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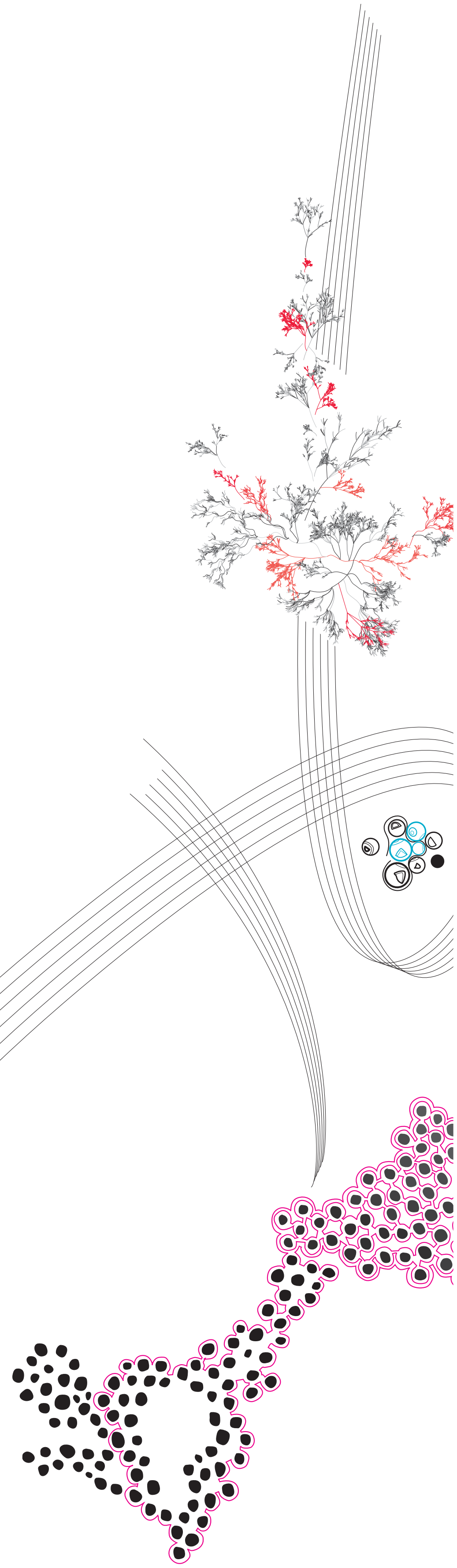

Breathless Battles: The Optimization of an eHealth Application for Support in Self-Management for COPD Patients with Complex Chronic Conditions through Human-Centered Design

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List of acronyms

COPD *Chronic Obstructive Pulmonary Disease*

HCD *Human Centered Design*

HCP *HealthCare Professional*

CCC *Complex Chronic Conditions*

mHealth *Mobile Health*

eHealth *Electronic Health*

UI *User Interface*

AI *Artificial Intelligence*

RRD *Roessingh Research and Development*

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Abstract

COPD is a progressive lung disease that makes it difficult to breathe. There is no cure for COPD, but it is possible to manage the symptoms and slow the progression of the disease. Self-management of the disease and symptoms is an essential part of treatment. COPD patients often have difficulty understanding and managing their disease.

The objective of this thesis was to optimize a self-management tool for COPD patients called Healthentia by improving its intuitiveness and accessibility and by doing so promoting the aspects of engagement, usability and a positive user experience. This was done by *Human Centered Design* (HCD) principles. First, the context of use was defined in a usability report. Second, this usability report was used for the ideation phase. New concepts and ideas for Healthentia were created and evaluated here, which led to the final proposed prototype. At last, this prototype was evaluated through a usability test with COPD patients.

Four main findings emerged. Firstly, is that the multifaceted nature of user satisfaction and engagement was highlighted. Notably, the completion time did not seem to influence user satisfaction and engagement, but rather the COPD patients' confidence and ease of navigation in the Healthentia prototype. Secondly, is that a clear distinction was found between the needs of inexperienced and experienced COPD patients. Experienced patients acknowledge the potential value of the Healthentia prototype for inexperienced COPD patients. However, this still needs to be validated with inexperienced COPD patients and unfortunately, the optimized prototype's precise utility for experienced COPD patients remains unclear. Thirdly, using a well-established design system as a building block for the optimization of a Health tool doesn't guarantee optimal usability for every target group. Especially for elderly target groups, which have their unique needs for digital tools. Lastly, it was shown how HCD could be optimized for COPD patients and how this can be used in future studies with this target group.

To conclude, this thesis used a holistic approach to optimize the self-management tool Healthentia for COPD patients. The insights gained from this research contribute valuable knowledge for design and usability considerations of digital health tools tailored to the specific needs of COPD patients.

Keywords: COPD, eHealth, mHealth, UX design, usability, HCD, UCD

1

Introduction

COPD is the third leading cause of death globally in 2019 [65]. Figure 1.1 summarises what COPD entails and what the symptoms and causes are. People living with COPD suffer from breathlessness and often have difficulty doing daily tasks such as cleaning the house, grocery shopping or going out in general among other things [50, 82]. COPD on its own is preventable and treatable, however many patients with COPD have multiple *Complex Chronic Conditions* (CCC) that make treatment difficult [59]. There are many disciplines involved with treating the complaints of COPD and their CCC, which makes it hard to find the right treatment. And, with the rising number of patients with COPD and multiple CCCs there is a need for a personalised and holistic approach to support and manage care for these patients [78].

There have been studies that have looked into how to improve the care that is provided to COPD patients, how COPD is managed and how COPD patients are supported. These studies varied from interventions for increasing or maintaining physical activity [57, 17, 18, 25] to smoking cessation [47], to improve health literacy [74] and more [20, 77, 52]. These interventions are all relevant for COPD patients and their *HealthCare Professional* (HCP). However, many are temporary solutions and there is also a need for long-term solutions for use at home [42]. For example, smoking cessation programs help COPD patients change their smoking behaviour [38], Nonetheless, the abstinence rate significantly decreases in the long term. The decrease in the abstinence rate over time shows that there is a need for a more permanent and consistent solution; a solution that leads COPD patients to be more independent by self-managing their disease.

Self-management is the process which helps people to actively cope with their disease in the context of their daily lives [58]. Supporting individuals to self-manage helps them reduce the burden of their disease [80, 19]. Additionally, supporting individuals with self-managing their disease can have positive effects on their quality of life [66]. There is some evidence that shows that patients with effective self-management skills make better use of healthcare professionals' time and have enhanced self-care [22]. There are different ways to stimulate and maintain self-management. Literature has shown that self-management mobile applications can be effective in supporting older patients in self-managing their disease [83, 62]. Therefore a *Mobile Health* (mHealth) application could be a possible solution. Hallensleben et al. did a scoping review of the effectiveness of *Electronic Health*

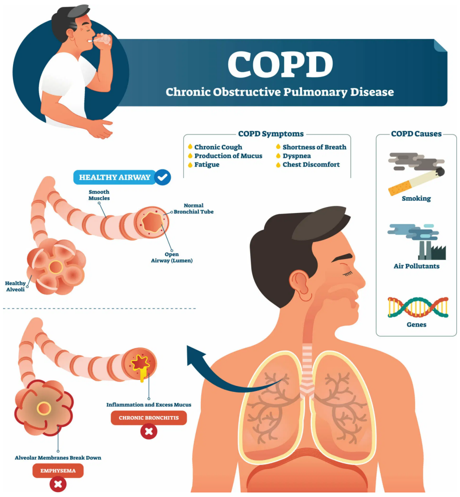


Figure 1.1: Chronic Obstructive Pulmonary Disease
[3]

(eHealth) for patients with COPD in the Netherlands [43]. They found 13 healthcare programs and patient platforms, 13 self-care and informative websites, and 15 applications that focus on COPD care, medication adherence, smoking cessation and information about COPD-related topics. Five of the 13 healthcare programs and patient platforms were evaluated through small studies. The findings show positive effects on improving the quality of life or reducing hospital admissions for COPD patients. At the time of the review, there was not yet evidence available about the effectiveness of the other programs and platforms as research was still ongoing for most of them. Then six out of the 15 identified applications were found to be effective. This shows the potential of these types of applications for COPD patients, but there is much left to improve before they can be used on a larger scale. For example, the amount of implemented functionalities in these applications. Furthermore, it is necessary to understand what type of support can be helpful, what is effective in supporting COPD patients with CCCs, and evaluate whether a proposed solution is suitable for COPD patients with CCCs.

Nimmanterdwon et al. conducted a systematic review that showed that HCD can be used to create mHealth solutions for older adults with positive outcomes [62]. Harte et al. developed a methodology to implement HCD while maintaining rapid development. This methodology can help to clearly define the process and ensure objective and quantifiable results[44].

Through the methodology of Harte et al., I aimed to contribute more evidence-based results through a case study as part of the European-wide project RE-SAMPLE [15] and give insights into how HCD can be optimized for this target group. RE-SAMPLE aims to mitigate the severity of COPD patients' complications and reduce their frequency. They use the Healthentia platform, developed by Innovation Sprint[11], as the foundation for their self-management application.

Healthentia is an eClinical solution that is designed to support COPD patients with CCCs [7]. I conduct this thesis in parallel to the development of Healthentia to collect insights into how the user experience of a self-management application for COPD patients with CCCs can be optimized to create an intuitive and accessible *User Interface* (UI) through human-centred design. RE-SAMPLE is an ongoing project and has severable deliverables. I use the first prototype deliverable, the monitoring app of Healthentia, as the foundation for further research. During this study, RE-SAMPLE continues to develop Healthentia. The

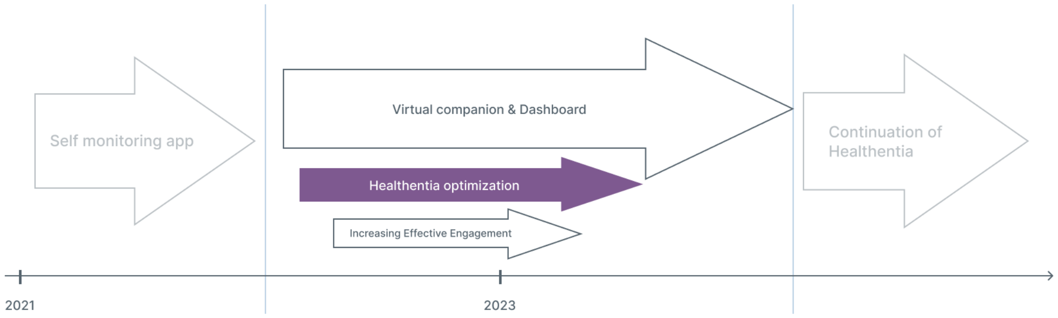


Figure 1.2: RE-SAMPLE project timeline

upcoming deliverables are the companionship program and a clinical dashboard. On top of that another study is conducted on how to promote engagement [30]. The intermediate results of those studies are not used in this study. The next step of RE-SAMPLE is to combine the monitoring app with the companionship program, this study and the study on how to improve the engagement of COPD patients to create the next deliverable. Figure 1.2 gives a visual overview of the timeline of deliverables.

Thus, I aimed to optimize Healthentia by creating an intuitive and accessible UI for a self-management support application for COPD patients with CCCs through a holistic approach with HCD. The application should promote engagement, usability and a positive user experience. To do this it was important to research what considerations are essential for creating an intuitive and accessible UI for COPD patients with CCCs. Through HCD, I also aimed to show how HCD can be applied and how it is beneficial for developing a self-management app for COPD patients with CCCs. My results give insight into how HCD can be applied to creating eHealth solutions for COPD patients. These insights can then be used for future developments in RE-SAMPLE.

1.1 Objective and research questions

The objective of my thesis was to optimize a self-management tool for COPD patients called Healthentia. I aimed to do this by improving intuitiveness and accessibility. Furthermore, the design should promote the aspects of engagement, usability and positive user experience. All this should be improved while also considering the specific needs and preferences of COPD patients with CCC. This led to the following research questions:

RQ 1: How can the design of a self-management tool for COPD patients be optimized to create an intuitive and accessible user interface that promotes engagement, usability, and positive user experience, while considering COPD patients' specific needs and preferences?

SQ 1.1: Can standardised design system guidelines be used to create and design an intuitive and accessible user interface for COPD patients to engage effectively with a self-management tool?

SQ 1.2: How do COPD patients perceive the usability and overall experience of using a self-management tool designed specifically for their condition?

SQ 1.3: How can human-centred design enhance the development of a self-management tool for COPD patients?

1.2 Approach and outline

To address the research questions, I aimed to optimize the design of the self-management tool, Healthenthia, for COPD patients with CCC, employing HCD principles. The HCD approach will provide valuable insights into the specific needs and preferences of users, informing the design elements essential for creating an engaging and user-friendly interface. To address SQ 1.1, I applied a material design system mixed with the Healthentia design system and conducted a focus group and a usability test to gather RE-SAMPLE researchers' and COPD patients' perspectives. By going through this process I gained insights into whether applying an existing design system will aid the design process and whether it can improve the usability and accessibility of Healthentia. To answer SQ 1.2, I employed a mixed-methods approach, incorporating interviews, surveys, and usability testing to assess COPD patients' perceptions and experiences with Healthenthia. Qualitative data offered in-depth insights into user satisfaction and identified areas for improvement. For SQ 1.3, I followed a HCD process for the development of Healthenthia, involving COPD patients, throughout the iterative design and prototyping phases. Their input was integrated into the tool's features and functionalities, ensuring it aligns with the needs of the COPD patients. Healthcare professionals and experts were also actively involved to ensure Healthenthia adheres to evidence-based COPD management practices. The study's outcomes contribute to optimizing Healthenthia's usability, engagement, and overall user experience for COPD patients. By prioritizing user preferences and needs, I aimed to empower COPD patients to effectively manage their condition, ultimately leading to improved health outcomes and an enhanced quality of life. I did this by creating an optimized Healthentia application and adjusting the HCD approach to the needs of COPD patients. The reflection on this process, combined with insights gained from usability testing, offers an understanding of how HCD principles can be effectively applied to the unique needs of COPD patients.

The remaining chapters of this document are related works about the needs of COPD patients in literature and the identified needs of internal studies of RE-SAMPLE. Furthermore, I gave an overview of previous mHealth applications for COPD patients and elaborated on Healthentia. In chapter three I described the context of use and in chapter four the ideation phase. In the latter chapter, I presented the idea generation, concepts, wireframes for the first prototype and the results of the evaluation with RE-SAMPLE researchers and usability experts. Then, in chapter five I described the usability test. Furthermore, in the general discussion, I discussed important and interesting findings. Next, I reflected on how the findings can be generalized and how these contribute to the RE-SAMPLE project in future work. At last, the conclusion is where I summarised and concluded my thesis.

2

Related Works

2.1 Needs of COPD patients

In this section, I delved into the discerned needs of individuals diagnosed with COPD as outlined in the existing literature. Numerous studies have explored the challenges faced by COPD patients and proposed various strategies to offer support. The structure of this section aligns with the three categories of COPD patients' needs, as identified by Gardener et al. [35].

2.1.1 Physical

This category describes three domains. The first is understanding COPD. Patients with COPD often feel they have inadequate knowledge of their illness. Although they receive information from their general practitioner and other HCPs, meetings are often short and insufficient to answer all their questions. The need for more information has been met in multiple ways. For example, Gysels & Higginson found that COPD patients, who succeed in self-managing breathlessness, viewed coping with breathlessness as a learning process and felt closer to relieving distressing symptoms with more information about COPD [42]. In addition, they found that those who participated and persisted in pulmonary rehabilitation (PR) experienced gradual progress and the achievement of working out of disability. PR taught the patients about their illness, its progression, care options, breathing skills, and all they missed in previous consultations at home. However, COPD patients still experience a lack of information about the nature of COPD and miss the opportunity to have an in-depth discussion about it. To summarise, COPD patients need to understand their illness better by having in-depth discussions about COPD to relieve themselves of distress.

The second domain is managing symptoms and medications. Similarly to the first domain, the unmet needs are mostly about insufficient and inadequate information [37, 68]. Gardener et al. found that the insufficient and inadequate information mostly is about the management of illness [37, 64]; medication and the side effects of medicine [68, 81]; information about the available tools [68, 69, 64] and when to seek help when symptoms deteriorate [68, 64, 67, 39]. Besides the need for more in-depth information, Gardener et al. found that COPD patients would like their medication reviewed more frequently [56] and would like someone to consult with about making decisions about lifestyle and other related topics about living with COPD [32].

Some of these needs can be or are already met through respiratory nurses providing information about breathing techniques and the effective use of medication [21] and PR where patients learn to cope with their symptoms, how to use the available tools and learn breathing exercises [42, 69, 33]. Other ways that could support the needs of COPD patients are swift support from the GP [21] and a direct contact that can respond to immediate concerns at all times [39, 21, 33, 50, 48].

The final category is the healthy lifestyle domain. The met need is to discuss or address their smoking behaviours [63]. However, COPD patients need more support in how to change their lifestyle [68]. These can be suggestions they can do at home or in a specific program [64, 40]. Most studies that Gardener et al. reviewed focused on smoking behaviour and how to change that. These findings are crucial for living a healthier lifestyle for patients with COPD, as smoking has a significant effect on the development of COPD. Moreover,COPD patients want to be able to discuss lifestyle choices in a non-judgemental context [68]. The non-judgemental context allows them to evaluate their lifestyle and potentially change their view on the need to change their lifestyle. A non-judgemental context establishes a safe and comfortable environment where COPD patients can discuss any concerns without feeling pressured to choose a specific lifestyle.

To summarise, COPD patients miss adequate and in-depth information about COPD the most. They want to understand what their illness is; what positive and what side effects medication has; and what they can do about their illness. Additionally, they want to be supported in their journey to improve their health. Specifically in the form of more information on how to improve their lifestyle; guidance in making decisions concerning their health; and an overview of who to call when. COPD can bring sudden concerns and COPD patients need to have a direct contact person that they can contact at all times to address these concerns. Whether this is during working hours, at night or during the weekends. At last, they want the possibility to discuss the nature and prognosis of COPD with their preferred HCP. From this, it can be concluded that COPD patients want more information about their disease and more guidance in improving their lifestyle.

2.1.2 Psychological and Emotional

Within this category, it becomes clear that COPD patients feel alone in dealing with COPD and often feel that they are the only one with COPD [69, 46, 26]. Even though their physical needs can be met, they still deal with feelings of frustration and anxiety [69]. They need psychological support and special services to deal with the psychological impact of COPD on the patients' lives. Additionally, COPD patients need to share their experiences and feel listened to and understood [21, 33, 46]. This can be either done by HCPs or peers [33]. This satisfies the need to be heard and helps them feel less alone [53]. Furthermore, it helps them validate their experiences [53]. At last, there is a need to discuss and plan for the future [67, 81, 60]. There are opportunities for COPD patients to plan for the future, however, they also want the opportunity to address emotions regarding the future [60, 46] and to discuss and plan for future treatment and care [60, 55]. In conclusion, COPD patients need professional support in dealing with the psychological impact of COPD and need the support of their peers to relieve feelings of loneliness and to live positively with COPD.

2.1.3 Social

This category is more about how one lives in society than it just is about the social lives of COPD patients. These needs show that COPD patients not only need support in improving their physical health and mental health but also need support to maintain independence at home[36]. Several ways are identified that can preserve and maintain the independence of COPD patients. Such as, support from the COPD patients' circle [45, 50, 48, 32]. This can be personal care at home by family or from professional care [32, 82, 48, 41]. Due to the breathlessness COPD, patients often struggle with daily life things. If family, friends or carers can help them with general house tasks and sometimes things such as medication, dressing, food and drink preparation, then COPD patients can maintain their independence at home. Additionally, mobility plays an important role in maintaining independence. COPD patients can be supported and encouraged to stay mobile through assisting devices like wheelchairs among others [32]. Assisting devices allow them to continue living on their own.

Similarly to the other categories, there is insufficient information about certain topics in this category. There is a need for information and support on how to access financial benefits [37, 69, 45, 39, 75] and housing options [67, 39]. Gardener et. al state that this information need is not directly reported. However, they mention that there is evidence of patient frustration and concern over the lack of information and the time required to access the financial benefits [36]. Also, there is a lack of information about available services [37, 39], which is relevant to maintaining social and recreational life and maintaining independence. Gore et. al did a survey and found that there is a lack of information regarding the possible social benefits and services COPD patients can receive [37]. However, they did not specify which specific services COPD patients need more information on. This shows that it is unclear to COPD patients what services there are in the first place and how to access these services. All in all, even though there are sources where COPD patients should be able to find the needed information, they do not know where to find it.

To conclude, there is a need to have help with daily life tasks and more information on how to access services for assisting devices to maintain independence. And there is a general need for information on available services and social benefits.

2.2 Human Centered Design

Harte et al. proposed a methodology that follows the four general phases of HCD while maintaining a rapid pace of development [44] specifically within the context of the competitive connected health industry. They defined a three-phased methodology. In the first phase, they establish the context of use and user requirements. The suggested activities are to present the use cases to a group of experts with knowledge of the system and/or usability and to present them to a group of end-user representatives. The process and findings should be reported in a usability report that is made up of user requirements defined through quantitative and qualitative data, flow diagrams, storyboards, screenshots, interface mock-ups, paper prototypes, and descriptive end-user profiles.

In the second phase, the prototype should be presented to an expert group. By doing this, the prototype can be tested on usability, human factors, overall user experience characteristics, and functionality of the prototype. Problems that are uncovered at this stage need to be prioritised and addressed by the design team. Tests can be performed until the requirements defined in phase one are met. The activities Harte et al. suggest for this phase are to perform a usability inspection with a multidisciplinary group of design

experts and system experts to identify usability and human factor problems. This can be done in the form of a heuristic evaluation or a cognitive walk-through. The findings of this phase should be added to the usability report. At the end of this phase, there should be an advanced prototype with full functionality available with accompanying user manuals.
In the last phase, phase 3, the final prototype should be evaluated with the end-users through user testing. Testing can take place in either a lab setting or, preferably, in a real-world setting. The tests should measure the three defined evaluations of ISO 94210 210: User satisfaction, efficiency, and effectiveness. User satisfaction can be objectively measured through scales such as the User Experience Questionnaire (UEQ) [14], Quebec User Evaluation of Satisfaction with Assistive Technology [29], the System Usability Scale (SUS) [24], and the eHealth UsaBility Benchmarking Instrument (HUBBI) [23].
M. Broekhuis & L. Van Velsen recently developed the (HUBBI). It uses a new ontology of usability factors that was specifically developed for the eHealth domain. This benchmark results in a score in seven categories, namely Basic System Performance, Task-Technology Fit, Interface Design, Navigation & Structure, Information & Terminology, Guidance & Support and Satisfaction.
Efficiency and effectiveness can be measured by measuring the time of task completion, task completion rates, and errors. In addition to the objective measures, it is insightful to video record and take notes during the evaluation. This could reveal any usability and human factor problems. Additionally, the think-aloud method can give deeper insights while performing the tasks for testing [28, 49].

To summarise, Harte et al. used these guidelines to define a methodology for rapid development within the context of the competitive connected health industry and suggested what activities could be used at each stage of the process.

2.3 Design Systems

A design system for mobile app design is a set of guidelines, assets, and documentation that defines and maintains the visual and functional aspects of a mobile application. It serves as a centralized resource to ensure consistency and efficiency in the design and development process. This is commonly used to stick to a certain brand, therefore many companies and brands create their own design system to maintain a unique identity. These design systems usually contain design principles, colour palettes, typography, iconography, components and UI elements, layout grids, user interface patterns, images and illustrations, animations and micro-interactions, accessibility, design assets, and documentation on all of these and how to use them. There are many of these design systems out there. However, it is not always necessary to create your own design system from scratch. Some companies can do many user studies and can gather data on what works best for usability, accessibility and more. Therefore, it can be tactical to use these design system's guidelines to ensure a certain usability and accessibility. The following design systems can be considered for this purpose:

- Google - Material design [12]
- Apple - Human Interface Guidelines [9]
- Microsoft - Fluent design system [8]
- IBM - Carbon design system [2]

2.4 RE-SAMPLE

The RE-SAMPLE project, initiated in 2021, is a European initiative aimed at improving the care provided to individuals with COPD and complex chronic conditions (CCCs) through innovative eHealth services. At the time of writing of this thesis, the project was in the development phase, with the primary goal of creating an effective tool to support COPD patients and healthcare professionals in managing COPD and reducing the burden on hospitals. At its state of development, the eHealth tool, Healthentia, could monitor and track the symptoms experienced by COPD patients. By leveraging this tool, patients could record their symptoms and other relevant information, allowing for continuous monitoring of their condition. This feature enables patients to have a better understanding of their health status and provides healthcare professionals with valuable data to assess their condition remotely.

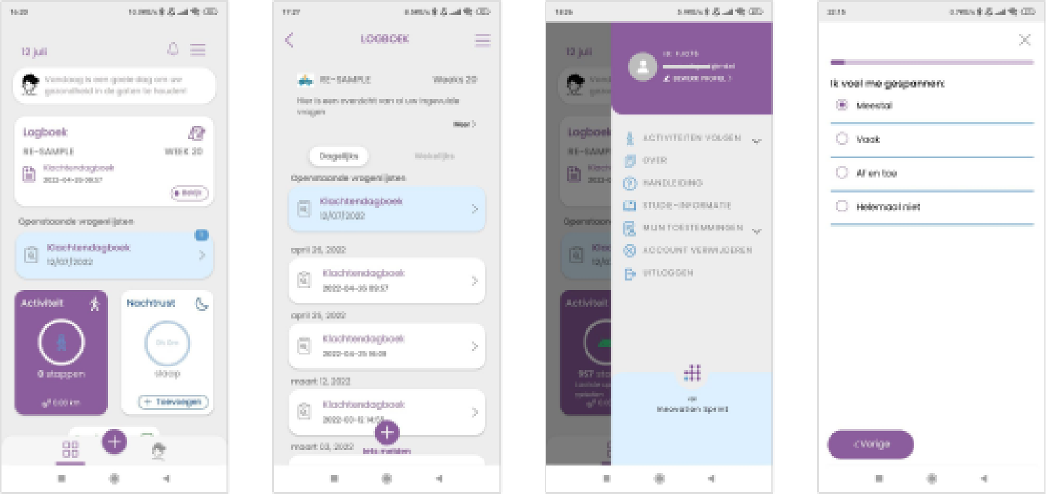
The project envisioned further advancements in the eHealth tool's functionality, such as implementing *Artificial Intelligence* (AI) techniques to predict the likelihood of exacerbations. This predictive capability should enable patients to receive personalized feedback and support, empowering them to take proactive measures in managing their condition effectively. Additionally, the eHealth tool aimed to provide COPD patients with personalized treatment recommendations and a virtual companionship program. These features have offered patients guidance and support throughout their COPD journey, improving self-management and overall well-being. Recognizing the importance of shared decision-making between healthcare professionals and patients, the project included an active support program specifically designed for healthcare professionals. This program aimed to aid professionals in making informed treatment decisions, monitoring patient progress, and predicting potential risks associated with COPD.

The RE-SAMPLE project is a four-year endeavour, spanning from 2021 to 2025, and involves a multidisciplinary consortium with partners in Italy, Estonia, and the Netherlands. *Roessingh Research and Development* (RRD) leads the user involvement for iterative design, ensuring that the eHealth tool is tailored to meet the specific needs and preferences of both patients and healthcare professionals. To develop the AI capabilities of the eHealth tool, Innovation Sprint with expertise and an interest in end-user insights is responsible for its implementation. This collaborative effort allows for gathering valuable user input and refining the technology based on user needs, ultimately enhancing its usability and effectiveness.

While the RE-SAMPLE project is still in development, the state of the eHealth tool enabled the monitoring and tracking of symptoms for COPD patients. The project's ultimate goal was to further enhance the tool's capabilities, leveraging AI to predict exacerbations and providing personalized feedback and support for patients, thereby improving self-management and reducing the burden on hospitals. This thesis contributed by focusing on optimizing the self-management tool Healthentia, developed within the RE-SAMPLE project, to improve its intuitiveness and accessibility while promoting engagement, usability, and positive user experience for COPD patients. The objective was to tailor the design of Healthentia to meet the specific needs and preferences of COPD patients, enhancing their ability to effectively manage their condition.

2.4.1 Healthentia

Healthentia is an eHealth tool developed by Innovation Sprint intended for monitoring non-vital parameters to support decision-making in clinical trials. This tool served as the foundation for the RE-SAMPLE project, with Innovation Sprint responsible for imple-



Ik voel me gespannen:
● Meestal
○ Vaak
○ Af en toe
○ Helemaal niet

Figure 2.1: Screenshots of the Healthentia app

menting the requirements and research within RE-SAMPLE. The monitoring app, used as a starting point for this thesis, provides several features for COPD patients, including symptom tracking, weight monitoring, and a history of filled-in symptoms. The app also integrates with smartwatches to automatically track variables such as steps taken and hours of sleep. Figure 2.1 showcases screenshots of the Healthentia app in its current state. While RE-SAMPLE continues to develop new features, these have not yet been implemented for the next deliverable of the project. Healthentia empowers COPD patients to monitor their symptoms and non-vital parameters, contributing to improved decision-making in clinical trials within the RE-SAMPLE project.

2.5 Applications and features

There were many eHealth implementations defined within literature and some were available in the app store, however, there seems to be a lack of evidence whether it is effective [79]. Although many eHealth implementations were not proven to be effective yet, there already have been a lot of studies exploring what kind of features such self-management applications should include. Sobnath et. al reviewed 48 mHealth applications [76]. In their approach, they looked into identified features in research studies and into features that are commonly used in self-management applications. The features that have been identified can be divided into six categories.

The first category is tools which help COPD patients with self-management of COPD. The tools varied from functionalities like diaries, questionnaires and reminders. But also included programs that are specifically focused on medication adherence. The following features can be considered in this category:

- Questionnaires
- Diaries
- Predicting exacerbation
- Tracking environmental factors

- Goal setting
- Reminders
- Device tracking
- Email/SMS
- Self-registration techniques
- Medication adherence

The second category is focused on the physical health of COPD patients. This category included a shuttle-walk test, dyspnea management, endurance shuttle-walking test, and other physical health programs.

Third, is the category that focused on education. Many studies are focused on educating COPD patients about their disease and how to manage it. Common topics that are handled in these studies are smoking cessation advice and support, breathing techniques, self-management for physical activity, lifestyle management and general COPD education.

Fourth, is the category which related to personal information. This category includes personalised feedback, personal reports on COPD patient health, nutritional advice and real-time personal information about their COPD.

The fifth category is social. The features that were included in this category are social networks and connecting COPD patients to their stakeholders. These stakeholders could be for example their HCPs or their general practitioner.

And lastly is the external category. This category included monitoring of the COPD patient and personalised coaching.

Furthermore, Sobnath et. al downloaded 20 of the 48 applications they found and identified the most common features. The following features were the most common in the downloaded applications:

- Education
- Medication treatment
- Guidelines
- Look-up tables
- Symptom tracking
- Diary or calendar History
- Email
- Calculators

2.6 Self-management

In self-management programs for COPD, interventions were designed to enhance the patient's efficacy beliefs and confidence in outcomes. This should be considered as important as strategies to increase the patient's knowledge about COPD because self-efficacy is a fundamental intermediary objective for reducing health care utilization due to COPD exacerbations [22]. Self-management interventions helped COPD patients to learn and practise skills that helped them to carry out disease-specific medical regimens, guide changes in health behaviour and provide emotional support to enable patients to control their disease[16]. Thus, self-management was where the patient had the skills to manage their disease and knew when to take certain actions based on their observations. This followed the definition of Barlow et al. [16]:

> "... manage the symptoms, treatment, physical and psycho-social consequences and lifestyle changes inherent in living with a chronic condition. ... (the) ability to monitor one's condition and to effect the cognitive, behavioural and emotional responses necessary to maintain a satisfactory quality of life"

As noted by Kaptein et al. [51] Barlow et al.'s definition emphasised the point of view of the patient, where second came that HCPs and the family of patients encouraged the patient to acquire and apply the skills for managing their disease. These skills pertain to [16]:

- Gathering information
- Managing medication
- Managing symptoms
- Managing psychological consequences
- Adjusting lifestyle
- Using social support
- Communicating effectively

In some cases, self-management was used as another word for "education" and "giving information". However, self-management is much more than the skills mentioned. Self-management for patients with chronic illness has three life-long self-management tasks medical and or behavioural management, life-roll management and emotional management [54]. For these three tasks, COPD patients need the skills previously mentioned. Self-management can be intimidating at first for COPD patients because they have to learn and practice multiple skills. A way to support COPD patients with self-management is through mobile applications. However, the effectiveness of self-management mobile applications in comparison to usual care is still unclear [73]. Therefore, more in-depth research on the effectiveness of mobile applications for the self-management of COPD is needed.

2.6.1 Building habits

Self-management programmes aimed for structural behavioural change to sustain treatment effects after the programmes have been completed [31]. Building healthy habits for self-management could be an interesting approach to sustaining treatment effects. A habit is a behaviour that has been repeated enough times to become automatic [27, 34]. Once behaviour becomes automatic it costs little energy and effort [27, 34] and should then make it easier to stay consistent with self-management.
According to James Clear, a habit can be broken down into four steps: cue, craving, response and reward [27]. These steps can be implemented by applying The Four Laws of

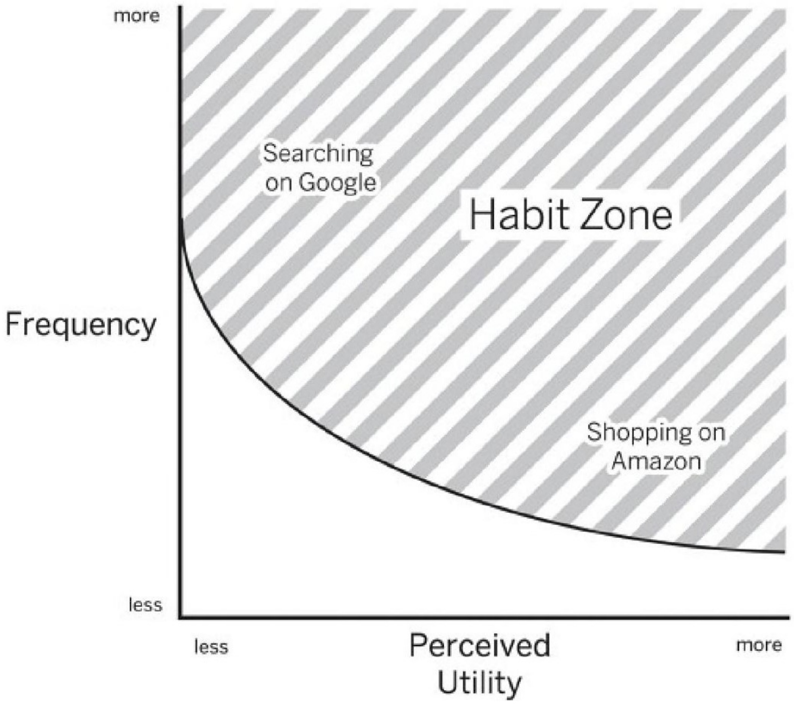


Figure 2.2: The habit zone
[34]

Behavioural Change [27]. The laws are to make it obvious, make it attractive, make it easy and make it satisfying.
Similarly, Nir Eyal defined the four steps as trigger, action, variable reward and investment [34]. Both models are similar and focused on creating habits. However, Clear's model is focused on creating and breaking general habits, and the Hook model is specifically made to create habit-forming products. One of the essential things for creating habit-forming products that Eyal elaborated on is the habit zone [34]. The habit zone is when a behaviour occurs with enough frequency and perceived utility. However, if any of these two falls short, then the habit is hard to form. Figure 2.2 shows a visualisation of the relation between the frequency and perceived utility of a potential habit.

To summarize, building habits for self-management could potentially help with sustaining the behavioural change treatment effects. To build a habit four essential steps can be implemented using the Four Laws of Behavioural Change defined by James Clear [27]. If these are implemented and the behaviour occurs with a certain frequency and perceived utility, then a habit is potentially formed.

2.6.2 Gamification

A possible way to implement building habits in the app is through gamification. Gamification is generally defined as the use of game elements and mechanics in non-game contexts [72]. There were some apps that used this approach to motivate and teach their users in a fun way. For example Duolingo [5], Fabulous [6] and MyTherapy [13]. These apps all used game elements to motivate their users and aimed to make a habit of using their app. In the literature review of Sardi et al. [70] they found, despite the challenges of gamification, that studies show a positive effect on the perceived experiences of users with diverse health conditions. Additionally, the studies they reviewed emphasized the positive effects of socialization on users' engagement with gamified applications. Most studies they reviewed reported to use of a combination of different game mechanics such as feedback, rewards, progression and social features. Similar to the previously mentioned examples. To summarize, gamification is the use of game elements and mechanics in non-game contexts. This can be used to positively influence the experience and motivation of users and with that stimulate them to build healthy habits.

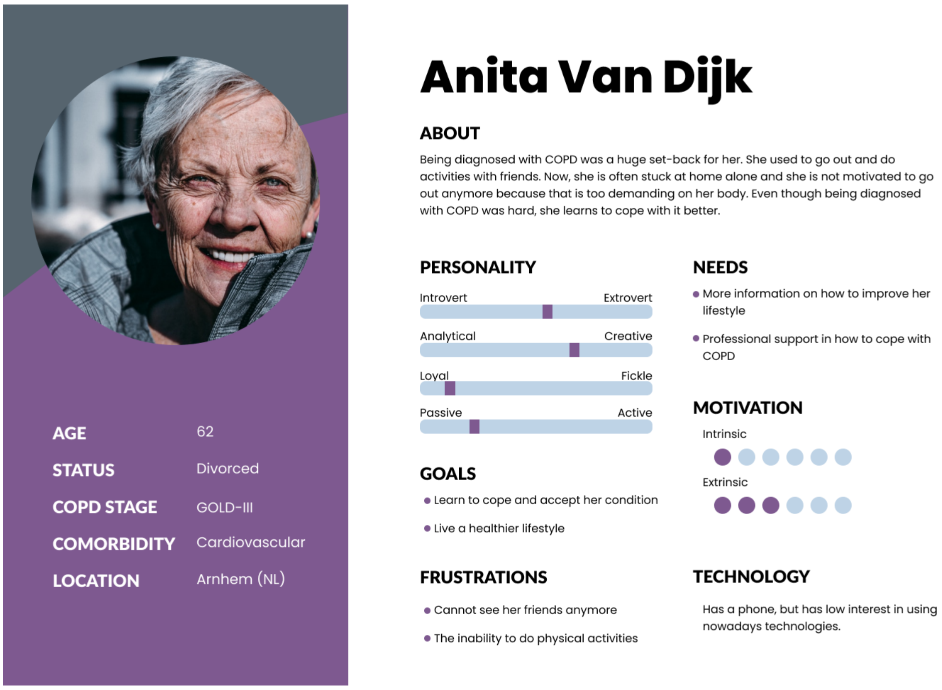
3
Defining the context of use

3.1 Introduction

In this chapter, I outlined the process of establishing the context of use and defining user requirements. The culmination of this process was a comprehensive usability report, which not only built upon prior research in RE-SAMPLE but also incorporated additional insights from relevant literature. The usability report served as a unifying document, consolidating previous work into a single, cohesive resource. In this report I included elements such as personas, user journeys, scenarios, inspirational design cues, and low-fidelity wireframes, all reframed to align with the specific use case. The primary objective of this report was to foster a deep understanding of the user, their tasks, the environmental context, and other pertinent factors. It's important to note that this report was a dynamic and evolving resource, subjected to continuous updates and reviews throughout the entire design process. In the subsequent sections, I provided a snapshot of the final version of this living document.

3.2 Personas

In the context of this particular use case, I involved the creation of distinct personas, each tailored to serve specific roles within the project in the development process. Notably, I designed two distinct personas to represent the end-users, while I also formulated an additional three personas to effectively encompass the diverse needs and perspectives of various stakeholders. These personas guided the user-centred design approach and ensured that the resulting solution aligned seamlessly with the requirements and expectations of the intended user groups and stakeholders. In this section, I provided a comprehensive overview of these personas and their significance in shaping the design process.



Anita Van Dijk

ABOUT

Being diagnosed with COPD was a huge set-back for her. She used to go out and do activities with friends. Now, she is often stuck at home alone and she is not motivated to go out anymore because that is too demanding on her body. Even though being diagnosed with COPD was hard, she learns to cope with it better.

AGE	62
STATUS	Divorced
COPD STAGE	GOLD-III
COMORBIDITY	Cardiovascular
LOCATION	Arnhem (NL)

PERSONALITY

GOALS

- Learn to cope and accept her condition
- Live a healthier lifestyle

FRUSTRATIONS

- Cannot see her friends anymore
- The inability to do physical activities

NEEDS

- More information on how to improve her lifestyle
- Professional support in how to cope with COPD

MOTIVATION

Intrinsic ●○○○○○

Extrinsic ●●●○○○

TECHNOLOGY

Has a phone, but has low interest in using nowadays technologies.

Figure 3.1: Persona Anita Van Dijk

3.2.1 Users

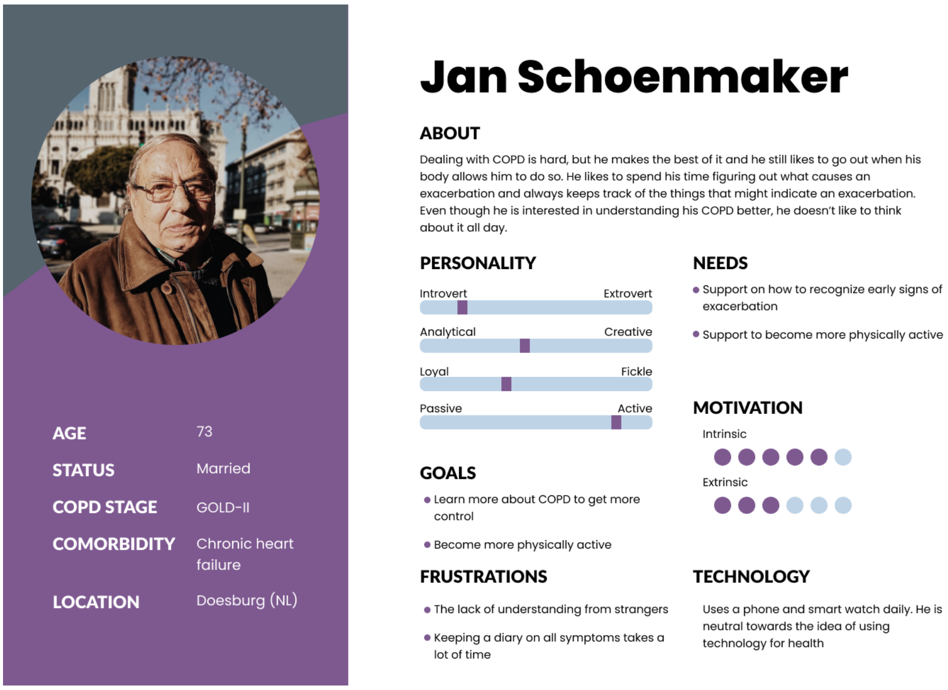
Anita's persona is shown in figure 3.1. She represented extroverted COPD patients who used to enjoy going out with their friends. Therefore being diagnosed with COPD is hard for these people because it drastically changes their lives. This makes it hard for them to cope with COPD. Also, she represented the people who are not very confident in using technology. Especially, for the older generation it is common that they are not comfortable with using new technology.

Jan's persona shown in figure 3.2 on the other hand represented the more introverted patients. His social circle is small and he doesn't enjoy going out as much. Also, unlike Anita, Jan is motivated to learn more about COPD and wants to do what he can to stabilize his health. Jan's persona also represented those who use technology daily. They are neutral towards using technology.

3.2.2 Stakeholders

In any comprehensive design process, it is paramount to consider not only the main end-users but also the stakeholders who may play pivotal roles in the system. What was particularly intriguing was that these stakeholders might eventually transition into becoming end-users themselves, underlining the importance of including them from the outset. RE-SAMPLE had already initiated conversations with several key stakeholders, and based on the insights gleaned from these engagements, I comprised the following personas that represented their diverse perspectives and needs.

First is Jessica Vos a pulmonary nurse shown in appendix A.1. Pulmonary nurses are frequently in contact with their patients and most likely know the patient the best within



Jan Schoenmaker

ABOUT

Dealing with COPD is hard, but he makes the best of it and he still likes to go out when his body allows him to do so. He likes to spend his time figuring out what causes an exacerbation and always keeps track of the things that might indicate an exacerbation. Even though he is interested in understanding his COPD better, he doesn't like to think about it all day.

AGE	73
STATUS	Married
COPD STAGE	GOLD-II
COMORBIDITY	Chronic heart failure
LOCATION	Doesburg (NL)

PERSONALITY

NEEDS

- Support on how to recognize early signs of exacerbation
- Support to become more physically active

MOTIVATION

Intrinsic ●●●●●○

Extrinsic ●●●○○○

GOALS

- Learn more about COPD to get more control
- Become more physically active

FRUSTRATIONS

- The lack of understanding from strangers
- Keeping a diary on all symptoms takes a lot of time

TECHNOLOGY

Uses a phone and smart watch daily. He is neutral towards the idea of using technology for health

Figure 3.2: Persona Jan Schoenmaker

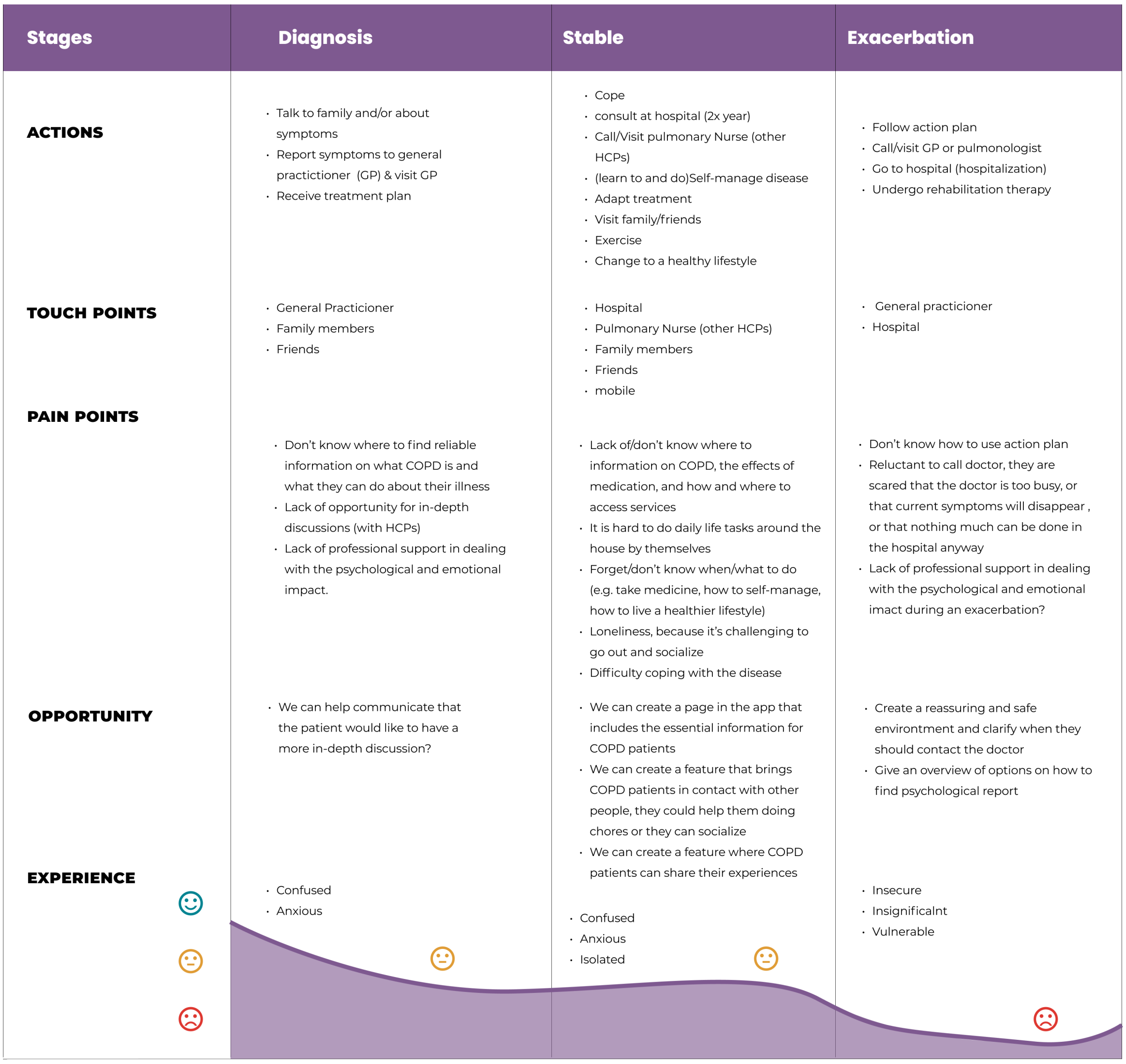
the healthcare system. They generally enjoy helping out patients and guiding them in the right direction. The most important thing for them is that a self-management system is clearly explained to COPD patients. The system should take a load off the pulmonary nurses' shoulders and assist them with helping COPD patients.

Second is Frank Hendriks shown in the appendix A.2. Pulmonologists are the ones who make the important decisions. They are incredibly busy with seeing patients and only have a short time to speak with the patients. They care about their patients, but they don't have the time to focus on the little fluctuations of each patient's life. The bigger trends give them more information. Additionally, there are already many eHealth systems, but these are often too tedious and complex. They don't have time to learn how to use such systems and put them into practice. Therefore it is important for them that the system is simple and easy to use for what they should contribute to the system.

Last is Maria De Jong, a seasoned psychologist with more than a decade of experience in the field, who is a dedicated advocate for holistic healthcare. Her passion lies in addressing the full spectrum of well-being, encompassing mental health, lifestyle, self-management, and social networks. While she may come across as slightly introverted and analytical, her frustration with the current healthcare system stems from its compartmentalized approach, often referring patients between specialists and neglecting their holistic needs. Maria advocates for multidisciplinary cooperation in healthcare.

3.3 User journey

RE-SAMPLE already made a user journey that described the different phases of COPD and what events happen during these phases. The user journey made by RE-SAMPLE can be found in the appendix A.4. I made the user journey more extensive to give deeper insights and understanding. Figure 3.3 shows this user journey with actions, touchpoints, pain points, opportunities and what patients experience emotionally.



Stages	Diagnosis	Stable	Exacerbation
ACTIONS	· Talk to family and/or about symptoms · Report symptoms to general practictioner (GP) & visit GP · Receive treatment plan	· Cope · consult at hospital (2x year) · Call/Visit pulmonary Nurse (other HCPs) · (learn to and do)Self-manage disease · Adapt treatment · Visit family/friends · Exercise · Change to a healthy lifestyle	· Follow action plan · Call/visit GP or pulmonologist · Go to hospital (hospitalization) · Undergo rehabilitation therapy
TOUCH POINTS	· General Practicioner · Family members · Friends	· Hospital · Pulmonary Nurse (other HCPs) · Family members · Friends · mobile	· General practicioner · Hospital
PAIN POINTS	· Don't know where to find reliable information on what COPD is and what they can do about their illness · Lack of opportunity for in-depth discussions (with HCPs) · Lack of professional support in dealing with the psychological and emotional impact.	· Lack of/don't know where to information on COPD, the effects of medication, and how and where to access services · It is hard to do daily life tasks around the house by themselves · Forget/don't know when/what to do (e.g. take medicine, how to self-manage, how to live a healthier lifestyle) · Loneliness, because it's challenging to go out and socialize · Difficulty coping with the disease	· Don't know how to use action plan · Reluctant to call doctor, they are scared that the doctor is too busy, or that current symptoms will disappear , or that nothing much can be done in the hospital anyway · Lack of professional support in dealing with the psychological and emotional imact during an exacerbation?
OPPORTUNITY	· We can help communicate that the patient would like to have a more in-depth discussion?	· We can create a page in the app that includes the essential information for COPD patients · We can create a feature that brings COPD patients in contact with other people, they could help them doing chores or they can socialize · We can create a feature where COPD patients can share their experiences	· Create a reassuring and safe environtment and clarify when they should contact the doctor · Give an overview of options on how to find psychological report
EXPERIENCE	· Confused · Anxious	· Confused · Anxious · Isolated	· Insecure · Insignificalnt · Vulnerable

Figure 3.3: User Journey of a COPD patient

3.4 Description of Environment

It was a crucial step for me to understand the environment and situations encountered by COPD patients for crafting a self-management tool tailored to their unique needs. COPD patients undergo distinct phases in their health journey, including diagnosis and stable phases, where they adapt to their condition, and exacerbation phases, marked by increased symptom severity. By delving into these phases and associated environmental factors, I aimed to create a holistic self-management tool that provides support during both stable and exacerbation periods, empowering COPD patients in their journey. In the following sections, I summarized what each of the phases entail.

3.4.1 Diagnosis and Stable phase

Most COPD patients usually have a low activity level to moderate activity. Low activity is almost no activity at all, housebound, chairbound and/or dependent on home care. Moderate activity is the patients that try to be as active as possible. They are still able to perform chores but are supported by caregivers. Those that have a high activity level are those that are not much affected by the disease yet. So the majority's environment is in and around the house.

3.4.2 Exacerbation

When a COPD patient experiences an exacerbation, hospitalization becomes necessary for their recovery. Following their hospital stay, these individuals transition to home-based rehabilitation to regain their health and independence. This rehabilitation phase at home is a critical period in their COPD journey, requiring effective self-management tools and support.

3.5 Storyboards

In my pursuit of creating a user-friendly self-management tool for COPD patients, I created storyboards to visualize key interactions and user experiences within the Healthenthia application. These storyboards provided an illustrative glimpse into how the app's features align with the specific needs and preferences of COPD patients, offering a tangible representation of the user journey.
The storyboards presented here show two different scenarios. One storyboard shows a scenario where a patient doesn't have the app to support them with managing their disease. See appendix A.5. The storyboard tells a story about the patient, Anita, who struggles to recognize her symptoms of exacerbation and exhaustion. Anita doesn't realise that she is pushing herself too much. This causes Anita to be overexerted and increases her risk of going into exacerbation. The story shows the difficulty COPD patients have with recognizing their symptoms and their limits. Even when they recognize their symptoms they often don't know what to do when they are experiencing these symptoms. Leaving them scared and afraid of what could happen.

Storyboard 2 shown in appendix A.6 shows a scenario where the app helps COPD patients recognize that they are pushing themselves a lot. The app advises them to do a breathing exercise to help them catch their breath and rest. This story shows a way an app could help COPD patients recognize when they are experiencing symptoms and what to do with it. In this case, resting and doing a breathing exercise. The app aimed to do two things here. That is to notify the patient when the symptoms worsen and advise on what to do, which should help them take timely actions to prevent exacerbation. Additionally, it may relieve feelings of anxiousness and helplessness, because the app helps them recognise and advise them what they could do about the situation.

3.6 Tasks

I defined a set of initial tasks, which I drew from insights garnered through the prior iteration of a usability study conducted by RE-SAMPLE. These tasks served as the foundational building blocks for shaping the Healthenthia system, aligning it more closely with the specific requirements and preferences of COPD patients.

3.6.1 Main tasks

- Track symptoms
- Evaluate progress

- Share progress/experience and support peers
- Learn about /do breathing techniques
- View and set goals - Create a habit

3.6.2 Optional Tasks

- View Action Plan/ Check what to do
- Change data sharing preferences
- Share progress/Contact HCPs
- Contact HCP
- Breathing techniques

3.7 Inspiration

Preceding the ideation phase, seeking inspiration becomes a vital preparatory step. At this point, I explored diverse possibilities and envisioned how various features could manifest in terms of interactions, design aesthetics, style elements, and layout. I drew inspiration from various sources and attempted to infuse Healthenthia with innovative, user-centric design concepts that enhanced the user experience for COPD patients. I made a collection of inspiration from sources such as Pinterest [1] and Dribble [4]. Figure 3.4 shows one part of the collection and appendix A.7 and A.8 show the remaining inspiration that I had used as inspiration.

3.8 Lo-fi wireframes

Lo-fi wireframes are instrumental in portraying the anticipated user interactions and design aesthetics within Healthenthia. These visual representations, which I show in this section, stemmed from the task flows defined in Section 3.6. I made these with inspiration drawn from the screens featured in Appendix 3.7. I created these wireframes to explore possible implementations of relevant features. I used this in my ideation to have an understanding of how the tasks could be translated to functionalities and as a base to start my ideation.

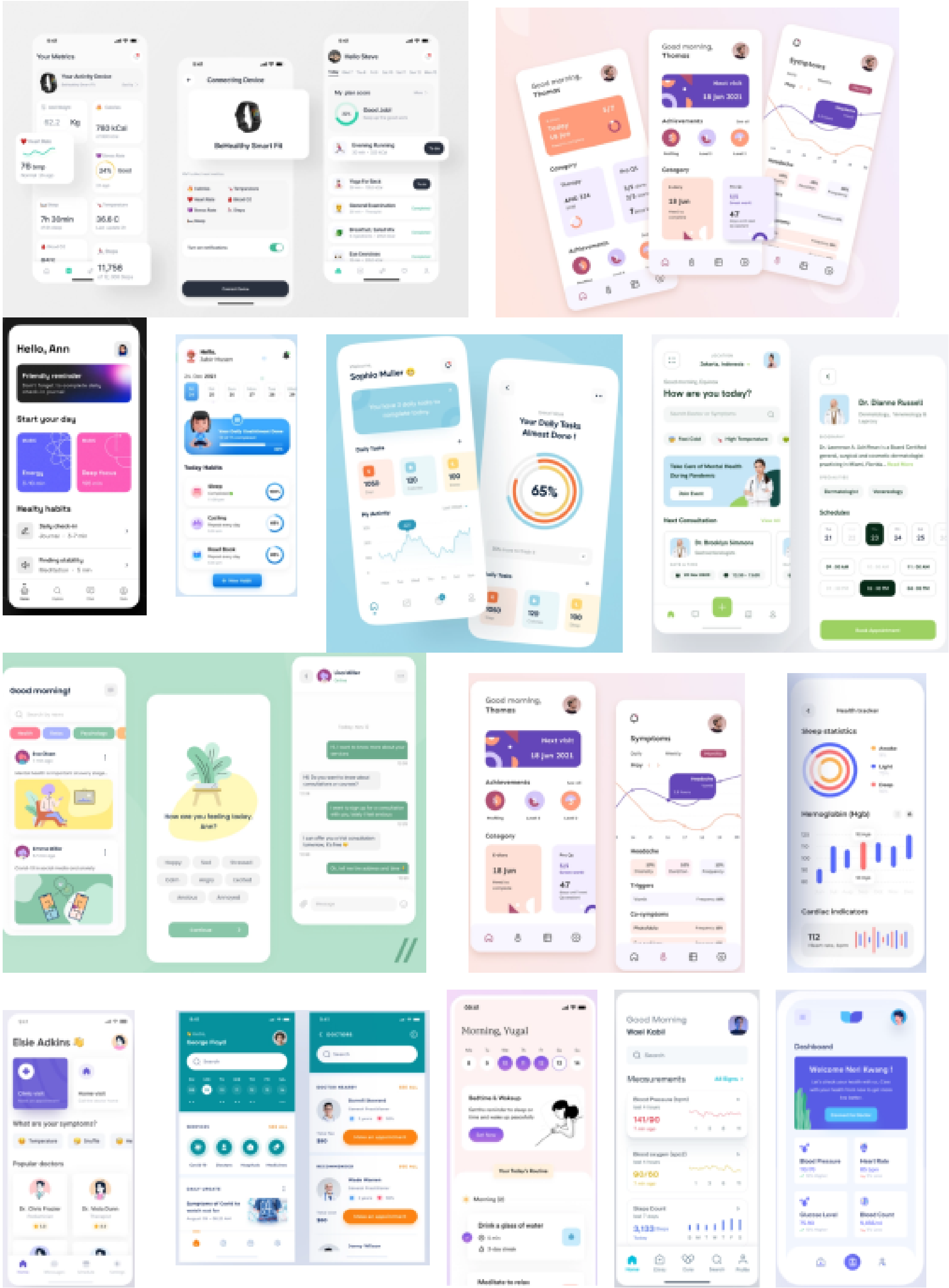


Figure 3.4: Collection of inspiration

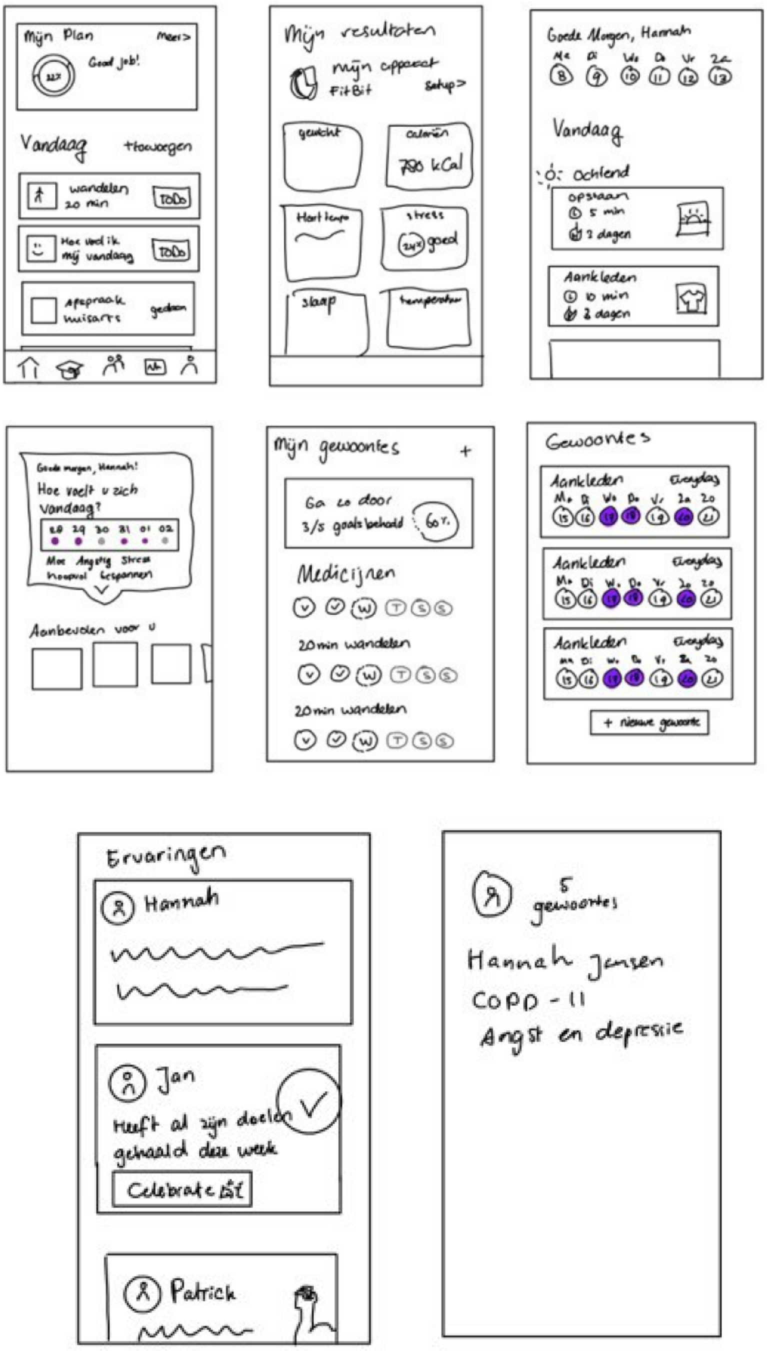


Figure 3.5: Lo-fi wireframes

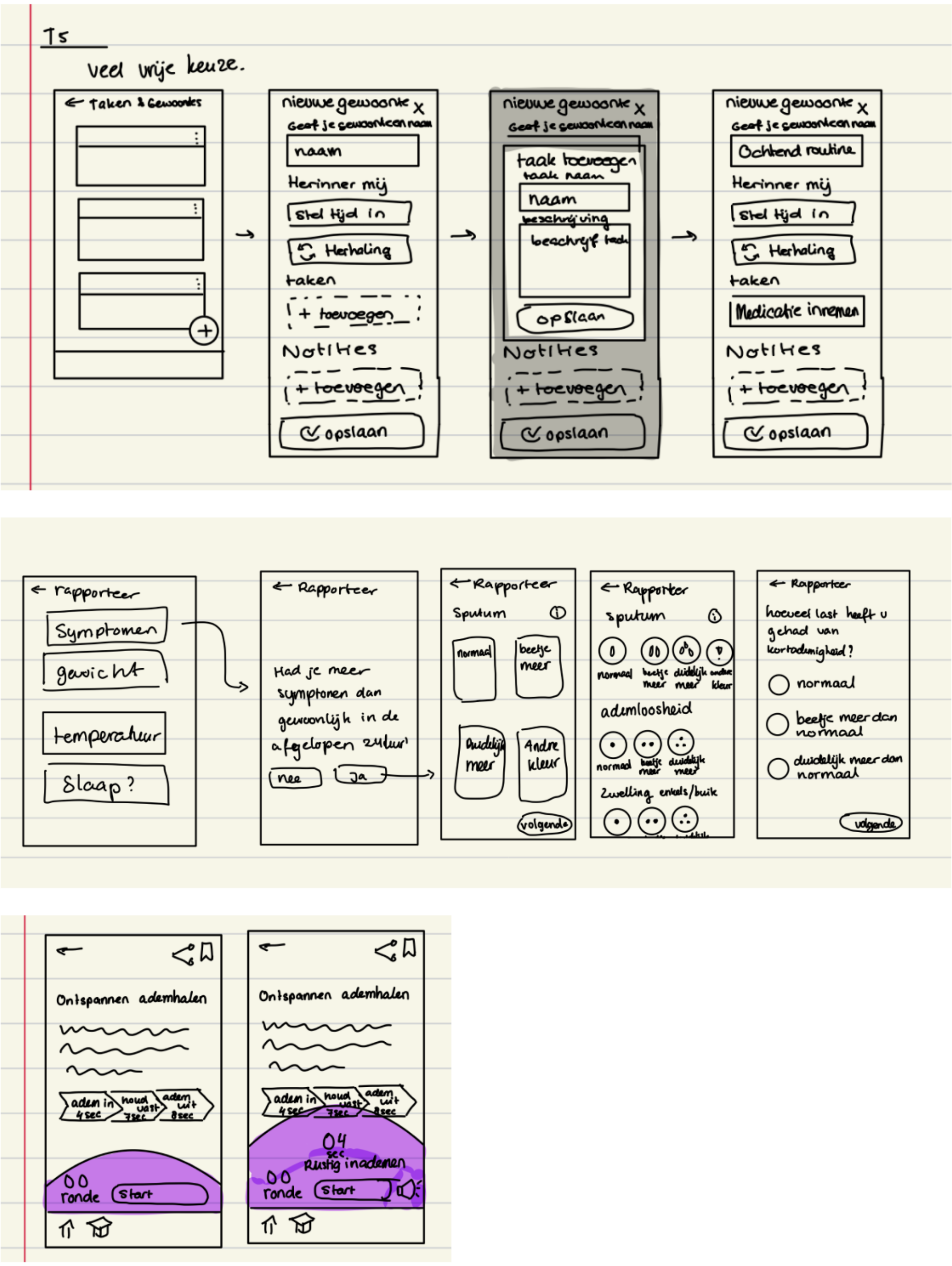


Figure 3.6: Lo-fi wireframes

4
Ideation

4.1 Introduction

In this chapter, I described the ideation phase. During the ideation phase, I developed and evaluated a prototype by project and usability experts. During this process, I undertook several steps. One of the steps was to investigate what needs are currently met by what features of other health applications for COPD patients. I used this as inspiration for suitable features for the new design. In addition to that, I brainstormed and conceptualized ideas for any needs that have not been met yet. Then I combined the suitable features from other applications and new features into a collection of features for the new application. After that, I sorted these features into groups to define the different sections of the application. From the groups and their designated features, I made wireframes. These wireframes formed the first concept. I evaluated this concept with RE-SAMPLE and usability experts. The feedback I then processed and finalised the final concept for the prototype. In the remaining sections of this chapter, I elaborate on these steps and show the final prototype.

4.2 Concepts and idea generation

4.2.1 Mapping of needs to features

In this section, I described how I executed the mapping of needs to common features for self-management apps. This was to give an overview of how well needs are generally covered by the commonly implemented features of such self-management apps and whether all the requirements could be covered. I did this analysis in several stages. The first stage was to list all the requirements, previously found needs and features mentioned in the related works.

The next step was to map the requirements and needs to the features listed. See figure 4.1. This mapping shows how some features are more relevant for this use case than others as they meet more needs and requirements. Additionally, it gives insight into what needs and requirements are not met. Next was to use these insights to brainstorm possible solutions for these and to complete the mapping of needs and requirements to features. The results of the brainstorming on the unmet needs and requirements are shown in figure 4.2.

After that I combined the results, and synthesized and categorized into relevant features. The results of that are shown in figure 4.3.

The results show five groups namely tools, education, personalized information on COPD, social network, and others. The tools included features such as questionnaires, diary, symptom trackers, environment trackers, goal setting and reminders. The education category shows what information COPD patients want. This includes topics such as breathing techniques, self-management, acceptance, coping with COPD, how to live with COPD, general information on COPD and more. Then a key category is the personalized information on COPD. The features noted here are personalized feedback, a history of the tracked symptoms and vitals, notifications of symptoms and motivational messages. The social network category is meant to relieve loneliness. There are a few features considered for this. These are to share experiences, connect with other COPD patients and a feature that shows when to ask for help from who. The remaining category are required features that don't fit in the other categories. These are medication adherence, emergency data review and managing the privacy of personal data and sharing data with HCPs.

4.2.2 Concepts

In this iteration, the primary objective was to enhance Healthentia's engagement and value proposition for COPD patients. This iteration explored the incorporation of gamification elements combined with habit-forming features, specially tailored to meet the distinctive needs and preferences of this user group. These strategic additions held the potential to transform Healthentia into a significantly more engaging and valuable tool for COPD patients, enhancing their overall experience and health management journey.

In an effort to enhance Healthentia's engagement and value for COPD patients, several gamification elements were integrated. Progress tracking features allow patients to visually monitor their health improvements and self-management journey through intuitive graphs and charts, empowering informed decision-making. The introduction of streaks incentivizes consistent positive behaviours, a key element in habit formation, by encouraging users to maintain their engagement over time. Challenges and social interaction foster a sense of community and friendly competition among users, further reinforcing the habit-building process. Personalization tailors the user experience to individual needs, complemented by timely notifications to reinforce positive habits. Furthermore, Healthentia integrates health data from various sources, offering a holistic approach to COPD management and habit-building. Collectively, these gamification elements create an interactive, motivating, and empowering environment for COPD patients, not only improving their self-management but also facilitating the development of sustainable, health-focused habits.

4.2.3 Wireframes

The categories I defined in the previous section were used as a guideline for creating some initial ideas on how these features can be implemented. In the usability report I already showed some lo-fi wireframes of some of these features and how these may look like. At this stage, I made more elaborate wireframes to make the first concept of the application. See figures 4.4, 4.5,and 4.6.

4.2.4 First concept

The wireframe sketches were used as a base to make hi-fi wireframes in Figma. Some of the designs were an exact implementation of the sketch. Some other designs I iterated

Figure 4.1: Mapping to needs and requirements to features

Figure 4.2: Brainstorm on unmet needs

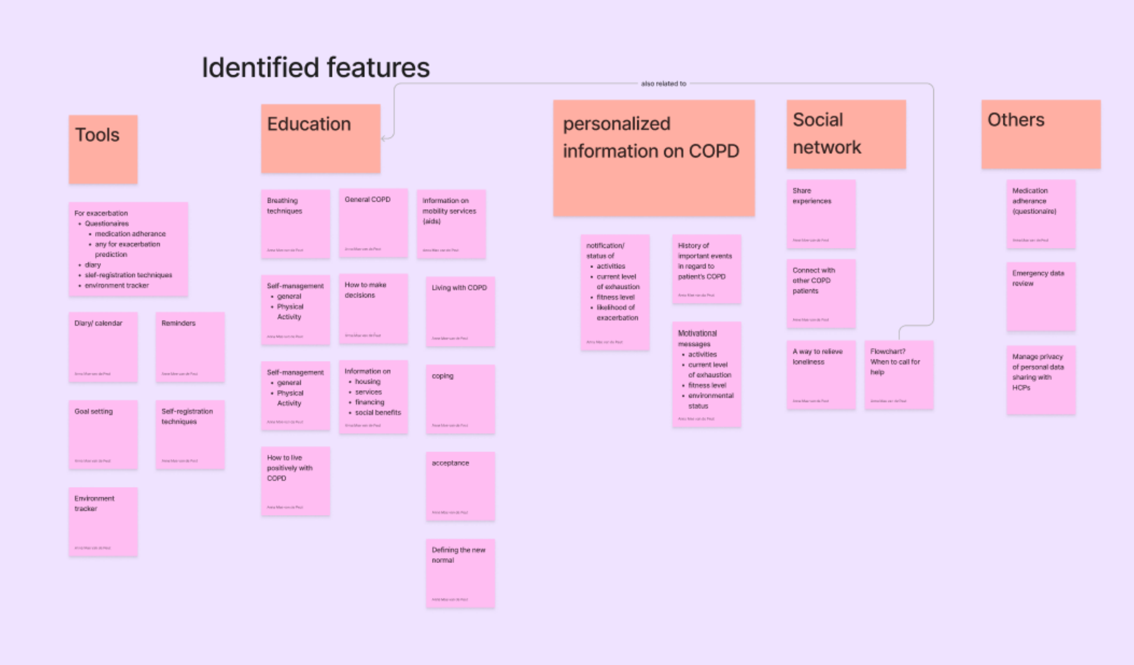


Figure 4.3: Results of feature mapping

on a couple more times to make them more suitable for digital implementation, such as the habits, profile and network screens. Additionally, I used Material Design guidelines for the structure, sizing, spacing of elements and more [12]. While I used Material Design as guideline, Healthentia also has its own branding. My aim was to stay as close to the Healthentia branding while applying the Material Design guidelines. See figures 4.7 and 4.8 for the hi-fi wireframe concepts.

4.3 Evaluation

Before moving to the next stage, I evaluated the first prototype with RE-SAMPLE researchers and usability experts. This section describes how I executed the evaluation.

4.3.1 Participants selection

The participants were a combined group of RE-SAMPLE researchers and usability experts fromRRD. The aim was to have five participants for the evaluation of the needs and the implementation of the features. These participants were the focus group and consist of experts on COPD, experts on the current design of Healthentia or general usability experts. These participants were recruited from the experts of the RE-SAMPLE project and employees ofRRD. There were no other specific inclusion or exclusion criteria.
A total of five (N = 5) participants were included in this study. Three out of five participants were RE-SAMPLE researchers and the remaining two were usability experts fromRRD. They were recruited through the company and based on their availability for the focus group.

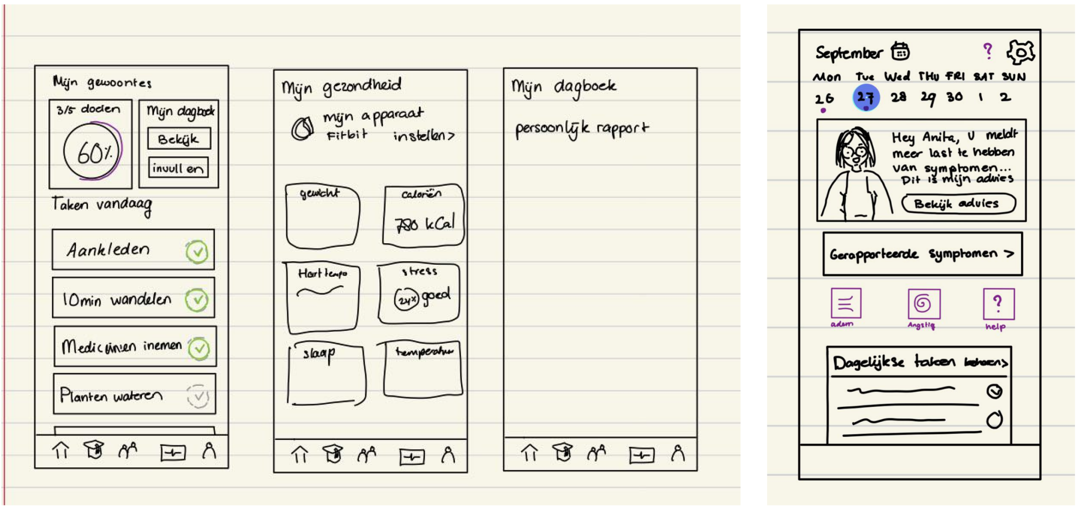


Figure 4.4: Healthentia concept ideas

4.3.2 Study setup

The study was conducted atRRD in a big meeting room. All participants were sitting around the table and were given a printout with different screens of the first prototype. The printout included flows for each task that was defined in the usability report of phase one. The printouts can be found in appendix B.

Study procedure

The study procedure was divided into three parts. First, in the introduction I explained what they were going to do during the focus group and that it was going to take around an hour. During the second part of the procedure I let them review the different screens. The screens were reviewed following the tasks that were defined in the usability report. Per task, the participants had a minute to get a first impression of the task and the features within it. After that, they had 5 minutes to discuss and write down their first impressions on the hand-out. Once, they had done this I elaborated the flow of the task. This was followed by another 5-minute discussion round on what the participants think about the task flow presented. This procedure was done for every task. For the third and last part, I gave a summary of the results of the focus group and the participants were asked whether they have any additional comments or questions.

4.3.3 Results

In this section, the results of the evaluation of the initial prototype concept are presented. Through the collaborative efforts of usability experts and RE-SAMPLE researchers, a thorough examination of the prototype's usability and effectiveness was undertaken through a cognitive walkthrough. The following insights highlight the areas for improvement in the prototype. I collected the insights from the printouts with the screens of the prototype. Figure 4.9 shows an example of what that looked like.

The feedback received from both the research team and usability experts generally conveyed positivity, highlighting the promising aspects of the Healthentia prototype. Most

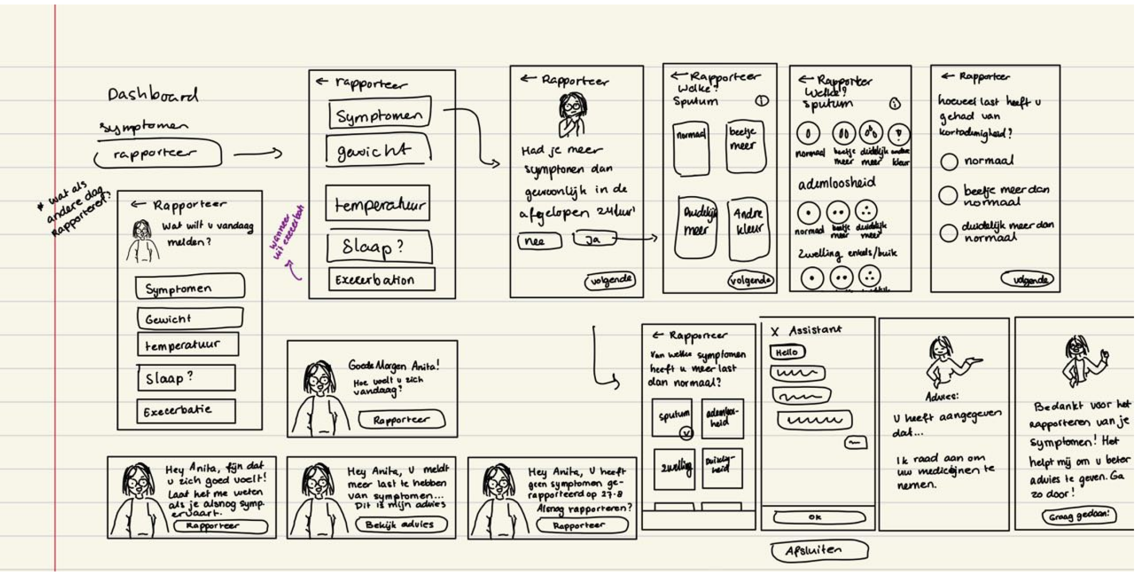


Figure 4.5: Healthentia concept ideas

of the feedback consisted of fine-tuning suggestions focusing on specific screen elements. Here's a breakdown of the key feedback points:

Home Screen Clarity: To enhance user comprehension, it was advised to segregate tasks and habits on the home screen, providing a clearer distinction between the two categories. Additionally, some concerns were raised regarding the response to exacerbation situations, with users seeking more explicit guidance. Besides seeking more explicit guidance, it can be valuable for COPD patients to have control and the possibility to report an exacerbation. However, this is a complex matter. What and how this should be implemented is a delicate problem by itself. Therefore, this is left out of the prototype in this iteration of the prototype. However, this should be considered in future iterations.

Report Sequence Enhancement: In the initial screen of the Report sequence, participants recommended the inclusion of the assistant to ensure consistent guidance. Furthermore, the need for distinct colours to represent the three symptom options on the report symptoms screen was highlighted. There was also a suggestion to clarify the selection of mucus (Slijm) as a symptom alongside its status, aiming for improved user understanding. Additionally, participants recommended the assistant's presence in the weekly report, as it plays a vital role in conveying results.

Habit Management: In the context of adding a new habit, participants suggested including a plus icon for the "nieuwe gewoonte" (new habit) button and removing the "Verder" (continue) button. There was also the observation of an overlap between the description and notes sections on the screen for adding a new habit, leading to the recommendation to remove the notes section. Furthermore, participants emphasized the importance of having an overview of all added habits for better management.

Community Engagement: Participants offered feedback on the "gemeenschap" (community) screen, suggesting a name change and exploring the possibility of allowing comments, in addition to reactions, on the updates shared within the community. Queries were raised concerning the meaning of streaks, the potential to add individuals to one's network, and the need for settings, possibly for toggling certain features on or off. There was also curiosity regarding the criteria for determining milestones and addressing situations involving multiple habits. The idea of incorporating "chill days" for instances like

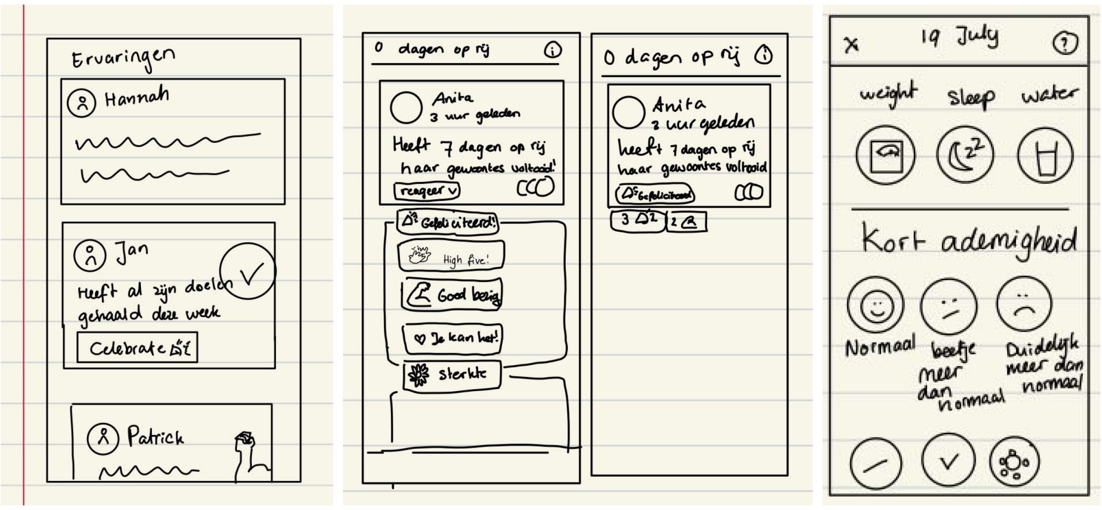
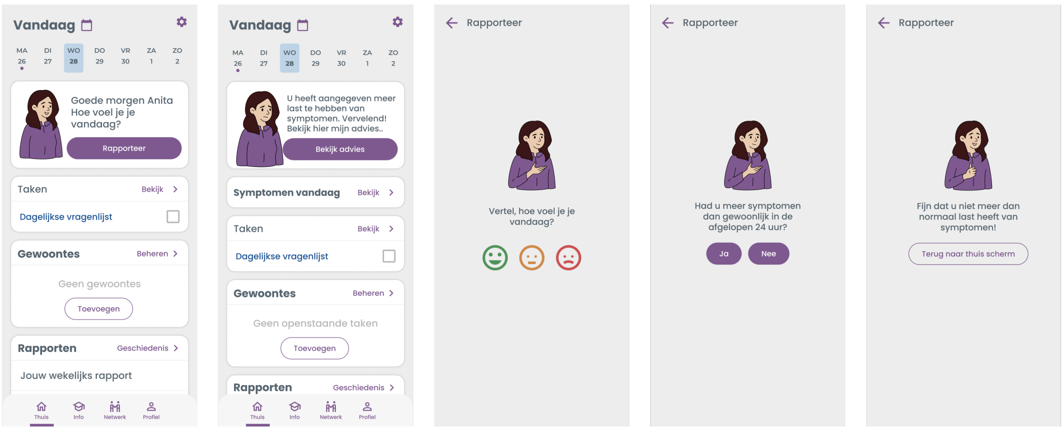


Figure 4.6: Healthentia concept ideas



Goede morgen Anita Hoe voel je je vandaag?

Geen gewoontes

Jouw wekelijks rapport

U heeft aangegeven meer last te hebben van symptomen. Vervelend! Bekijk hier mijn advies..

Geen openstaande taken

Vertel, hoe voel je je vandaag?

Had u meer symptomen dan gewoonlijk in de afgelopen 24 uur?

Fijn dat u niet meer dan normaal last heeft van symptomen!

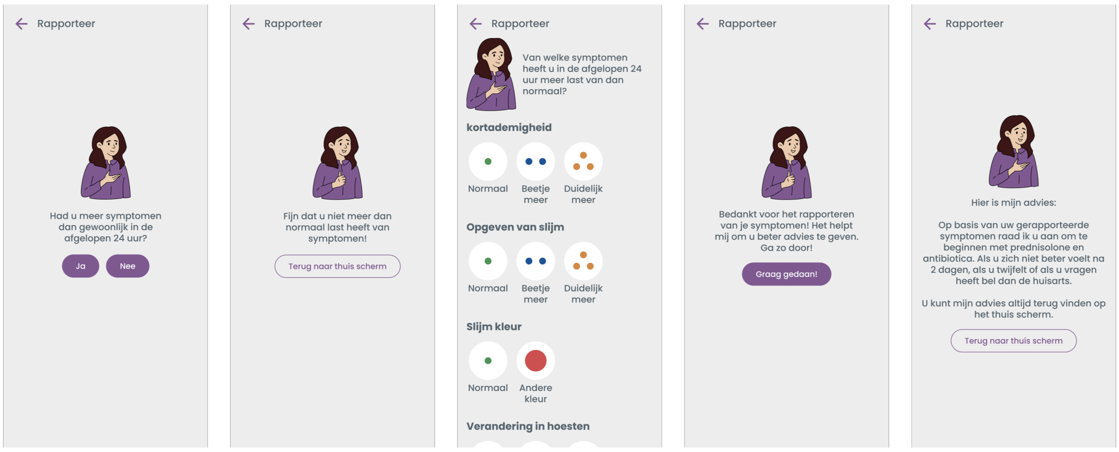
Figure 4.7: Hi-fi wireframes first concept

exacerbation was proposed to allow flexibility in users' routines.

Profile Page Improvement: The profile tab did not meet initial expectations. Participants recommended relocating the tracker information of the smartwatch to a separate tab, while utilizing the profile page for displaying personal information and settings related to the patient.

Information Tab Enhancement: Within the information tab, concerns were raised regarding the readability of card subtitles due to insufficient contrast. Participants suggested adjusting the contrast to improve readability. Additionally, there was ambiguity regarding where bookmarked articles would be saved, prompting the proposal to add a dedicated section on the info screen specifically for bookmarks. Questions also arose concerning filtering and ordering options for articles and the sharing capabilities of articles, such as identifying with whom they can be shared.

These valuable insights provide a roadmap for refining the Healthentia prototype, ensuring it aligns seamlessly with COPD patients' needs and preferences. Although these are all valuable insights, due to the complexity of some issues and the time constraint some of the insights cannot be implemented for this iteration of prototype. However, these should be considered for future iterations.



Had u meer symptomen dan gewoonlijk in de afgelopen 24 uur?

Fijn dat u niet meer dan normaal last heeft van symptomen!

Van welke symptomen heeft u in de afgelopen 24 uur meer last van dan normaal?

Bedankt voor het rapporteren van je symptomen! Het helpt mij om u beter advies te geven. Ga zo door!

Hier is mijn advies:

Op basis van uw gerapporteerde symptomen raad ik u aan om te beginnen met prednisolone en antibiotica. Als u zich niet beter voelt na 2 dagen, als u twijfelt of als u vragen heeft bel dan de huisarts.

U kunt mijn advies altijd terug vinden op het thuis scherm.

Figure 4.8: Hi-fi wireframes first concept

4.4 Final prototype

I processed the feedback from the evaluation into a final prototype. Figure 4.11 shows some wireframes of the final prototype. More wireframes along with the link to access the prototype can be found in appendix C. In figure 4.11a, you can see the home screen. The home screen consists of different elements. The virtual companion is shown at the top which gives information to the patient directly. Below that there are three different sections. They cover tasks they need to complete, habits they want to maintain and reports. The tasks can be the daily check-in of the symptoms they experience or any other questionnaires they need to fill in. The habits section allows the patient to make their own habit. This can be targeted to stopping smoking, being more active, breathing exercises or anything else they want to build a habit out of. The reports section shows a personalized report of their symptoms and advice on how to deal with their current health.

Figure 4.11b shows the new questionnaire form. This overview shows all questions on one page. This allows the patient to see how much they need to fill in in one glance.

Figure 4.11c shows the network of the patient. This is included so that COPD patients can give peer-to-peer support. Since COPD patients struggle to be understood, having a community that goes through the same experience could possibly help them cope with COPD. On this wireframe you can find some of the gamified elements. Such as the streak of doing their habits. The goal is to externally motivate patients through this and also build a community with other COPD patients. So they can support each other as well in the good and the bad times.

At last, the final wireframe shown in figure 4.11d is the information section. Here the patient can find any information they need about COPD and how to cope with it. They can either browse the different categories or use the search bar to find a specific article that they are looking for.

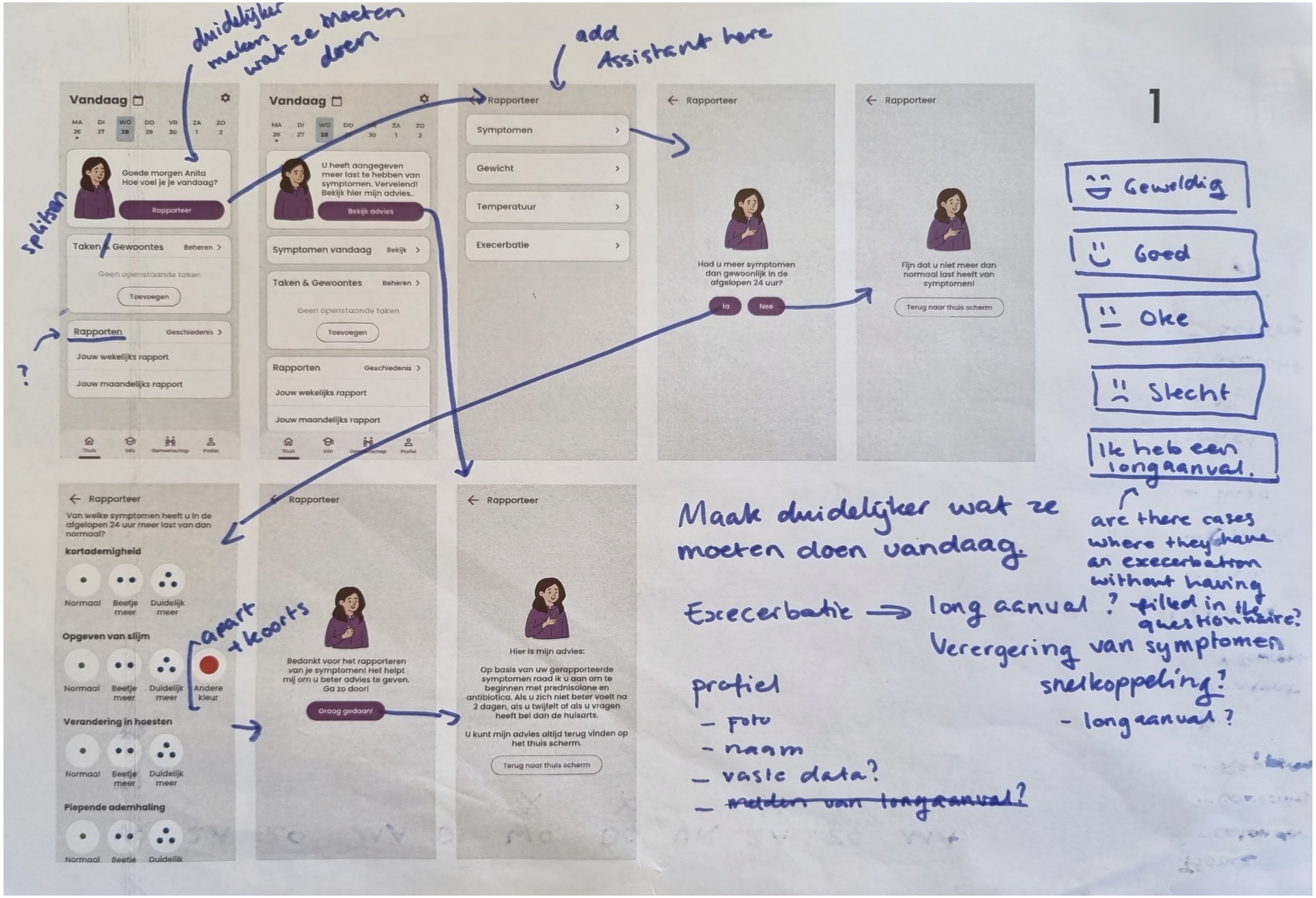
4.5 Discussion

I would like to address two key aspects of the ideation phase in this discussion. Firstly, it was essential to recognize that COPD patients exhibit a wide range of CCCs, which vary in their combinations and progression for each patient. Given this diversity, I made a deliberate choice to pursue a modular design approach instead of attempting to create a one-size-fits-all solution. By doing so, I aimed to cater to the specific and varied needs of each patient within this elderly demographic, many of whom may not be tech-savvy. Keeping the design modular allows for a more precise and tailored solution, avoiding overwhelming patients with unnecessary complexity. While I didn't create modular components for every conceivable CCC, I did factor in the possibility of incorporating CCC-specific elements in the future. Further research and iterative development will be necessary to address these specific needs comprehensively.

Secondly, user interface design relies on the foundation of design systems to maintain uniformity, bolster usability, and ensure accessibility across diverse digital products. Standardized design systems evolve through iterative processes of ideation, user testing, and evaluation, meticulously honing their attributes. In this thesis, I delved into the prospect of harnessing these established design systems as cornerstones for crafting an intuitive and accessible user interface tailored to the distinctive demands of COPD patients.

To accomplish this, I embraced Material Design as a fundamental building block. Collaborating it with the existing Healthentia design, I conceived concepts and developed prototypes. Throughout this journey, I encountered the challenge of judiciously deciding when to adhere to the Material Design guidelines and when to align with the unique Healthentia design ethos. For most design elements, I embraced the principles of Material Design concerning spacing, layout, structure, and typography size. Conversely, aspects that bore significant influence on branding, including typography, icons, and borders, were drawn from the Healthentia design. In cases where Healthentia had not yet defined certain elements, Material Design assumed the role of the primary guide, with only color schemes and typography borrowing from Healthentia.

The decision to use Material Design as a foundation expedited the design process significantly. However, it necessitated a careful trade-off between Material Design and Healthentia's unique identity, potentially impacting overall usability. A design system is meticulously crafted to optimize usability, and using it solely as a guideline may have introduced certain trade-offs.



Goede morgen Anita
Hoe voel je je vandaag?

U heeft aangegeven meer last te hebben van symptomen. Vervelend! Bekijk hier mijn advies..

Had u meer symptomen dan gewoonlijk in de afgelopen 24 uur?

Fijn dat u niet meer dan normaal last heeft van symptomen!

Van welke symptomen heeft u in de afgelopen 24 uur meer last van dan normaal?

Bedankt voor het rapporteren van je symptomen! Het helpt mij om u beter advies te geven. Ga zo door!

Hier is mijn advies:

Op basis van uw gerapporteerde symptomen raad ik u aan om te beginnen met prednisolone en antibiotica. Als u zich niet beter voelt na 2 dagen, als u twijfelt of als u vragen heeft bel dan de huisarts.

U kunt mijn advies altijd terug vinden op het thuis scherm.

duidelijker maken wat ze moeten doen

add Assistant here

splitsen

?

apart + koorts

Geweldig

Goed

Oke

Slecht

Ik heb een longaanval.

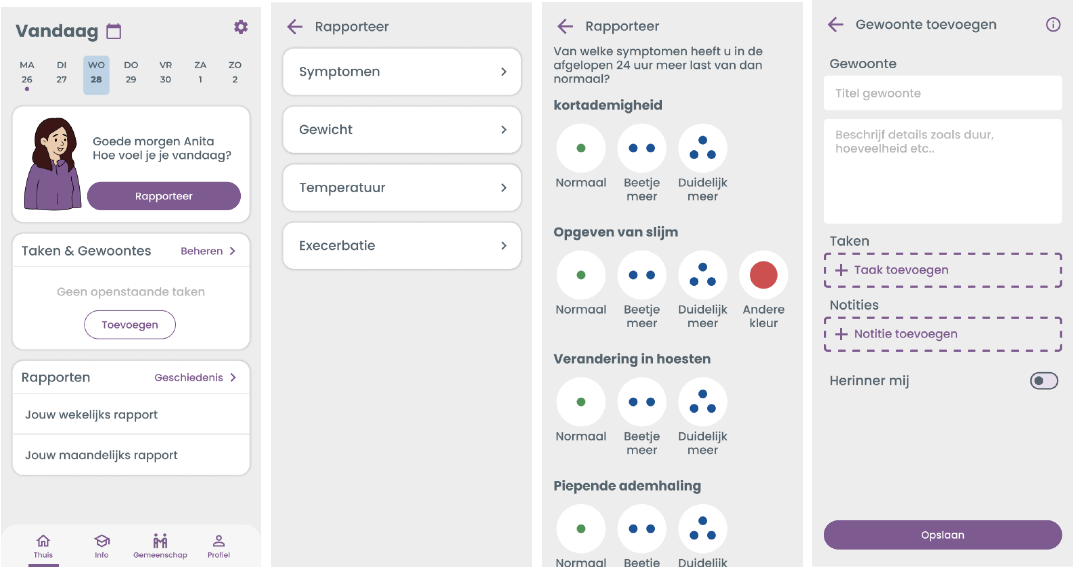
Maak duidelijker wat ze moeten doen vandaag.

are there cases where they have an exacerbation without having filled in the questionnaire?

Execerbatie → long aanval ?
Verergering van symptomen
snelkoppeling?
- longaanval ?

profiel
- foto
- naam
- vaste data?
- ~~melden van longaanval?~~

Figure 4.9: Evaluation of first prototype concept


Goede morgen Anita Hoe voel je je vandaag?

Van welke symptomen heeft u in de afgelopen 24 uur meer last van dan normaal?

(a) Home (b) Report 1 (c) Symptoms (d) Add habit

Figure 4.10: First concept wireframes


Goede morgen Anita Hoe voel je je vandaag?

Dit zijn de symptomen die u heeft gerapporteerd.

(a) Home (b) Symptoms (c) Network (d) Education

Figure 4.11: Final prototype

5

End-user testing

5.1 Introduction

The final step was to evaluate the finalised prototype with the end users. To execute the end-user usability test, the prototype needed to be usable. I did this by making a clickable prototype in Figma. This working prototype was used for the evaluation. The aim was to evaluate the final prototype and see whether the HCD approach was effective in creating a satisfying and usable prototype. This chapter describes the methods, results, discussion and conclusion of the usability test.

5.2 Methods

5.2.1 Participants selection

I included a total of eight (N=8) participants in this study. The participants were recruited through Roessingh Research and Development (RRD). RRD has a panel of people who are interested in participating, have participated in other COPD studies, and are willing to participate in other related studies. One of the other researchers at RRD contacted the potential participants as she was already familiar with them and was also planning another test with the same target group.

The sample size aim was to recruit between 5-10 participants because I expected to find most usability problems with this amount of participants. This usability test is a formative test to find the most critical usability issues at this early stage of the HCD iterative process. As Jeff Sauro and James R. Lewis describe and calculate in their book 5-10 participants should be enough to find the most critical and probable usability issues [71]. Therefore, for this formative test, the sample size should have been enough.

The inclusion criteria for the participants were that they had to be older than 18, and diagnosed with COPD. The exclusion criteria were:

1. Unable to read and speak Dutch.
2. Not being willing to provide informed consent
3. Have used the Healthentia application before

After planning the usability tests, one had to drop out because of sickness. Leaving a remainder of seven (n=7) participants that participated in the final evaluation. From this selection, one was female (N=1) and six were male (N=6). Their age ranged from 65 to 76 years old. Three of them have been diagnosed with COPD for more than 10 years. The other four have been diagnosed for 6-10 years. Five of the participants also were diagnosed with one or more comorbidities. The most common comorbidity is heart disease. Other comorbidities they had were sleep apnea, Diabetes Mellitus type 2, Rheumatism, asthma and other allergies. The participants were a mix of low- and highly-educated people. On a scale from 1 (very low) to 5 (very high), one participant scores a 3 on health literacy. The others score a 4 or 5 on health literacy. Signifying that they have high health literacy. Regarding digital skills, on the same scale, one participant scored their digital skills as a 2. Three participants scored themselves as a 3 on the scale of digital skills. And the remaining three scored themselves as a 4. The lower the rating, the lower they perceive their digital skills.

5.2.2 Study setup

The study took place in a meeting room at RRD. Two microphones were used to record the usability test audio and were placed in the middle of the table. The participant sat on one side with the provided Android phone that showed the prototype. On the other side of the table, I sat with a laptop, instructions and the questionnaires. Using Figma, the prototype was mirrored from the laptop to the phone. Last, a screen recording of the usability test was made.

5.2.3 Study procedure

For the study procedure of this usability test I made a detailed protocol for how to execute it. The detailed protocol can be found in appendix D. The general outline consisted of the introduction, warm-up, body, cool-down and closing. During the introduction, I explained both the outline and duration of the usability test. In addition, the participant had to sign an agreement form to be able to participate in the usability test. After the agreement form was signed, I asked permission to start the recording.
Next in the warm-up, the participant could explore the prototype by themselves, and simultaneously practice how to think aloud. After they explored the prototype for a couple of minutes I showed the participant Anita's persona illustrated in Figure 3.1.
Then in the body of the usability test, the participant had to execute five tasks. After each task, they got the ASQ questionnaire. And after completing all five tasks they get the HUBBI questionnaire.
During the cool-down, the participants were shortly interviewed on their experience of the usability test, the prototype and how the application could be improved. To close the usability test they were asked whether they did have any other questions they would like to ask or comments they would like to make.

5.2.4 Questionares

I used two questionnaires for the usability study. That was the ASQ questionnaire, filled in after each task. This questionnaire gauges the satisfaction of the task per participant. And the HUBBI, filled in after all tasks have been completed. The HUBBI is a benchmark specifically developed for the eHealth domain to evaluate the usability of eHealth. The benchmark covers seven different categories, namely Basic System Performance, Task-

Technology Fit, Interface Design, Navigation & Structure, Information & Terminology, Guidance & Support and Satisfaction.

5.2.5 Metrics

I used several metrics to analyse the usability test. In this section, I describe each one of the metrics I have used.

Lostness metric

The lostness metric measures how lost participants get during their task. This says something about the app's structure and how well users can navigate that. A high lostness score, close to 1, indicates that users are very lost and have difficulties completing the task. A low score, close to 0, indicates that the user can solve the task relatively easily. The lostness metric is as follows:

$$L = \sqrt{(N/S - 1)^2 + (R/N - 1)^2}$$

L = Lostness N = The number of different screens visited during the task. S = The total number of screens visited during the task. R = The minimum number of screens that must be visited to complete a task.

Note that I did not consider pop-ups as a unique screen.

Task specific

Besides the lostness metric, I also used some more general metrics to analyse the usability test. These are task completion rate, task completion time and the task path. First, task completion rate is the indicator of how many participants have completed a task. Second, the task completion time is the time a user takes to complete a task. I measured this for every participant and averaged that per participant and per task. Last, is the task path. I analysed the paths users take to get to the goal of their task. This gives insight into the users' mental model which is important for structuring the app.

5.3 Results

5.3.1 Summary of interviews

In this section, I synthesized the interviews using themes I derived from reading through the interviews and becoming familiar with them. I defined four overarching themes. Those are usability, suitability, mobile app novelty and respiratory distress.

Usability

Interaction gestures and touch targets
The participants had no difficulties using different interactions such as tapping, swiping, and scrolling vertically and horizontally. They did make the most errors with tapping. This was because either the component they were tapping was not an active element that could be tapped, or they missed the tap target. This was mainly for the buttons. Overall, the participants could use the app comfortably in terms of interactions. However, when the app did not respond as they expected, as with missing the button target, they would

express their frustration.

> "Nou toe dan! Waarom doet dat het niet"
> - Participant 1

Some participants had trouble tapping the touch target of buttons on either the navigation bar or primary buttons. Next to that, some participants tried to tap title headers, profile pictures, or cards, but there was no interaction designed for that.

Other prototype issues

One participant tried to and two more participants asked the researcher if it was possible to add more than one habit. However, the prototype only allowed to add of one habit. The last thing that was a usability issue of the Figma prototype, was the possibility of closing a pop-up. Most pop-ups had at least a close button. Only the reaction pop-up in the social network doesn't have a close button. The idea was to be able to close all pop-ups by tapping outside of it, however, this didn't work in the prototype.

Phone habits

Besides the issues of the prototype, I made some other notable observations in terms of phone habits. These habits were different from the intended habits that patients want to learn in the app. Some participants had phone habits that they had built through for example using other phone brands before participating in this usability test. Such habits were for example scrolling down to check whether any new messages have appeared or more information can be found. They did this even when they have reached the bottom of the page. Another habit I observed was the gesture of swiping right, which on some phones allows the user to go back to the previous page.

I made three more observations. First, was that participants tried to check checkboxes under tasks. These specific tasks could not be checked because they did not complete the task in the app. However, it would be possible to check their habits. This was not included in the usability test. Second, was that participants did not fill in everything for the symptoms. Meaning that some participants would only fill in the symptoms that they did experience more and did not select anything for the symptoms they did not experience according to the task of the usability test. Last, is that one of the participants commented on the length of the Weekly report being too extensive.

> "Was een heel verhaal - Participant 1"

Suitability

During the interviews, it became clear that the participants think that such an app is valuable for those with COPD. Because it can help support those who are new to COPD and those who don't have the tools or still have difficulty coping with it. The app can provide fast and clear insights when patients feel unsure, insecure, depressed or anxious.

> "Wat ik al aan het begin al zei. Het zal Anita helpen dat ze sneller en duidelijker een antwoord geeft over hoe ze zich voelt en hoe de ziekte op dat moment is"
> - Participant 1

> "Maar ik kan inderdaad voorstellen als je alleen bent en je bent al wat depressieferig of anstig ja dan dan zou dit wel kunnen helpen ja"
> - Participant 6

Besides helping COPD patients when they experience negative emotions, the participants expressed that it could help motivate and stimulate them to form good habits. For example habits for moving more or finishing their chores.

> "Dat zou me wel meer stimuleren om niet zo gauw van ik kan dit niet dus ik ga maar weer even zitten. Want de afwas doe ik in 3 keer stofzuigen doe ik in 5 keer. Kijk en dan denk ik ga even door en dan heb je net iets meer gehad hebt. Ik denk dat dat voor mij wel goed helpt"
> - Participant 2

However, some participants also expressed that as experienced COPD patients they did not have much use for such an app, because they already have the tools to cope with COPD. They often can predict themselves when they are likely to have an exacerbation. On top of that, they usually already have their solutions in place in case this happens.

> "Ik denk voor ervaren COPD'ers zoals ik zelf. Heb ik zoiets van ik kan hier weinig mee. Of ik zou het niet gebruiken. Dat zei ik nog van van longaanval die voel je wel aankomen en je hebt gewoon medicijnen in huis. En dan weet je van te voren het is er weer been"
> - Participant 6
>
> "... Ik heb al hulp. Ik krijg hulp. ... 3 keer In de maand ga ik naar de longverpleegkundige dan moet je puffen en doen en die geeft ook advies. ... Maar die geeft mij ook handvaten en nogmaals Ik ben sociaal bezig natuurlijk. En Ik ga één keer In de week fitness en daar krijg je ook hulp en handvaten en daar heb ik die die app dus ook niet meer nodig. Ik denk dat de app meer nodig is voor Mensen die niet sociaal zijn of niet naar buiten wilden of of als als begint zeg maar. En als je dan in zo'n wandelgroepje zit of een zwemgroep die ja dan gaat het ook allemaal zelf. Denk ik. maar voor mij is de overbodig ik ik doe al wat de app wil zeg maar."
> - Participant 4
>
> "Voor mij persoonlijk. Ik ben al zo ver al. ik heb dit al jaren dus. ... en ik ga niet eens met mijn huisarts meer. Ik ga regelrecht naar de specialist. Dus op een geven moment net zoals nu. Ik zit nu in fase we hebben thuis een 3 fase in stappen. Groen is goed, Oranje en rood. Ik zit nu in oranje. Dus ik ben ik ben.. dan weet je al van jezelf at je de pretnisol moet gebruiken dat ik al aan de verneveling zit de zuurstof heb ik nog niet nodig. Maar kom ik aan de zuurstof dan ga ik automatisch al bellen met het ziekenhuis. Dus dan wordt de boel al in gang gezet. Dus voor mij is ehh deze app met alle respect. Ik zou het kunnen gebruiken. Maar ook niet. ... Voor andere mensen kan het geweldig zijn. Voor mij twijfelachtig."
> - Participant 5

Mobile app novelty

Sometimes it occurred that a participant was experiencing difficulties in either understanding the task or executing the task. They would then ask for help or would feel frustrated.

> "Help me is meid."
> - Participant 1
>
> "Goed dit gaat niet goed dus. Ik blijf hangen op die vorige. Het gaat om een wekelijkse rapportage. Toch? Daar kom ik niet aan. Nou. Ik kom er niet uit"
> - Participant 6

However, even if they felt frustrated they also expressed that they had difficulties in navigating the app because of its novelty.

> "Ik denk als je die app dus een tijdje heb. Het zelfde wat ik uitleg met deze dan leer je het wel. En het taalgebruiken die wij spreken. Jullie zijn van een andere generatie. Ik bedoel dat niet gemeen. Jullie werken anders met computers jullie doen dat allemaal veel sneller. Dus dat het ook makkelijker is om dingen aan te toetsen"
> - Participant 1
>
> "Ja je moet een beetje gewend raken aan de app. Dus voor mij is het vrij nieuw"
> - Participant 3
>
> "Het is natuurlijk nog een beetje ongewend. Dus je moet heel even zoeken als je nu de tweede keer zou zijn dan gaat het gewoon makkelijker. Dus het is al doende leren gewoon."
> - Participant 5
>
> "... Dat was net even zoeken maar als je dus een of twee keer een app gebruikt. Dan gaat het heel goed"
> - Participant 7

Respiratory distress

Applying the Thinking Aloud Protocol [28, 49] to COPD patients has yielded a deeper understanding of their cognitive processes during app interaction. While most of the participants did not experience much difficulty in doing so, one participant in particular mentioned that thinking and reading out loud costs him a lot of energy.

> "Ja ik moet even lezen
> I: Ja u mag de taak ook hard op lezen
> P: Dat kost me heel veel moeite." - Participant 5

During the usability test, the researcher closely observed the participants in case they experienced any respiratory distress. If any respiratory distress was observed the researcher refrained from cueing the participant to continue talking, to prevent any exacerbation of symptoms.

5.3.2 Analytics

Lostness metric

To analyse the usability test, different methods were used. I analysed the screen recordings and based on the optimal path, amount of screens visited and the total different screens visited a lostness quotient was calculated. See table 5.1. The lostness metric shows how lost one is on a task. Generally, anything under 0.4 indicates that they are not lost. Anything above that means that it needs improvement. The figure shows how lost the participants were on average individually and per task. You can see that on average participants get lost on task 4. Task 5 was the most straightforward and most intuitive followed by task 1. Then, tasks 2 and 3 are also within acceptable range and don't need improvement.
Table 5.1 also shows the lostness metric for each task. In the figure, you can see that every participant doesn't get lost on average. However, looking at the individual task per person, each participant gets lost on some task. Even though the participants get lost, they still manage to complete the task in the end. Noteworthy, was that there seems to be a correlation between lostness and task satisfaction.

Task completion

As displayed in Figure 5.1, the completion rates for each task offer valuable insights into participants' performance during the usability testing. The figures underscore the varying degrees of success among participants in accomplishing the assigned tasks.
Four out of the five tasks witnessed a notable level of success, with six out of the seven participants completing them. Notably, it was a different participant who faced challenges for each of these four tasks, indicating a distributed range of obstacles rather than consistent hurdles. This diversity in task completion rates underscores the multifaceted nature of user interaction within the prototype.
Task Three presented an exception to the trend, boasting a 100% success rate. All participants effectively completed this task, pointing to a higher level of clarity, intuitiveness, or ease associated with this specific task. The universal success of Task Three highlights its alignment with user expectations and capabilities.

Completion time

Figure 5.1 shows the boxplot for the completion time for each task. The figure shows that tasks 1, 2 and 5 were relatively consistent in completion time. With just one outlier for task 5. Tasks 3 and 4 were less consistent. Especially task 4 the completion time was widely spread and took longer. Also, some tasks just took longer than others. For example, task 2 generally took longer because they needed to read a lot of text from their weekly report. The duration also varied depending on the complexity of the tasks. However, all tasks given were relatively simple and should therefore not take too much time. The tasks were completed by most of the participants. However, participants 2,3,4 and 6 each failed one of the tasks. Notably, tasks with shorter completion times were not correlated with higher task satisfaction.

Task path

The exploration of participant paths in completing tasks offered a detailed understanding of user behaviour and interaction patterns. In this section I delve into the distinct paths

Lostness Metric							**Literacy**	
	Task 1	Task 2	Task 3	Task 4	Task 5	Average	Technology	Health
Participant 1	0.00	0.00	0.55	0.86	0.00	0.28	2	3.0
Participant 2	0.00	0.00	0.75	0.43	0.00	0.24	3	4.7
Participant 3	0.42	0.00	0.00	0.58	0.33	0.27	3	4.0
Participant 4	0.35	0.00	0.00	0.64	0.00	0.20	4	4.3
Participant 5	0.00	0.61	0.50	0.55	0.00	0.33	3	4.7
Participant 6	0.00	0.55	0.00	0.32	-	0.22	4	4.3
Participant 7	0.00	0.00	0.42	0.76	0.00	0.23	4	5.0
Average	0.11	0.17	0.32	0.59	0.06		3.29	4.3

Table 5.1: Lostness metric and literacy

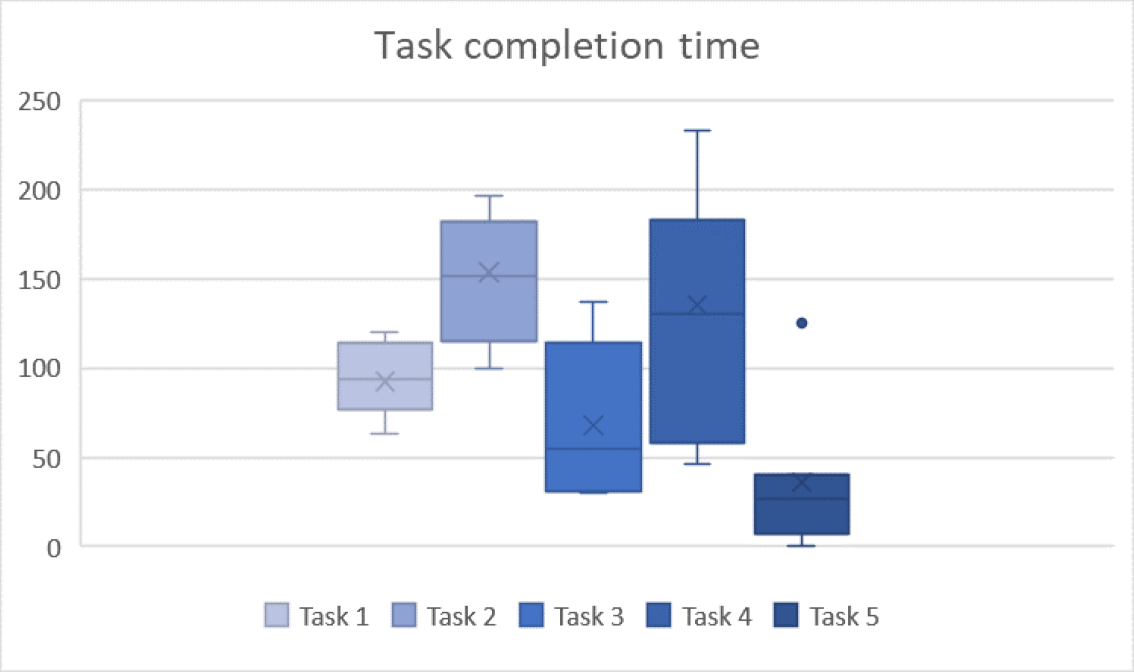


Figure 5.1: Boxplot: Task completion time per task in seconds

participants took for each task, unveiling the challenges, optimal routes, and their implications for enhancing user experience.

In Task One, the majority of participants smoothly navigated to their goal, employing the optimal path effectively. Impressively, five out of seven participants followed the optimal path. However, one participant struggled at the beginning, initially perusing the history of reports before locating where to report symptoms. Intriguingly, the first participant became completely disoriented during the task, erroneously veering towards habits. A bug further complicated their navigation, leading to premature access to reported symptoms, which were not yet submitted.

Similar to Task One, Task Two showcased most participants successfully employing the optimal path to locate the weekly report. Notably, two participants attempted to access the weekly report through reported symptoms instead of seeking it in the designated home page section.

In Task Three, it was evident that the participants looked for the network on the home page. Participants, however, swiftly adapted, shifting their focus to the navigation bar

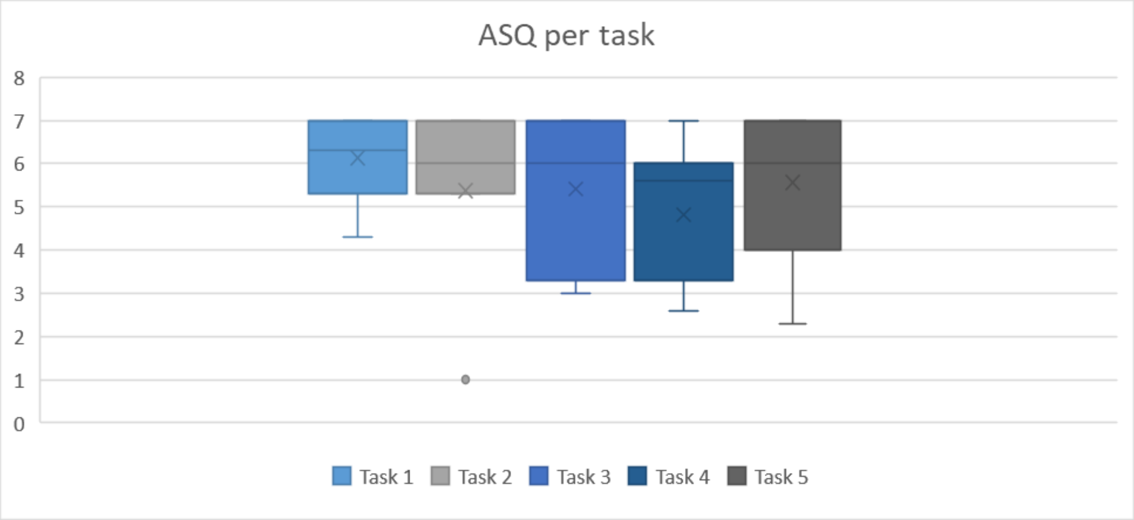


Figure 5.2: Boxplot: ASQ per task

upon realizing its absence on the home page. Notably, three participants managed to complete the task using the optimal path.

Task Four emerged as the most challenging task, as participants sought an article on habits. While five of seven participants ventured directly to the habits section, they encountered difficulties within the section, straying from the task's objective. Clarification was necessary to realign them, leading them to utilize the navigation bar to access articles. This task complexity underscores the significance of precision in task formulation and the need to guide users within complex interfaces.

Task Five stood as the simplest task, with participants effortlessly adding habits, often unintentionally having completed a similar action in a previous exercise.

5.3.3 ASQ and HUBBI benchmark

ASQ questionaire

Table 5.3 shows the results of the ASQ questionnaire for each task per participant. Additionally, figure 5.2 shows the ASQ results per task as boxplot. Overall, the results were positive about the tasks. The participants somewhat had the same experience for each task, with just one outlier for task 2. Task 1 scored the best and task 4 was the lowest.

Task	Completed	Avg completion time (s)	ASQ
Task 1	6	92.3	6.1
Task 2	6	153.4	5.4
Task 3	7	68.0	5.4
Task 4	6	135.3	4.8
Task 5	6	42.0	5.6
Average	6.2	98.2	5.5

Table 5.2: Tasks summary

Participant	Task 1	Task 2	Task 3	Task 4	Task 5	Average
Participant 1	6.3	5.3	3.3	2.6	5.6	4.62
Participant 2	7	7	3	5.6	7	5.92
Participant 3	5.3	5.3	6	3.6	2.3	4.5
Participant 4	4.3	6	5.6	3.3	7	5.24
Participant 5	6	6	6	6	6	6
Participant 6	7	1	7	7	4	5.2
Participant 7	7	7	7	5.6	7	6.72
Average	6.1	5.4	5.4	4.8	5.6	

Table 5.3: ASQ by task

HUBBI benchmark

The results of the HUBBI for the new design were mostly positive. Figure 5.3 shows the results. The app scored the highest in the information & terminology category with a score of 4.1. The interface design followed that with a score of 4.0. The three categories satisfaction, task-technology fit and navigation & structure all had a score of 3.8. Then guidance & support is second to last with a score of 3.4. Finally, the basic system performance of the app scored the lowest with a 2.4.

5.4 Discussion

I designed the usability test to assess the tool's functionality, ease of use, and overall user experience. Through a combination of qualitative feedback and data, the test aimed to capture COPD patients' perspectives, preferences, and challenges while interacting with the prototype. By dissecting completion rates, lostness, task satisfaction, usability problems, and a synthesis of interviews, insights were gained for enhancing the user experience of Healthenthia for COPD patients.

To recap the usability test shortly, there were five tasks that the participants had to

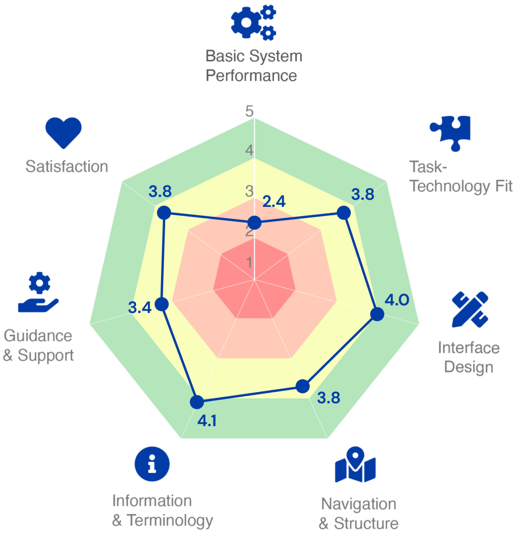


Figure 5.3: HUBBI results

complete by immersing themselves in the persona of Anita. The following five tasks were included:

1. Report Symptoms
2. Read Anita's weekly report
3. React to Jan's status in Anita's network
4. Learn about how habits can improve Anita's life
5. Create a new habit

5.4.1 Completion rates and completion time

The combination of completion rates and completion times, as well as their relationship with user satisfaction, offered a nuanced understanding of participant performance during the usability testing phase. My synthesis not only highlights users' efficiency in accomplishing tasks but also underscored the multifaceted nature of user satisfaction and engagement within the prototype. The completion rates across the administered tasks I found to be generally satisfactory. Participants demonstrated a commendable ability to complete the assigned tasks within the given time frames. However, a closer examination of completion times revealed patterns that offer insights into user interaction dynamics and task complexity. Such as, participants taking longer on more complex tasks. For example when they had to navigate to other navigation tabs. Notably, it looked like they got familiar with the app by task 5 and knew exactly where to find what they were looking for without thinking too long about it and therefore had a relatively short completion time.

The observed variation in completion times can be attributed to several factors. Task 2, for instance, typically took longer due to the necessity of reading extensive text from the weekly report. Additionally, the complexity of the tasks influenced completion times, with more intricate tasks demanding more time. It's essential to note that while the tasks were intentionally designed to be relatively simple, the inherent complexity of certain objectives naturally extended the time required for successful completion. Additionally, when something new was introduced to them in task 3, where they had to navigate to another tab, they also needed more time to adjust. However, when they found the navigation bar it only took a short amount of time for them to reach their goal and finish the task.

While most participants succeeded in completing the tasks, it's worth noting that participants 2, 3, 4, and 6 encountered difficulties in completing one of the tasks. This diversity in task completion rates underscores the varied skill sets and familiarity with the app among participants. It highlights the importance of accommodating diverse user competencies to ensure an equitable user experience for all.

Interestingly, despite variations in completion times, there was no evident correlation between shorter completion times and higher task satisfaction. This suggests that the speed at which participants completed tasks did not necessarily equate to greater satisfaction.

To conclude, the analysis of completion rates and completion times reveals the dynamic nature of user interaction with the prototype. Participants demonstrated efficiency in completing tasks, but the relationship between completion time and task satisfaction appears complex. This underscores the multifaceted nature of user satisfaction, influenced by factors beyond task completion speed. To enhance the user experience, a holistic approach that considers task complexity and user proficiency is imperative, ensuring that tasks are not only completed efficiently but also contribute to overall user satisfaction and engagement.

5.4.2 Lostness and task satisfaction

Participants were generally satisfied with the tasks, highlighting their adaptability and comfort in engaging with the prototype. However, Task 4 emerged as a notable exception, posing challenges both in terms of comprehension and navigation. Six out of seven participants were disoriented during this task, shedding light on specific areas that demand improved user guidance.

Task 4, centred on finding an article related to habits, presented the most significant hurdles in both task comprehension and navigation. Several factors contributed to the navigational difficulties encountered by participants. One key aspect was the clarity of the task formulation, which appeared to leave room for interpretation. Participants' struggles in understanding the task's specific requirements contributed to their navigation difficulties. They made the mental connection to "habits" instead of "articles". Therefore, they tried to look for this article within the habits section, instead of where the all articles are located.

Furthermore, the design of the information page within Task 4 seemed to hinder participants in their quest to find a suitable article. Participants primarily focused on reading article titles, neglecting the section titles, which could have guided them more effectively. The sheer volume of articles and the time it took to locate the appropriate tab exacerbated the challenge, often resulting in participants losing track of their task objectives.

Despite these difficulties in Task 4, it's important to note that the overall lostness metric, which quantifies participants' disorientation, was positive. The participants' abilities to complete tasks, on average, show relatively low levels of disorientation. This suggests that while specific tasks may present navigational challenges, participants generally felt oriented within the prototype.

In conclusion, the participants' overall satisfaction with the usability tasks aligned with their adaptability and competence in using the prototype. However, the difficulties encountered in Task 4 underscore the importance of refining task clarity and providing enhanced navigational support, particularly within information-rich sections. The section titles on the information page should be improved to enhance the clarity of those elements. This targeted approach can further elevate the usability and user experience of Healthenthia for COPD patients, ensuring that all tasks are not only comprehensible but also navigable with ease.

5.4.3 Perception of App Usability and Suitability

The participants' experiences during the usability testing shed light on both the suitability and usability of the tested prototype, Healthenthia, for COPD patients. Overall, participants exhibited comfort and competence in utilizing various interaction methods such as tapping, swiping, and scrolling, both horizontally and vertically. However, it is essential to delve deeper into their interactions to comprehensively assess the prototype's suitability and usability.

Interaction issues

The usability test uncovered that participants encountered the most issues with tapping interactions. These problems often arose when participants tapped components that were not interactive or missed the intended tap targets, primarily concerning buttons. Such challenges resulted in participant frustration when the app did not respond as expected. These observations emphasize the usability of the prototype.

Figma issues and limitations

It is crucial to recognize that most usability issues stemmed from the limitations of the Figma prototype. Certain components were not interactive, leading to confusion and frustration among participants when the app did not behave as anticipated. These limitations included the inability to interact with specific buttons and text boxes, causing some participants to struggle with tapping the touch targets on navigation bars and primary buttons. Moreover, participants attempted to interact with elements such as titles, profile pictures, or cards and there were no interactions designed for them at this stage. Additionally, some participants questioned the possibility of adding more than one habit, which the prototype did not allow. Lastly, the inability to close pop-ups outside of using the close button or issues with tapping outside the pop-up further contributed to usability challenges.

Phone habits

Beyond the limitations of the prototype, notable observations were made regarding participants' phone interaction habits. These were habits made outside of the usability test. Several participants displayed habits acquired from using other phone brands, such as continuously scrolling down to check for new messages or additional information, even when they reached the bottom of the page. The gesture of swiping right, which on some phones allows users to go back to the previous page, was also evident among participants. While these observations highlight participants' propensity to apply existing habits, they also suggest that the prototype should be adaptable to accommodate these behaviours in a fully implemented app.

Other observations

Other observations made were that participants attempted to check checkboxes under tasks, although these specific tasks could not be checked. For them to check them, they need to actually complete the task within the app and then the app itself will mark the task as completed. This could suggest that the participants did not completely understand the intention of the task to be completed in the app. However, at the time they were trying this, they were lost and probably just trying things. Further tests should be executed to shed more light on this issue. Another observation made was that some participants did not fill in every symptom as instructed in the usability test, selecting only those symptoms Anita experienced as more severe. The other symptoms participants left them as they were. Therefore, it could be useful to design for this. For example, in case someone doesn't select the state of a symptom, the symptom will be automatically saved as "Normal" indicating no exacerbation of that symptom.

The perceived value of Healthentia

During the interviews, participants expressed that Healthenthia could hold value for COPD patients, particularly those who are newly diagnosed or still grappling with the condition. The app was perceived as a valuable tool offering quick, clear insights, especially during moments of uncertainty, insecurity, depression, or anxiety. Furthermore, participants believed the app could serve as a motivational and stimulating tool, encouraging the formation of positive habits like increased physical activity or completing daily tasks.

However, some participants, who had extensive experience managing COPD, felt the app might not be as beneficial for them. They already possessed the necessary coping tools and often anticipated exacerbations and had strategies in place to address them. This viewpoint underscored that the app's utility might vary among COPD patients, depending on their experience and readiness to adopt such a digital self-management tool.

In conclusion, the usability test provided valuable insights into the suitability and usability of Healthenthia for COPD patients. While participants demonstrated competence in using the app, usability issues were primarily linked to the limitations of the Figma prototype. Recognizing user habits and navigation patterns is essential for the app's future adaptation and improvement. Moreover, the varying perceptions of the app's utility among experienced and newly diagnosed COPD patients highlight the importance of tailoring Healthenthia to meet the diverse needs of its users. Ultimately, the usability test served as a foundational step toward refining Healthenthia to ensure it aligns seamlessly with COPD patients' expectations and abilities.

5.4.4 Usability test execution

Executing usability tests was a complex endeavour, even when guided by established methodologies such as those outlined by Nielsen [61]. The process required a delicate balance between obtaining genuine user insights and adhering to testing protocols to ensure reliability and consistency. It was essential to recognize that while usability tests aim to evaluate a system's inherent user-friendliness, they must also consider the unique needs and anxieties of the participant, particularly in the context of COPD patients.

Performing usability tests was particularly challenging, especially when working with individuals who may be experiencing anxiety, insecurities, or other emotional factors related to their health condition. As patients verbalize their thoughts, I gained access to the rationale behind their decisions, uncovering implicit challenges, hesitations, and moments of confusion that might not be evident through mere observation. It offered valuable insights into the interaction of COPD patients with Healthenthia, but it was essential to acknowledge the negative effects that arose from its application. COPD patients often experience respiratory distress and limitations in lung function. Engaging in the Thinking Aloud Protocol, which necessitates continuous verbalization of thoughts during the usability test, can exacerbate their physical strain. The act of speaking aloud may lead to increased breathlessness, contributing to discomfort and potentially undermining the accuracy of their verbalizations. This physical strain could compromise their overall well-being during the protocol.

Balancing the adherence to testing guidelines with the need to empower and encourage participants was crucial, especially with a target group as sensitive as COPD patients. Usability tests aim to assess the inherent usability of a system, and ideally, a well-designed system should require minimal guidance. However, real-world users, especially those dealing with chronic health conditions, may encounter challenges and uncertainties that need addressing.

To strike this balance, it can be worth considering a compassionate and empathetic approach during usability tests. While maintaining the core principles of usability testing, some mild direction and encouragement can be permitted for example. This approach would involve providing subtle guidance or reassurance to participants, particularly when their anxiety or insecurity becomes evident. Such interventions can help participants feel more comfortable during the test, allowing them to provide more authentic feedback.

Ultimately, the goal of usability testing was to evaluate the design's effectiveness in delivering a user-friendly experience. By allowing for measured assistance when necessary, the test can better assess whether the design itself meets the needs of its target users or if certain usability issues persisted that require attention. Striking this balance ensured that the usability test remained a valuable tool for refining the design while also respecting the unique challenges faced by the participants.

In summary, the execution of usability tests, especially with a sensitive target group like COPD patients, demanded a thoughtful approach. By carefully considering the need for mild direction and empowerment, usability tests can provide more comprehensive insights into the design's usability while ensuring participants' comfort and cooperation. This approach served to enhance the overall usability of the system and improve the user experience, ultimately benefiting the individuals it aims to support.

5.4.5 Limitations

Reflecting on my usability test, it's essential to acknowledge several limitations. Something to consider is that I may not have reached a proper saturation of participants for my usability test. Participants, mainly experienced with COPD, may not fully represent those in earlier stages. Additionally, the test involved individuals with higher health literacy, potentially biasing results. I tried to get as many participants as possible to reach that saturation, but was unable to do so as other participants did not respond or are maybe not even in the panel of RE-SAMPLE. To address this, future evaluations should encompass diverse health literacy levels. Moreover, participants demonstrated high technological proficiency, which could influence outcomes, especially considering the varied technology skills among COPD patients. To provide a more realistic assessment, future tests should include participants with varying technology skills, ensuring a comprehensive understanding of the app's accessibility and usability within the intended demographic. And if they are not included in the RE-SAMPLE panel it is essential to attempt to specifically recruit those.

6

General discussion

Delving into the discussion, I analyzed the broader implications and connections of the findings, aiming to make a meaningful contribution to the larger discourse within my field. First, unpacking the results of the usability tests among COPD patients, a critical disparity emerged—participants in the study predominantly possessed high technology skills. In part, this may be due to the nature of the recruitment process that unintentionally favoured those interested in and proficient with technology. This observation sheds light on the inherent challenge in recruiting a diverse panel, where the saturation of COPD patients with low technology skills is limited. This contrasted with the broader COPD patient population where low technology skills are more prevalent. While there might not have been an intentional exclusion of individuals with low technology skills, the natural inclination of those interested in technology to participate may have inadvertently skewed the panel towards proficiency.

The consequences of this limitation are far-reaching. The panel, currently skewed toward individuals with proficient technology skills, may inadvertently overlook the needs and challenges of the majority of COPD patients who grapple with low technology skills and limited digital interest. As a result, it might undermine the tool's effectiveness for those who stand to benefit the most. Addressing this limitation is not merely about refining the tool's usability but fundamentally about recalibrating the composition of the panel to mirror the diversity of the COPD patient population. Diversifying the panel becomes a strategic imperative, allowing for a more accurate reflection of the challenges faced by individuals with low technology skills.

While strategies to enhance accessibility, like a simplified user interface, remain relevant, it is essential to actively seek representation from COPD patients with varying degrees of technology familiarity, health literacy and COPD experience. This is particularly pertinent considering the suitability of a mobile app for this demographic, a consideration that must be validated through direct engagement with these individuals. By prioritizing the diversification of the COPD patient panel, a more inclusive and representative foundation for usability tests is established. This approach allows for a comprehensive exploration of the diverse range of technology skills, health literacy, COPD experience and preferences within the COPD community, fostering the development of a more universally accessible and user-friendly design for the Healthentia tool.

Second, the insights I have collected by applying HCD to this project. HCD is a holistic approach with many different tools which are used to prioritise the needs, preferences, and behaviours of the end-users. However, as I encountered in my thesis, these tools can be optimized for the target group, which is in this case COPD patients. This type of tweaking is important to be recorded so it can be used in future studies. This was also done before by for example Eagle Science for inclusive design [10]. It is known that COPD patients suffer from conditions such as shortness of breath. Therefore it is important to recognize that during usability tests and accommodate for that. Besides that, it is common for COPD patients to have some sort of anxiety or feel insecure about using technology. This occurs not only in daily life but also during these tests. To not aggravate any negative feelings for using technology it is crucial to consider this while having these tests with COPD patients with limited functioning prototypes. As they can question their skills more rather than the interface itself. In short, it is essential to not only consider the needs and preferences of COPD patients for the end product but also in the process of building, evaluating and testing a prototype with COPD patients.

Furthermore, I question whether Figma is an appropriate tool to prototype for a usability test for COPD patients. While I was preparing the prototype it soon became obvious to me that Figma was limiting, and this could influence the usability test with the COPD patients. The limitations primarily revolved around the inability to input text or numbers using a keyboard and the restricted interactivity of certain elements within the system. I still chose to continue to design the app within Figma, because this is the tool I was most familiar with. But as expected, during the usability test, Figma showed its limitations. This was confusing for the participants of the usability test. The experiences of the participants varied about this issue. Some were very neutral and even understanding. They continued to narrate what they would do if they could interact with it as they expected. Because they could understand that it was just a limitation of the prototype and not a limitation of the concept of the app. However, for others, it was restricting. It kept them from properly executing some tasks. This was more concerning to me as this influenced their perspective and experience of the app's concept. Therefore, for future prototyping, the limitations of prototyping tools should be considered. Depending on the goal of the prototype certain tools can be more suitable than others. In this case, because it was a test in an early stage of testing this concept, I think it was suitable enough. The results of the usability test showed its limitations, however, it gave enough insights to continue the development and optimization of Healthentia. Also, Figma continues to evolve and some of the limitations I encountered in my prototyping have already been resolved as of writing this. So, it is essential to consider what the goal is of a test in order to find a suitable tool to create and test a prototype.

At last, I reflected on different aspects of the procedure and tools I used, but now I want to go back to the actual result of my attempt to optimize Healthentia through HCD. Looking at all of the metrics and questionnaires it looks like I made a step forward in terms of user experience, intuitiveness and accessibility. The results suggest that the concept of the app is well-perceived. Of particular note, Dotinga did a complimenting study and used my designs in one of her tests as well [30]. She got corroborating results.
However, something else I observed while the participants were filling out the HUBBI questionnaire was that they related differently towards the questions. Some participants explicitly asked me whether they should fill in how they generally feel about the app and how they could foresee how the app would work or how they experienced it during

the usability test. If they asked I told them to consider what they experienced during the usability test. Additionally, there were questions in the questionnaire that actually couldn't be answered as these aspects of the app were not shown during the usability test or even made in the prototype. This could have influenced some parts of the results. Nonetheless, it is clear what the main issues were with the prototype and what needs to be improved in future iterations.

6.1 Limitations

In the course of this thesis, I've built upon Healthentia's prior work, which opted for a mobile application for COPD patients. However, it's crucial to recognize that the explored solution might not be the definitive choice for addressing this patient group's needs. My focus on this specific solution stemmed from thesis constraints and scope, leaving other viable options unexplored. Interviews with experienced COPD patients unveiled existing support networks involving family and friends, suggesting potential avenues for further investigation.

If the pursuit of an app continues, future iterations could benefit from considering personalized action plans. Currently overlooked in the app's design, integrating individualized plans could significantly enhance its utility, providing a powerful tool for COPD patients. However, achieving this potential requires additional research and development, accounting for the diverse range of CCCs and the need for tailored action plans.

It's important to note that the app presented here isn't a complete solution. Practical limitations led me to focus on specific aspects, but future developments should consider expanding capabilities for a closer connection with HCPs. Patient feedback highlighted the desire for rapid and direct communication with HCPs, indicating an area for improvement in subsequent versions.

7

Future Work

Moving forward, I have several points for future work that converge on enhancing the overall impact of the Healthentia self-management tool for COPD patients, how my work can be used for RE-SAMPLE and how it can be generalized and used on a bigger scale. Firstly the points that enhance the overall impact of Healthentia. In the iterative development of Healthentia, I made progress towards crafting a comprehensive self-management tool for COPD patients. However, numerous aspects and opportunities remain unexplored, highlighting key areas for future exploration.

Addressing the distinct needs of both inexperienced and experienced COPD patients emerges as a priority for Healthentia. Experienced COPD patients state that the solution is suitable for the inexperienced COPD patient. However, this still needs to be verified with them. Additionally, it is necessary to uncover the specific needs of experienced COPD patients. This exploration is especially pertinent if RE-SAMPLE aims to cater to this demographic. Furthermore, research should delve into the varied needs of COPD patients with specific CCC and how these can be effectively addressed. I made the design modular so that different components can be designed and integrated for the different needs of each CCC.

Additionally, the conceptualization of a virtual companion was introduced in this iteration, however, it still requires further elaboration in subsequent iterations. Something else that might be worth exploring is leveraging existing action plans for COPD patients, each unique to the individual holds the potential to enhance the tool's value significantly..

Furthermore, RE-SAMPLE needs to diversify its panel, specifically including more COPD patients with low skills in technology and health literacy. This expansion ensures a more accurate representation of the broader COPD patient population, addressing the limitations in the current study and enhancing the applicability of the Healthentia tool.

Then I discovered a key recommendation for future endeavors. Focusing on the development and research of defined design guidelines or a design system tailored specifically for the older age demographic could prove beneficial when designing applications targeted at this demographic. While design systems are intended to be accessible for all, the elderly often encounter challenges in using applications and grasping interaction nuances. Therefore a bespoke design system or specific guidelines could be invaluable in ensuring that applications are comprehensible for the elderly, providing a level of uniformity that enhances their overall user experience.

Then the next thing for RE-SAMPLE. The next crucial step for RE-SAMPLE involves synthesizing my findings and design with the complementary study conducted by Dotinga [30] and the investigations on companionship by RE-SAMPLE. This integration presents a challenging yet crucial task to improve the engagement, accessibility and usability of Healthentia. Finally, my study conducted in the Twente region for the Dutch COPD patient community offers insights that extend beyond local boundaries. The insights into HCD) specifically for this target group derived from my research possesses universal applicability, providing valuable guidance for future studies aiming to adopt a holistic approach in addressing the needs of COPD patients on a global scale.

While my findings pertain specifically to The Netherlands, they reflect the broader challenges encountered by COPD patients worldwide. The insights uncovered in this study, rooted in the local nuances of Twente, carry the potential to resonate with and inform initiatives aimed at enhancing the well-being of COPD patients in various international contexts. Specifically, the principles derived from the HCD approach implemented in this study can serve as a valuable blueprint for addressing the unique needs and challenges of COPD patients beyond the Netherlands. By adopting a holistic perspective that places the patient at the centre of the design process, future studies can draw upon the lessons learned in Twente to tailor interventions.

As an exemplar of international collaboration, RE-SAMPLE, can contribute these findings to the different findings of other countries involved in their project outside of The Netherlands. The synergistic integration of insights garnered from diverse cultural contexts ensures a comprehensive and culturally responsive framework for addressing the complex landscape of COPD care.

Consideration should be given to contextual variations, healthcare infrastructures, and socio-cultural dynamics in each participating country. Collaborative efforts between international partners, informed by the foundational principles of HCD, have the potential to redefine the landscape of COPD care on a global scale. As such, the impact of this research is not confined to the Twente region or even the Netherlands but resonates as a beacon guiding transformative approaches to COPD patient well-being worldwide.

8

General conclusion

In the pursuit of optimizing the design of a self-management tool tailored for COPD patients, I addressed a series of critical research questions aimed at enhancing the tool's user interface, promoting user engagement, and elevating the overall user experience while taking into account the unique needs and preferences of this specific user group. Guided by these research questions, I embarked on a thorough investigation that encompassed diverse aspects of design and user interaction. Subsequently, the study's findings offer valuable insights into the complex interplay of design elements, usability, and user perception. To conclude my thesis I will answer my research questions in this chapter.

SQ1.1: Can standardised design system guidelines be used to create and design an intuitive and accessible user interface for COPD patients to engage effectively with a self-management tool?
In my thesis, my primary aim was to enhance the intuitiveness and accessibility of the Healthentia self-monitoring app, ultimately striving to promote user engagement, improve usability, and ensure a positive overall user experience. I capitalized on the advantages of an established design system, Material Design, integrating it with the existing Healthentia design framework. This process entailed a meticulous evaluation of prior design components, pinpointing and addressing any existing usability issues. Subsequently, I delved into the creation of new design elements custom-tailored to Healthentia's unique requirements. By merging Material Design principles with the existing Healthentia design, I managed to fine-tune the app's user interface, making it more intuitive and accessible. This comprehensive approach yielded positive results, substantially elevating the overall user experience.
However, it's essential to note that despite these improvements, there remained untapped potential for further enhancement. The usability test revealed certain issues, particularly related to the size of specific interface elements. Participants found them challenging, necessitating extra effort for reading and interaction. This observation underscores the fact that while leveraging standardized design system guidelines like Material Design can be advantageous for boosting intuitiveness and accessibility, there are still hurdles and opportunities for refinement. These considerations are particularly pertinent for the unique needs of COPD patients, especially those within the elderly demographic who may not be well-versed in technology usage.

SQ1.2: How do COPD patients perceive the usability and overall experience of using a self-management tool designed specifically for their condition?

I will answer this question in two parts. First, the COPD patients who participated in the usability test had a generally positive perception of the usability and overall experience while using the self-management tool. The HUBBI benchmark revealed that the tool is acceptable and satisfactory in most of the categories. The basic system performance was the category that scored the worst. This was mainly due to the limitations of Figma and the design system not specifically being designed for an elderly demographic with minimal technology skills. However, even though the basic system performance was not well perceived, that did not seem to influence the satisfaction of using the tool. The results showed that the lostness correlated with (task) satisfaction instead. This is a valuable finding for future iterations. It seems that how confident and knowingly the COPD patient can navigate the app has an impact on how well the usability is perceived. As long as the COPD patients feel like they know what they are doing then the time it takes them to reach their goals is insignificant to a certain extent.

Second, while the usability and overall experience were satisfactory, most COPD patients expressed concerns about whether it would be valuable for themselves. Those who participated in the test were generally more experienced COPD patients who already know how to cope, recognize an exacerbation and have their network for help in place. The needs that the tool covers do not match the needs of experienced COPD patients. Even though these COPD patients were reluctant about using the tool in this state, they did mention that they see the value for recently diagnosed COPD patients and those who have difficulty coping with it. Whether the tool is valuable, usable and accessible for inexperienced COPD patients is yet to be confirmed.

To summarise, the tool was generally well-perceived by more experienced COPD patients. Experienced COPD patients see the value of the tool for inexperienced COPD patients but are reluctant to use it themselves. Whether the tool is valuable for inexperienced COPD patients needs to be further explored. Furthermore, it should be considered whether such a tool is relevant for experienced COPD patients in the first place. And if so, what needs should still be met for experienced COPD patients with such a tool?

SQ1.3: How can human-centred design enhance the development of a self-management tool for COPD patients?

In this thesis, I used a HCD approach and with that showed how it enhances the development of a self-management tool for COPD patients. This approach allowed me to empathise and get a deep understanding of COPD patients and utilize that to create a user interface that is satisfactory in intuitiveness and accessibility. While I was able to utilize the HCD approach, I encountered that it needed some enhancement so the approach fitted the sensitive target group. During the usability test, I saw that some COPD patients experienced insecurity, anxiousness and sometimes shortness of breath. There are two key points here. First, the think-aloud protocol defined by Nielsen [61] requires the facilitator to refer the participant to the task description or prompt the participant to continue speaking in order to maintain the integrity of the test. However, since this target group is already coping with emotions like insecurity and anxiousness it is crucial to support and maybe even encourage them during these tests to relieve some of these emotions and make them more confident in using technology. Second, Thinking aloud can give key insights into what thought processes the users go through while using the app. So if such methods are required, then it is important to pay close attention to the condition of the

COPD patient during these tests. And carefully evaluate when to prompt the participant to continue thinking aloud or when to give the participant some time to catch their breath.

RQ 1: How can the design of a self-management tool for COPD patients be optimized to create an intuitive and accessible user interface that promotes engagement, usability, and positive user experience, while considering COPD patients' specific needs and preferences? In my thesis, I embarked on the journey to optimize the design of a self-management tool for COPD patients, with the primary objective of crafting an intuitive and accessible user interface that would not only encourage engagement but also enhance usability and provide a positive user experience. My approach involved several key insights. First, I recognized the role of HCD as the foundation of this endeavour. By immersing myself in the world of COPD patients, and taking the time to truly understand their unique needs and experiences, I developed a deep understanding so I could create an interface that resonated with them. This empathetic approach formed the cornerstone of my design process.

Second, through my research, I uncovered the diverse needs of COPD patients. While some needs were universal, such as the need for effective self-management tools, there were notable distinctions between inexperienced and experienced COPD patients. Experienced individuals exhibited specific needs and preferences, including a reluctance to engage with a tool that didn't cater to their particular requirements. Recognizing these differences underscored the importance of tailoring the self-management tool to address the wide spectrum of COPD patients' needs including both inexperienced and experienced COPD patients.

Third, I acknowledged the significance of usability in the design of the self-management tool. I explored the potential of design systems, such as Material Design, as valuable assets in streamlining the design process. However, this comes with careful consideration. The design system should be designed for the intended target group. COPD patients who are generally elderly have specific needs in terms of technology because they often have poorer vision and their coordination diminishes. All the more reason that they need a specific design system. However, it has come to my attention that there is no widely recognized design system specifically tailored for the elderly. Most design systems claim to be all-inclusive and accessible for everyone, however, this study showed that is not always the case. Therefore, a design system or defined guidelines seem to be a gap in this field.

Furthermore, for COPD patients, particularly those in the elderly demographic, user confidence and ease of use emerged as important factors. While the time it takes to reach their goal within the tool may not have been the primary concern, ensuring that users felt secure and confident while navigating the tool was crucial. I recognized that the comfort and ease with which COPD patients could use the tool were essential in ensuring a positive user experience.

In conclusion, my experience to enhance the design of a self-management tool for COPD patients was a profound journey, intricately weaving together the fabric of HCD principles, a nuanced understanding of diverse patient needs, and the strategic selection and adaptation of design systems. Rooted in a commitment to bolster user confidence and ease of use, I aspired to craft more than an interface – a companion in their self-management journey. This journey wasn't just about pixels and buttons; it was a commitment to building an intuitive and accessible space that resonates with the very heartbeat of COPD patients. I aimed to not only elevate engagement, usability, and the overall user experience but to empower individuals in their path towards managing their health. As the horizon unfolds, these endeavours serve as a launchpad for the future, holding the promise of continual refinement of COPD patient care and the potential to transform the landscape of self-management tools. This journey is not just a chapter in design optimization; it's a prelude to a future where the intersection of empathy, innovation, and patient-centric design propels COPD care into new realms of effectiveness and compassion.

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A

Usability report

A.1 Personas

AGE 44

STATUS Married

OCCUPATION Pulmonary Nurse

WORK EXPERIENCE 12

LOCATION Enschede (NL)

Jessica Vos

ABOUT

Seeing her patients regularly is what Jessica loves about her job, because it gives her the opportunity to build a relationship with her patients and that feels human to her. Patients are humans and not a number out of a thousands. Jessica believes that empowering COPD patients is the key for positive results in the patients' health and self management skills. She wants to support her patients and guide them in the right direction.

PERSONALITY

Introvert — Extrovert

Analytical — Creative

Loyal — Fickle

Passive — Active

NEEDS

- An eHealth application that is time efficient and easy to use

MOTIVATION

Intrinsic ●●●●●●

Extrinsic ●●●○○○

GOALS

- Empowering patients to be able to self-manage their disease
- Support and guide patients in the right direction

TECHNOLOGY

Believes that eHealth is the future.

FRUSTRATIONS

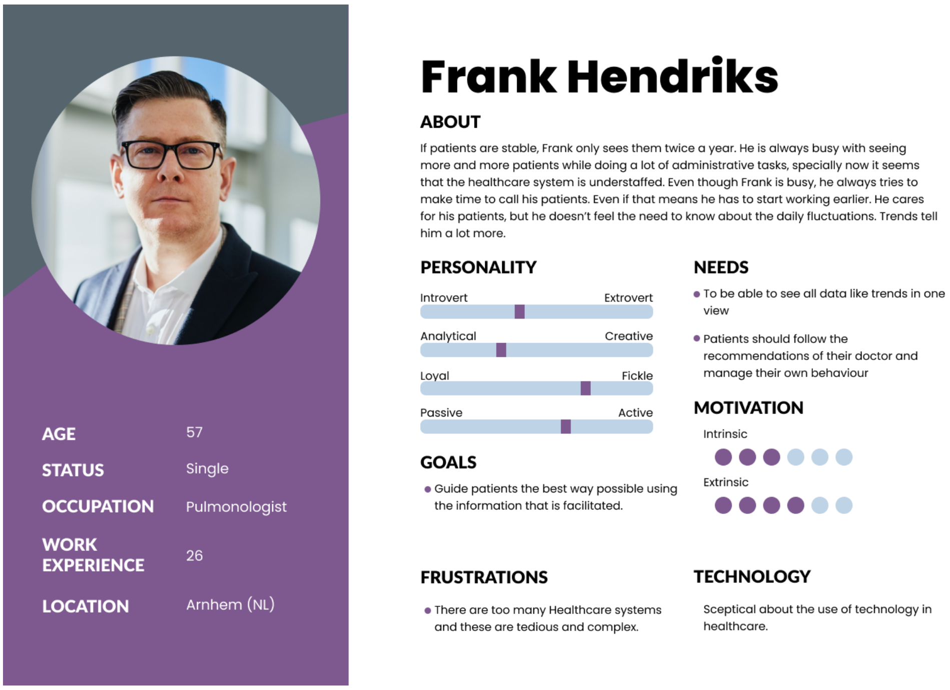
- eHealth needs to be clear and extensively explained to the COPD patients

Figure A.1: Persona Jessica Vos

A.2 User Journey

A.3 Storyboards

A.4 Inspiration



Frank Hendriks

AGE 57

STATUS Single

OCCUPATION Pulmonologist

WORK EXPERIENCE 26

LOCATION Arnhem (NL)

ABOUT

If patients are stable, Frank only sees them twice a year. He is always busy with seeing more and more patients while doing a lot of administrative tasks, specially now it seems that the healthcare system is understaffed. Even though Frank is busy, he always tries to make time to call his patients. Even if that means he has to start working earlier. He cares for his patients, but he doesn't feel the need to know about the daily fluctuations. Trends tell him a lot more.

PERSONALITY

Introvert Extrovert

Analytical Creative

Loyal Fickle

Passive Active

NEEDS

- To be able to see all data like trends in one view
- Patients should follow the recommendations of their doctor and manage their own behaviour

MOTIVATION

Intrinsic

●●●○○○

Extrinsic

●●●●○○

GOALS

- Guide patients the best way possible using the information that is facilitated.

FRUSTRATIONS

- There are too many Healthcare systems and these are tedious and complex.

TECHNOLOGY

Sceptical about the use of technology in healthcare.

Figure A.2: Persona Frank Hendriks

Maria De Jong

AGE 39

STATUS Married

OCCUPATION Psychologist

WORK EXPERIENCE 10

LOCATION Arnhem (NL)

ABOUT

Maria De Jong is a psychologist who specializes in mental health and has been working in the field for over a decade. She is passionate about holistic healthcare and believes that the well-being of individuals cannot be solely addressed by focusing on their bodily functions. Maria is frustrated with the current healthcare system, which primarily focuses on treating physical symptoms and often fails to consider the mental state, lifestyle habits, self-management, and social networks of patients.

PERSONALITY

Introvert Extrovert

Analytical Creative

Loyal Fickle

Passive Active

NEEDS

- Health care that also considers mental state, lifestyle habits, self-management and social network
- Health care with multidisciplinary cooperation

MOTIVATION

Intrinsic

●●●●●○

Extrinsic

●●●●○○

GOALS

- Give care using an holistic approach.

FRUSTRATIONS

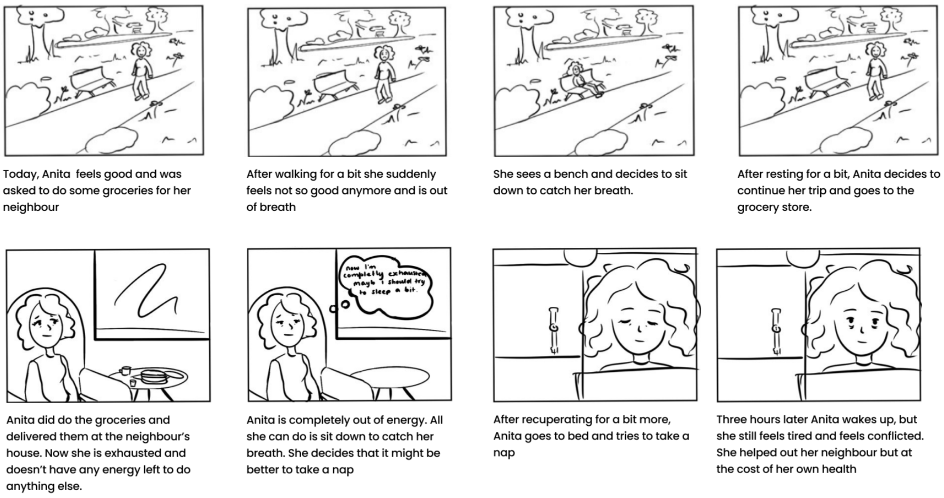
- Health care that is only focused on bodily functions
- Patients that are refered to one specialist to another.

TECHNOLOGY

Believes that eHealth could be an addition to current care

Figure A.3: Persona Maria De Jong

Figure A.4: DutchCOPDpatient journey



Today, Anita feels good and was asked to do some groceries for her neighbour

After walking for a bit she suddenly feels not so good anymore and is out of breath

She sees a bench and decides to sit down to catch her breath.

After resting for a bit, Anita decides to continue her trip and goes to the grocery store.

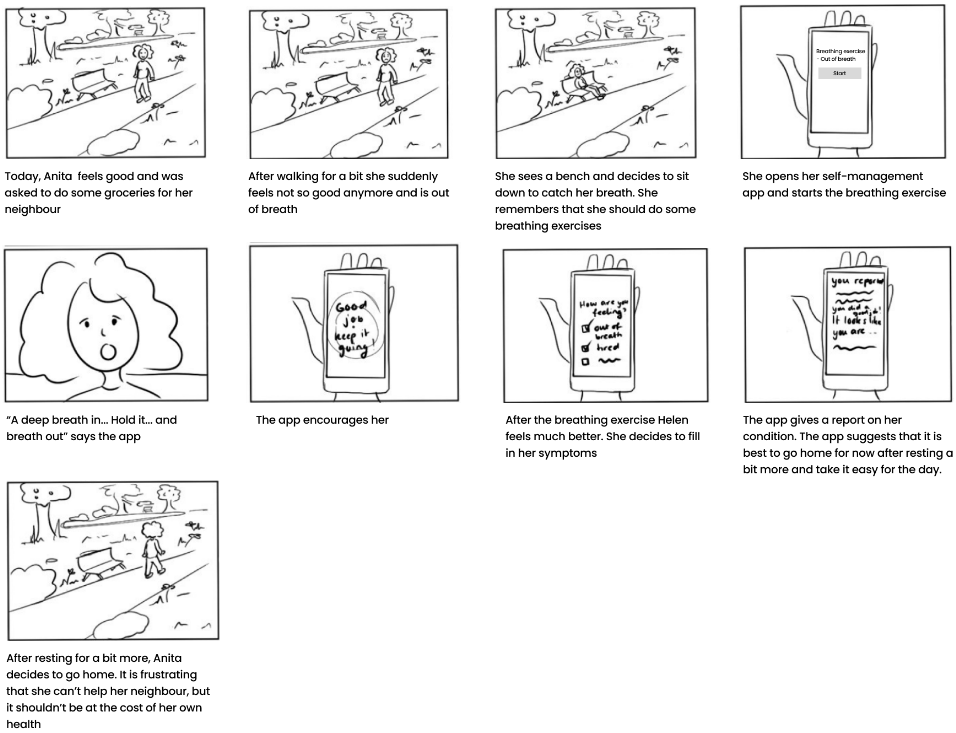
Anita did do the groceries and delivered them at the neighbour's house. Now she is exhausted and doesn't have any energy left to do anything else.

Anita is completely out of energy. All she can do is sit down to catch her breath. She decides that it might be better to take a nap

After recuperating for a bit more, Anita goes to bed and tries to take a nap

Three hours later Anita wakes up, but she still feels tired and feels conflicted. She helped out her neighbour but at the cost of her own health

Figure A.5: Storyboard - A scenario of a COPD patient without an eHealth app



Today, Anita feels good and was asked to do some groceries for her neighbour

After walking for a bit she suddenly feels not so good anymore and is out of breath

She sees a bench and decides to sit down to catch her breath. She remembers that she should do some breathing exercises

She opens her self-management app and starts the breathing exercise

"A deep breath in... Hold it... and breath out" says the app

The app encourages her

After the breathing exercise Helen feels much better. She decides to fill in her symptoms

The app gives a report on her condition. The app suggests that it is best to go home for now after resting a bit more and take it easy for the day.

After resting for a bit more, Anita decides to go home. It is frustrating that she can't help her neighbour, but it shouldn't be at the cost of her own health

Figure A.6: Storyboard - A scenario of a COPD patient with an eHealth app

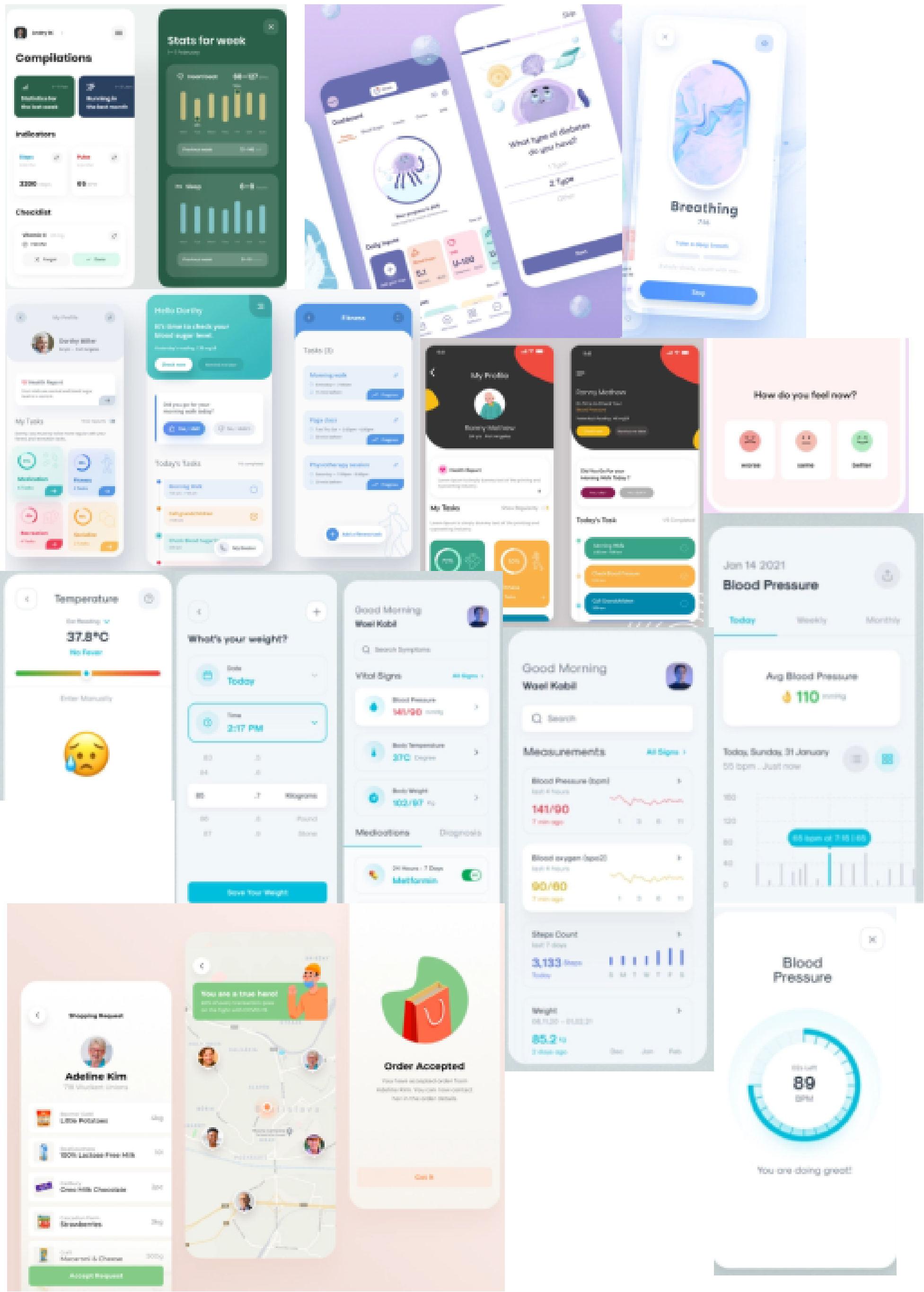


Figure A.7: Collection of inspiration part 2

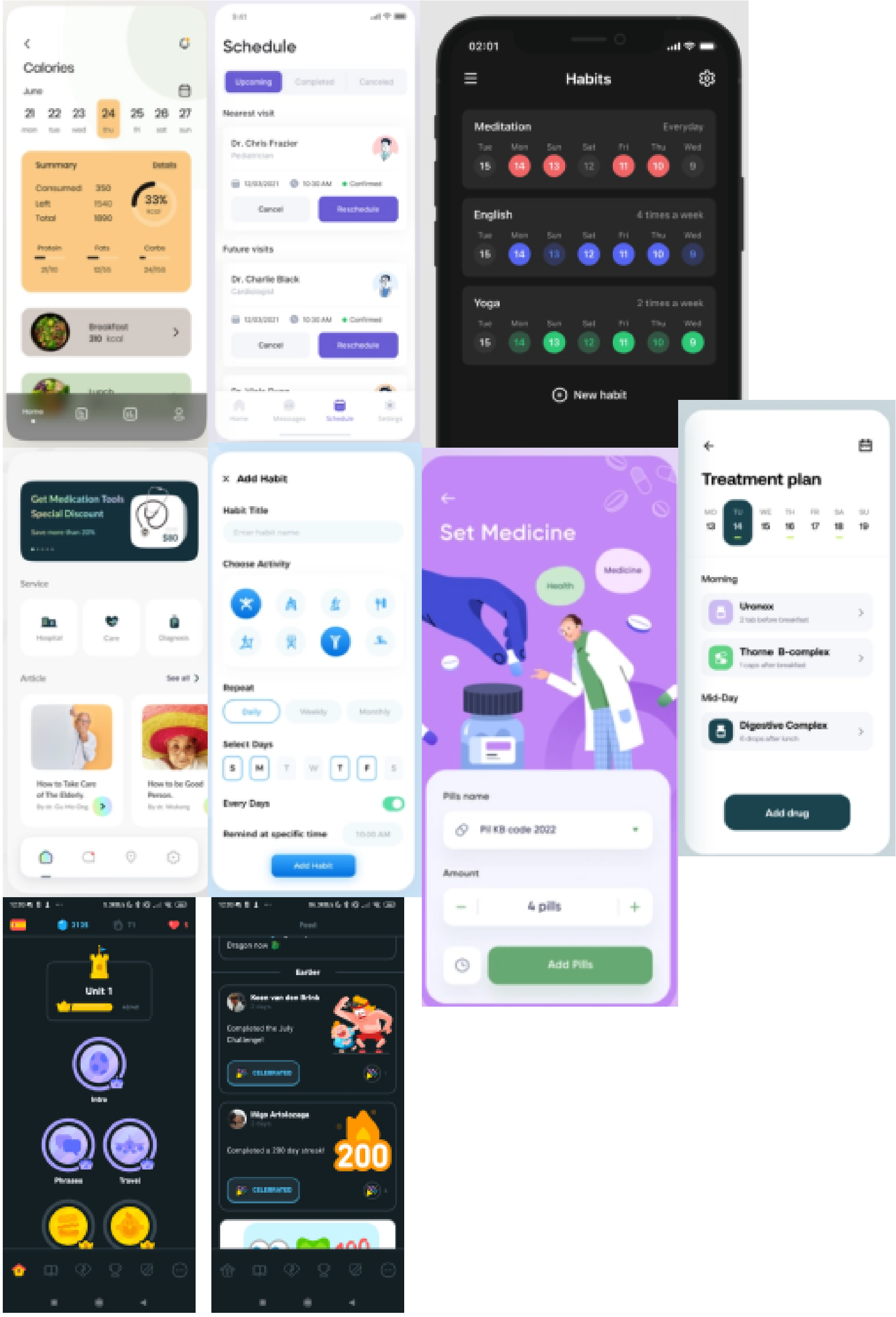


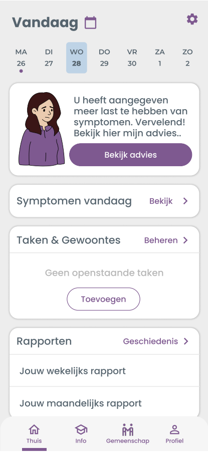
Figure A.8: Collection of inspiration part 3

B

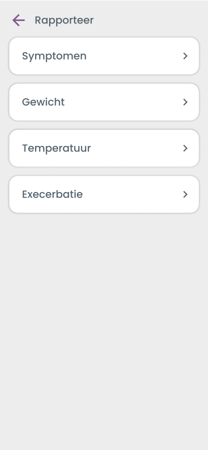
Usability review - printouts

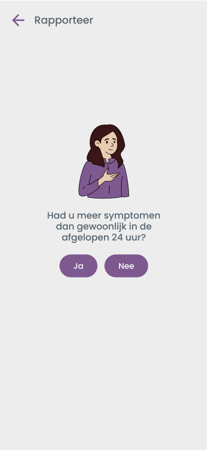
1

Goede morgen Anita
Hoe voel je je vandaag?

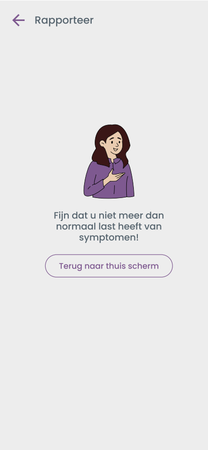


U heeft aangegeven meer last te hebben van symptomen. Vervelend! Bekijk hier mijn advies..





Had u meer symptomen dan gewoonlijk in de afgelopen 24 uur?



Fijn dat u niet meer dan normaal last heeft van symptomen!

Van welke symptomen heeft u in de afgelopen 24 uur meer last van dan normaal?

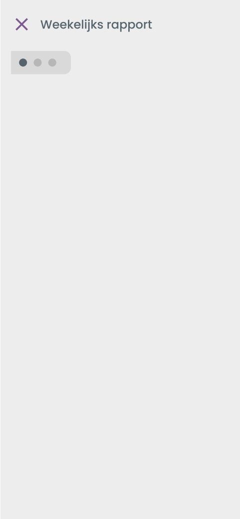
Bedankt voor het rapporteren van je symptomen! Het helpt mij om u beter advies te geven. Ga zo door!

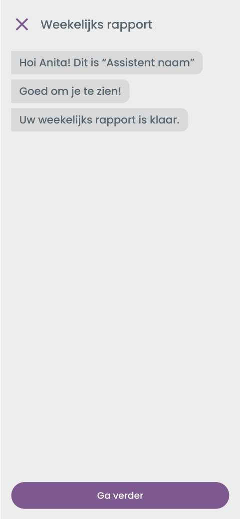
Hier is mijn advies:

Op basis van uw gerapporteerde symptomen raad ik u aan om te beginnen met prednisolone en antibiotica. Als u zich niet beter voelt na 2 dagen, als u twijfelt of als u vragen heeft bel dan de huisarts.

U kunt mijn advies altijd terug vinden op het thuis scherm.

2

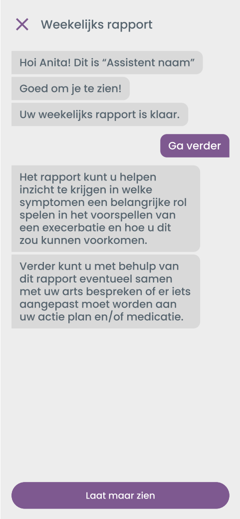




Hoi Anita! Dit is "Assistent naam"

Goed om je te zien!

Uw weekelijks rapport is klaar.



Hoi Anita! Dit is "Assistent naam"

Goed om je te zien!

Uw weekelijks rapport is klaar.

Het rapport kunt u helpen inzicht te krijgen in welke symptomen een belangrijke rol spelen in het voorspellen van een execerbatie en hoe u dit zou kunnen voorkomen.

Verder kunt u met behulp van dit rapport eventueel samen met uw arts bespreken of er iets aangepast moet worden aan uw actie plan en/of medicatie.

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Laten we kijken naar uw rapportage van de agelopen week en laten we dat opsplitsen

Deze week heeft u 2 keer

Hoi Anita! Dit is "Assistent naam"

Goed om je te zien!

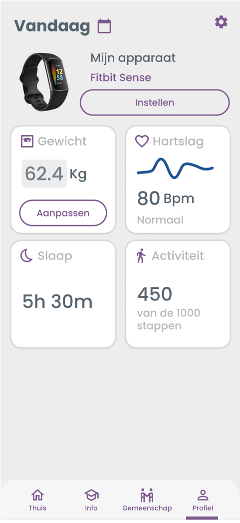
Uw weekelijks rapport is klaar.

Het rapport kunt u helpen inzicht te krijgen in welke symptomen een belangrijke rol spelen in het voorspellen van een execerbatie en hoe u dit zou kunnen voorkomen.

Verder kunt u met behulp van dit rapport eventueel samen met uw arts bespreken of er iets aangepast moet worden aan uw actie plan en/of medicatie.

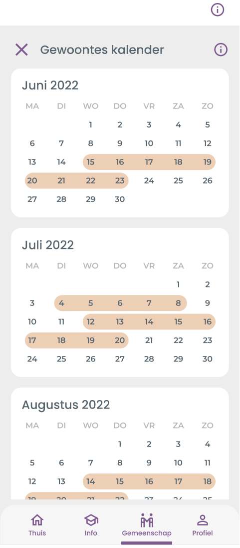
Laten we kijken naar uw rapportage van de agelopen week en laten we dat opsplitsen

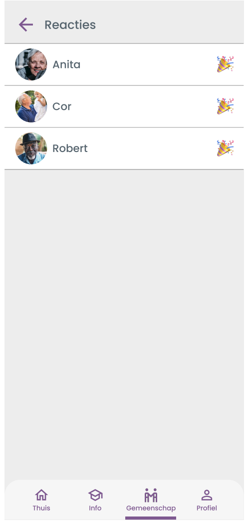
Deze week heeft u 2 keer gerapporteerd meer last te hebben van symptomen dan normaal.



3

Heeft 7 dagen op rij zijn gewoontes voltooid!





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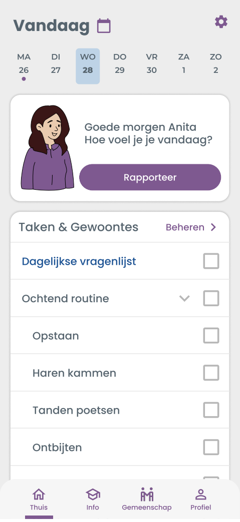
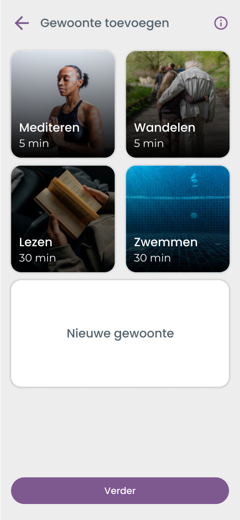
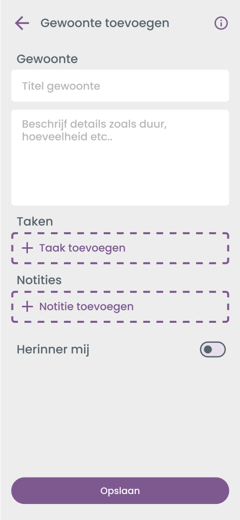
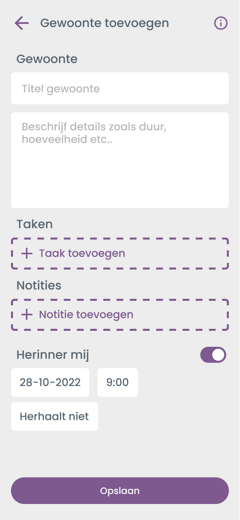


Goede morgen Anita
Hoe voel je je vandaag?







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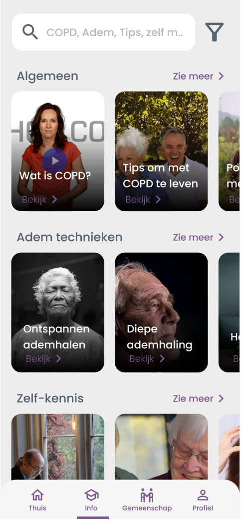
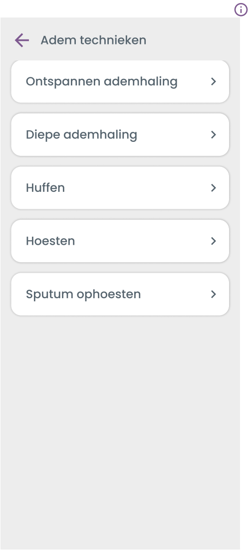


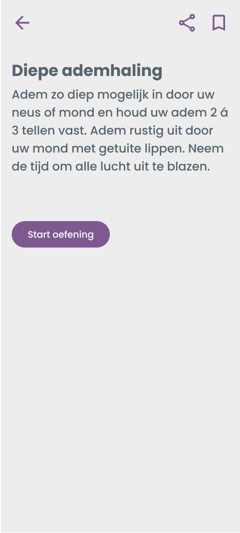
COPD is een ziekte van de longen die niet kan genezen. Dit komt meestal door roken.

Als u rookt, ademt u rookdeeltjes in. Deze komen via de longbuisjes bij de longblaasjes.
Deze rookdeeltjes zorgen dat uw longen altijd een beetje ontstoken zijn. De longbuisjes worden smaller (nauwer) en er komt meer slijm. Hierdoor komt er schade in de longbuisjes en longblaasjes. Bij COPD gaat deze schade niet meer weg. Uw longen gaan hierdoor



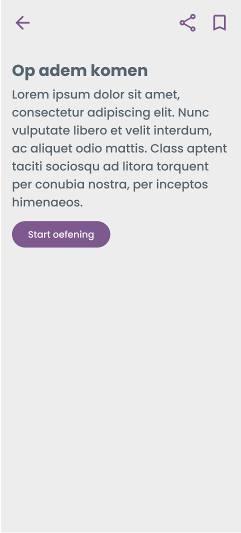
Ontspannen ademhalen

Adem zo rustig mogelijk in door uw neus of mond. Adem uit door uw mond. De fysiotherapeut bespreekt met u of u uw lippen moeten tuiten bij het uitademen of niet.



Diepe ademhaling

Adem zo diep mogelijk in door uw neus of mond en houd uw adem 2 á 3 tellen vast. Adem rustig uit door uw mond met getuite lippen. Neem de tijd om alle lucht uit te blazen.



Op adem komen

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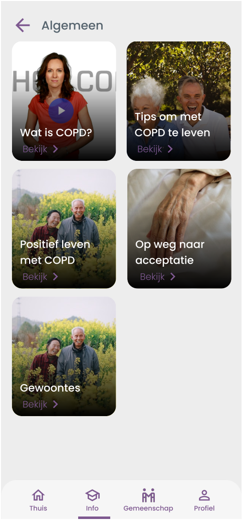
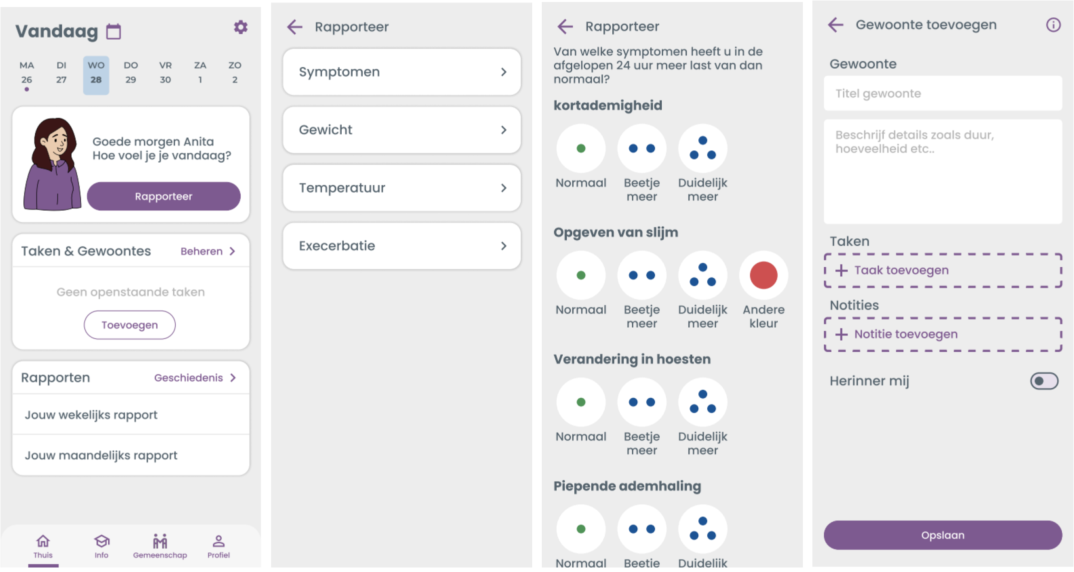


C

Final prototype

In this appendix, I provide more wireframes of the prototype I developed for the study. You can also access the clickable prototype at `https://www.figma.com/proto/9UmSWcUPNE1MiY4htCyVa8/Healthentia?page-id=909%3A2626&type=design&node-id=909-2627&viewport=477%2C393%2C0.09&t=0qERe6OqsrKYpZji-1&scaling=scale-down&starting-point-node-id=909%3A2627&mode=design`.

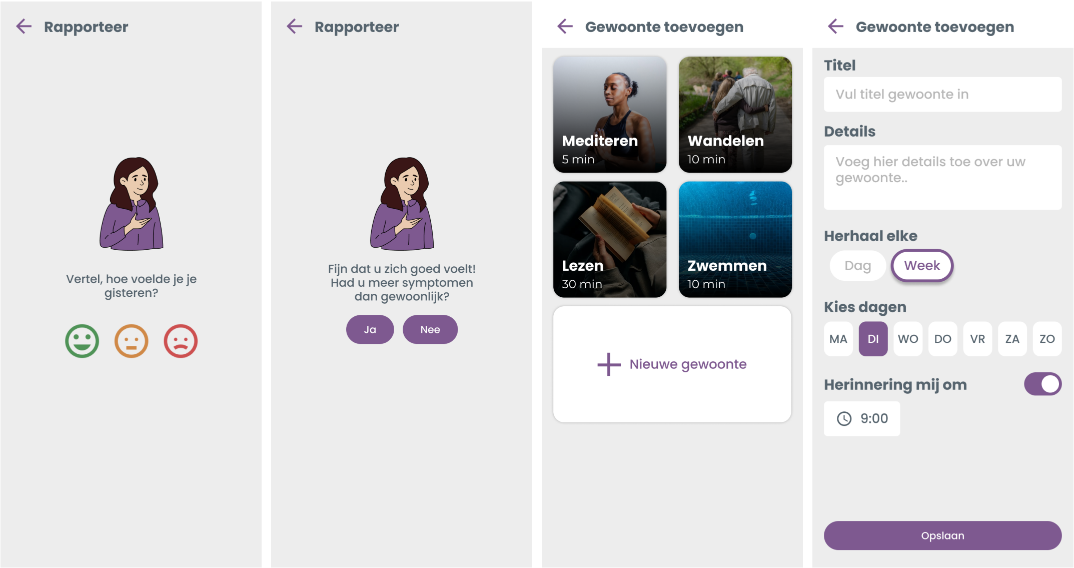


Goede morgen Anita
Hoe voel je je vandaag?

Van welke symptomen heeft u in de afgelopen 24 uur meer last van dan normaal?

(a) Home (b) Report 1 (c) Symptoms (d) Add habit

Figure C.1: First concept wireframes

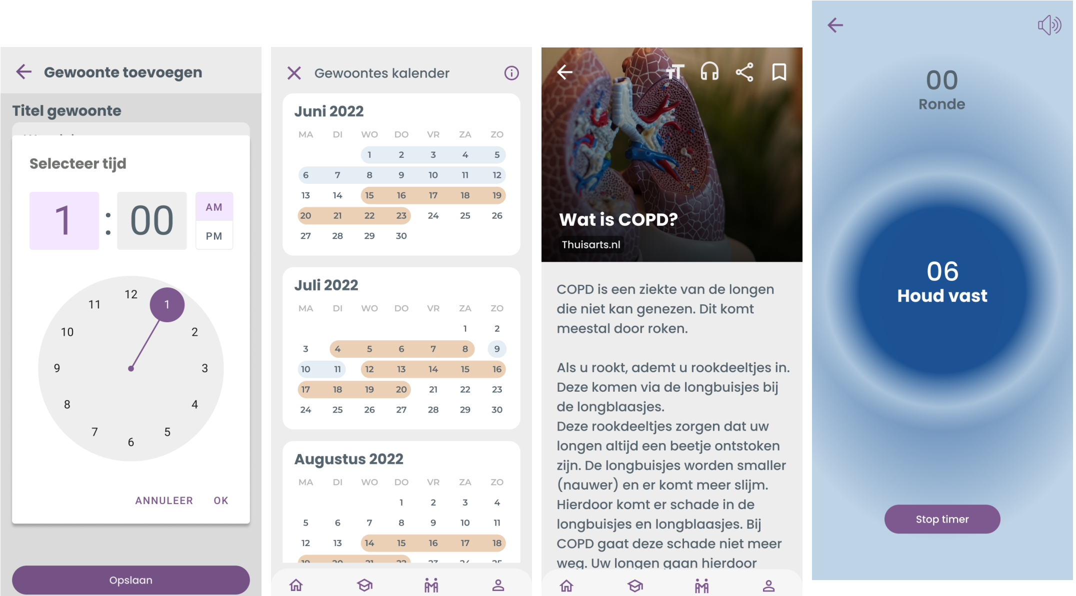


Vertel, hoe voelde je je gisteren?

Fijn dat u zich goed voelt! Had u meer symptomen dan gewoonlijk?

(a) Report (b) Report (c) Symptoms (d) Add habit

Figure C.2: Final prototype wireframes



Juni 2022

MA	DI	WO	DO	VR	ZA	ZO
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Juli 2022

MA	DI	WO	DO	VR	ZA	ZO
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Augustus 2022

MA	DI	WO	DO	VR	ZA	ZO
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18

Wat is COPD?

Thuisarts.nl

COPD is een ziekte van de longen die niet kan genezen. Dit komt meestal door roken.

Als u rookt, ademt u rookdeeltjes in. Deze komen via de longbuisjes bij de longblaasjes.
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(a) Add habit (b) Network (c) Article (d) Breath exercise

Figure C.3: Final prototype wireframes

D

Usability test protocol

Research protocol

Introduction (5 min)	*"Hoi "naam participant". Hoe gaat het met u? Ik waardeer het enorm dat u de tijd neemt om vandaag deel te nemen aan dit gebruikersvriendelijkheidsonderzoek. Ik ben Anna Mae en ik doe mijn afstudeeropdracht bij RRD.* (Als er anderen aanwezig zijn introduceer hen ook) *Oké, ik zal eerst vertellen hoe het zal gaan. Zoals u waarschijnlijk weet maakt dit onderzoek deel uit van RE-SAMPLE. Binnen RE-SAMPLE wordt er gefocust op het veranderen van de zorg voor COPD-patiënten met andere chronische aandoeningen door het zelf leren omgaan met symptomen met behulp van een virtuele metgezel. Dit is een persoon in de app die u helpt, naar u luistert en u advies geeft.* *Tijdens het uitvoeren van de taken zal ik u vragen om hard op na te denken. Ik zal beginnen met kort uitleggen op welke manier ik verwacht dat u hard op nadenkt. We zullen eerst een korte oefening doen om het hard op na te denken te oefenen. Na de oefening mag u kort de app zelf eerst uitproberen. dan zal ik u laten kennismaken metAnita. Ik wil u vragen om in haar schoenen te stappen voor dit onderzoek. Nadat u kennis gemaakt heeft met Anita zal u een paar takenuitvoeren in de test versie van de Healthentia app.Wanneer u de taken heeft voltooid, mag u een korte vragenlijst invullen over de Healthentia app. Om het af te sluiten, wil ik graag wat feedback van u over hoe ervaring was.* *Tijdens dit onderzoek krijgt u een app te zien. Met dit onderzoek willen we in kaart brengen hoe gebruikersvriendelijk de app is, hoe mensens de app gebruiken en hoe mensen over de app denken. We proberen de app zo goed mogelijk te maken. Dus uw eerlijkheid is erg belangrijk voor ons.* *Is er iets dat u wilt vragen voordat we verder gaan?* *Voor we starten moet ik u vragen of u comfortabel bent met dat wij een audio opname maken van het onderzoek en een schermopname van de telefoon. Is dat oke? En als laatste vraag ik u om dit toestemmingsformulier te ondertekenen als u dat nog niet had gedaan.* Top, dan start ik nu de audio opname en zullen we gelijk beginnen met wat achtergrond vragen. " (* startgeluidsopname)
Warm-up (10 min)	*Oke, "participant naam", als u zo de taken gaat uitvoeren wil ik u verzoeken om hard op na te denken. Dat is ook hard op lezen, en hard op zeggen waar u mee bezig bent. Bijvoorbeeld "Oke.. ik moet dus dit vinden.. waar zou dat staan? "Menu" Hier misschien? Nee.. Ook niet hier..Waar zou het nog meer kunnen staan"* *We zullen dit eerst even oefenen. Hier is een telefoon. En ik wil u vragen om een nieuws artikel te vinden. En terwijl u dat doet natuurlijk hard op na te denken.*

	Top gedaan! (Geef eventueel tips over wat ze wel en niet mogen zeggen. Het gaat hier alleen om level 1 en 2 verbalisering volgens het 3-level model van verbalisatie) *Dan wil ik graag eerst u laten kennismaken met Anita. Anita is ook een COPD patiënt en heeft last van angst? En diabetes. Ze vind het lastig om te accepteren dat ze nu niet meer de dingen kan doen die ze voorheen wel kon. Nu zit ze vaak alleen thuis en is ze niet echt gemotiveerd om erop uit te gaan omdat het teveel vraagt van haar lichaam. Maar ook al is het lastig, ze probeert het te accepteren en gezonder te leven.* *Heeft u nog een vraag over Anita?* *Nou "naam participant", u mag nu eerst de app kort uitproberen om een idee te krijgen wat het inhoud.* (1-2 min)
Body (~45 min)	*"Dan zijn we nu op het punt gekomen waar u de taken mag uitvoeren. Stap in de schoenen van Anita en vergeet niet om hard op na te denken terwijl u de taak uitvoert. Ik zal u nu een voor een de taken geven."* Als de participant stil valt, spoor dan de participant aan om hard op na te denken. Doe dit door non-verbale cues zoals "mm-hmm" indien nodig zo min mogelijk met woorden door level 1 en 2 verbalisatie. Bijvoorbeeld: "Blijf praten, alstublieft" "Waar kijkt u nu naar?" "Welk woord leest u nu?" "Wat ziet u op het scherm?" Geef de taken een voor een en laat de participant de taken zelf lezen en uitvoeren. Als de participant stopt met hard op nadenken, herinner de participant eraan om hard op na te denken. " (*start scherm opname) Taken: 1. Invullen Symptomen 2. Bekijk Anita's wekelijks rapport 3. Reageer op een vriend(in)'s status in Anita's netwerk 4. Leer over hoe gewoontes Anita's leven kunnen verbeteren 5. Maak een nieuwe gewoonte: 10 min wandelen "Dank u wel voor het uitvoeren van alle taken. Dat waren ze allemaal. Zou u nu de volgende vragenlijst willen invullen?" Geef HUBBI Vragenlijst.
Cool down (5 min)	"Dan heb ik ten slotte nog een paar vragen. 1. Denkt u dat de app Anita zou kunnen helpen met het omgaan van haar ziekte?

	- Zo ja, wat zou Anita helpen? - Wat zou er anders moeten worden om Anita beter te helpen? 2. Denkt u dat de app u zou kunnen helpen met het omgaan van uw ziekte? - Zo ja, Wat zou u helpen? - Wat zou u anders willen zien zodat het u beter zou helpen? 3. 4.
Wrap-up (1-3 min)	“We zijn aangekomen bij het einde van het onderzoek. - **Is er nog iets wat u wilt delen of benoemen?** Oké, dan is dit het einde van het onderzoek. Heel erg bedankt voor uw aanwezigheid en hulp bij dit onderzoek. Nadat ik alle onderzoeken heb afgerond zal ik een samenvatting maken en deze met u delen. “