action planning worksheet made approaches concrete and specific
- Check-in survey prompted reassessment and adjustment of goals and strategies

5.4 Study 2

Building on these findings, Study 2 focused specifically on (re)set moments where users define or redefine their approach. To address participants' expressed need for a structured overview of strategy options, we developed a strategy menu that

provides concrete behavioral mechanisms users can select and combine for their goals.

5.4.1 Designing the Menu

Based on Study 1 findings, we designed a strategy menu to guide users in self-tailoring strategies to their behavioral goals. We established four design requirements:

- **Versatility**: Applicable across different goal types
- **Approach-oriented**: Focused on adopting new behaviors rather than avoiding existing behaviors
- **Modularity**: Strategies that can combined as building blocks used towards the same goal
- **Self-enactable**: Can be used independently by the user

The first author compiled an initial pool of strategies from three sources, each selected because the strategies are self-enactable: users can implement them independently, without requiring a designer or system to operationalize them. This distinguishes them from the broader BCT literature, which is primarily designer-facing and requires translation into intervention logic before reaching the user.

The first source was participant-generated strategies from Study 1, capturing approaches adolescents had developed in practice. The second was the Compendium of Self-Enactable Techniques (Knittle et al., 2020), a theoretically grounded taxonomy of strategies individuals can use to regulate their own motivation and behavior autonomously. The third was Atomic Habits (Clear, 2018a) and its accompanying online resource 30 Days to Better Habits (Clear, 2018b), a popular science resource based on habit formation research whose practical phrasing made strategies user friendly and actionable. Together, these sources provided a broad pool spanning theory-grounded but practice-oriented items, yielding an initial set of 214 strategies.

Strategies were clustered inductively by behavioral mechanism, such as reducing effort, planning, cueing, or social accountability, focusing on functional similarity rather than surface phrasing. Duplicates were removed and near-identical strategies serving similar actions were merged. The remaining strategies were evaluated against the four design requirements, and those that were domain-specific, required external support, or could not be flexibly combined were

excluded, resulting in 32 strategies. Each strategy was then reformulated with an actionable title, short description, and cluster label.

Three of the authors [TAH, FSV, VV] then collaboratively reviewed the candidate set. Through discussion the remaining redundancies were resolved by checking against the design requirements and merging strategies with similar functionality, and cluster names were refined to reflect the shared underlying mechanism of each cluster. This resulted in a final set of 29 strategies organized into six categories (Table 5.3).

Table 5.3. Strategies included in the menu organized into six categories.

 **Space:** Environmental design	 **Time:** Scheduling and transitions	 **Action:** Breaking up or adjusting actions	 **Symbols:** Visual cues and celebrations	 **Social:** Accountability and support	 **Mindset:** Mental reframing
Make it easy	Time blocking	Stack habits	Celebrate your success	Do it together	Every day is a reset
Remove temptations	Time pressure	Start small	Visualize streaks	Tell it somebody	Every obstacle has two sides
Add obstacles	Use transitions	Break up actions	Visual memory	Find like-minded people	Enjoy the moment
Setting the stage		Track behavior	Make it stylish	Public commitment	Visualize pride
		Make it more fun			Positive perspective
		Add challenge			Anticipate regret
		2-in-1 actions			Mental rehearsal

To guide systematic application, we incorporated a temporal dimension inspired by ritual design frameworks (Venkataramani & Menter, 2022). Users would consider when to deploy each strategy: before (setting up conditions), during (in-the-moment support), or after (tracking outcomes) the goal activity.

5.4.2 Process

To explore how adolescents can be supported in crafting their own health behavior change strategies using a menu, we created a worksheet (Figure 5.4) tested the strategy menu with twenty bachelor students through a two-stage process.

Stage 1: Goal Selection

Participants chose one health goal from three domains:

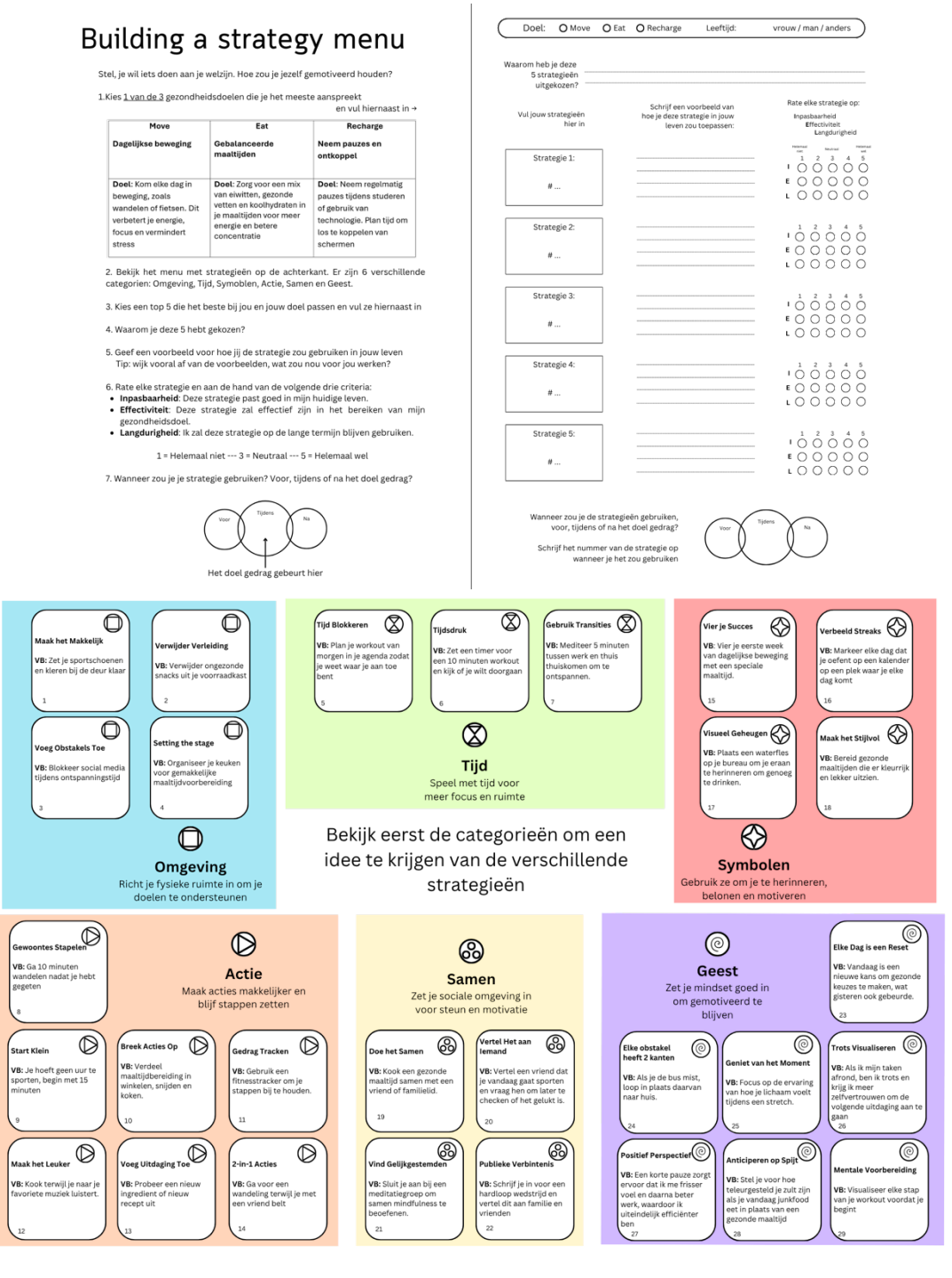
- **Move:** Move daily through walking or biking to improve energy, focus, and lower stress
- **Eat:** Consume a balanced mix of protein and healthy carbs for more energy and mental focus
- **Recharge:** Take regular breaks from studying or technology with planned screen-free time

Stage 2: Strategy formation

Participants then:

1. Selected their top 5 strategies from the 29-item menu
2. Wrote an example for each strategy
3. Rated each strategy on applicability, effectiveness, and longevity (1-5 Likert scale)
4. Indicated temporal placement (before, during, or after the activity)

Figure 5.4. Overview of worksheet used during test.



5.4.3 Results

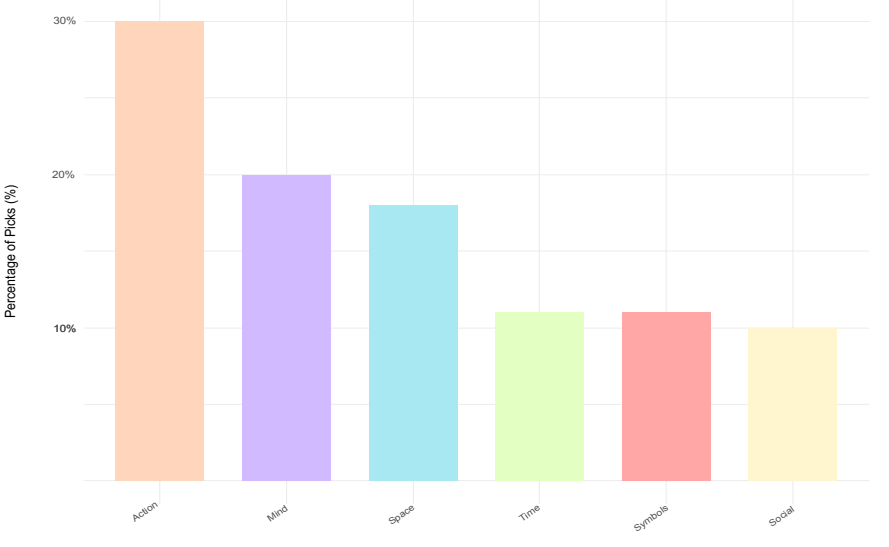
Overall Strategy Selection Patterns

Of the 20 participants, 11 chose move goals, 8 chose eat goals, and 1 chose a recharge goal. Each participant selected a unique combination of five strategies, no two sets were identical. Each set of strategies selected by a participant included at least 3 different categories, demonstrating that participants liked to draw from different categories. The distribution of the chosen strategies per category is shown in Figure 5.5.

The menu was used almost in its entirety. Out of the 29 strategies, only two were not selected: 'Use transitions' (Time) and 'Celebrate your success' (Symbols). The most frequently chosen strategies and their ratings on applicability, effectiveness and longevity is shown in Table 5.4.

The most selected individual strategies were Remove temptations and Time blocking. Participants grounded these in their own contexts, for example removing temptations by "not having anything unhealthy in the house" or time blocking by scheduling "an hour dedicated so I don't have any excuses".

Figure 5.5. Percentage of chosen strategy categories overall.



Participants also selected strategies to make activities more appealing. Some added enjoyable elements by "listening to music at the same time" while others

introduced challenges like "trying a new vegetable in a recipe every week". Finally, Symbol and Social strategies were chosen to provide environmental and interpersonal support, such as "put the healthy snacks within sight" and "going [to the gym] with a friend works best, you motivate each other". Notably, Likert ratings for the same strategies varied widely across participants, suggesting that different strategies resonate with different users.

Strategies were predominantly placed **before** (n=53) or **during** (n=50) the target activity, with very few selected for **after** (n=9) (some strategies were placed at multiple timepoints e.g. both before and during), suggesting participants prioritized preparation and in-the-moment support over post-activity monitoring.

Table 5.4. Mean ratings for most frequently selected strategies.

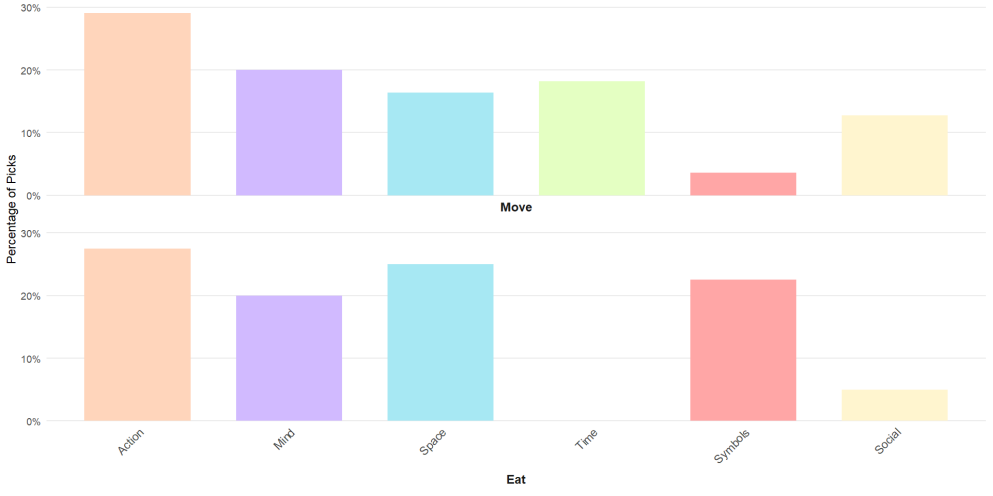
Strategy	**Category**	**# of picks**	**Goal domain**	**Applicability** Mean (range)	**Effectiveness** Mean (range)	**Longevity** Mean (range)
Remove temptations	Space	9	Eat (6) Move (3)	3.67 (1–5)	4.22 (3–5)	3.44 (1–5)
Time blocking	Time	9	Move (9)	3.67 (2–5)	4.44 (3–5)	3.44 (2–5)
Make it more fun	Action	6	Eat (4) Move (2)	3.83 (2–5)	3.83 (3–5)	4.00 (2–5)
Add challenge	Action	6	Eat (4) Move (2)	3.50 (3–4)	3.83 (3–5)	3.33 (2–5)
Setting the stage	Space	5	Eat (4) Move (1)	4.00 (3–5)	3.80 (3–5)	3.60 (3–4)
Stack your habits	Action	5	Move (5)	3.80 (2–5)	4.60 (4–5)	4.20 (2–5)
Visual reminders	Symbols	5	Eat (5)	4.60 (4–5)	4.00 (2–5)	4.20 (3–5)
Do it together	Social	5	Eat (2) Move (2) Recharge (1)	3.80 (2–5)	4.40 (3–5)	3.40 (2–5)

Domain-Specific Selection Patterns

Distinct patterns emerged across goal domains (Figure 5.6). Due to having only one participant, Recharge was excluded from comparative analyses. While Move and Eat goals both relied heavily on Action and Mindset strategies, they differed in other categories. Participants with Move goals favored Time and Social strategies, while participants with Eat goals favored Space strategies (e.g., controlling food

availability) and Symbol strategies (e.g., creating visual reminders in eating contexts).

Figure 5.6. Percentage of chosen strategy categories per goal domain.



Insights study 2

Study 2 demonstrated how a strategy menu can facilitate self-tailored behavior change planning among adolescents by scaffolding deliberate strategy selection. Participants selected 27 of the 29 available strategies with minimal overlap in their set of strategies. Ratings for the same strategies varied widely across participants, suggesting that perceived strategy effectiveness and applicability is highly personal.

While Action strategies appeared universally, complementary patterns differed by goal type. Move goals paired with Time and Social strategies; Eat goals paired with Space and Symbol strategies. These patterns reveal adolescents' intuitive understanding of domain-specific needs: dietary change requires controlling food availability and visual cues, while physical activity benefits from time planning and social motivation.

The strategy menu supported self-tailoring again through expanded awareness and creating focus (Chen & Schmidt, 2024)

Expanding awareness:

- The menu presented an overview of strategy options
- Diversity in strategies suggest exploration of personal fitting strategies

Creating focus:

- Participants had to make deliberate choices and make the strategy concrete with an example
- The menu provided strategies to support the goal, either inhibiting automatic behaviors (removing cues) or activating new behaviors (stack habits)

5.5 Discussion

This paper explored how self-tailoring can be designed in health behavior change tools. Through two iterative studies, we examined how adolescents construct, apply and reflect on their behavior change strategies. We organize our discussion around three key themes: adolescents' capacity for self-tailoring, how self-tailoring can be operationalized, and the strategic timing of positive friction. We then provide design implications and conclude with limitations and future directions.

5.5.1 Adolescent Capacity for Self-Tailoring

Our studies demonstrate that adolescents are capable of self-tailoring their health behavior change trajectory in two ways: they craft strategies that already incorporate behavioral change principles, and they update their approaches based on self-knowledge gained through experience. Our studies demonstrate that adolescents are capable of self-tailoring their health behavior change trajectory in two ways: they craft strategies that already incorporate behavioral change principles, and they update their approaches based on self-knowledge gained through experience.

In Study 1, participants autonomously specified goals and strategies using only basic prompts. Participants generated their own strategies rather than receiving them, placing themselves as the authors of their own behavioral plans. Without explicit instruction, participants' strategies already reflected established behavior change principles such as reminders, social accountability, and environmental modification.

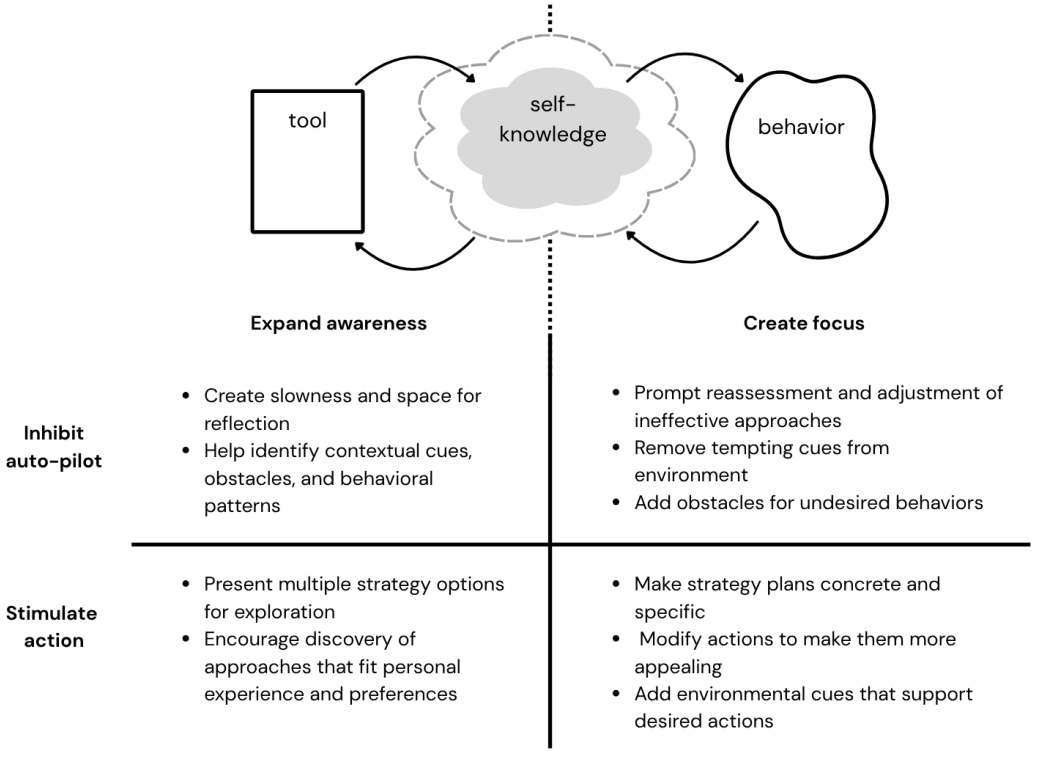
The two-week experimental period revealed participants' capacity to build self-knowledge through that experience. They discovered what worked, identified barriers, and adjusted accordingly. Broad intentions like "establish a morning routine" evolved into specific commitments like "wake at 07:45 without snoozing," demonstrating reflection and refinement of their plan. These shifts reflect participants adapting their approaches in response to what they experienced, tuning them to fit their personal circumstances (schraefel & Hekler, 2020).

Study 2 showed that despite gravitating intuitively toward domain-specific strategies, each adolescent constructed different approaches, reflecting their own preferences and life contexts. This suggests that adolescents bring their own self-knowledge into the behavior change process, and strategy menus can scaffold those choices. Together, both studies show that with minimal guidance, adolescents were able to draw on their experiential insights, build self-knowledge, and use it to construct their strategies.

5.5.2 Operationalizing Self-Tailoring for Health Behavior Change

Across both studies, the design elements we developed supported self-tailoring by creating conditions for users to construct, enact and reflect on their behavioral strategies. Drawing on Chen and Schmidt's (2024) positive friction framework, we find that these conditions operate at two levels: the level of tool interaction and the level of the behavior itself. Self-knowledge connects these two levels: rather than prompting behavior directly, the tool scaffolds self-knowledge, which in turn informs how users choose to act. Figure 5.7 summarizes these insights.

Figure 5.7. Summary of insights on how self-tailoring can be operationalized at the level of tool interaction and at the level of the behavior.



At the tool level, behavior change tools can support self-tailoring by expanding user awareness about possible actions. Study 1 demonstrated this through workshops and motivational timelines that provided time and space for reflection, helping participants identify contextual barriers and behavioral patterns that disrupted existing automatic routines. Study 2's strategy menu expanded awareness by presenting diverse strategy options and enabling users to search for approaches that fit their needs, preferences, and goals.

At the behavior level, creating focus proved essential for structuring engagement with the behavior change process. Auto-pilot behaviors could be inhibited through prompts to refocus on goals, such as Study 1's check-in, which redirected participants who had lost focus amid life's demands, and through strategies that added obstacles or removed cues to prevent temptations and unwanted behaviors. To stimulate new actions, tools helped users make plans concrete, structured, and actionable. This included making deliberate choices about when to deploy strategies temporally and providing modular building blocks that users

could apply to modify their actions, making them more appealing or adding visual cues and reminders to support desired behaviors.

These findings suggest how to promote self-tailoring in health behavior change interventions. Behavior change tools can create more space for reflection, slowdown, and option exploration, elements currently underdeveloped in DBCIs (Ekhtiar et al., 2022). Providing actionable strategies that users can enact themselves, rather than predetermined by designers, enables users to actively shape their behavior change process by modifying their actions and environments, and to develop an understanding of what works for them through doing so. Framing behavior change as explorative experiments (Fedlmeier et al., 2022) can also encourage users to approach their own behavior as personal scientists (Heyen, 2020): trying out strategies, observing what happens, and interpreting the results in light of their own context. Repeated cycles of this kind can build the insourced knowledge, skills, and practices that over time inform health decisions independently of the tool (Schraefel et al., 2021).

5.5.3 Timing of positive friction

We found that motivation fluctuates during the behavior change process in a consistent pattern. Motivation tends to dip due to life circumstances and schedule changes that break regular routines. However, (re)setting goals and strategies emerged as particularly motivating moments that provided a fresh start effect (Dai et al., 2014). In Study 1, the check-in survey restored motivation through goal revisiting, leading all participants to recommit to their strategies. Beyond restoring motivation, these moments are also opportunities for users to compare what they expected with what actually happened, and to revise their understanding of what their own context demands. Positive friction applied at these moments can support users in translating experiential insight into revised strategies, converting lived experience into the kind of self-knowledge that can guide future behavioral choices.

5.5.4 Design Implications

Our findings offer directions for designers working on self-tailoring in behavior change tools. Although our studies focused on adolescents, these insights may apply to other populations. We organized them around four themes.

Delegate strategy construction to users. Rather than pre-selecting behavior change techniques on users' behalf, tools should provide diverse strategies that users can select, combine, and adapt to their own needs. In this way, users with

different needs, meanings, and skill levels can design their own realities with them (Krippendorff, 2005). Offering strategies across multiple dimensions, such as modifying actions, restructuring environments, using time cues, or drawing on social support, gives users the material to construct approaches that fit their particular context.

Keep strategies actionable but open to interpretation. Strategies should be concrete enough to act on, but leave sufficient room for users to bring in their own experiences and meanings. A degree of ambiguity can invite personal interpretation rather than foreclose it (Homewood & Vallgårda, 2020). Filling a strategy in with one's tacit understanding own context, history, and constraints is how users draw on (tacit) self-knowledge to make it their own. Providing examples can help users envision how a strategy might work in their own life, without prescribing a single way of enacting it. A balance between clarity and ambiguity is what gives self-tailoring room to work.

Design around the rhythms of people's lives. Cognitively effortful engagement should not be applied continuously but timed to align with motivational peaks, particularly at moments of goal (re)setting. The fresh start effect (Dai et al., 2014) suggests these moments carry heightened motivation and openness to change. Tools should make the most of them by supporting users to translate reflective insights into concrete, focused next steps, helping them rebuild momentum rather than simply revisiting what went wrong.

Design for pause. Slowing down interactions at reset and check-in moments creates space for users to reflect on what worked and what did not during the preceding experimentation period. Rather than pushing toward the next action, slow technology (Odom et al., 2022) can support moments of mental rest and reflection before users commit to next steps.

5.5.5 Limitations

Our findings should be interpreted with several limitations in mind. First, our studies were done with a small sample of Dutch Industrial Design Engineering students. This population is highly educated and may be used to abstract reasoning. Self-tailoring and strategy menus might work differently with populations with different educational backgrounds, cultural orientations, or age groups, and different people may benefit from or prefer different degrees of self-tailoring.

Second, we did not test our set-up in a digital format. Our methods included the use of social spaces and physical worksheets which will influence the experience. Nonetheless, the principles we found may still be relevant for the design of digital interventions.

Third, our studies emphasized conscious, intentional pursuit of approach goals, the deliberate addition of a healthy lifestyle activity. It is unclear how self-tailoring might work for other types of behavior, such as avoidance goals (e.g. stopping smoking), or within health behavior change interventions embedded in clinical care. These contexts may place different demands on users and warrant separate investigation.

5.5.6 Future Directions

First, longitudinal studies are needed to examine how self-tailoring operates over time, and how repeated cycles of self-tailoring can be designed to build self-knowledge and support increasingly independent behavior regulation. Second, the strategy menu represents only one operationalization of self-tailoring. Alternative approaches, including those tailored to specific health behaviors such as sleep, nutrition, or physical activity, warrant further investigation in terms of how to best scaffold behavioral choices within those domains. Third, our second study focused on the upper part of the self-tailoring cycle: how tools can scaffold behavioral choices by drawing on users' existing self-knowledge. Future research should also explore the lower part of the cycle, examining how lived experience with behavior can generate new self-knowledge and feed back into behavior change tools. Rather than reducing self-understanding to individually tracked parameters, tools could move toward representations that also capture the subjective dimension of how people make sense of their own body and behaviors (Homewood & Vallgårda, 2020).

5.5.7 Conclusion

Our findings provide initial insight into how self-tailoring can be operationalized in health behavior change tools. We show that adolescents are capable of constructing, enacting, and reflecting on their own behavioral strategies, and that scaffolding behavioral decisions can help bring self-knowledge into the behavior change process. By shifting from system-driven tailoring toward self-tailoring, behavior change tools can support users in building the self-knowledge that makes it possible to navigate health decisions autonomously.

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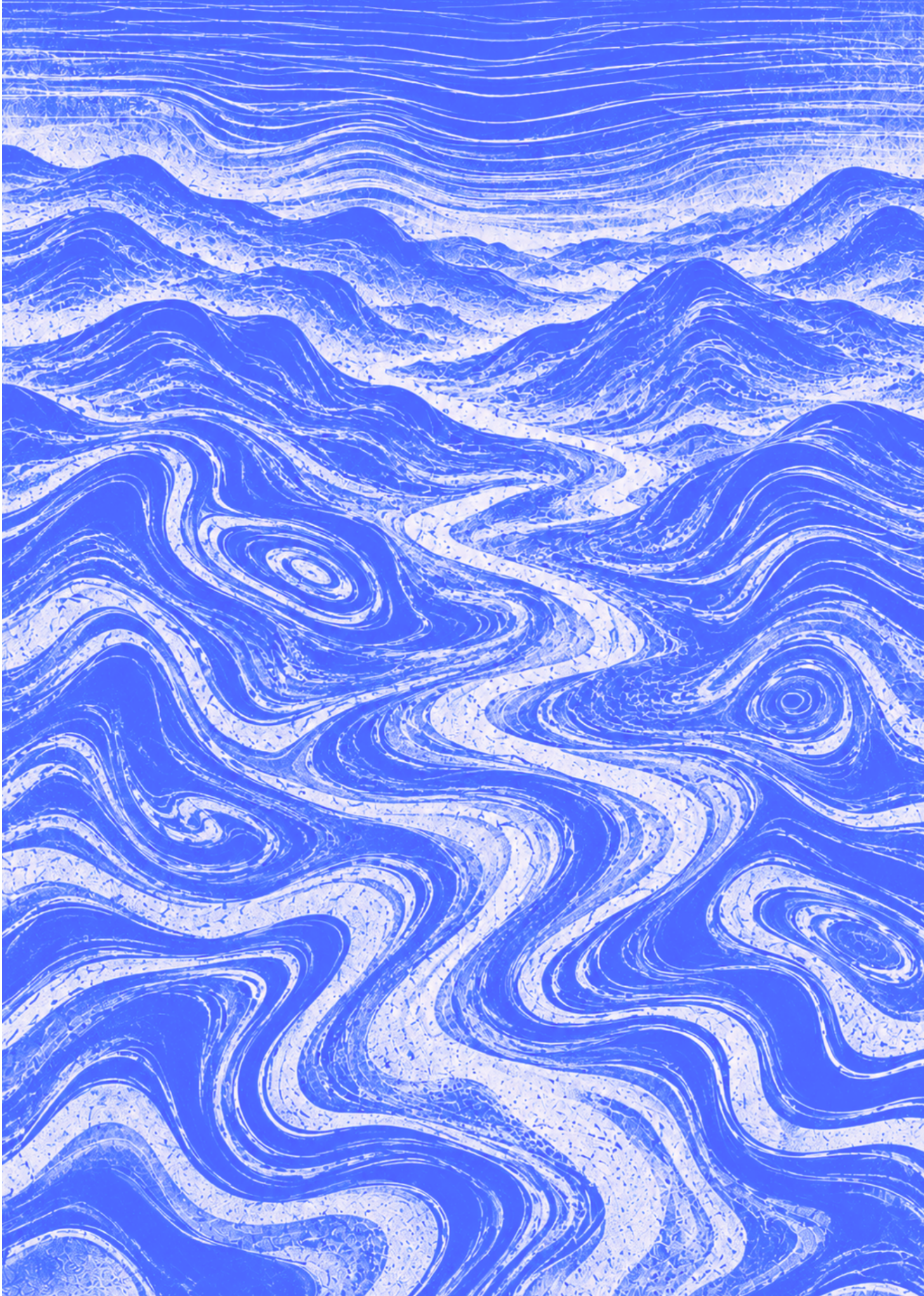


Chapter 6. Evaluation of Mapping of Me: A serious game for adolescent health behavior change

This chapter is submitted as:
Houtman, T. A., den Besten, D., Sleeswijk Visser, F., van Grieken, A., Bas, M., & Visch, V. *Evaluation of Mapping of Me: A serious game for adolescent health behavior change*.

Abstract
Serious games are increasingly used to support health behavior change among adolescents, as they can make engaging with health content more appealing than conventional approaches. However, they tend to focus on conveying health information and knowledge, which does not necessarily translate into changes in behavior. In this study, we therefore examine how a serious game can scaffold self-experimentation, so that adolescents develop not only health knowledge but also the skills and self-knowledge needed to enact behavior change in their own daily lives. We designed and evaluated Mapping of Me (MoM), a three-week hybrid journaling game in which adolescent work in pairs to pursue a self-chosen health goal across two cycles of self-experimentation. In a mixed-methods study with 36 adolescents, we analyzed session booklets, web application usage, and a one-month follow-up questionnaire to examine the strategies participants generated (RQ1), strategy maintenance one month later (RQ2), and the insights participants developed about their own behavior change (RQ3). Participants generated highly diverse, personal sets of strategies. At follow-up, about three-quarters still used at least one strategy, and some had applied strategies in other life domains.Reflexive thematic analysis identified insights about strategies, goals, latent problems, and motivation. These findings show that serious games can support adolescents in constructing their own behavior change strategies and in developing insights about their own behavior through experience.

6.1. Introduction

Healthy lifestyle behaviors established during adolescence, including physical activity, nutrition, and sleep, carry lasting implications for current and future wellbeing (Hayes et al., 2019; Patton et al., 2016). Yet efforts to promote them across school, community, and digital settings show modest and heterogeneous effects, and engaging adolescents consistently over time remains difficult (Jacob et al., 2021; Rose et al., 2017). Serious games are a promising avenue, as embedding health content within interactive game contexts can help engage adolescents (Mancone et al., 2024), and they can improve health knowledge and attitudes toward health behaviors (Ancona et al., 2024; Hammady & Arnab, 2022). However, such improvements are not always sufficient to produce behavior change in practice (Conner & Norman, 2022); while they can raise intentions, intentions do not reliably translate into action (Rhodes et al., 2022; Sheeran & Webb, 2016). Meta-analyses show that roughly half of those who intend to be physically active fail to follow through, a pattern also documented among adolescents (Haider et al., 2024). Accordingly, there is growing recognition that serious games for health need to be designed more explicitly around the behavioral mechanisms that help close this intention-behavior gap, rather than around knowledge delivery alone (Andrew et al., 2023; Hammady & Arnab, 2022).

Changing health behavior is particularly challenging in adolescence, a developmental period shaped by rapidly shifting interests and motivations, developing autonomy, and new social roles and relationships (Crone & Dahl, 2012; Dahl et al., 2018). Although adolescents value health, it often competes with more immediate priorities, such as spending time with friends or doing things they enjoy (Strömmer et al., 2021). At the same time, adolescents are increasingly making independent decisions about how they eat, move, and spend their time (Kimiecik et al., 2020). Enabling healthy behaviors during adolescence therefore involves learning to manage and negotiate these evolving and competing needs.

Behavior change techniques (BCTs) have been developed to support individuals to change their behaviors (Michie et al., 2013). However, because individuals differ in their needs, motivations, and contexts, some approaches may fit some people better than others. In an adolescent physical activity intervention that offered a range of BCTs, adolescents engaged selectively with certain BCTs, seemingly those they found personally fitting and actionable (Hankonen et al., 2017; Palsola et al., 2020), and the extent to which they used these techniques in their own lives predicted long-term outcomes (Palsola et al., 2025). This has prompted growing interest in more person-centered approaches that attend to individual differences, values, and circumstances (Kimiecik et al., 2020; Strömmer et al., 2021), and in

techniques that people can enact themselves and fit into their daily lives (Hankonen, 2021). From this perspective, serious games promoting healthy lifestyle behaviors could focus more on involving participants in discovering and enacting the regulation strategies that fit their own preferences and life circumstances.

Self-experimentation offers a concrete approach for developing personalized behavior change strategies. It involves individuals systematically testing behavioral changes on themselves to determine what works for their own health (Karkar et al., 2016; Neuringer, 1981), typically through an iterative cycle of selecting a change, trying it out in daily life, and reflecting on whether it worked before adjusting or replacing it. Its aim is not to produce generalizable knowledge but self-knowledge about how to approach one's own behavior change (Choe et al., 2014).

Self-experimentation offers two benefits for adolescent behavior change. First, individuals choose their own goals rather than working toward a prescribed target, which makes the resulting behavior more autonomous (Deci & Ryan, 2000), an important factor in sustaining it over time (Kwasnicka et al., 2016). Second, when used in an exploratory way, self-experimentation helps people discover which factors and strategies work in their own lives (Fedlmeier et al., 2022), drawing on their own experience rather than on general health information. Both benefits match the characteristics of adolescence, a life stage marked by a heightened need for autonomy and by exploration (Kimiecik et al., 2020; Yeager et al., 2018). Through repeatedly acting and reflecting within their own daily contexts, adolescents can learn how to navigate the competing demands they face in pursuing healthy behaviors.

To investigate how serious games can support the discovery of personal health behavior strategies through self-experimentation, we designed and evaluated Mapping of Me (MoM). MoM is a multiplayer journaling game built around self-experimentation in which two players team up over a period of three weeks and undertake two iterative self-experiments. Across these experiments, players try out a personal health goal, discover new strategies and together reflect on their experience to update their goal and how they approach their goal. Through this process, players construct a personal Map of Me, a representation of their self-experiment progress that helps them identify personal behavior change strategies.

This paper is structured around three research questions:

RQ1. What health behavior change strategies did participants generate through MoM?
RQ2. To what extent did participants maintain their strategies one month after MoM?
RQ3. What insights did participants develop about their own behavior change through MoM?

6.2 Design of Mapping of Me

Mapping of Me (MoM) is a three-week hybrid journaling game in which adolescents, working in pairs, pursue a personal health goal across two cycles of self-experimentation (Figure 6.1). MoM was developed through an iterative co-design process involving multiple rounds of ideation and prototype testing with adolescents (Houtman et al., 2026), in collaboration with human-centered designers and the serious gaming company &RANJ.

The game frames behavior change as the mapping of an uncharted personal landscape. Each cycle of self-experimentation is an expedition, and the in-person sessions between expeditions are framed as returns to basecamp. MoM thereby alternates between two settings: collaborative in-person sessions, in which pairs plan their goals and strategies and reflect on their experiences using booklets and stickers, and a digital web app, which participants use to carry out and track their individual self-experiment in daily life.

In the first session, participants choose a health goal in one of three domains (move, eat, or recharge) and formulate a first behavior plan. During the expedition that follows, they check in daily in the digital app and collect new strategies. At the end of the expedition, their app data are turned into personalized physical materials, which pairs use in the next session to review the expedition and revise their plan. The second expedition repeats this cycle over two weeks, and in the final session participants identify the strategies that worked best and consolidate them into a final behavior plan. Table 6.1 summarizes this structure per session and expedition, and Figure 6.2 shows what an in-person session looked like.

Figure 6.1. Overview of Mapping of Me structure including three collaborative in-person sessions and two digital expeditions, ending with an follow-up questionnaire filled online after a month.

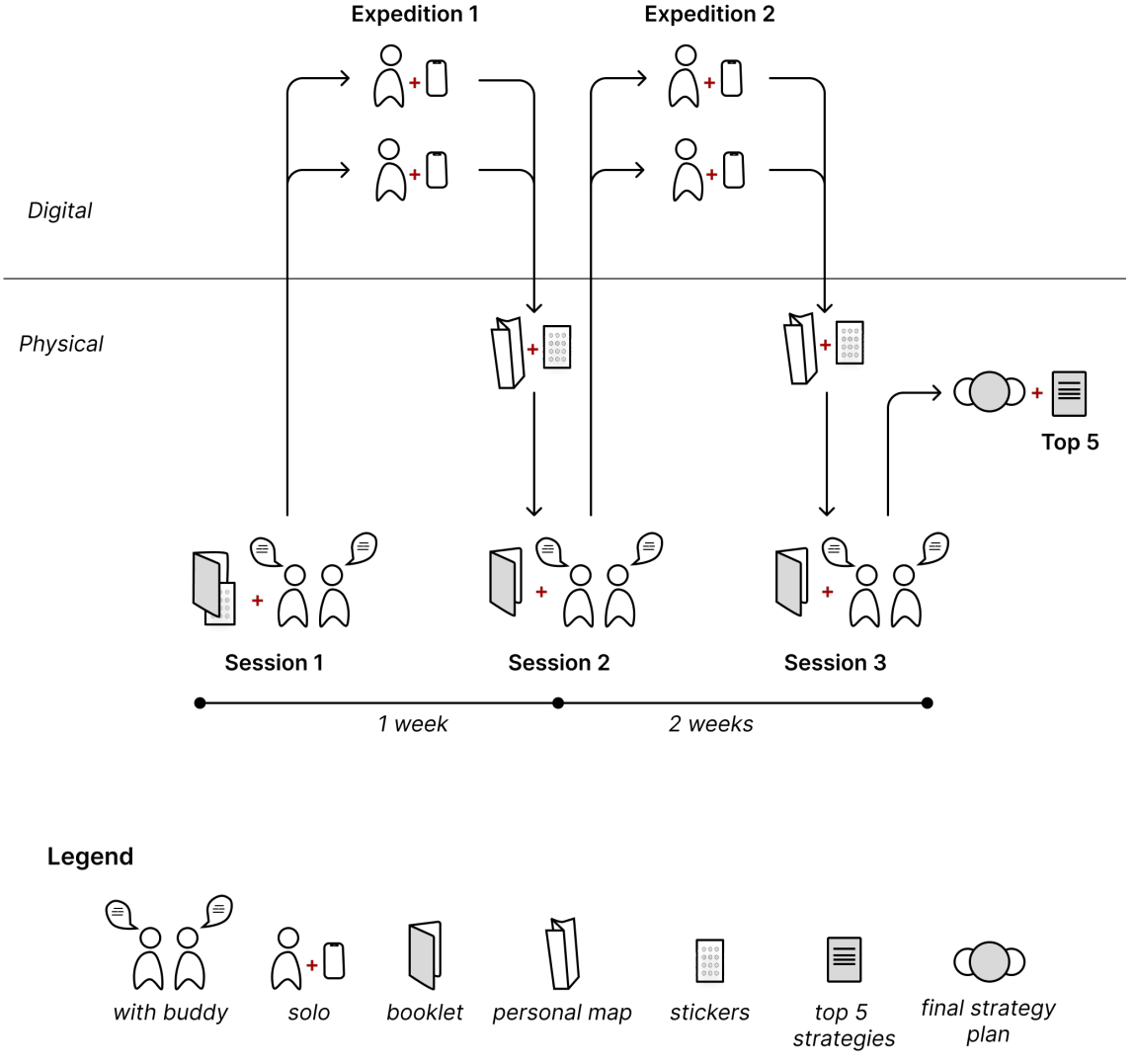
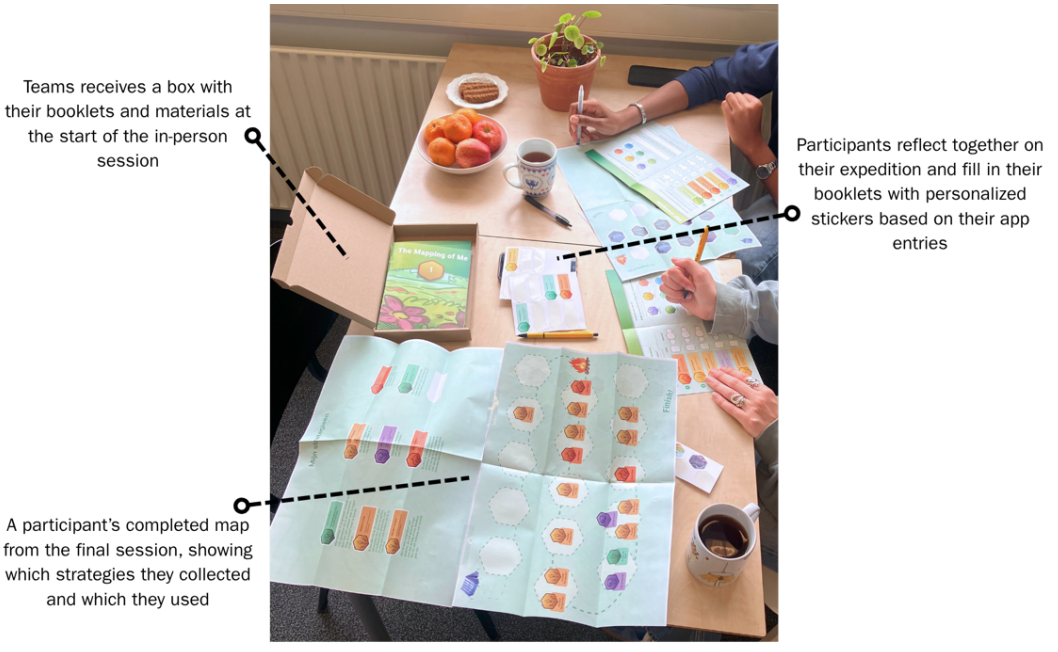


Table 6.1. Structure of Mapping of Me, showing each phase's goal, duration, activities, and materials.

Phase	Phase goal	Duration	Activities	Materials
Session 1: onboarding	Plan the first self-experiment with a partner	1 hour	Choose a personal health goal in move, eat or recharge; map out the day to find opportunities; formulate a first behavior plan and set an intention for the first expedition	Session 1 booklet with stickers
Expedition 1	Try out the initial plan and track progress	1 week	Daily check-in: open a new landscape tile, log expedition progress; every other day: browse and select one strategy	Digital application
Session 2: First return to basecamp	Translate accumulated experience and strategies into a new behavior plan, with a partner	1 hour	Review Expedition 1 using the personalized map and stickers; partner discussion; refine the strategy plan in before-during-after, specifying conditions of use	Session 2 booklet; personalized stickers and foldable map of Expedition 1
Expedition 2	Try out the revised approach and track progress	2 weeks	Daily check-in: open a new landscape tile, log expedition progress; every other day: browse and select one strategy	Digital application
Session 3: Final return	Identify personally effective strategies and consolidate learnings into a final behavior plan, with a partner	1 hour	Review Expeditions 1 and 2 together; partner discussion; identify the strategies that worked best personally	Session 3 booklet; personalized stickers and foldable map of Expedition 2

Figure 6.2. Participants working in pairs with their booklets and stickers during an in-person session of Mapping of Me.



The following sections elaborate the design logic of the three main game elements: the narrative framing, discovering landscapes and strategies, and the personalized interactive physical materials.

6.2.1 Narrative framing

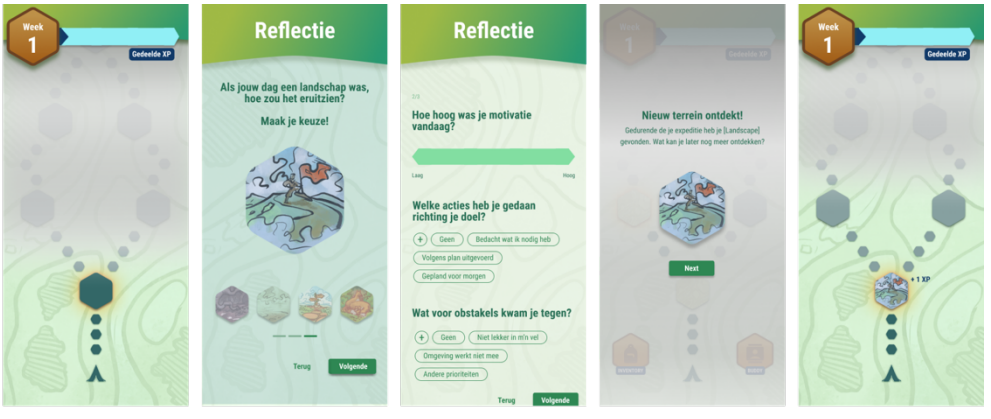
MoM uses a narrative in which exploring and mapping an unknown landscape serves as a metaphor for investigating one's own behavior change. This positions participants as explorers on an expedition rather than recipients of prescribed guidance. Narrative can help motivate players by giving them a sense of purpose and a call to action (Chou, 2015). The metaphor also provides a shared vocabulary that makes the mechanics of the game easier to understand and interact with. The two expeditions are framed as time to explore the landscape, while the returns to basecamp during the in-person sessions mark the moments at which participants step back from everyday life to plan, review, and consolidate what they have learned. The narrative runs through all elements of the game, from the instructions in the booklets and the digital app to the visual design, which draws on the imagery of nature and cartography.

6.2.2 Discovering landscapes and strategies

The digital app has two functions during the expeditions: it lets participants keep track of their experiences through daily journaling, and it offers them new strategies to try. We designed its gameplay loop using the lens of intrinsic skill atoms (Deterding, 2015). Rather than adding game elements on top of an activity, this method identifies the challenges inherent to the activity users are trying to perform and restructures them in a motivating way. In self-experimentation, the inherent challenge is making sense of one's own behavior in daily life and deciding what to try next. The core loop of the app is therefore built around a daily check-in.

Each check-in follows the same steps. Participants open a new tile on their digital map board, select a landscape type that characterizes their day, write a brief reflection, record whether they used their planned strategy, and note what they might do differently the next day (Figure 6.2). The completed tile is added to the map, extending a path across the board, so that the landscape of the expedition unfolds with every day of journaling. Every other day, starting on day one, participants encounter a falling star as they "set up camp" for the night. The star presents the strategies from the strategy menu (Houtman et al., 2026; Table 6.2), through which participants can swipe to pick one they want to use. The chosen strategy is added to their backpack, ready to try in the days that follow (Figure 6.3).

Figure 6.2. Screen walkthrough of the daily reflection in the Mapping of Me app.



A glowing tile on the map shows that the daily reflection is ready

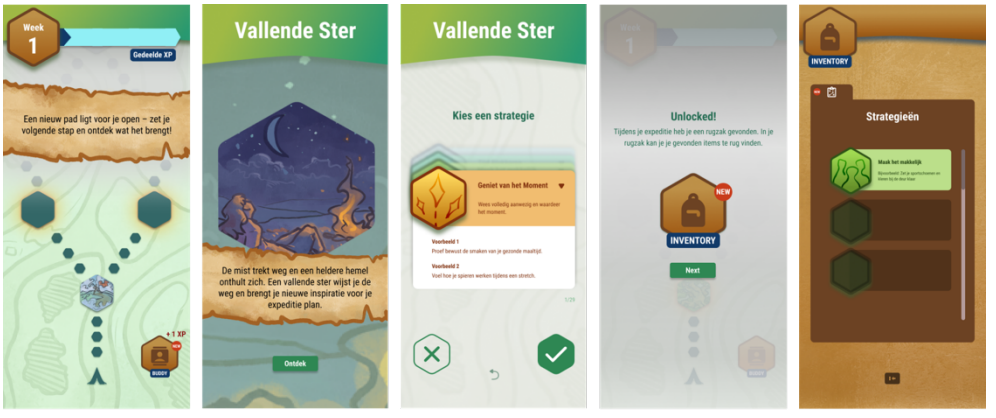
Participants describe their day by choosing the landscape that fits it best

They rate motivation and select the actions they took and the obstacles they faced

The chosen landscape is unlocked as a new piece of terrain

The landscape is placed on the map

Figure 6.3. Screen walkthrough of strategy collecting in the Mapping of Me app.



Every other day, a new path opens on the map

A falling star brings inspiration for a new strategy

Players swipe through strategies from the strategy menu and choose one

The first strategy unlocks the backpack

Collected strategies are stored in the backpack and shown during the daily check-in

The in-game goal of each expedition is to collect a set number of landscapes: five in the first expedition and ten in the second. This goal is tied to journaling rather than to attaining the health goal: every check-in counts, regardless of how the day went. A difficult day therefore still adds to the map and to the player's progression and can be just as informative as a good one. This keeps the challenge on learning from one's behavior rather than on performing it perfectly.

6.2.3 Personalized interactive physical materials

Representing personal data in physical form can invite people to reflect on it (Bentvelzen et al., 2023). In MoM, the landscape tiles and strategies that participants collected in the digital app during an expedition were therefore returned to them during the in-person sessions as personalized stickers and a foldable map providing an overview of the completed expedition (Figure 6.4). They used these materials to complete the exercises in their session booklets. Because participants worked in pairs, they could also compare their data with their partner's, which can help people make sense of their own data (Yan et al., 2025). The stickers also offered a playful, low-threshold alternative to writing. When revising their strategy plans, pairs placed strategy stickers before, during, or after the goal activity (Figure 6.5), which made strategy planning tangible.

Table 6.2. Strategies included in the menu organized into six categories.

Space: Environmental design	**Time:** Scheduling and transitions	**Action:** Breaking up or adjusting actions	**Symbols:** Visual cues and celebrations	**Social:** Accountability and support	**Mindset:** Mental reframing
Make it easy	Time blocking	Stack habits	Celebrate your success	Do it together	Every day is a reset
Remove temptations	Time pressure	Start small	Visualize streaks	Tell it somebody	Challenges are chances
Add obstacles	Use transitions	Break up action	Visual memory	Find like-minded people	Enjoy the moment
Setting the stage		Make it more fun	Make it stylish	Public commitment	Visualize pride
		Add challenge			Positive perspective
		2-in-1 actions			Anticipate regret
					Mental rehearsal

Note. The menu contains 28 of the 29 strategies developed by Houtman et al. (2026). The strategy "track behavior" was omitted, as tracking is already built into the game through the daily check-in in the digital app.

6.3 Methods

6.3.1 Sample

Thirty-six participants (18 pairs) completed the three-week MoM intervention. The sample comprised 30 women, 5 men, and 1 non-binary participant, aged 13 to 23 years (M = 18.7, Mdn = 19.5). University participants (n = 30; ages 18–23) were first- (n = 10), second- (n = 14), or third-year (n = 6) bachelor's students in Industrial Design Engineering at TU Delft, except for one participant studying mechanical engineering. High school participants (n = 6; ages 13–14) were recruited from a local high school and were in the second (n = 5) or third year (n = 1).

6.3.2 Recruitment

Participants were recruited through convenience sampling through in-lecture announcements, flyers distributed in learning spaces, social media postings, and

personal social networks. Eligible participants were required to enroll with a partner (friend, housemate, or fellow student) with whom they had an existing social connection.

Participants received €20 in vouchers as compensation: €10 after completing the three physical sessions and €10 after completing the one-month follow-up questionnaire. Sessions took place between March and June 2025 at a dedicated location in the Faculty of Industrial Design Engineering, TU Delft.

6.3.3 Ethics

The study was approved by the Human Research Ethics Committee TU Delft (Approval number: 4971). All participants provided informed consent prior to participation. For minors, parental or guardian consent was obtained in addition to participant assent.

6.3.4 Procedure

In-person sessions were facilitated and prepared by the first two authors. Each pair attended three one-hour sessions over three weeks. Between sessions, participants independently pursued their health goals and completed daily check-ins using the MoM digital application.

6.3.5 Data

Three data sources were combined for the analysis: booklets responses from the in-person sessions, a self-reported questionnaire at one-month follow-up, and digital application usage data.

Booklets. From the booklet of the final session, we used each participant's behavioral goal (formulated as an if-then statement), the top five strategies they selected, and their answer to the open question, "What is the most important insight you gained about yourself over the past expeditions?" For each strategy, participants indicated when they intended to use it relative to their goal behavior (before, during, after, or a combination) and rated its perceived effectiveness on a scale from 1 to 10.

Follow-up questionnaire. One month after the final MoM session, participants completed a questionnaire developed for this study. Closed items had five response options unless stated otherwise:

- *Activity frequency*: *"How often did you do your activity in the past month?"* Response options were never, two to three times per month, once per week, two to three times per week, and daily.
- *Activity change relative to baseline*: *"Compared to before Mapping of Me, how often are you doing your activity now?"* Response options were much less often, somewhat less often, about the same, somewhat more often, and much more often.
- *Strategy use frequency*: *"How often did you use your strategy or strategies in the past month?"* Response options were the same as for activity frequency.
- *Strategies still used* (open-ended): *"Which strategies are you still using?"*
- *Strategy adaptations or additions* (open-ended): *"Have you adapted or added any strategies since the intervention?"*
- *Strategy transfer to other domains* (yes/no): *"Did you use your strategy or strategies for other domains of your life in the past month?"* Participants answering yes were asked to describe in their own words what they had used the strategies for.
- *Main takeaway from MoM* (open-ended): *"Now, one month later, what has stuck with you from Mapping of Me?"*

Digital application data. Data from the digital application was used to characterize participants' engagement, specifically the number of landscape reflections they wrote and the number of strategies they collected and reported using.

Participants entered between 4 and 15 landscape reflections with a mean of 12.36 reflections per participant (Mdn = 13.5; maximum possible = 15).

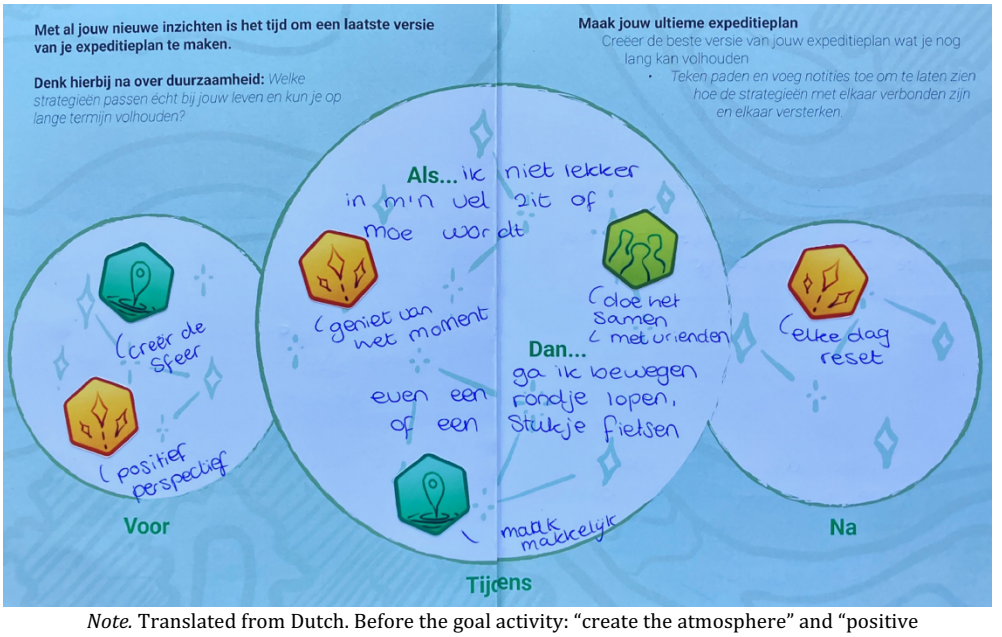
To check whether self-experimentation actually took place, we examined the strategies participants collected and reported using during MoM. All nine available strategies were selected at least once across the sample. Individual participants selected between 3 and 9 of the 9 strategies (M = 7.28, Mdn = 8), and reported using 1 to 7 of them (M = 3.86, Mdn = 4). The total number of strategy uses varied considerably across participants, ranging from 1 to 23 reported uses (M = 9.19, Mdn = 7).

6.3.6 Analysis

To contextualize our findings, we first characterized the goals that participants choose. We clustered the final behavioral goals by domain (eat, move, or recharge), summarized their distribution, and thematically clustered the if-then

statements to show the intent of the behavioral goals in each domain. Figure 6.5 shows an example of a completed final strategy plan.

Figure 6.5. Example of filled in strategy plan.



Note. Translated from Dutch. Before the goal activity: "create the atmosphere" and "positive perspective." During the goal activity: "If I don't feel good or become tired, then I will move by going for a walk or a bike ride," supported by the strategies "enjoy the moment," "do it together with friends," and "make it easy." After the goal activity: "every day is a reset." Sticker colors indicate strategy category: yellow = Mindset, dark green = Space, light green = Social.

To identify the strategies participants generated (RQ1), we used the top five strategies each participant selected in the final session booklet, together with their effectiveness ratings and placements. We conducted three analyses on these data.

Strategy selection. For each category of the strategy menu, we describe which strategies were most often included in participants' top five, along with their mean effectiveness ratings.

Top strategies. To identify which strategies worked best for individual participants, we examined each participant's highest-rated strategy. Where two strategies shared the highest rating (n = 7), both were included.

Temporal placement and functions. For each top strategy, we recorded whether the participant placed it before, during, or after the goal activity;

strategies placed in more than one phase were counted in each. We grouped the top strategies per phase by category and described the functions they served at each phase, based on their content and placement.

To assess whether participants maintained their strategies one month later (RQ2). we used the one-month follow-up questionnaire.

Activity frequency and change. We report the distribution of self-reported activity frequency in the past month and of their activity frequency relative to before the intervention, across the full sample and by goal domain.

Strategy use frequency. We report the distribution of responses to the strategy use frequency item across the full sample.

Strategy categories retained. Free-text responses to the open-ended items asking which strategies participants were still using, and whether they had added or adapted any strategies, were coded against the six MoM strategy categories (Space, Time, Action, Symbols, Social, Mindset). We counted the distinct categories named in each response (zero, one, or multiple), with responses such as "no", "none", or naming only the activity rather than a strategy, counted as zero.

Strategy transfer to other domains. We report the proportion of participants who indicated transfer to other life domains and the domains they named in the accompanying open-ended responses.

To explore the insights participants developed about their own behavior change (RQ3), we conducted reflexive thematic analysis (Braun & Clarke, 2006) on participants' open responses from two sources: (1) the final session booklet ("*What was your main insight gained during Mapping of Me?*") and (2) the one-month follow-up questionnaire ("*Now, one month later, what has stuck with you from Mapping of Me?*"). The first two authors independently coded responses from each source, then collaboratively refined themes through discussion and constant comparison between the raw data and emerging patterns (Glaser & Strauss, 1967; Charmaz, 2014). We report immediate insights from the booklet and sustained insights from the follow-up separately.

6.4 Results

Participants' goals were relatively evenly distributed across the three domains: 13 focused on movement, 13 on recharge, and 10 on eating. The types of goals and examples of if-then statement are shown in Table 6.3.

Table 6.3. Goal Distribution and Representative Examples

Domain	*n*	Goal Types	Example if-then statements
Movement	13	• Increasing daily activity • Engaging in intensive exercise	If I come home from studying, then I will go for a walk If there is an opportunity to move, then I will do it, regardless of intensity
Eating	10	• Healthier food choices • Improved hydration • Reduced snacking	If I want an unhealthy snack, then I first eat something healthy and wait for 10 minutes If I enter the cafeteria, then I will drink water
Recharge	13	• Sleep schedule improvement • Reduced snoozing • Morning routines • Meditation • Hobby time • Productivity • Limited phone use	If I am scrolling on my phone at home, then I will play guitar to do something fun or educational instead of wasting time If it is 7.5 hours before I need to wake up, then I go to sleep

RQ1: What health behavior change strategies did participants generate through MoM?

Participants generated highly diverse sets of strategies. Each of the 28 strategies in the menu (Table 6.2) appeared in at least one participant's top five. No two participants selected the same top five, and only two participants shared four of their five strategies.

Mindset strategies appeared in almost every participant's top five: 31 of 36 participants included at least one, of whom ten included two and seven included three. The other categories were chosen by a similar number of participants. Despite their popularity, Mindset strategies were among the lowest rated, together with Symbols, while Action, Space, and Time strategies were rated highest (Table 6.4).

Popularity and perceived effectivess did not always coincide. The most popular strategy, *Everyday is a reset*, was chosen 13 times but had an average rating of 5.95 (range 2-9). On the other hand, the most effective strategy, *Make it stylish*,

was chosen by only one participant but received a rating of 9. Among strategies chosen by at least two participants, the highest rated were *Remove temptations* (Space; chosen 5 times, M = 8.8, range 7-10) and *2-in-1 actions* (Action; chosen 5 times, M = 8.4).

Table 6.4. Categories of strategies and the descriptives of their popularity in use by the participants

Category	N participants	% of 36	Mean rating	Median	Range
Mindset	31	86.1%	6.83	7.00	2.0–10.0
Action	21	58.3%	7.57	7.75	5.0–9.5
Symbols	19	52.8%	6.50	7.00	1.0–9.0
Space	18	50.0%	7.75	7.75	5.5–10.0
Time	17	47.2%	7.43	8.00	5.0–9.0
Social	15	41.7%	7.06	7.00	5.0–10.0

To identify personally effective strategies, we looked at the top picked strategy per person. Six participants had two strategies tied for the highest rating, resulting in a total of 42 top strategies (ranging from 7 to 10) across 21 unique strategies (Table 6.5). The table shows diversity in strategies chosen by participants, suggesting that participants found effective strategies in each category.

Table 6.5. Highest rated strategies per participant, by category.

Mindset **13 (31.0%)**	**Space** **8 (19.0%)**	**Action** **7 (16.7%)**	**Time** **6 (14.3%)**	**Social** **4 (9.5%)**	**Symbols** **4 (9.5%)**
Positive perspective (4)	Remove temptation (4)	Start small (2)	Block time (3)	Tell someone (3)	Visual reminders (2)
Mental preparation (3)	Make it easy (2)	Make it more fun (2)	Use time pressure (3)	Find like-minded people (1)	Visualize your streaks (1)
Anticipate regret (2)	Setting the stage (2)	Stack habits (2)			Make it stylish (1)
Visualize pride (1)		2-in-1 actions (1)			
Every day is a reset (1)					
Enjoy the moment (1)					
See challenges as opportunities (1)					

Note. Numbers in parentheses indicate the number of participants that rated the strategy their most effective.

Mapping the top strategies onto the phase in which participants placed them (before, during, or after the goal activity) reveals several patterns (Table 6.6). Most top strategies were placed before the activity, fewer during it, and only a few after it. Some strategies appeared in more than one phase; positive perspective, for example, was placed in all three and rated highly in each. Despite this overlap, the strategies in each phase served distinct functions.

The before phase contained the widest range of strategies, including most of those placed in only one phase. These strategies prepared participants for the activity in advance, both practically and mentally: setting up the space, adding visual reminders, removing temptations, and reframing the upcoming activity in motivating terms. Participants also used this phase to block time for the activity and to involve like-minded people.

A substantial group of strategies was placed both before and during the activity. These adjusted the activity itself, for example by starting small, making it easier or more fun, or creating the right atmosphere, and so helped participants both to get started and to keep going.

Table 6.6. Participants' top strategies by phase of the goal activity (before, during, after), grouped by strategy menu category.

Before	During	After
Mindset		
Positive perspective	Positive perspective	Positive perspective
Mental preparation	Anticipate regret	
Every day is a reset	Enjoy the moment	
See challenges as opportunities		
Visualize pride		
Space		
Make it easy	Make it easy	
Setting the stage	Setting the stage	
Remove temptations		
Action		
Start small	Start small	
Make it more fun	Make it more fun	
	Stack habits	Stack habits
	2-in-1 actions	
Time		
Time blocking	Time pressure	
Social		
Tell it somebody		Tell it somebody
Find like-minded people		
Symbols		
Visual memory		
Make it stylish		
Visualize streaks		

Strategies placed only during the activity focused on the moment of action. Participants combined the activity with something else or used mental strategies to stay motivated, such as enjoying the moment, anticipating the regret of not following through, and setting a time limit to create urgency.

The after phase contained the fewest strategies, all of which also appeared in earlier phases: keeping a positive perspective, telling someone what they had accomplished, and linking the activity to an existing habit.

RQ2: To what extent did participants maintain the strategies developed one month after MoM?

At the one-month follow-up, 34 of 36 participants completed the questionnaire (Table 6.7). Most did their chosen activity at least once per week (28/34, 82%), and most reported doing it more often than before MoM (25/34, 74%); the remaining nine reported doing it about as often as before or less often. About three quarters of participants (25/34, 74%) were still using strategies from MoM for this activity, at least two to three times in the month after MoM.

Table 6.7. Activity engagement and strategy use at one-month follow-up (n = 34).

	n	**%**
Activity frequency in the last month		
Daily	2	6%
Two to three times per week	16	47%
Once per week	10	29%
Two to three times per month	5	15%
Never	1	3%
Activity compared to month before MoM		
Much more often	7	21%
Somewhat more often	18	53%
About the same	3	9%
Somewhat less often	3	9%
Much less often	3	9%
Strategy use frequency for MoM goal activity in last month		
Daily	2	6%
Two to three times per week	9	26%
Once per week	11	32%
Two to three times per month	3	9%
Never	9	26%

When asked which strategies they were still using, for their MoM activity or for something else, 27 of 34 participants (79%) named at least one. Nine (26%) applied strategies to other areas of life, such as studying, sleep scheduling, cleaning routines, and general planning. Strategies also continued to change after MoM: ten participants (29%) adapted existing strategies or added new ones, such as adding music, using transitions between activities to exercise, or no longer keeping their phone in the bedroom.

RQ3: What insights did participants develop about their own behavior change through MoM?

Through reflexive thematic analysis of the final session booklet and follow-up questionnaire responses, we identified four insights participants developed about their own behavior change, relating to strategies, goals, problems, and motivation.

6.4.1 Discovering fitting strategies

Participants generated insights about which strategies worked for them in their own contexts. Some found that visual cues helped bridge the moment between intention and action: *"When I half feel like it but not fully committed to start, visual reminders gave me that itch to get going again"* (Participant 14B). Others recognised the value of restructuring their surroundings: *"By changing my environment, I push myself in the right direction, making it easier for me to make the right choices. I can do it, as long as I help myself by preparing!"* (Participant 5A). Participants also discovered the value of combining planning with mindset work: *"I learnt that I find it difficult when I have no planning in my day, it helps to set certain fixed times during the day. My mindset is also important"* (Participant 8B). Several noticed that strategies transferred to other domains of their life: *"The strategies (start small & do with friend) are also applicable to other parts in my life, like studying and sports"* (Participant 12A). However, the breadth of available strategies could itself become a problem: *"I wanted to try out all the strategies but that really felt like an overload"* (Participant 9B).

At follow-up, participants mainly recalled strategies they had found personally effective and saw them as continuing support: *"I think it's the strategies you can apply. Having them can be a helpful support"* (Participant 2B). Others named individual strategies that had stuck: "*Everyday is a reset, this is a way; I had not seen it in that way before"* (Participant 3A), and *"The strategy in which you combine actions helps"* (Participant 17A). The strategies participants discovered during MoM were thus not only useful during gamplay, but continued to be seen as helpful after it had ended.

6.4.2 Calibrating realistic goals

During MoM, several participants discovered that their initial goals had been too ambitious and required scaling down. One participant adjusted her movement goal to her energy levels: *"I realize that I am often very tired and I don't want to do any sports. It is better for me to go for a walk"* (Participant 10B). Others found that goals which were too abstract or too long-term were difficult to act on: *"In the*

beginning it was too general and too long, then it is difficult to change your routine. In the end I was happy with my endgoal. Your goal should be realistic, so you will feel more motivation, otherwise you lose it" (Participant 2B). Participants also discovered that what felt unattainable in one large move could become manageable when broken into smaller daily steps: *"My surroundings don't help, planning helps. Walking small bits during the day also contributes to moving more in total on a day"* (Participant 7B).

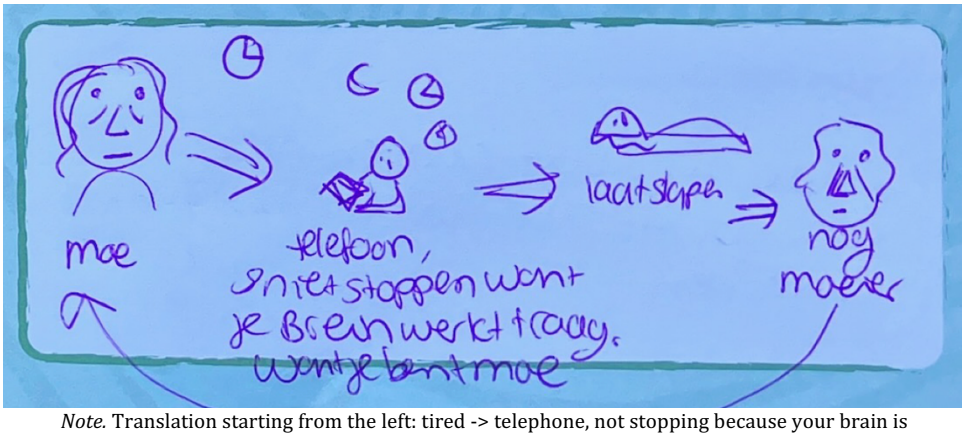
At follow-up, the need for achievable goals remained a takeaway, with participants valuing adjustment over giving up: *"That your first goal is often not achievable, and that can be disappointing. It's better to adjust your goal afterwards rather than give up"* (Participant 7B). Others reflected on the mismatch between goal scope and intervention duration: *"Sometimes your goal is too big to solve within a month, and starting is the hardest part when you're trying to build a routine"* (Participant 2B). Participants thus seemed to have retained the understanding that goal-setting is an iterative process that needs calibration.

6.4.3 Uncovering latent problems

Trying out strategies in context helped participants recognize that the problem they intially tried to solve was not always the actual problem. For example, a participant who had intended to eat a healthy breakfast realised that the problem was not in food choices but in the daily routines surrounding them: *"Eating poorly is a result of not waking up early and not doing grocery shopping"* (Participant 15B). This reframing also helped to reveal wider benefits: *"Waking up early will also benefit me in other ways"* (Participant 15B).

Phone use emerged as a common latent problem, especially for participants pursuing recharge goals: *"I want to do real things instead of just scrolling on my phone"* (Participant 3B). Participants discovered that their phone behavior was tied to their broader emotional state: *"My behaviour related to my phone is dependent on how my day went and how I feel about that. I want to have more energy for creativity and seeing other people, so I will feel happier and mentally healthy"* (Participant 5B). One participant who had used their phone as part of her motivational strategy recognised its double-edged role: *"I become more motivated when I watch guitar videos and practice after that. I also realize I waste a lot of time scrolling on my phone"* (Participant 4A). The role of phone use as an underlying problem in participants' goal pursuit was also captured in a drawing by one participant (Figure 6.6), which depicts how using the phone in the bedroom led to a vicious cycle.

Figure 6.6. Drawing made by participant 14A about the role their phone played in their goal.



Note. Translation starting from the left: tired -> telephone, not stopping because your brain is too slow because you are tired -> sleeping late -> more tired

At follow-up, latent problems remained as an important insight. One participant returned to the phone as the underlying barrier: *"I think it was mostly that I didn't feel like putting my phone away, which meant I didn't end up getting any work done. In that sense, my strategy of going for a short walk before starting work actually helped"* (Participant 10B). Another noted that addressing the latent problem produced downstream benefits: *"Implementing my goal of using my phone less before bed had a positive effect on my energy levels"* (Participant 5B). The participant that wanted to eat a healthy breakfast reiterated their uncovered latent problem: *"My problem wasn't the food itself, but making time and doing the groceries"* (Participant 15B). These insights show that self-experimentation was useful to uncover latent problems and produced a form of self-knowledge about why something worked for them or not.

6.4.4 Constructing and sustaining motivation

Several participants discovered through self-experimentation that the motivation they had initially named was not the motivation that actually drove them. One participant reframed their sleep goal when they discovered what they actually wanted: *"I wanted to improve my sleep, however, the why behind this was actually being more motivated for university. When that became my goal, it motivated me"* (Participant 2B). Another connected their goal to a desire for autonomy and resilience: *"My mood depends a lot on external factors. I want to live more in the moment and become less dependent on these factors"* (Participant 3A). For some, clarifying motivation involved recognising that the goal itself was not yet ready to be pursued, because the underlying values had not been clarified. After trying

numerous strategies, one participant concluded: *"I cannot simply change my daily routine, I should start with smaller steps. First I should find out which values are important to me in order to really want to realise a behavioral change"* (Participant 11A).

At follow-up, motivational insights took a different form. Rather than recalling moments of motivational clarity, participants articulated the difficulty of sustaining motivation across time. Looking back on the intervention as a whole, they described the difficulty of recovering after breaks in their routine: *"I found it difficult to pick up my goal again after having a day where I didn't do it well"* (Participant 8B), and "*Once it has 'failed', it's about figuring out how to move forward again"* (Participant 7A). Participants thus recognized behavior change as ongoing daily work, in which lapses are part of the process and starting again is a central challenge.

6.4.5 Memorable features of the MoM process

Some follow-up responses concerned features of MoM itself rather than what participants had learned about behavior change.

Time and structure for reflection. Participants described that the regularity of filling in the booklet entries had supported their engagement: *"That actually filling it in on a regular basis really helped"* (Participant 16B). The in-session reflection also created a space for deliberate attention to their goals: *"Each session gave me an hour to be really conscious and actively engaged with it"* (Participant 8A). For some, the reflective practice itself was retained as a habit beyond the intervention: *"I often reflect on my actions at the end of the day now and think about what went well, what didn't, and what I could do differently tomorrow to make things easier for myself"* (Participant 12B).

Partner-based engagement. Participants valued doing MoM together, as both a source of accountability and a meaningful shared experience: *"Doing it together with my housemate and wanting to support each other in our goals"* (Participant 15A), *"I also enjoyed sitting down with [my partner] every other week"* (Participant 6A), and *"Seeing how the other person was doing was very interesting and fun to share"* (Participant 9A).

Tangible, playful materials. Three participants simply mentioned "stickers" as the most memorable element of the experience, suggesting that the materials made a lasting impression. This aligns with observations during the in-person

sessions, where participants expressed enthusiasm upon discovering their personalized strategy and landscape stickers.

6.5 Discussion

MoM is a serious game designed around self-experimentation as a behavioral mechanism to support adolescents in discovering personal strategies for health behavior change. In this mixed-methods study, we examined what strategies participants generated through MoM (RQ1), whether they maintained them one month later (RQ2), and what insights they developed about their own behavior change (RQ3). Findings indicated that participants pursued diverse health goals and generated unique sets of personal strategies through MoM. Most were still using at least one strategy at follow-up, for their goal activity or for something else. Furthermore, MoM produced personal insights produced by the experiences from trying to enact behavioral change. Below, we discuss the implications of these findings and then turn to design recommendations for serious games supporting adolescent health behavior change.

6.5.1 Personalized strategy generation as autonomy-supportive scaffolding

Over the course of MoM, participants generated heterogeneous sets of strategies through a process of selecting and trying out different options. The top-rated strategies were largely unique and spanned all six strategy categories. Rating patterns for the same strategies diverged widely in perceived effectiveness, which suggests that a strategy's perceived value was tied to personal fit rather than to any inherent strength of the strategy itself. Adolescents further favored "before" and "during" strategies to bridge their intention-behavior gap, broadly concerned with preparing the conditions for change, physically or mentally, and lowering the threshold for getting started or staying engaged.

Adolescents in our study took markedly different approaches to their health behavior change. These differences partly reflect the different goals they chose, but likely also differences in personal preference, context, and circumstance. This echoes findings that adolescents adopt specific subsets of behavior change techniques rather than applying them uniformly (Hankonen et al., 2017), and suggests that adolescents can tailor their own behavioral approaches. Choosing and testing their own strategies also supports autonomy. Self-chosen goals make behavior more autonomous (Deci & Ryan, 2000), which is important for sustaining it over time (Kwasnicka et al., 2016). In MoM, this autonomy extended beyond the choice of goal to the choice of how to pursue it, which fits the heightened need for autonomy that characterizes adolescence (Kimiecik et al.,

2020). For serious games design, this implies a shift in focus from transferring health information to facilitating adolescents' engagement with the behavior change process, in which they act as active agents and experts of their own lives. Self-experimentation offers one way to achieve it: by helping adolescents discover personally fitting strategies, a serious game allows them to author their own approach rather than having one prescribed for them (Yeager et al., 2018).

6.5.2 Strategy retention and cross-domain transfer

The one-month follow-up provides initial signals that participants maintained strategies they had generated during MoM. Roughly three quarters still used at least one strategy, mostly for their original goal behavior. Some participants also added or adapted strategies after MoM ended, and others applied them in other areas of their lives, suggesting that strategies were not always tied to a single behavioral goal.

This transfer suggests that some participants may have begun to internalize strategies as heuristics: personal principles or mental shortcuts that help people bring intentions into action and adapt across contexts (Schraefel et al., 2021). In this way, a heuristic supports not only the current behavior, but also future behavior change goals. That some participants kept adjusting their approaches further suggests they continued to "tune" the fit between their activity, strategy and life circumstances (Schraefel & Hekler, 2020). For adolescents, who must navigate competing and evolving demands and motivations (Houtman et al., 2025; Strömmer et al., 2021), heuristics may be especially useful to help support the maintenance healthy lifestyle behaviors during future shifts in preference, motivation, and circumstance. Future research should examine how strategies learned in one domain can become transferable heuristics that adolescents can carry forward to other (health) behaviors.

6.5.3 Generating self-knowledge through experience

Beyond creating fitting strategies, participants also generated personal insights through the behavior change process itself. These insights were typically prompted by the challenges they encountered. Some participants learned to set more realistic goals after recognizing they had been overly optimistic and would do better to start smaller. Others uncovered that the actual problem standing between them and their goal lay elsewhere than they had assumed, or that their motivation for the goal differed from what they had initially believed.

These were highly personal insights about what did and did not work for each participant and led to new decisions about how to reframe or adjust the approach towards their goal. The insights appeared to emerge from trial-and-error process, and from attempting to enact a behavior in the context of one's own life. In this sense, self-experimentation functions as a form of experiential learning, in which concrete experience and reflection generate understanding that instruction alone cannot provide (Kolb, 2015). What participants gained was not the health knowledge typically transmitted by serious games, but a type of self-knowledge (Houtman et al., 2026), a personal understanding of how their own behavior change unfolds, what supports it, and where it tends to break down which only can be learned from practice.

6.5.4 Design recommendations

Based on our findings, we formulate five design recommendations for using self-experimentation in serious games for health behavior change. These recommendations are not a checklist but a set of considerations that shift the behavior change process toward the participant, supporting them in discovering what to change, how to approach it, and why it matters.

1. Anchor the experiment in a self-endorsed goal

The starting point should be a motivation the participant already holds, rather than a blank canvas. The goals participants chose in MoM ranged from drinking more water to limiting phone use, showing how much adolescents differ in what they want to change. When designing for health behavior change, the aim should be to help participants translate that motivation into a concrete experiment they can try, for example by analyzing their daily routine to find an anchor for the new behavior, offering example goals, and helping them give the goal a concrete structure such as an implementation intention.

2. Offer open strategy elements for participants to tailor

Rather than offering strategies in a fixed order, serious games can let participants choose the strategy that is most relevant to them at that moment. Participants are best placed to judge this, as they know their own context, motivation, and experience best. This makes strategies a toolkit to draw from when needed, rather than a script that dictates what to use when. Strategies should also be open enough for participants to bring in their own experiences, rather than being rigidly defined. Mechanics that let participants annotate, adapt, or rephrase strategies in their own words allow them to tailor strategies to themselves.

Because some participants found the full set of options overwhelming, strategies may also need to be introduced gradually and in limited numbers, scaffolding the choice without making it for them**.**

3. Make room to pivot and learn from challenges

The initial goal and strategy are rarely the final ones. Participants often learned most from what did not work, whether that was a goal that turned out to be too ambitious or a problem that turned out to lie elsewhere. Because setbacks can be frustrating, participants need a way to reset, integrate what they have learned, and pivot to a new goal or strategy. Framing self-experimentation as a process of exploration lowers the stakes of "getting it right," since success lies in finding a better approach based on experience. Treating goal and problem revision as a core mechanic, with prompts that ask whether the right problem is being worked on, supports this recalibration.

4. Connect action with reflection, and how with why

In MoM, participants mostly focused on the *what* (their goal) and the *how* (applying it in daily life). They did go through cycles of action and reflection, but these mainly led them to adjust how they pursued their goal, and several participants found it difficult to articulate *why* they were pursuing it. Designs should therefore support iteration not only on the what and how, but also on the why. A focus on action remains valuable, as getting started is hard and some participants asked for more action cues, but it should leave room to revisit motivation.

5. Combine digital, physical, and social elements

The social and physical sticker materials were well received. The company of a friend and lighthearted materials smoothed the reflection process. Physical materials provided tangible entry points and directed attention to the immediate space, freeing cognitive resources for reflection and offering a reason to set the phone aside. Face-to-face sessions created social accountability and turned reflection into a shared activity, where participants made sense of their experiences together and the burden of self-understanding was lowered. Digital elements, by contrast, let participants capture their experiences in context. Phones were a double-edged sword, often distracting from behavior change as much as supporting it; digital tools can play an important role, but only when placed at the right moment and given the right function.

6.5.5 Limitations

Several limitations should be considered when interpreting these findings. First, our sample consisted mainly of female university students in late adolescence who volunteered for the study. This is a well-educated group that was likely already motivated to change their behavior. Future research should test the approach with younger and more diverse adolescents, to assess whether it works across age groups and motivational starting points. Second, the balance between play and serious purpose may have leaned toward the serious (Caserman et al., 2020). Further development of MoM's game mechanics could make the experience more engaging and, in turn, strengthen its support for behavior change. Finally, change is difficult to assess in an individualized intervention such as MoM. Because participants defined their own goals and strategies, and outcomes were self-reported, standardized measures at group level capture this change poorly. Such interventions may benefit from an idiographic research approach, with measures that can follow individual behavior change trajectories.

6.6 Conclusion

Overall, our findings indicate that self-experimentation can be a valuable mechanism for serious games aimed at promoting health behaviors. Beyond transmitting health knowledge, such games can create the conditions for adolescents to discover which behavioral strategies work for them and to generate personal insights which could help them navigate current and future health behaviors.

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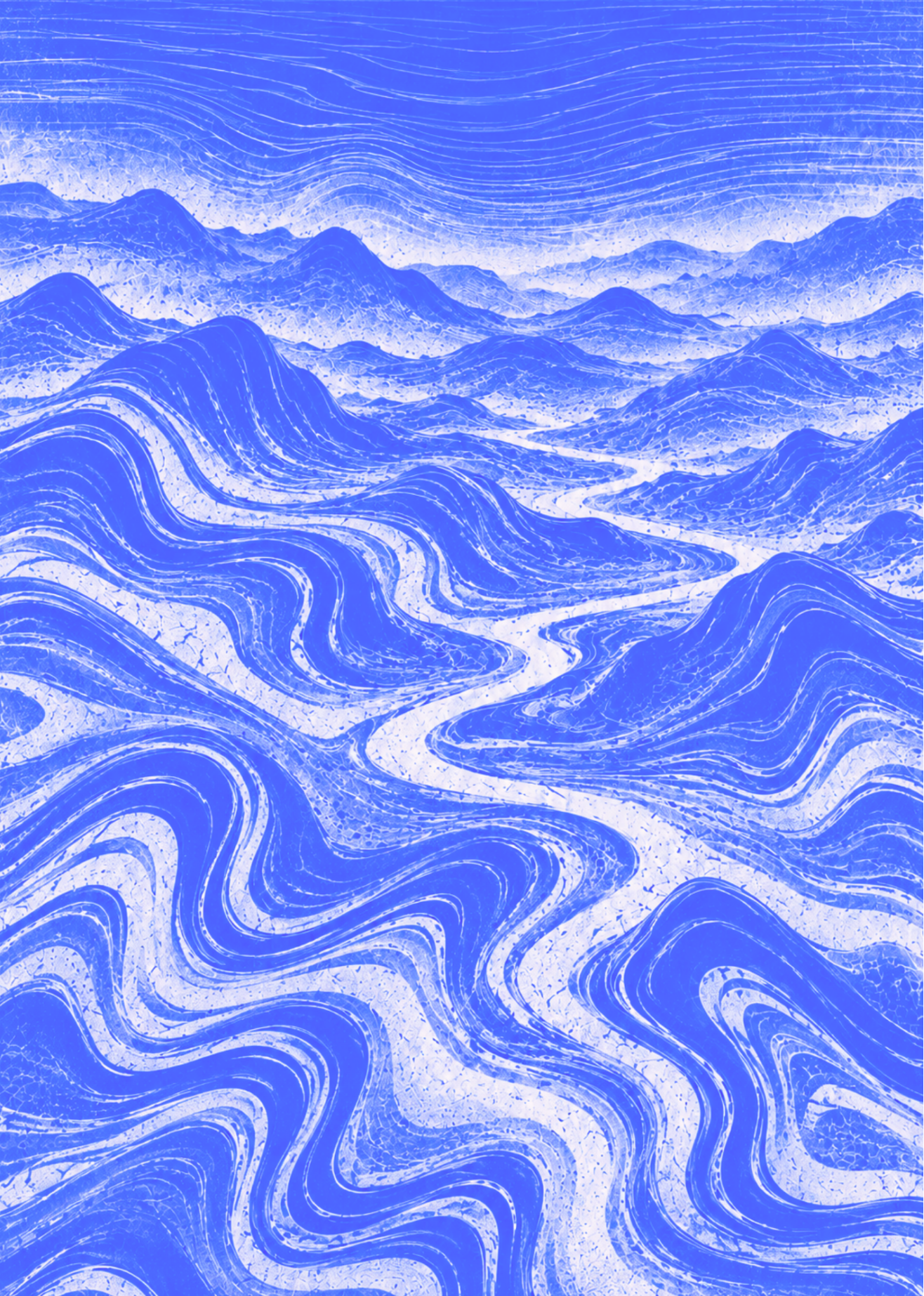


Chapter 7. Discussion

7.1 Recalling the research aim

Changing and sustaining healthy lifestyle behaviors is challenging, particularly during adolescence. Adolescence is a developmental period shaped by rapidly shifting interests and motivations, the exploration of new social roles and identities, stronger peer influence, and increasing autonomy over everyday choices. These developmental shifts unfold within contemporary environments that make healthy choices harder, from the availability of energy-dense foods to public infrastructures that invite sedentary behavior. Despite efforts across school, community, and digital settings, interventions promoting healthy lifestyles among adolescents a significant and difficult challenge. Serious games have emerged as a promising avenue for adolescent health promotion. By embedding health content within interactive game contexts, they offer a format that can help engage adolescents in healthy lifestyle behaviors. However, such games tend to focus on knowledge and attitude change, which does not always translate into (lasting) behavioral changes.

The aim of this dissertation was to generate knowledge about how serious games, and health behavior change interventions more broadly, can be designed to support adolescents in changing and sustaining healthy lifestyle behaviors. Across multiple studies, and in collaboration with adolescents, researchers, and designers, I developed Mapping of Me (MoM), a hybrid serious game designed to support adolescents in discovering and experimenting with personalized health behavior strategies. In this chapter, I reflect on the contributions of my work. I begin by answering the research questions I established in Chapter 1, then synthesize the contributions this dissertation makes to the field of health behavior change and reflecting on its limitations and directions for future research.

7.2 Answering the research questions

In Chapter 1, I developed three research questions, each addressing a distinct facet of the overall inquiry which are addressed in this section

Research question 1: *What barriers and facilitators do adolescents experience around maintaining physical activity?*

In Chapter 3, I showed that adolescents' barriers and facilitators for physical activity maintenance are neither uniform nor static but form distinct profiles that evolve over time. Using a mixed-methods approach combining Q-methodology

and interviews involving 30 adolescents aged 13 to 18, five facilitator profiles and four barrier profiles emerged. These ranged from profiles grounded in the immediate activity experience, such as fun, stress relief, and social belonging, to profiles centered more on personal development and autonomous goal pursuit. Barrier profiles similarly varied from predominantly internal sources such as low motivation and depleted energy, through profiles predominantly made up of environmental obstacles.

These profiles were not fixed per person. 70% of participants reported that their facilitators had changed over time, and 57% reported changes in their barriers, with older adolescents more likely to report both. Past facilitators were more often tied to the immediate, in-the-moment activity experience, whereas present facilitators were more self-directed and identity-oriented. Past barriers tended to be connected to characteristics of the activity itself, whereas present barriers were dominated by external obligations and competing demands.

This chapter provided three main findings. First, barriers and facilitators for maintained physical activity are not homogeneous but diverse across adolescents. Second, these configurations shift over time, even within the same person for a single activity. Third, as adolescents grow older and their motivations become more aspirational, they simultaneously face increasing competing demands. For the design of adolescent health promotion, this means interventions must account for individual differences in barriers and facilitators, recognize that these change over time, and contend with the tension between changing aspirations and increasing constraints.

Research question 2: ***How can adolescents be supported in constructing and adapting their own health behavior strategies?***

Building on the findings of research question 1, Chapters 4 and 5 explore how health behavior change interventions can be designed to respond to the diversity and dynamics of adolescents' barriers and facilitators. I investigated this through an iterative participatory design process centered on two interconnected concepts: self-tailoring, the process through which adolescents construct their own behavioral approach to fit their goals and personal circumstances; and self-experimentation, the process of trying that approach out in daily life to discover whether it works. Together, they move the act of personalization away from the designer or system to adolescents themselves.

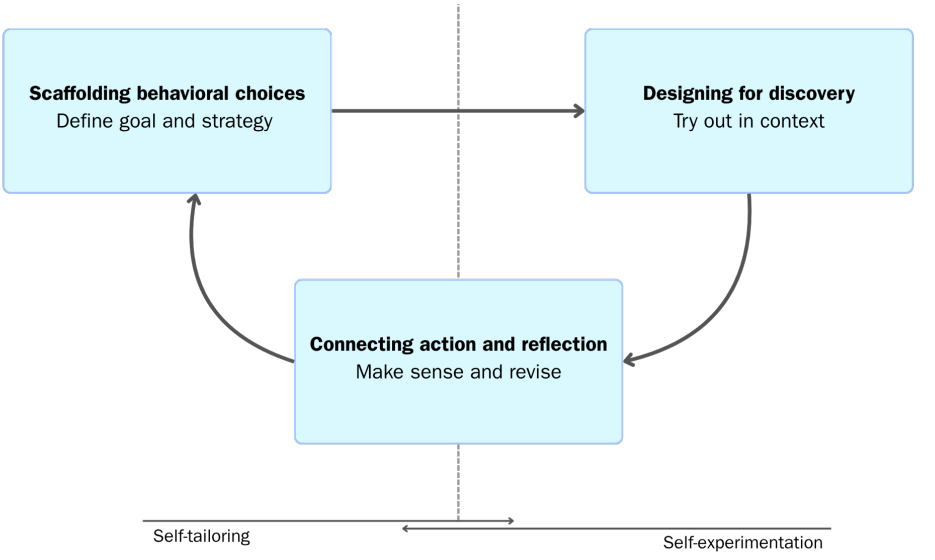
Chapter 5 focussed on two specific research through design activites that investigated how adolescents construct, apply, and reflect on their own behavior

change strategies. Seven adolescents participated in two workshops, in between which they experimented with a self-chosen health goal for two weeks (study 1). This produced three main findings. First, adolescents are capable of self-tailoring: given only basic prompts, participants specified their own goals and strategies, and these already reflected established behavior change principles such as reminders, social accountability, and environmental modification. Second, trying out a goal generated insights that participants used to revise their approach, as broad intentions became more specific and actionable over time. Third, motivation fluctuated during the self-experimentation period, dipping when contextual demands such as exams disrupted routines and recovering at goal resetting moments, where an online check-in acted as a fresh start that helped participants recommit to their plans.

Although adolescents could formulate goals and strategies with limited guidance, they expressed a need for more support in planning their approach. Based on the findings of study 1, together with existing literature, a strategy menu was designed to guide adolescents in self-tailoring strategies during goal (re)setting moments. The final menu consisted of twenty-nine self-enactable strategies across six categories of action, space, time, mindset, social, and symbols. The menu was tested with twenty adolescents (study 2). Each participant selected a unique combination of five strategies, even within the same goal domain and drawing from at least three categories. Ratings for the same strategy varied widely across participants suggesting that perceived strategy effectiveness and applicability was highly personal.

These insights were further developed in three main principles underlying the design of MoM (chapter 4): scaffolding behavioral choices, designing for discovery, and connecting action and reflection. Figure 7.1 shows how they relate to the two concepts, with scaffolding choice primarily supporting self-tailoring, designing for discovery primarily supporting self-experimentation, and connecting action and reflection bridging the two.

Figure 7.1. The three design principles and how they relate to self-tailoring and self-experimentation.



Scaffolding behavioral choices

By keeping strategies modular and open to personal interpretation, the menu developed in Chapter 5 delegates the act of constructing a strategy to the participant, positioning them as the author of their own approach. It does so by expanding participants' awareness of the strategies available to them, while asking them to select and adapt those that fit their goal and circumstance as they themselves saw it. Through these choices it could help create focus and settle on something concrete to try out in their daily context. MoM integrated the menu by offering participants a range of options from which to construct and discover strategies for the specific goal or challenge they were tackling. The same logic was applied to the choice of goal itself: participants started from broad domains, move, eat, and recharge, and were supported in narrowing these into a goal that was specific and personal to them over time, preserving their autonomy over their own behavioral choices.

Designing for discovery

Participants learned most when their plan met reality, uncovering an actual barrier or finding which strategy genuinely fit their context. Framing goal pursuit as an experiment, in which a self-tailored approach was tried out to learn whether it worked, made this something to discover rather than something to get right the first time. In MoM this was supported by a narrative framing of discovering a daily

landscape, and by digital tracking aimed not at goal attainment but at noticing what worked, when, and in which situations.

Connecting action and reflection

Insights from experience have to be carried back into a revised approach. Goal (re)setting moments are motivating occasions to reflect on what helped or stood in the way, and to translate these insights into a revised approach. This formed the basis for MoM's in-person reflection sessions, where participants had a dedicated space to make sense of their captured data together, supported by playful physical materials and personal data visualizations, before updating their goals and strategies.

Taken together, these findings suggest that adolescents can be supported in constructing and adapting their own health behavior strategies by giving them structured support to make their own behavioral choices; by giving them the opportunity to try those choices out in real life and treat the results as something to learn from; and by making space to reflect on what they experienced and inform a revised approach.

Research question 3: ***What strategies and insights for health behavior change do adolescents develop through a self-experimentation serious game, Mapping of Me?***

In Chapter 6, I evaluated Mapping of Me, a three-week hybrid serious game in which adolescent pairs pursue a self-chosen health goal across two cycles of self-experimentation. In a mixed-methods study with 36 adolescents, I examined the strategies participants generated, to what extend goal behavior and strategies were maintained one month later, and the insights participants developed about their own behavior change.

The strategies adolescents developed were highly diverse and personal. Every strategy MoM offered was selected by at least one participant among their top five. Mindset strategies of this last kind were the most widely chosen, appearing in almost every participant's top five, although they were also among the lowest rated for perceived effectiveness, while Action, Space, and Time strategies were rated more highly. The same strategy was often rated differently by different adolescents, indicating that its perceived value lay in personal fit rather than in any inherent strength of the strategy itself. Participants tended to place their strategies before and during the goal activity rather than after it: before-activity strategies prepared the conditions for change, mentally or physically, while

during-activity strategies worked to sustain motivation and lower the threshold for staying engaged, and few strategies were used after the activity was done.

At the one-month follow-up, about three-quarters of participants reported still using at least one strategy; some had applied their strategies to other life domains such as studying, sleep, or cleaning routines, and a subset described adapting existing strategies or adding new ones in the month after MoM. The strategies adolescents developed were therefore not only diverse but, for many, durable and transferable beyond the original goal.

Beyond the generating fitting strategies, adolescents also generated personal insights from their experience. Reflexive thematic analysis of participants' written reflections identified four insights adolescents developed about their own behavior change. The first concerned discovering fitting strategies: through trying strategies in context, participants learned which ones worked for them and why, and several recognized that a strategy chosen for one goal transferred to other parts of their life. The second concerned calibrating realistic goals: participants discovered that initial goals were often too ambitious, abstract, or long-term, and learned that goals should be adjusted rather than abandoned when they proved unworkable. The third concerned uncovering latent problems: participants found that the problem they had set out to solve was not always the actual problem, and only by attempting a solution did upstream issues surface, such as phone use or daily routines underlying a goal to eat better. The fourth concerned constructing and sustaining motivation: participants discovered that the motivation they had initially named was not always what actually drove them, and at follow-up reflected on the difficulty of sustaining motivation across time and recovering after a lapse.

In this sense, self-experimentation functioned as a form of experiential learning. What adolescents gained through Mapping of Me was not the health knowledge typically delivered by serious games, but a form of self-knowledge: a personal understanding of how their own behavior change unfolds, what supports it, and what challenges they encounter. In answer to this research question, adolescents develop diverse, personally fitting, and partly transferable strategies through Mapping of Me, alongside insights about strategies, goals, latent problems, and motivation generated through their experiences.

7.3 Contributions

The main contribution of this dissertation is a design rationale for a person-based, development-oriented approach to health behavior change for adolescents (Kimiecik et al., 2020). This rationale develops in three parts that build on one another: an empirical account of how interconnected barriers and facilitators shape adolescents' experience of health behavior (a), a conceptual argument for self-tailoring as an approach suited to adolescents (b), and initial design principles through which this approach can be operationalized in serious games and beyond (c).

a) Adolescent barriers and facilitators as dynamic configurations

Research on adolescent physical activity has already identified themes of barriers and facilitators shared across a sample (Martins et al., 2015, 2021) or subgroups such as gender (Duffey et al., 2021; Knowles et al., 2014), providing a valuable overview of the common factors at play. Building on this work, Chapter 3 used these common factors in a mixed-methods approach combining Q-methodology and interviews to investigate the relative importance of these barriers and facilitators from individual adolescents' perspectives. Where longitudinal studies have documented developmental declines in physical activity (Corder et al., 2019; Farooq et al., 2020) and qualitative work has traced how adolescents narrate changes in their engagement (Agans & Lerner, 2021; Knowles et al., 2014), this chapter showed that perceptions of barriers and facilitators are not stable individual characteristics but dynamic configurations that shift with age with facilitators becoming more self-development oriented, while barriers tend to accumulate due to increasing responsibilities. This shows how adolescents need to navigate their own specific configuration of barriers and facilitators in order to sustain physical activity behavior. Although this study was specific to physical activity, interconnected barriers and facilitators are likely also relevant to other health behaviors.

b) Self-tailoring as an autonomy-supportive approach

Based on these findings, this dissertation conceptualizes self-tailoring as an approach that positions adolescents as a more active agent in shaping the behavioral change process. Self-tailoring plays into adolescents' growing autonomy and supports them in crafting their own approach to health behavior change.

Starting from health intentions that adolescents may already hold can help bring behavior change interventions into closer connection with their own values and intrinsic motivation (Deci & Ryan, 2000; Strömmer et al., 2021). Rather than delivering standardized behavior change techniques, the design of how to change is delegated (Krippendorff, 2005) to adolescents themselves, who construct their own approach using self-enactable strategies (Knittle et al., 2020). In this way, adolescents are supported in their autonomy while also constructing personal, actionable strategies they can use to overcome the intention-behavior gap. Trying out these self-tailored goals and strategies in daily life through cycles of self-experimentation can help build personal knowledge, skills, and practices (Schraefel et al., 2021) to support health behavior beyond the intervention.

Self-tailoring contrasts with increasingly automated forms of personalization, such as system-driven tailoring, in which a system adjusts content according to demographics, goal types, or usage patterns (Klooster et al., 2024; Rivera-Romero et al., 2023), which can reduce friction in the behavior change process. In self-tailoring, adolescents are instead guided to find out what fits for themselves, scaffolding their autonomy rather than undermining it (Reeve & Cheon, 2021). Although this approach demands more cognitive involvement from adolescents, it may be this kind of macro-engagement (Yardley et al., 2016) with the behavior change process may act as a form of positive friction (Chen & Schmidt, 2024) that helps generate the capacities needed for sustainable behavior change.

c) Design principles for operationalizing self-tailoring

Finally, the dissertation shows how this approach can be operationalized. These design principles were developed and tested in the form of a serious game, but they could also apply to other types of interventions. By scaffolding behavioral choices, designing for discovery, and connecting action and reflection, adolescents become active agents in personalizing and contextualizing their health behavior change. These principles are not exhaustive but offer initial directions.

Design principles like these may help respond to a broader challenge for the field. Behavioral science has accumulated substantial theory and evidence for what sustained change requires (Chapter 2), but the difficulty tends to lie in translating these insights into lasting change. Even interventions that are theory- and evidence-based still routinely produce short-term gains that erode within six to twelve months (Lv et al., 2017; Rhodes et al., 2022). This may be due in part to how interventions are conceived, for instance through the Behavior Change Technique Taxonomy (Michie et al., 2013), which breaks interventions down into their active ingredients in search of the most effective one for use across contexts.

Although some ingredients may be more effective than others, this decomposition may not capture the interconnected and shifting conditions under which real-world behavior takes place (Heino et al., 2021). What makes behavioral science robust, its focus on aggregate effects across populations, may also leave it less equipped to address how behavior change becomes embedded in messy, situated personal contexts. This is where self-tailoring could play a role: rather than adjusting an intervention to a person's characteristics and context on their behalf, it creates the tools and conditions for adolescents to tailor behavior change to themselves.

7.4 Limitations

This dissertation has several limitations, four of which are outlined below.

Sample characteristics. The sample across this dissertation ranged from 13 to 23 years, spanning high school and bachelor students. While this breadth enriched the design process, the life circumstances of these groups differ considerably, making it difficult to determine how the mechanisms investigated here hold across different ages and educational contexts. Participants were also frequently already motivated to change a health behavior and were more often female. Finally, this research took place in a Dutch cultural context that places considerable value on individual autonomy, a value that is central to self-tailoring as an approach. How self-tailoring should be adapted for adolescents of different ages, educational level, and cultural backgrounds should be further explored.

Assessing the impact of an individualized intervention. The personalized design of MoM made its impact difficult to assess. Because each participant pursued their own goal, selected their own strategies, and developed context-specific insights. The evaluation relied instead on self-reported accounts of behavior change and strategy use, which carry a risk of social desirability as well as recall bias. Furthermore, the one-month follow-up suggests some maintained use of strategies but is too short to claim sustainable effects. Future evaluations would benefit from idiographic methods such as N-of-1 designs or longitudinal approaches (Kwasnicka & Naughton, 2020), which track individual trajectories on their own terms and reduce reliance on retrospective self-report.

Focus on approach goals. The intervention was designed around approach goals, the deliberate addition of a healthy behavior, across the Move, Eat, and Recharge domains. It is unclear how self-tailoring and self-experimentation would function for avoidance goals, such as reducing phone use, which may place different demands on participants. The approach developed here should therefore be

understood as evidenced for the voluntary adoption of healthy behaviors, with its applicability to avoidance of unhealthy behaviors remaining open.

7.5 Critical Reflections

Developing health behavior change interventions for adolescents is not a neutral undertaking. Interventions carry assumptions about what causes the problem and who should solve it, and what they can achieve depends on the institutions and research conditions around them. I reflect here on three areas in which this dissertation ran into limits that an individual-level approach cannot address.

Individual agency within structural constraints. Building individuals' capacity to navigate an obesogenic environment can help them, but it does not change the environment itself. When adolescents struggle to maintain a healthy lifestyle because their neighborhood lacks safe outdoor spaces or healthy food is out of reach at home, strengthening their agency is not enough, and structural changes are needed in parallel. Self-tailoring is one response to the diverse needs of adolescent around health behavior, but it is not a sufficient one and must go hand in hand with better policy and urban planning to make a healthy lifestyles more accessible. In addition, self-tailoring requires a significant room for reflection which not every child may be able to afford.

Health behavior change in educational settings. Mapping of Me was designed with secondary schools in mind, but two developments outside the project's control made this difficult. During the project, municipal funding for Lekker Fit!, the health promotion program to which this project was linked, was cut (Kooyman, 2023; Reitema & Bokhove, 2024). At the same time, the Dutch government introduced a ban on mobile phone use in secondary schools from January 2024 (Ministerie van Algemene Zaken, 2023), which directly affected the digital components of the originally planned game. Together, these changes made it unfeasible to embed Mapping of Me in secondary schools within the project timeline, and the final evaluation therefore shifted mainly to university students. How the game would work in secondary schools, and how useful these findings are for school-based health promotion, therefore remains an open question.

Research infrastructure for participatory work. The participatory aims of this project were only partially realized: I had intended to involve adolescents more closely in developing the intervention than I ultimately did. Genuine participatory design requires trust, reciprocity, and sustained relationships (Slingerland & Wang, 2024). Building these proved a considerable challenge, and one I came to understand only late in the process. The transition out of the COVID-19 lockdowns

added to this, as schools were dealing with other pressing challenges. This project illustrates that participatory research may need a different structure than conventional research, with longer timelines that leave room for relationship-building and the flexibility to adapt the design when institutional circumstances change. These are conditions I could have attended to more deliberately in this project.

7.6 Future Directions

This dissertation points to several directions for future research.

The most immediate direction follows from the limitations of the current evaluation. Longitudinal studies are needed to examine whether interventions built around self-tailoring and self-experimentation can translate into more sustainable health behavior over time. Such studies would benefit from idiographic evaluative methods capable of tracking individual trajectories relative to participants' own goals.

The design principles explored here for operationalizing self-tailoring and self-experimentation are initial directions but should be investigated further. There may be many more ways to design scaffolding behavioral choice, designing for discovery, and connecting action and reflection can be expressed across different formats, including fully digital implementations, and adapted to different target groups and behavior domains.

A further direction concerns how self-tailoring and system-driven tailoring might strengthen one another. The two are not a binary but may also be combined where self-tailored goals and approaches are supported by more automated systems. What matters is giving the person greater agency over the systems that support their health behavior change, which can in turn help bring those systems into closer alignment with the user's own long-term interests. Advances in artificial intelligence, and large language models in particular, offer opportunities to enable self-tailoring in this way; for instance by scaffolding self-knowledge, helping adolescents articulate goals and prompting reflection at moments of recalibration rather than substituting algorithmic judgment for personal decision-making.

A final direction concerns the social dimension of health behavior change support. In Mapping of Me, working in pairs appeared to support motivation and accountability. This suggests that the value of the game lay not only in its materials, but also in the social practice it created: a recurring moment in which

partners came together to work on their healthy lifestyle. Designers and researchers of health behavior change interventions, digital ones in particular, could therefore pay more attention to the social practices that form around their tools, as this may be where much of the change takes place.

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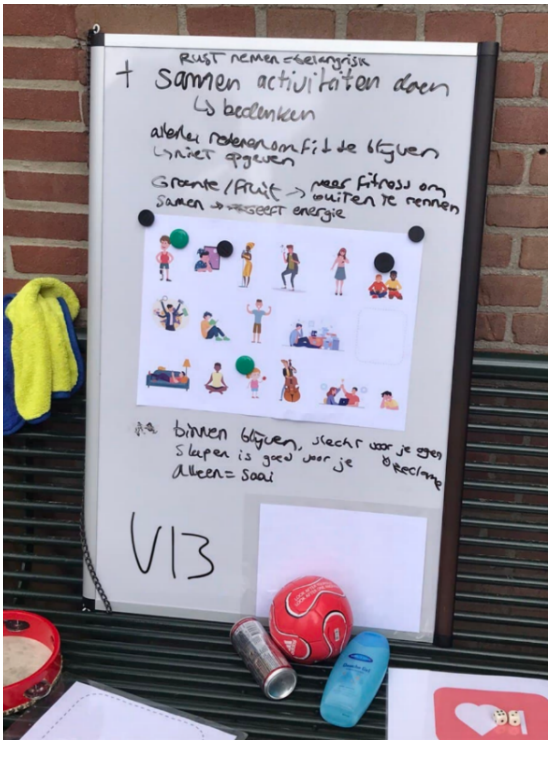
Appendices

Appendix 2A

Materials used during interviews to sensitize adolescents about their active lifestyle.





Appendix 2B

Final list of facilitators used during Q-sorting.

Theme	Facilitator	#
Intrapersonal	Able to be myself	1
	Able to do something that others can't	2
	For my future	3
	Feeling strong	4
	Looking good	5
	Clearing my mind	6
	Feeling good in my body	7
	Competing against others	8
	Learning new things	9
	Releasing my energy	10
	Having good conditioning	11
	Reaching my goals	12
	Making my own choices	13
	Developing myself	14
	Gaining self-confidence	15
	Feeling energized	16
	It's a habit	17
	For my health	18
Interpersonal	Support from family/parents	19
	Avoiding punishment	20
	Being like a role model	21
	Encouragement from others	22
	Being part of a team	23
	Meeting (new) friends	24
	Doing things with others	25
Activity nature	Having fun	26
	Physicality of sports	27
	Challenge	28
	A lot of variation	29
	Good guidance	30
Life factors	Easily combined with other activities	31
	A balanced life	32
	Wanting to maintain something	33
(Environmental) resources	Good weather	34
	In my neighborhood	35
	Environment in which I feel safe	36

Final list of barriers used during Q-sorting.

Theme	Barrier	#
Intrapersonal	Too much on my mind	1
	Too many other distractions	2
	Not feeling well	3
	Feeling lazy	4
	Low energy	5
	Not wanting to go too hard	6
	No motivation (anymore)	7
	Not as expected	8
	Had a bad experience	9
	It doesn't fit me	10
	Not enough freedom	11
	Having to choose	12
	Got out of the rhythm	13
	Not being good enough	14
	Forgot my (long-term) goals	15
Interpersonal	Being judged by others	16
	No support from parents/family	17
	Perceiving pressure from others	18
	Being alone	19
Activity nature	No fun	20
	Not the right level	21
	Not seeing progress	22
Life factors	Lack of time	23
	Other responsibilities	24
(Environmental) resources	Bad weather	25
	Distance	26
	Preparation is annoying	27
	Too expensive	28
	Not enough options	29
	Not the right material	30
	Unsafe environment	31

Appendix 2C

The different types of physical activities that adolescents had maintained.

Activity	Participants
Football	5
Gymnastics	4
Dancing	4
Martial arts	3
Tennis	3
Biking	2
Field hockey	2
Basketball	2
Fitness	2
Sport climbing	1
Skateboarding	1
Playing outdoors	1

Appendix 2D

Weighted average z-scores per facilitator factor.

	Factor				
Facilitator	**A**	**B**	**C**	**D**	**E**
Learning new things	0	0	1	0	0
Doing things with others	2	2	0	0	0
Feeling strong	0	0	0	2	0
Feeling energized	1	0	0	0	2
A balanced life	0	0	2	0	0
Being part of a team	1	1	0	0	0
Meeting (new) friends	0	1	0	0	0
Challenge	0	0	2	0	0
Able to be myself	0	4	0	4	0
Having fun	3	3	1	0	3
Support from family/parents	0	2	1	2	1
For my health	2	0	3	0	0
Reaching my goals	0	0	4	2	0
Good guidance	0	1	0	1	0
Wanting to maintain something	0	0	2	1	0
Having good conditioning	1	0	3	0	1
Clearing my mind	4	0	0	1	0
In my neighborhood	0	0	0	0	1
For my future	0	0	0	0	2
Competing against others	0	0	0	0	0
Releasing my energy	3	0	0	0	0
Feeling good in my body	1	2	0	1	0
It's a habit	0	0	0	0	1
Gaining self-confidence	0	0	0	3	0
Developing myself	0	0	1	3	4
Making my own choices	0	1	0	0	3
Physicality of sports	2	0	0	0	2
Environment in which I feel safe	0	3	0	0	0
Able to do something that others can't	0	0	0	0	0
Looking good	0	0	0	0	0
Avoiding punishment	0	0	0	0	0
Being like a role model	0	0	0	0	0
Encouragement from others	0	0	0	0	0
A lot of variation	0	0	0	0	0
Easily combined with other activities	0	0	0	0	0
Good weather	0	0	0	0	0

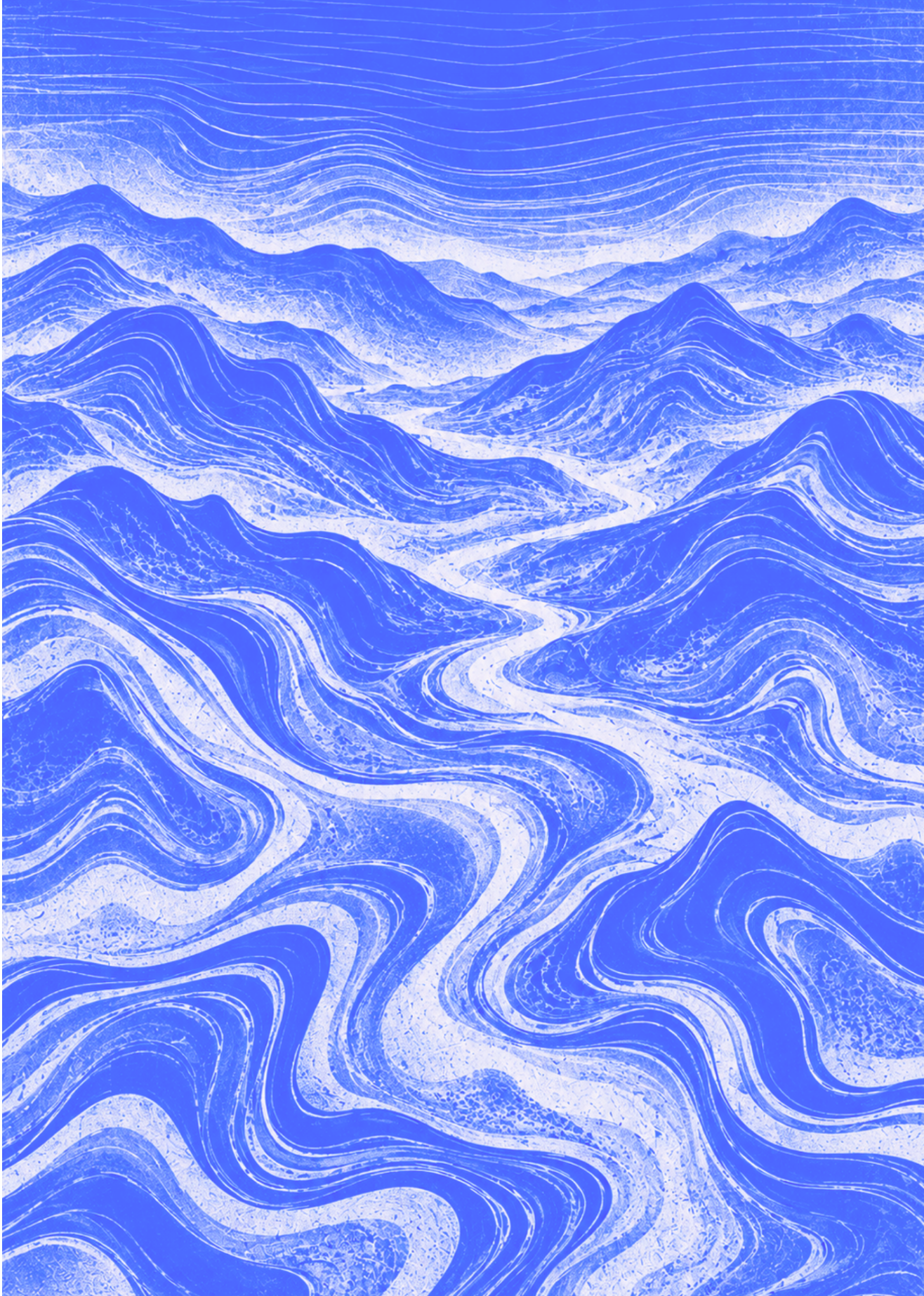
Note: A = '', B = '', C = '', D = '', E = '' and F = ''. "0" indicates that the adolescents in that factor on (weighted) average found that *facilitator not important*; "4" indicates adolescents in that factor

on (weighted) average found that *facilitator most important*. 0 in all columns means that this facilitator was not significantly associated with any factor.

Weighted average z-scores per barrier factor.

	Factor			
Barrier	**A**	**B**	**C**	**D**
Not enough options	0	0	1	0
Other responsibilities	1	1	4	3
Unsafe environment	0	4	0	0
Bad weather	0	0	0	2
Distance	0	0	0	4
Got out of the rhythm	1	0	3	1
Not feeling well	3	0	0	3
Lack of time	2	3	2	0
Perceiving pressure from others	0	0	0	1
Low energy	3	0	0	0
No fun	1	2	0	0
Not the right level	0	0	0	2
Being judged by others	0	0	0	2
It doesn't fit me	0	3	0	0
Not enough freedom	0	1	0	0
No motivation (anymore)	4	0	1	0
Had a bad experience	0	1	1	1
Too expensive	0	2	0	0
Not wanting to go too hard	0	0	1	0
Having to choose	0	0	2	0
Feeling lazy	2	0	3	0
Too much on my mind	2	2	0	1
Too many other distractions	1	0	2	0
No support from parents/family	0	1	0	0
Not being good enough	0	0	0	0
Forgot my (long-term) goals	0	0	0	0
Not as expected	0	0	0	0
Preparation is annoying	0	0	0	0
Not the right material	0	0	0	0
Being alone	0	0	0	0
Not seeing progress	0	0	0	0

Note: A = '', B = '', C = '' and D = ''. "0" indicates that the adolescents in that factor on (weighted) average found that *barrier not important*; "4" indicates adolescents in that factor on (weighted) average found that *barrier most important*. 0 in all columns means that this barrier was not significantly associated with any factor.



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About the Author

Timothy Andrew Houtman was born on July 24, 1994, in Leiden, the Netherlands.

After completing his secondary education at the Visser 't Hooft Lyceum in Leiden, he obtained a bachelor's degree in Liberal Arts and Sciences at Erasmus University College in Rotterdam, graduating in 2016 with a double major in Neuroscience and in Social and Behavioral Sciences. His bachelor's thesis examined the effects of psychosocial stress on health and well being, and how the biological, psychological, and social effects of stress interact.

In 2018 he obtained a master's degree in Health Psychology at Maastricht University, where he studied health behavior change and theories of behavior. He wrote his thesis during an internship at the Psychopharmacology department, on the effects of ayahuasca on well being. In 2020 he obtained a research master's degree in Behavioural Science at Radboud University in Nijmegen. He wrote his master's thesis at the Developmental Psychobiology Lab of the Donders Institute for Brain, Cognition and Behaviour, on long-term associations between infant gut microbiota and weight development over the first twelve years of life.

He then carried out his doctoral research at the Department of Human-Centered Design, Faculty of Industrial Design Engineering, Delft University of Technology, where he focused on how digital technology and serious games can support adolescents in changing their health behaviors. This dissertation is the result of that work.

Timothy currently works as a postdoctoral researcher in the Department of Design, Organisation and Strategy of the same faculty, where he investigates how personalization can support meaningful engagement with digital mental health interventions.

List of publications

Journal articles

(under review) Houtman, T. A., den Besten, D., Sleeswijk Visser, F., van Grieken, A., Bas, M., & Visch, V. *Evaluation of Mapping of Me: A serious game for adolescent health change*. Submitted to a peer-reviewed serious gaming journal.

(under review) de Buisonjé, D. R., Houtman, T. A., Hondmann, S. M., Janssen, V., Sleeswijk Visser, F., Evers, A., & Visch, V. *Designing interventions for maintenance of health behavior change: Insights from health psychology and human-centered design*. Submitted to a peer-reviewed health psychology journal.

Houtman, T. A., Sleeswijk Visser, F., van Grieken, A., & Visch, V. (2025). Dynamics and diversity in adolescents' experienced barriers and facilitators for physical activity maintenance. *PLOS ONE, 20*(9), e0333120. https://doi.org/10.1371/journal.pone.0333120

Houtman, T. A., Eckermann, H. A., Smidt, H., & de Weerth, C. (2022). Gut microbiota and BMI throughout childhood: The role of firmicutes, bacteroidetes, and short-chain fatty acid producers. *Scientific Reports, 12*, 3140. https://doi.org/10.1038/s41598-022-07176-6

Conference papers

Houtman, T. A., Sleeswijk Visser, F., Şekerli, E., & Visch, V. (2026). Designing for self-tailoring in adolescent health behavior change. DRS2026, Edinburgh, United Kingdom. https://doi.org/10.21606/drs.2026.1212

Presentations and posters

Houtman, T. A., Quijada Fernandez D., Jung, J. (2026). *Using genAI as a design tool to co-create personalized digital depression interventions* [Oral presentation]. 40th Annual Conference of the European Health Psychology Society, Pafos, Cyprus.

Houtman, T. A., Sleeswijk Visser, F., van Grieken, A., & Visch, V. (2025). *Self-tailoring health behaviors: Crafting personal strategies with adolescents* [Poster presentation]. ISBNPA 2025 Annual Meeting, Auckland, New Zealand.

Houtman, T., & Bao, K. (2024). *The Mapping of Me: Crafting sustainable health practices* [Dialogue session, Health and Wellbeing]. 4TU.Design United Dialogues "Changing Gears", Dutch Design Week, Eindhoven, the Netherlands. https://www.4tu.nl/du/projects/The-Mapping-of-Me-Crafting-Sustainable-Health-Practices/

Houtman, T. A., Sleeswijk Visser, F., van Grieken, A., & Visch, V. (2023). *Adolescents' perceptions on barriers and facilitators of physical activity maintenance: Diversity and dynamics* [Poster presentation]. ISBNPA 2023 Annual Meeting, Uppsala, Sweden.

Houtman, T. A., Sleeswijk Visser, F., van Grieken, A., & Visch, V. (2023). *Adolescents' perceptions on barriers and facilitators of physical activity maintenance: Diversity and dynamics* [Poster presentation]. 12th Supporting Health by Technology Conference, Enschede, the Netherlands.

Rieff, E., Houtman, T.A., Vijfvinkel, T., Wang, T., Netten, M., & Sweeney, J. (2022). *The Generation Care story and organizing framework* (Version 1.0). Science Education and Innovation Festival: Sustain the Future of Healthcare, Rotterdam, the Netherlands. Zenodo. https://doi.org/10.5281/zenodo.8013123

Workshops

Houtman, T.A., & Faber, J. S. (2023). *Gedragsinzichten toepassen met design thinking* [Workshop]. Congres Gedragsinzichten voor een Gezonde Samenleving, Mechelen, Belgium.

Houtman, T.A., & Faber, J. S. (2023). *Improving the science/society loop by design: How can we strengthen the impact of behavioral science?* [Dare2Share session]. ISBNPA 2023 Annual Meeting, Uppsala, Sweden.

Visch, V., Faber, J. S., Houtman, T.A., Vegt, N., & van den Brink, N. (2023). *Exploring transdisciplinary collaborations for healthy cities* [Workshop]. The Healthy City Conference, Rotterdam, the Netherlands.

Adolescence is a period of shifting interests, new social roles, and growing autonomy. Amid these changes and competing demands such as school, friendships, and other obligations, establishing and maintaining a healthy lifestyle is difficult, and health behavior change interventions for adolescents tend to show short-term effects. This dissertation asks how interventions can be designed to support sustainable health behavior change during this period, by helping adolescents learn to navigate these competing demands themselves. I investigate how insights from behavioral change theory can be translated into serious games through human-centered design. First, I examine adolescents' experiences with one healthy lifestyle behavior, physical activity, and identify the facilitators and barriers they encounter, which differ between adolescents and change over time. Building on these insights, I developed Mapping of Me together with adolescents, a game designer, and design researchers. In this serious game, adolescents set their own health goal and experiment with self-enactable strategies to reach it, learning through experience which approaches fit them. An evaluation with thirty-six adolescents showed that most continued to use their strategies one month later, both for their goal and in other areas of life. These strategies can act as learned skills that support not only current behavior change goals but potentially future ones as well.