Design of a Camera-Voice Assistant for Seniors

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MASTER THESIS

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Abstract

An increased need for elderly care and health care is expected due to a population that is only getting older. Swedish health care is already known to be burdened. As a result, Sweden aims to become the best country in the world in using digitalisation and e-health solutions.

This thesis was done in collaboration with Doro Care, an international company that offers digital solutions enabling digital telecare at home. The scope of this thesis was to explore a good relationship between a camera-voice service and a senior in need of care. The focus was to investigate how the interaction between these two parties should look by finding the needs of the user to feel secure and trust the technology without a sense of surveillance.

The user's needs and requirements were found using different data gathering methods such as interviews and questionnaires. Needs such as a discrete device and the need for a screen were used as a basis when generating concepts. This was then followed by creating four low fidelity prototypes and four high fidelity prototypes. By testing the prototypes, it was discovered that today's older adults (55+) may prefer interacting with bigger screens such as tablets. This could be a generational preference and could change over time. A combination of the three final prototypes or the possibility of choosing between them was discovered to be a good option for a home assistant. More tests would have been needed to explore this possibility further.

Keywords: User experience, eHealth, interaction design, elderly care, digitalisation, concept development, smart home, safety, welfare technology, telecare

Sammanfattning

Ett ökat behov av äldreomsorg förväntas på grund av en befolkning som bara blir äldre. Svensk hälso- och sjukvård är känd för att redan vara belastad och som ett resultat strävar Sverige efter att bli bästa landet i världen på digitaliserings- och e-hälsolösningar.

Examensarbetet har gjorts i samarbete med Doro Care, ett internationellt företag som arbetar med digitala lösningar som möjliggör digital vård hemma. Arbetets syfte var att undersöka hur en bra relation mellan en kamera-röstassistent i hemmet och en senior kan se ut. Denna avhandling fokuserade på hur interaktionen mellan dessa två parter bör se ut så att användaren känner sig säker och litar på tekniken utan att känna att intergriteten påverkas allt för mycket.

Användarens behov och krav hittades med hjälp av olika datainsamlingsmetoder såsom intervjuer och frågeformulär. Krav så som en diskret enhet eller behovet att interagera med en skärm, användes som bas när olika koncept av en kamera-röstassistent skapades. Därefter utformades fyra low fidelity-prototyper samt fyra high fidelity-prototyper. Genom att testa prototyperna upptäcktes det att äldre vuxna (55+) föredrar att interagera med större skärmar liknande surfplattor. Det visade sig att denna preferens skiljer sig mellan generationer och kan därför ändras med tiden. En kombination av de tre slutliga prototyperna ansågs vara ett bra alternativ för en hemassistent, alternativt möjligheten att välja mellan de olika koncepten. Fler test hade behövts för att ytterligare undersöka denna möjlighet.

Nyckelord: Användarupplevelse, eHälsa, interaktionsdesign, äldreomsorg, digitalisering, konceptutveckling, smart hem, trygghet, välfärdsteknik, telecare

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Lund, June 2021

Louise Wedberg and Anna Dalgren

Contents

List of acronyms and abbreviations

3D = Three dimensional.

AI = Artificial intelligence.

App = Application.

AR = Augmented Reality.

COVID-19 = Coronavirus Disease of 2019.

GPS = Global Positioning System.

Hi-fi = High fidelity.

Lo-fi = Low fidelity.

PACT = People, Activities, Context Technology.

SUS = System Usability Scale.

UCD = User-Centered Design.

UI = User Interface.

UX = User Experience.

WiFi = Wireless Fidelity.

Chapter 1
Introduction

The report starts with an introduction of the subject of the thesis. A short description of the company Doro Care, is given followed by the scope and delimitations.

1.1 Digitalisation in elderly care

According to the Swedish National Board of Health and Welfare, the world population's life expectancy is increasing, in 2020 around 20% of the Swedish population was 65 years or older. An older population implies more individuals suffering from diseases related to aging such as dementia or cancer. This will, in turn, result in an increased need for healthcare and elderly care [1]. The health care in Sweden is already known to be burdened and needs help to ease the workload of its employees. The Swedish government has, as a result of this need, created a goal called "Vision e-health 2025", where the aim is to make Sweden the best country in the world in using digitalisation and e-health solutions, while making all health-related operations more effective, equal, available, and secure [2].

Having an ageing population will in turn increase the pressure on elderly care. It is important, in relation to "Vision e-health 2025", to invest in digitalisation of the elderly care which would ease the workload of the caregivers, letting them focus on the quality of their work.

This report is a master thesis in Interaction Design at the Department of design science at Lund University and has been done in collaboration with Doro care. The company wanted to investigate the possibility of developing a camera and voice assistant for the older population living at home. This home assistant would make the users feel safe, help them with their everyday tasks, their loneliness and reduce risks at home. In this way, the writers of this thesis are contributing to the United Nations Sustainable Development Goal number 3, *Good health and well-being* [3]. By exploring the opportunities with a camera-voice assistant and how it could improve the seniors' living standards. Doro wanted to investigate the relationship between the user and this service. The report will therefore describe the design process of a camera-voice service placed in the homes of the users. Henceforth, the word *seniors* will refer to persons 65 to 75 years old, and the word *elderly* meaning persons that are 75 years old or older.

1.2 About Doro

Doro is a Swedish company founded in 1974 with headquarters in Malmö. It is the global market leader for mobile phones designed for seniors with sales operations in 27 countries. In addition to phones, they also offer technology enabling digital telecare at home [4]. Meaning the ability to offer care remotely through telecommunication technology [5]. Doro provides services that are connected to one of Doro's seven alarm-receiving centres, such as stationary and mobile social alarms or cameras that can be placed at the user's home. [6]. These devices and services are sold to public entities, civil society, and private companies. At present, Doro is collaborating with over 150 municipalities in Sweden, making it one of the market leaders in social alarms in Sweden. Likewise, in the United Kingdom and Norway [4].

Doro's organisational structure has changed during the work of this thesis and is now divided into Doro Group and Doro Care. Doro Care also changed its name recently to Careium.

1.3 Scope

This study aims to explore a good relationship between a camera-voice service and independent users in need of elderly care. The focus of this report is on how the interaction between these two parties should look, so that the user feels secure and trusts the technology without a sense of surveillance. With user mapping, the goal is to determine what needs and requirements should be fulfilled and what a service like this should offer, including any ethical aspects. A few concepts will be developed through an iterative design process. Redesigning and evaluating the concepts according to the existing design principles. To achieve the goals of the thesis, the following research questions will be investigated:

- Which are the requirements a camera-voice assistant should cover according to today's and tomorrow's seniors?
- What characterises a good and safe interaction with a home assistant consisting of camera and voice interaction?
    - Does the preference of interaction depend on the context the service is being used in?
- How to make a user trust the technology in their home without invading their privacy?
- How can this service help a range of target groups, such as people suffering from cognitive disorders, loneliness, or motor skills difficulties?

1.4 Delimitations

This study is limited to analysing Swedish elderly care and users. Its' focus is on the users' needs and requirements, meaning that cost and technological capabilities are not considered. The caregivers' perspectives are not considered due to time constraint and the current COVID-19 pandemic. Another consequence of the pandemic was that the primary users of this study, today's seniors, were difficult to contact. The secondary users, identified as the seniors' relatives, were contacted and were easier to get in touch with in these circumstances. The main focus while designing the service has been the voice function rather than the camera function, as this is a new function to Doro Care that has not yet been implemented in their present product range.

1.5 Related works

Existing studies explore the capability of diagnosing patients with the help of an AI that analyse the voice pattern of the patient. Diseases such as Parkinson's or Alzheimer's can show symptoms in the patient's voice and be recognised by the AI. These patterns can, for instance, be pauses during speech or pitch variations. Some of these vocal biomarkers are sometimes overlooked by both patients and physicians but can be a non-invasive biomarker to diagnose some diseases. It is expected that this field of study will soon be combined with video adding in that way images to the voice [7].

Technology based solutions as enablers for active and assisted living (AAL) is a master thesis written at Lund University, where a similar home assistant was designed. The assistant was formed as a digital picture frame and could be fixed to the wall or placed on a stand. The frame was complemented with sensors distributed throughout the user's home. As well as this thesis, it mainly focuses on a conceptual design and does not go into too much detail. Unlike this thesis, the study only explores a setup with radars and not with cameras. The two theses have the same end-users, older adults living at home. However, that report was able to reach out not only to the end-users but also the tertiary users (the care professionals and the municipalities) [8]. The tertiary users have not been contacted in this thesis. However, the user research of *Technology based solutions as enablers for active and assisted living (AAL)* was kept in mind through this master thesis.

Nielsen Norman Group published a book called *UX Design for Seniors (Ages 65 and older)*, where usability tests were conducted 18 years apart, showing that the digital environment for seniors has changed. The persons born between 1946-1964 represent today's and tomorrow's seniors and have been exposed to more digital technology than any other senior generation so far. The target group in their study showed significant digital development, implying that the stereotypes of seniors not being technological savvy may be outdated. This continuously changing target group is something to have in mind when designing for seniors and has been considered during this master thesis as well. Even though seniors' technological and digital knowledge is improving, some physiological changes are impossible to avoid. Hearing, vision, and hand and finger coordination decrease with age. However, several products fail to consider these changing needs, such as small font sizes and poor colour contrast on UIs. The authors of the book believe there is room for improvement for devices targeted to seniors [9].

Chapter 2
Background

In this chapter, the reader is given a background and some theory to support the thesis. First, the ageing population is mentioned, followed by a short description of the elderly care in Sweden today. Then the technology behind the camera-voice assistant is explained before all the design theory used during the process is described.

2.1 Ageing population

As mentioned in section *1.1 Digitalisation in elderly care*, the global population's life expectancy is increasing. In Sweden, persons over 65 years old account for two-thirds of all fatal accidents and for half of all those who need medical care due to injuries. Fall accidents are the most common cause of care and account for 64% of the people who need medical care. The most common fall accidents are by slipping, stumbling, or tripping at home [10]. The older the population gets more people will need elderly care in some way. This happens simultaneously as the occupational group of the population will decrease from 2019 to 2030. As a result, more individuals will need help with fewer potential persons to take care of them. This is one of the Swedish health care system's most significant challenges and why the digitisation of elderly care is so important [1].

Older persons are also overrepresented in suicide statistics [10]. This brings us to the societal problem that many older individuals feel alone. At least one in ten persons over the age of 75 are socially isolated, a risk factor for mental illness. Socially isolated is defined as persons who live alone and are not meeting friends or family more than a few times a month. One might think that living in a retirement home would make the elderly feel less alone, but that is not the case. Loneliness is less noticeable among persons still living at home with home care assistance, than for persons living in retirement homes [1]. Giving the elderly the possibility to stay in their home as long as possible can therefore be seen as recommended. This is why a digital home assistant is an exciting area to explore further.

2.2 Elderly care in Sweden today

Today, about 36% of the population over the age of 80 has some sort of involvement with elderly care, such as home care service, special housing, or short-term housing [1]. The quality of Swedish elderly care can, however, vary depending on regions. The responsibility is mainly placed on the municipalities, who all have different guidelines and budgets to follow [11]. This is why the level of digitalisation also varies over different cities in Sweden. Nevertheless, the overall usage of welfare technology has increased, and many municipalities are piloting projects to explore the areas of use. They test, among other things, care planning with video, GPS- alarms, and monitoring cameras with excellent results [1].

A common factor between municipalities is the high cost of care and nursing of the elderly. Increased cost for home care services mainly drive the total cost for elderly care. This cost is a result of the ageing population, leading to a more significant need for home care, which increases the cost per capita [1]. Cost-effectiveness is discussed when discussing the plan for the future of elderly care and relieving employees' workload. This is why digitalisation is of utmost importance as it will help decrease the labour cost and reduce the caregivers' workload. A camera-voice assistant could be a possible solution to decrease cost in elderly care, as it could prevent injuries and reduce perceived loneliness, which in turn affects health care. A study shows that over a hundred persons a day use their social alarm just to get social contact, even when there is no ongoing pandemic [12]. This shows how vital technology is and that loneliness is a problem that should not be overlooked.

European Parliamentary Technology Assessment published a report in 2019 on welfare technology. The report gave examples of different technologies that can benefit elderly care such as robotic technology which can be used to assist in daily life and counteract loneliness [1]. Maybe a digital home assistant could become an opportunity for entertainment and social contact for seniors?

2.3 Similar products on the market

There are similar concepts in the market called "Granny Cam", which have lately been at the centre of discussion between nursing homes and the user's relatives in the United States of America. The main concern is the invasion of the care provider's privacy that the camera represents [13]. This shows that the idea of installing cameras in seniors' homes is relatively new and has not yet established itself as something normal.

Offering an automated and combined camera and voice service is not prominent in the market. However, several products have the two functions (voice and camera) separately. Products such as Apple's Siri [14], Microsoft's Cortana [15], Google Assistant, and Amazon's Alexa are examples of home assistants that only use the voice function.

Other companies such as PROKNX have combined a voice assistant with sensors such as motion sensors that contact the assistant through radio waves. PROKNX's voice-controlled smart home system, *Aragon*, uses Artificial intelligence, AI, to learn the user's routines and, in that way, predicting future or unusual behaviour [16].

In Sweden, video cameras can be installed in senior's homes if there is a need for them. According to the municipality of Lund, installing a camera in a user's home could be a good solution for a care recipient needing surveillance during nighttime. This is done as an alternative to letting health care professionals physically visit the user. The care recipient and the municipality decide at what time periods the cameras should be turned on. The cameras will then only be activated during these set periods. If the healthcare professionals verify that the care recipient is fine, the camera is instantly turned off. If the well-being of the care recipient cannot be concluded, the camera will be turned on for an extended period until this can be verified [17].

As mentioned before, Doro already has several digital solutions in the market aimed at senior citizens. Other than phones designed for an older population, Doro also offers different digital solutions such as stationary and mobile social alarms, environmental safety products, and personal wellbeing products [18]. Examples of these are “Doro Eliza”, a social alarm with the ability to connect to telecare accessories such as smoke detectors connected to alarm-receiving centres [19]. Mobile social alarms such as “Doro Secure 480” resemble a regular watch but have GPS tracking and can trigger an alarm [20]. Doro offers, as well, different sensors such as Heat detectors, flood detectors, or smoke detectors [21]. Doro also commercialises other personal wellbeing products such as fall detectors or cameras. As explained earlier, the cameras can only be controlled by authorised personnel [22].

2.4 Technology

A short description and background of different cameras and voice technologies will be presented in this section.

2.4.1 Camera

Video recording cameras used in, for example, home security cameras, capture footage from the user’s home. Depending on the model, they can either start recording when sensing something (for example, movement) or continuously record a so-called continuous video recording camera [23].

Different kinds of image sensors exist in the market; what differentiates them is, among other things, the photodetector they use. Infrared image sensors can detect or emit infrared radiation. They can detect the heat emission from objects and can, thus, detect movement. Infrared radiation is frequently used in industries and daily life. It is radiation not visible for the human eye and is situated between the microwave and visible light spectrum. This kind of technology is used in many situations such as night vision or infrared tracking [24].

Digital image processing and analysis are processes when a computer receives, processes, and analyses an image. When analysing an image, different shapes can be registered, recognised, and quantified. This field of science has many applications, such as in the biomedical field analysing and detecting disease like cancer in mammograms. It can also be applied for face recognition [25].

2.4.2 Voice interaction

Speech recognition is the ability of a system to receive and interpret spoken commands and convert them to text [26]. There are systems, such as Microsoft’s so-called WisperID that do not only recognise what is being said, but also recognise the speaker. Where different vowel sounds or the origin of the sound are analysed to identify the speaker [27].

Conversation design

According to the Head of Conversation Design Outreach at Google, Cathy Pearl [28], we will soon be having conversations with everything around us, like our toothbrush and trash cans. When designing new voice interactions, it is, therefore, essential to understand how conversation design works. With conversation design, we create experiences that enable computers to communicate like humans, and not the other way around. One should design for how people actually talk and not how you want them to talk. The voice interaction should be clear and concise, and follow-up questions should be asked when needed to make sure that everything is correct.

Pearl [28] also explains the importance of not delaying the answer as a human would not. Also, a human would design the response depending on how the question was asked. For example, you would respond differently to these questions, asking the same thing;

– "Is restaurant XXX open?" – *No, but it will open in one hour, at 11AM.*
– "What time is restaurant XXX open?" – *XXX is open today from 11AM to 10PM.*

For a voice assistant, it is hard to design the answer, but this is very important for conversation design. However, the most important thing is not giving unnecessary information and only responding to what is asked. Start responding with the most important, such as Yes/No and then follow-up with additional details if necessary. Most people also want a gracious way to exit the conversation, so it is also essential to make the voice system polite. Hence, for example, say goodbye when ending a conversation [28].

2.5 Design theory

The process used in this thesis is based on the interaction design process described by Preece et al. [29] and will be presented in chapter *3 Design process overview*. The design theory used in this thesis can be found below to give the reader the necessary background.

2.5.1 Interaction design

A product or service has a good interaction design if it is easy, effortless, and enjoyable to use. Interaction design deals with creating user experience that enhance and augment the way people work, communicate and interact in their everyday life [29]. To create the best design, persons with different backgrounds are usually involved in an interactive design process. The one thing they have in common is that all have the user in mind during the process. Preferably a user-centred design is carried out, meaning that the user is involved from start to finish. Such a process is used in this thesis where users are involved throughout the project, trying to create the best design.

A fundamental aspect in the process of interaction design is to design with user experience in mind. The international standard on Ergonomics of human-system interaction, ISO

9241-110:2020, defines user experience as a combination of perceptions and responses that result from the use and/or anticipated use of a product. The user's perception refers to how they feel about the product and the satisfaction before, while, and after using it [30]. It can be said that a good user experience is enabled if the product follows the six usability goals:

- Effective to use
- Efficient to use
- Safe to use
- Having good utility
- Easy to learn
- Easy to remember how to use [30].

2.5.2 User-centered design

As mentioned, there has been a user-centred design, UCD, approach in this thesis. This approach means that the actual users and their goals are a driving force behind product development in every step of the process. The international standard on Ergonomics of human-system interaction, ISO 9241-210:2019, has defined six principles that are accepted as a basis for a user-centred approach:

– Design is based upon an explicit understanding of users, tasks and environments.
– Users are involved throughout design and development.
– Design is driven and refined by user-centered evaluation.
– Process is iterative.
– Design addresses the whole user experience.
– Design team includes multidisciplinary skills and perspectives [31].

Following these principles, one can ensure that a design is user-centered and identifies the need of the user. Let the user interact with simulations and prototypes in that way, analysing their performance and reactions. If problems or difficulties are observed, these can be improved in other tests making the developing process iterative until it is no longer necessary [29].

2.5.3 Triangulation

Triangulation refers to the investigation of something from at least two different perspectives to obtain multiple views. One example of triangulation is *Methodological triangulation* which means using several different data gathering methods. Triangulation can also be achieved by retrieving data from different groups of persons [29]. In this study, the primary users were interviewed, and a questionnaire was filled out by mostly secondary users.

Interviews, where a structure is followed throughout the interview but follow up questions are allowed to be asked when necessary, are called semi-structured interviews. These interviews were used when identifying the needs of the primary users. [29]. Questionnaires are, as interviews, a data gathering method. Similar to interviews, they can contain open and closed-ended questions, but once a questionnaire is finished, it can be distributed to a more significant number of people [29].

Usability tests were also performed on both target groups to get the two perspectives and validate the result. In these tests, *Investigator triangulation* has sometimes been the approach when two participants' schedules collided. This means that different researchers have been collecting and interpreting the data [29].

2.5.4 Usability testing

Usability testing emphasises how usable a product is for the intended purpose and whether users are satisfied with their experience. This is an important part of an interaction design process where the user interacts with the prototypes. In this study, a "think aloud" technique, among other things, was carried out where the participant describes what he or she is doing and thinking. Interviews were also held to get a feeling of the perceived level of difficulty and the general satisfaction [29].

In this thesis, usability testing has been combined with A/B testing, which could be seen as a type of usability testing. A/B testing is the act of running an experiment between two or more features to see which has better performance and user perception. This method is preferred when there are several designs to choose from, and one has to find which solution would work best for users. The main difference between them is that in A/B testing, the goal is to find the product with a better performance. In usability testing, the goal is to find usability issues that deteriorate the user experience [32]. Therefore, a combination of these has been the optimal method for this study.

The number of participants in usability testing is generally recommended to be as many as possible to represent a more extensive and broader selection of target user. Nevertheless, early research suggests that 5 to 12 persons are acceptable and should uncover most usability problems [29].

2.5.5 Design principles

Designers often use design principles to help their thinking and consider different aspects of their designs [29]. This is only to trigger the mind and help the designer determine what the user should see, feel or hear when using the product. Many principles have been promoted, but in this thesis, Preece et al.'s [29] design principles have been considered while designing the prototype. These design principles are listed below:

Visibility

This design principle describes the importance of verifying the status of a system and what interactions are possible. This is done by making the product's features visible to the eyes and ears to verify how it works and how it can interact. The more visible functions are, the more likely it is that users will be able to know what to do next [29].

Feedback
This principle is related to visibility so that users get visual feedback directly after performing a task. Thus, feedback involves returning information about what has been done or accomplished, allowing the person to continue the activity [29]. The feedback can, for example, be signalised by sound, highlighting, vibration, animation, or a combination of these.

Constraints
Constraints restrict the possible actions that can be performed and therefore helps prevent users from selecting incorrect options and making errors. Clues and constraints in the design make it possible for users to decide what a good approach can be even in an unfamiliar situation [29].

Consistency
This principle refers to designing similar systems and products with consistency to make it easier for users to learn and use them. If consistency is followed, the user can use their previous experience when approaching a new system. This is beneficial when designing new systems because by following consistent rules, the product will be user-friendly, and confusion will be avoided [29].

Affordance
The term affordance refers to the relationship between a user and a product and, in particular, the product's attributes that allow the user to know how to use it. The affordance of a physical object is of great importance but does not have to be visible. Preferably it is perceptually apparent, so it is easy to know how to interact with it [29]. The first step when approaching a new product or system is to know how to interact with it, not how it works.

2.5.6 PACT analysis

The use of the PACT framework allows the designers to create interactive, meaningful, and practical designs. The PACT model consists of *People*, *Activities*, *Context*, and *Technology*, which are the four segments a designer should understand when thinking about a design situation. The component *People* involves understanding the relevant user characteristics and skills, such as how the user's motor abilities may affect the product's design. The *Activities* component refers to how and why tasks will be performed with the product and considers the frequency and duration of tasks. The organisational and social environment of the activity is involved in the segment *Context*. The last component, *Technology*, refers to the user's input and output, the communication, user interface, and technical attributes like the size of a screen or offline mode. This framework is helpful when identifying the needs and the problem space in a design process [33].

2.5.7 System Usability Scale

A System Usability Scale (SUS) is a quick way to evaluate the usability of a product looking at effectiveness, efficiency, and satisfaction. When using SUS during a usability test, a 10-question questionnaire is given to the participant right after testing the prototype. The respondent then scores the ten statements about the perception of the product, which can be seen below. The scoring is based on a 5-point Likert Scale from *Strongly disagree (1)* to *Strongly agree (5)* [34].

1. I think that I would like to use this feature frequently.
2. I found the feature unnecessarily complex.
3. I thought the feature was easy to use.
4. I think that I would need the support of a technical person to be able to use this feature.
5. I found the various functions in this feature were well integrated.
6. I thought there was too much inconsistency in this feature.
7. I would imagine that most people would learn to use this feature very quickly.
8. I found the feature very cumbersome to use.
9. I felt very confident using the feature.
10. I needed to learn a lot of things before I could get going with this feature.

Calculation and interpretation of SUS score

According to Smyk [34], feedback from at least five participants should be collected to ensure a somewhat reliable result. A SUS score can, in that case, be calculated from all respondents' answers on the ten statements. By calculating this score, the sample products can be compared with each other in terms of usability [34].

The following framework determines the score: ***SUS score = (X+Y) *2.5***

This is calculated by adding the total score for questions 1, 3, 5, 7, and 9. The result from the first addition should then be subtracted with five to get X. Simultaneously, the scores from questions 2, 4, 6, 8, and 10 are added. The result of this sum is then subtracted from 25 to get Y. Add up the total score of the new values X+Y and multiply by 2.5 to get the SUS score [34].

By following this framework, a score between 0 and 100 is obtained. The average SUS score is 68. Scoring below 68 indicates an issue with the design. Scoring over 68 indicates that the design only needs minor improvements. In Figure 2.1 a scale for interpretation of the score can be seen. SUS scores fall into the range of worst imaginable, poor, OK, good, excellent, and best imaginable. The SUS score is only an indication; it is always up to the designers to decide the course of action after the result [34].

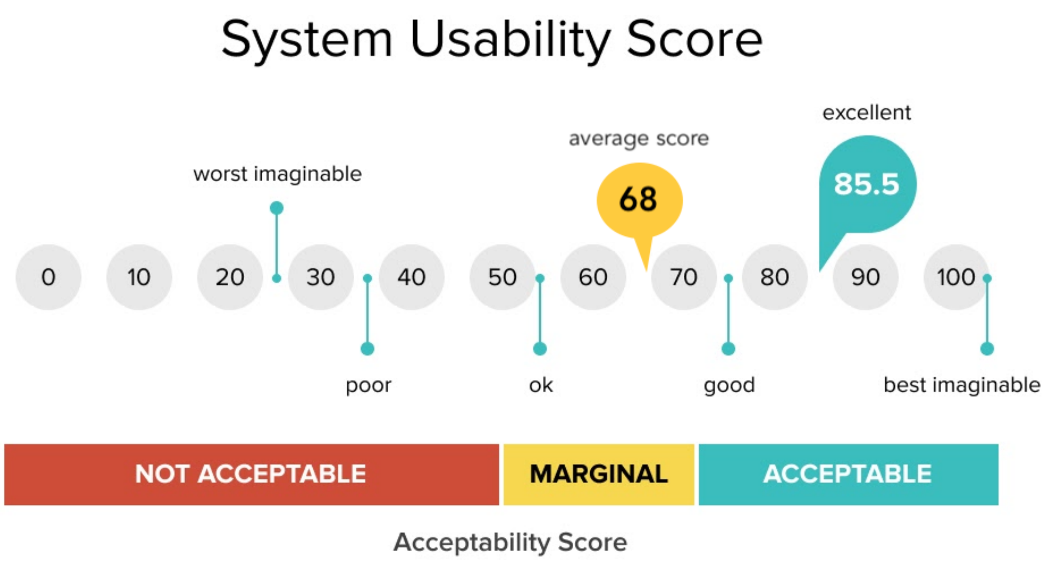


Figure 2.1: The SUS score scale made for the interpretation of the result. It is possible to interpret with the number scale, acceptability score and the range of adjectives [34].

Chapter 3

Design process overview

In this chapter, a description of the methodology and design process followed in this study is presented. Note that this is only an overview and that every step performed in the process will be explained more in detail in the following chapters.

The interaction design process used is based on the method described by Preece et al. [29]. The process consists of four segments that are adjusted to fit this thesis. According to Preece et al. [29] the first activity is to *Establish the needs* followed by the second activity, *Generating design concepts* to meet those needs. The third activity is *Prototyping* the design alternatives, quickly followed by the fourth activity, *Evaluation*. The process should be iterative to enhance the possibility of correcting all problems and making a design with a good user experience. This means that the direction of the design process can change and that the four activities are not following each other linearly. The four activities performed can be seen below and in Figure 3.1, where the light grey arrows show the iterative approach. Four iterations were performed in this thesis, one lo-fi and three hi-fi iterations.

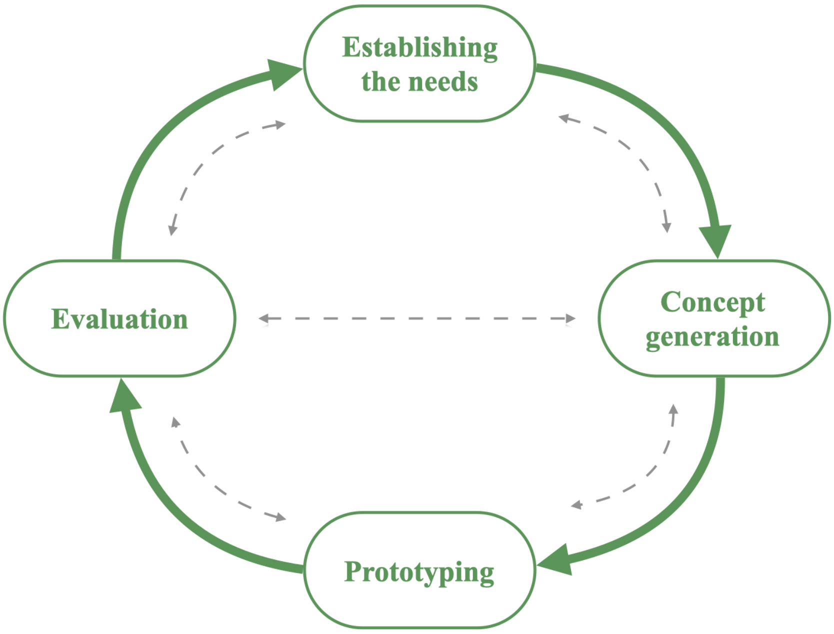


Figure 3.1: An overview of the design process used in this thesis with its four basic activities described by Preece et al. [29]. The green arrows indicate the main direction of the process, starting with *Establishing the needs*. The light grey arrows show the iterative approach to the process.

3.1 Establishing the needs

In the first step of the design process, the aim is to find the target group and understand their needs. By gathering data and analysing it, it is possible to decide how the prototype should look and what it should provide to meet those needs. Interviews with seniors were held, and a questionnaire was shared through social media. The data was then analysed by performing an affinity diagram, PACT analysis and creating personas, these analysing methods are further explained in chapter *4 Establishing the needs*.

3.2 Concept Generation

When the needs are identified, a series of possible concepts are generated as a second step. It is crucial to ensure that the design alternatives fulfil the requirements gathered in the previous step. The concepts are presented with conceptual models and storyboards to clarify the difference between them. A conceptual model describes a system or product that can be used to convey how to understand what a product is for and how to use it [29]. In comparison, a storyboard is a walkthrough process through a sequence described with illustrations, showing how a user might progress in a scenario using the device [29].

3.3 Prototyping

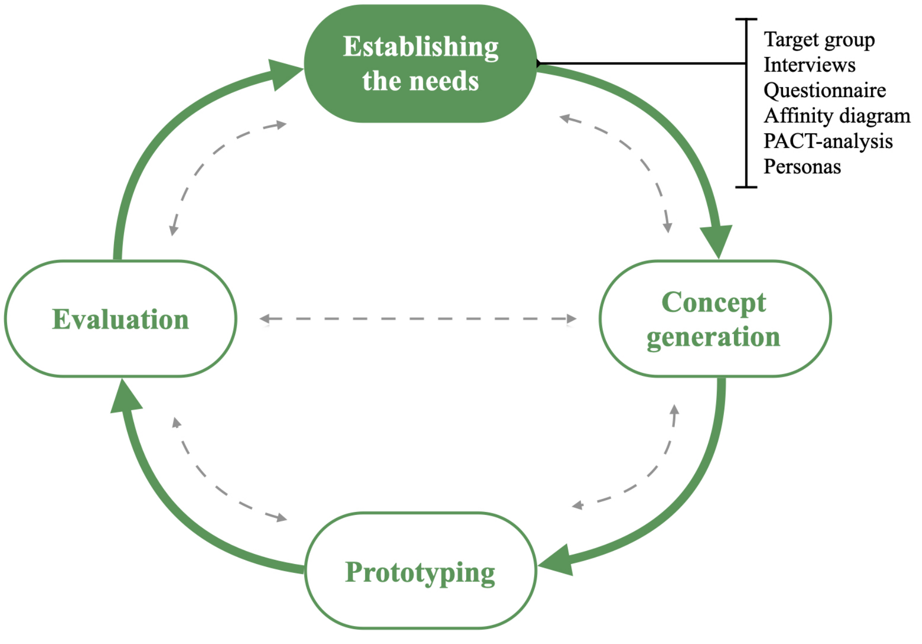
The next step is to create prototypes of the concepts. This makes it possible for a user to interact with, or visualise, how the final product could look during the evaluating stage and helps the designers to choose between the alternatives. In this activity, the mentioned iterations are happening. In this thesis, four lo-fi prototypes were generated and four hi-fi prototypes. The hi-fi prototypes were then modified during three iterations. Low fidelity prototypes are, compared to high fidelity prototypes, not similar to the final product and tend to be easy and quick to build. High fidelity prototypes are, on the other hand, more time consuming and are usually similar to the final product [29].

3.4 Evaluation

In the last step of the design process, the final prototype is evaluated. How an evaluation is conducted varies from project to project. However, the common goal is to ensure that the product meets the prescribed user experiences and usability criteria [29]. In this study, usability testings combined with SUS scores and interviews are used to evaluate the different prototypes. The feedback also included verbal comments received from the participants during the tests.

Chapter 4
Establishing the needs

The target group is identified. Interviews and surveys were the two data gathering methods used to gain as much data as possible about the needs regarding a camera-voice assistance. The data analysis was obtained through an affinity diagram, PACT-Analysis and developing several personas.



4.1 Target group

As a result of the COVID-19 pandemic, senior citizens have turned to digital solutions to stay in touch with friends and loved ones. Indicating that their technical skills have improved and are not as bad as the stereotype may imply [35], this also agrees with the book, *UX Design for Seniors (Ages 65 and older)*, mentioned in section *1.5 Related works*. Due to this, and because the camera-voice assistant is aimed to be used by future senior generations, a more technologically capable generation is assumed to be the user of the service.

The primary users were identified as seniors living alone at home, thus being the ones interacting with the camera-voice assistant. The secondary users were identified as relatives to the primary user. The tertiary users have been identified as care providers and health care personnel in general.

4.2 Data gathering

Before any data gathering began, the goals for this process were identified. These are presented below:

– What does the elderly generation of today need help with?
– What digital technology is used by today's seniors and what is the attitude to try new?
– What characteristics should the home assistant have?
– Should the communication be one-sided or two-sided?
– What does the user need the assistant to accomplish to feel safe?

Two data gathering methods were used to triangulate the user's needs: interviews and questionnaires. Today's elderly generation, living alone, were interviewed to understand the needs of the elderly. The aim of the survey was to understand the view on technology of the future elders and their relatives.

4.2.1 Interview

An interview was the method of choice to contact today's seniors due to the facility for them to elaborate their answers using the spoken word compared to, for example, a questionnaire. Other data gathering methods, such as surveys, would have required the participants to use a more complex digital technology, which was considered, by the designers, to be more complicated for them.

The sampling for the interview respondents was initially going to be random. Doro got in touch with the municipality, which would enable the contact information of elderly volunteers. However, the process took more time than expected, and a convenience sampling was done instead. A convenience sampling is when participants are chosen due to their availability instead of being specifically selected [29]. Therefore, four participants were recruited from the two designers' families and two persons were found through contacts.

Due to the ongoing COVID-19 pandemic, all interviews were either performed as a video call or a phone call. The six participants were asked which format they preferred. The duration of each interview varied between 20-40 minutes. Table 4.1 shows the age and gender of the seniors that participated and the platform that was used. Three females and three males were selected for equal gender distribution. The minimum age to participate in the interview was set to 65 years old as that is the lowest limit to be classified as a senior in this report.

Table 4.1: The number, gender and age of the participants in the interviews as well as the platform that was used to conduct the interviews.

Number of interviewee	Gender	Age	Interview platform
1	Male	74	Video call
2	Female	77	Phone call
3	Female	85	Phone call
4	Male	65	Phone call
5	Male	69	Phone call
6	Female	83	Phone call

The interview consisted of 15 main questions regarding attitude towards technology, their living situation and privacy invasion. All formulated in Swedish but translated and presented in Appendix A in this report. The interview questions were tested on the two tutors of this thesis, who came with valuable feedback. The feedback was mainly the importance of the wording in the interview so that nothing that was said could be misinterpreted or misunderstood.

4.2.2 Questionnaire

As questionnaires can be distributed to a large number of people, a digital questionnaire was chosen as the method to triangulate the needs. It was also believed to be a safe method to use due to the pandemic, in that way gathering a large amount of data without physically meeting the participants. The target group for the questionnaire were the secondary users, meaning persons with older relatives that may live alone at home or in a residential home.

All questions were written in Swedish. The wording and phrasing of the question were carefully put together to avoid stigmatising the service or relating the voice-camera-assistant for a device designed to sick patients. It was also important to meticulously choose the correct words so that the participants did not relate the product to a device that aims to invade the user's privacy.

The structure of the questionnaire can be sorted into three different themes:

– Demographic
– View and usage of digital technology, and privacy invasion
– Questions about the camera-voice assistant.

If a questionnaire is too long, it can be divided into different subsections giving it a more structured sense [29]. However, this questionnaire did only include 15 questions and was therefore believed to be short enough to have all the questions in one section. The questions have been translated to English and can be found in Appendix A.

Demographic questions are usually asked to get a context on the gathered data [29]. Therefore, relevant demographic questions such as age and gender and living situation were asked. This was done mainly to observe how the view on technology differed between the age groups as well as to control if an even gender distribution was achieved.

A range of response formats were used in the questionnaire, such as ranges, multiple-choice, scales, and free-text answers. Range responses were used when asking the age of the participants. When using ranges, it is important not to make the ranges overlap and that the interval in the different cases do not have to be the same size as it depends on the aim of the study [29]. In this questionnaire, the age-intervals started at 18 years of age and then increased till the age of 90+, see Figure 4.1.

Multiple-choice questions were asked where participants gave one or more answers. These questions had the option "other" that could be chosen if an alternative was felt to be missing.

One big difference between an interview and a questionnaire is that in an interview, the person answering the questions has more freedom to speak freely or ask questions if something is unclear [29]. To offer the questionnaire more flexibility, four optional text questions were added, allowing the respondent to give more detailed answers if they wished to.

Likert scales were used as rating scales. These were used so that the answers from the respondents could be easily compared. Likert scales are used when the respondent can choose an opinion from a scale (in this case 1-4) as an answer for a question [29]. The scales were given an even number. This was believed to be a good idea compared to an uneven scale, not allowing them to choose the median number and remaining neutral.

The questionnaire was tested on two pilot subjects. Some rephrasing and explanations were done before its distribution on Facebook, internally in Doro and internally in the design faculty. The response rate is unknown, as it was distributed through three different channels.

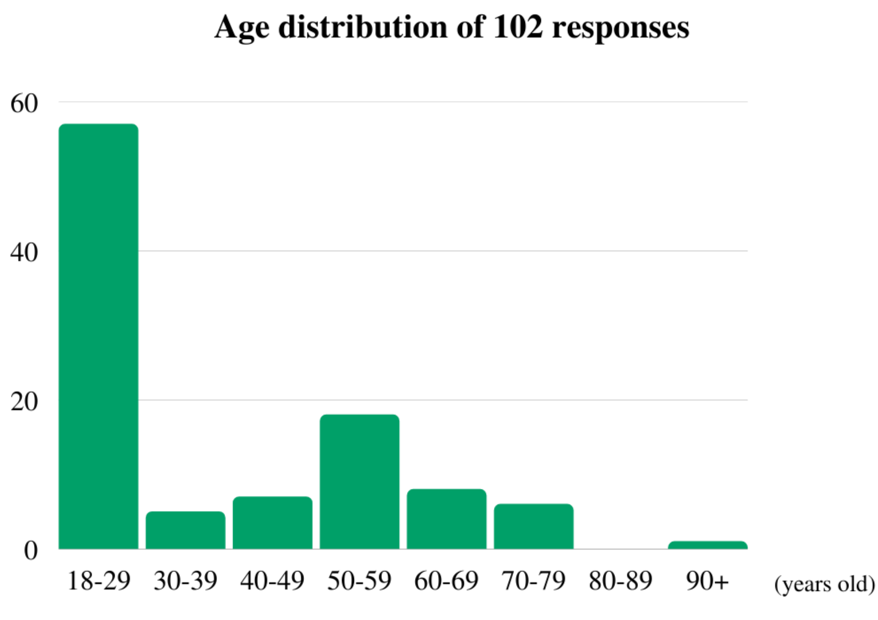


Figure 4.1: The age distribution of the 102 questionnaire respondents. With the number of respondents on the y-axis and the age group on the x-axis respectively.

The gender distribution was not in equilibrium but was believed to be acceptable. Of the questionnaire respondents, 60,8% were women, and 39,2% were men. The age distribution of the respondents to the questionnaire was not ideal. An older demographic was wished for, ideally persons from 40 years of age and older. However, due to the somewhat random sampling, this ideal was not achieved. The age distribution is shown above Figure 4.1, where it can be seen that 57 of the 102 answers originated from the 18-29-year-old respondents. Although this was not an ideal situation, the designers believed that the answers received from the questionnaire combined with the answers gathered from the interview were enough to triangulate the needs of future senior citizens. Also, the device being designed is aimed at future seniors meaning that the most prominent response group represents the future senior's relative.

4.2.3 Results from the data gathering

Comparing the interview answers and the questionnaire results, one could argue that people's views on technology change with age. The respondents of the questionnaire were relatively open to try new technology. The interview respondents had a common denominator; their contentment with the technology they already know and their lack of curiosity towards new products in the market. Indicating that the design of the home assistant should resemble products in the market today as the users of the home assistant will be future seniors.

The most common products around the respondent are smartphones and computers, meaning that they interact with screens. From the questionnaire, it was clear that the participants are not used to use voice functions, suggesting that sight is one of the most common senses used when interacting with technology. Persons who use voice functions daily use it mainly to control their music and interact with their smartphones. The respondents that do not use voice assistance claim that the main reason is that they do not see the need or the common misunderstanding of their commands.

When exploring what today's seniors need assistance with, it was clear that the interviewed seniors had a hard time imagining what that could possibly be. Even the two participants who had a social alarm respectively a digital reminder for medication did not admit any need for help, even though they already used telecare solutions. They did not want to admit needing help for daily tasks, they did however, see a purpose of a home assistant if an accident occurred.

When asking about how technology affects their privacy, the respondents refer to their feeling of being listened to, how their personal information is being sent to companies, and how the advertisement is tailored to their interests.

When imagining having a camera-voice assistant at home, people interviewed wanted to make sure that the product was activated if an accident occurred. However, 49% of the questionnaire respondents wanted to be in control of when the assistant was turned on. This disagreement of opinion is believed to be due to the age difference. A majority of all respondents want two-way communication. The main characteristics of a home assistant are portability, discrete design, and, most importantly, complete control over its activations and knowledge of when the product is turned on. The view on AI and machine learning was heterogeneous, but the data suggests that the older population mistrust AI or machine learning, while there is a more welcoming feeling among the younger population.

4.3 Data analysis

Before being able to start analysing the data, it was processed. The relevant information from the 102 responses on the questionnaire was sorted and identified. Simultaneously, the ten computer-written notes from the interviews were reviewed before identifying the essential comments from the seniors. The data was mainly qualitative, which makes a thematic analysis a suitable method to examine the data. This is a technique of analysing data to find essential themes of needs for future progress [29].

A PACT analysis was performed to give another perspective on the problem and to reduce the risk of neglecting essential factors. Personas were also developed to understand the user better.

4.3.1 Affinity diagram

The qualitative data from the user research methods (questionnaire and interviews) were analysed using an Affinity diagram on a whiteboard. An affinity diagram is a technique used to identify themes from a large amount of data. It is done to identify the main areas, identify connections in data, and organise data. It is a simple and creative method to understand data. However, one of the disadvantages of using this method is that the diagram is not portable and can be time-consuming if there is a large amount of data [29].

The process can be summarised by firstly identifying the crucial topics from the gathered data. Interesting points are written on post-it notes. Data from the interview was written on orange post-it notes and data from questionnaires on green ones, as shown in Figure 4.2. Secondly, clustering is done of all the post-it notes that are believed to belong together. This was done by placing one piece at a time after careful discussions between the two designers. Once the clustering was finished and all post-it notes were sorted in groups, a header representing the theme of each group was indicated. The result of the categorisation and the 11 identified themes can be seen in Figure 4.2.

Finally, to understand which themes were more important and which ideas should be carried forward, three voting dots were introduced per person. Meaning that one person could vote for three of the themes in the diagram that they believed are the most important to have in mind when continuing to the next step of the design process [36]. The themes with a vote can be seen as bold text in Table 4.2.

4.3.2 Goals

The identified themes from the affinity diagram were summarised and presented in a table column. Together with the themes, the responses on the associated post-it notes worked in parallel to formulate goals and demands for the home assistant, as can be seen in Table 4.2. Since many responses from the interviews and questionnaires were almost identical, some were eliminated before translated to goals. These 33 goals and demands formulated can be seen in Table 4.2.

The themes that were considered most important and got a vote during the affinity diagram method can be seen as bold in Table 4.2. The themes that did not get a vote were decided not to be carried forward. These were *Attitudes towards technology*, *Technical solutions*

Figure 4.2: Image of the affinity diagram created from the data gathered. The orange notes are the results from the interviews, and the green notes are from the questionnaire.

at home, *Design*, *Care perspective*, and *Camera function*. The camera function and the care perspective are themes that early on in the process were deleted. The general attitude towards technology, technical solutions at home, and the design aspect was considered to be taken into account by focusing on the other themes and following the design process.

The themes that were focused on were:

- *Attitude towards the home assistant*
- *Information management*
- *Activation Control*
- *Voice function*
- *Difficulties at home*
- *Privacy*.

Below are the themes and their critical needs described in detail.

Attitude towards the home assistant
There is a need to make the user understand the need and purpose of using this kind of product. Preferably before it is necessary and before the user gets too old, or in case of illness, before the condition gets too bad, probably making the learning curve shorter. Also, if the users are used to the product, they will probably keep using it when getting older or weaker when it is most critical. Therefore, the goal is not only to make the relatives less worried, but also to make the users see the purpose of using the assistant.

Information management
The greatest need expressed is the importance of the assistant sending an alarm when an emergency occurs. If a trigger event has been detected, the assistant should ask the user if it needs help and wait for the user's answers. A concern was expressed if the user cannot respond to the assistant; hence, it is essential the alarm central will call if no response is detected. Mixed responses were expressed if relatives should be contacted or if just the home care service should be contacted when an accident has occurred. Some saw it as an obvious response, while others did not want to disturb their loved ones. An option of whom to contact in case of an emergency should exist.

Activation control
Concerning privacy, there was a common demand of being able to control the product. Mainly because then it would be easier to accept the installation of cameras and voice assistants at home. The threshold for instalment would be smaller if the user could turn the product on and off and control the data that is being shared.

Voice function
A significant need for two-way communication was shown as the users expected a response after calling the assistant. A demand for well-trained voice recognition was identified after some bad experiences of other voice assistants. The participants reported problems when interacting with existing voice assistants that did not understand what the user was saying. Once again, a demand to control the function was expressed, in this case, the listening function.

Difficulties at home
It is relevant that the home assistant can remind the user of important tasks or events. This could remind everyday tasks such as taking medicine, eating or waking up. It could also schedule events such as home care visits and birthdays. It would be beneficial if the assistant could play music, audiobooks, turn on/off lights and control the home. By detecting routines, it could also predict risks like forgetting to extinguish the candles or forgetting to lock the door. Overall, there was an interest and revealed value in detecting accidents at home, both small and large.

Privacy
The concerns around privacy were received with mixed answers. Some wanted to feel monitored, while others thought it was important not to feel observed. Participants, in general, preferred an AI behind the assistant and not a real person. However, a need for human interaction in case of an accident was noted, meaning that when the assistant calls for help,

an actual person should answer on the other side of the line. Still, the popular view was the importance of secure information management and let the user feel ownership data-wise. The ability to see when the product is turned on and the ability to control the assistant is important to reduce the intrusion on the users' privacy.

Formulated goals

Table 4.2: The 11 identified themes from the affinity diagram together with the 33 corresponding formulated goals and demands.

Themes	Goals/Demands
Attitude towards the home assistant	• Identify a need to use this product before needing it. • The goal is to not make the relatives worried.
Digital solutions at home	• Accomplish all functions that are taken for granted today in similar products.
Attitude towards technology	• Easy to understand how to use the product. • Including for all ages and disabilities . • Make it natural to use. • See the purpose of new technology. • Should feel like an efficient technology. • Fun and trustworthy to use.
Information management	• Send an alarm when a triggering event occurs. • Choose who to contact, for example relatives or friends. • Ability to call the alarm central.
Activation control	• Ability to control the product.

Design	• Simple design. • The user needs to see when it is turned on. • Should not have many buttons and colors. • Should have some kind of screen e.g an app to a smart-phone.
Care perspective	• A complement to home care. • A goal is to use it for complementing other types of care. • Minimize the workload for home care.
Camera function	• No recording. • No recognition, only detection.
Voice function	• Duplex communication. • Demand: well-trained voice recognition. • To be able to control the listening function.
Difficulties at home	• Reminder. • Accident control. • Routine check. • Help user with daily tasks.

Privacy	• Secure information management. • A feeling of owning one's data. • Need of human contact in case of an accident. • Notified when the product is turned on.

4.3.3 Function categorisation

The data from section *4.3.2 Goals* was used to formulate functions that the home assistant needs. 42 functions were generated from the 33 goals. The specified functions were valued in a hierarchy running from not necessary, necessary to desirable, which can be seen in Table 4.3. Unnecessary functions were not considered relevant at this stage of the development, but should be considered for future work. Furthermore, necessary functions were the functions that were considered essential to have in mind during the design process. These were considered the most important functions; thus, the product would not achieve its purpose if they were missing. The desirable functions were deemed to add more value to the product. These were not prioritised but might be included later on in the process

In conclusion, all the functions classified as necessary were taken into account except one. As mentioned before, the camera function has not been further explored due to limitations set early on in the process. Therefore, all functions concerning the camera have been overlooked and can be seen in italic text in Table 4.3. However, the night vision function was classified as a necessary function. A non-recognizable sensor like an infrared camera is desirable, as can be seen in Table 4.3. The camera used in this thesis is assumed to be an infrared camera, which is considered to fulfil the necessary needs such as night vision and detection of the user. In section *2.4.1 Camera*, this kind of camera is described in more detail. Note that an infrared sensor is only a suggestion.

Formulated functions and function hierarchy

Table 4.3: The 42 formulated functions and function categorization in the hierarchy running from not necessary, necessary to desirable.

Not necessary	Necessary	Desirable
Portable	Machine learning / AI	Turn on and off different functions
Not expensive	Connection to internet	Connect to other devices in the home
Linked to my hospital record	Detection of accidents	Timer/watch/alarm
Home care can look at data if needed/authorized	Light signaling	Connected to the phone
Choose the gender of the voice	On and off button	Music/Spotify connection
Off-line function	Get a notice when it needs loading or maintenance	Connect with TV
	Activation when accidents occur	GPS connection
	Notify when the camera is on	Weather information
	Analog buttons on the product	*Usage of filters*
	Two-way communication	Be able to schedule events in your calendar
	Mother tongue	*Ability to schedule camera activation*
	Good voice recognition quality	Mute function
	Turn on and off	*Non-recognizable sensor e.g infrared camera*
	Night vision camera	Control the lights/lamps at home
	Routine detection	Be able to erase data from the product
	Can be controlled only with voice	Detect risks and tell if so
	Additional/including screen	*Switch camera filters*
	Get in contact with a real-life person	
	Contact the alarm central and relatives	
	Fast response from the voice function	

4.3.4 PACT analysis

The result from the PACT analysis, described in section *2.5.6 PACT analysis* is shown below. This was done when identifying the needs to clarify the problem and understand if another perspective had to be considered before starting the concept generation.

P- People
Everybody can use the camera-voice assistant, but it is mainly designed for the future elders that live at home and want to keep their independence as long as possible. People with disabilities or difficulties at home should have no problem using the device. Exceptions are persons with speech disabilities people; thus, they would not be able to communicate with their voice. The user's cognitive abilities should not affect their use of the product, meaning that people with cognitive diseases could use it. The user should have some technical knowledge, and optimally, he or she should have a positive attitude towards technology in general. The user sees a need to feel more secure at home or has a relative who identifies the need for this service. The primary users are the seniors; nevertheless, other people will be involved, such as home care assistants and relatives. The user can talk in their mother tongue to the product; it is, however, important to point out that this report focuses only on Swedish voice interaction.

A- Activities
This thesis mainly focuses on activities performed at home. The user should have the ability to choose which function to activate. Everyday usage and for more security, 24-hour usage is recommended. It is a passive product in the sense that it does not interact with the user even though it is activated. However, it can also be considered as an active product as it would be able to interact with the user when so needed. The product should help with daily tasks, such as music playing, establishing phone calls, sending SMS-messages, turning the lights on and reminding about medication and other daily tasks. It should also detect risks and accidents and contact the alarm central if needed. The time duration for the different activities varies depending on the task and can range from one minute to several hours. The data input is in the form of the user's voice and images from the installed cameras.

C- Context
The home assistant should be used at home in a safe and quiet environment. It has to be able to detect the person during all hours of the day. Most of the activities will happen during the day when the user is awake and wants help with tasks. Accidents can occur at any time, meaning that the product should also be available during the night, making it essential to have night vision cameras. A manual or a tutorial should exist to teach the users how to use the product.

T- Technology
The service has to function offline if the connection is lost. It should have WiFi access and possibly Bluetooth. The product should be somewhat mobile and can potentially be combined with an application. The primary issues are its security, data management, and surveillance method: as it has to register information during all hours of the day. The communication should be two-way and go in two directions, User - Device - Alarm central.

4.3.5 Developing personas

Personas is a commonly used technique in a UCD process to bring requirements to life and guide the development of a product. Personas are detailed descriptions of typical users that the designer can focus on during the process. Each persona is characterised by their goals related to the product under development and behaviour, attitude, and environment. They represent a set of real users who have been involved in the data gathering and are based on user profiles [29]. In this case, our personas are based on Doro's existing user profiles, but are modified to suit the user personas for this home assistant. The idea behind personas is to help to understand whether a particular design decision will be an advantage or a disadvantage for the user. Personas help designers make decisions during the process as well as reminder that real physical persons will be using the product [29].

In the last step of establishing the needs, four personas were created. The different personas are presented below where their faces have been AI-generated, giving the personas more realism.

Persona 1

Name: Lena Hansson
Age: 60
Role: University Professor
Living situation: In a house in Lund with her husband

Scenario:
Lena has been on sick leave for a year after a car accident and is currently in a wheelchair. Lena's husband, Carlos, finds it hard to go to work and leave her alone every day. Once she fell when moving from the wheelchair to the toilet seat. The time she fell in the bathroom she was able to call Carlos with her mobile phone. Lena is afraid that something similar will happen again and she will not have the phone in her hand to get help. They have been talking about buying a camera-voice assistant but she is uncertain about how her privacy will be affected.

Goal with product use:
Lena wants to feel safe at home when she is alone, especially when going to the bathroom.

Persona 2

Name: Basilio Modica
Age: 78
Role: Pensioner
Living situation: Lives alone in an apartment in Malmö

Scenario:
Basilio is of Italian origin and has a family spread throughout Europe. He loves talking to his brother who lives in Italy. Basilio has osteoarthritis and has difficulties using his phone. He has difficulties cooking, and that is with what the home care services mainly helps. He does not want to pick up the phone when he receives a visit as he thinks it is rude, but needs help with the phone or computer.

Goal with product use:
Technological help specially with his phone such as calling or texting.

Persona 3

Name: Sofia Rudhag
Age: 64
Role: Working part time in a flower shop
Living situation: Lives alone in a house in Ystad

Scenario:
Sofia is a very tech savvy and self-conscious woman who suffers from early stage dementia. So far, she can still manage to remember most things, but sometimes gets confused and forgets the stove, or forgets to take her medicines. She bought a home assistant mainly to take advantage of the voice function. She uses it to ask questions, play music, add reminders etc. She knows that the more her dementia develops, she will probably activate the camera function in that way, detecting if something happens or if she leaves the house in the middle of the night.

Goal with product use:
To get reminders and keep control of her routines but also to increase the standard of living and use it for controlling music, setting timers, and alarms and so on.

Persona 4

Name: Sune Granberg
Age: 81
Role: Pensioner
Living situation: Lives alone in a house in Stockholm

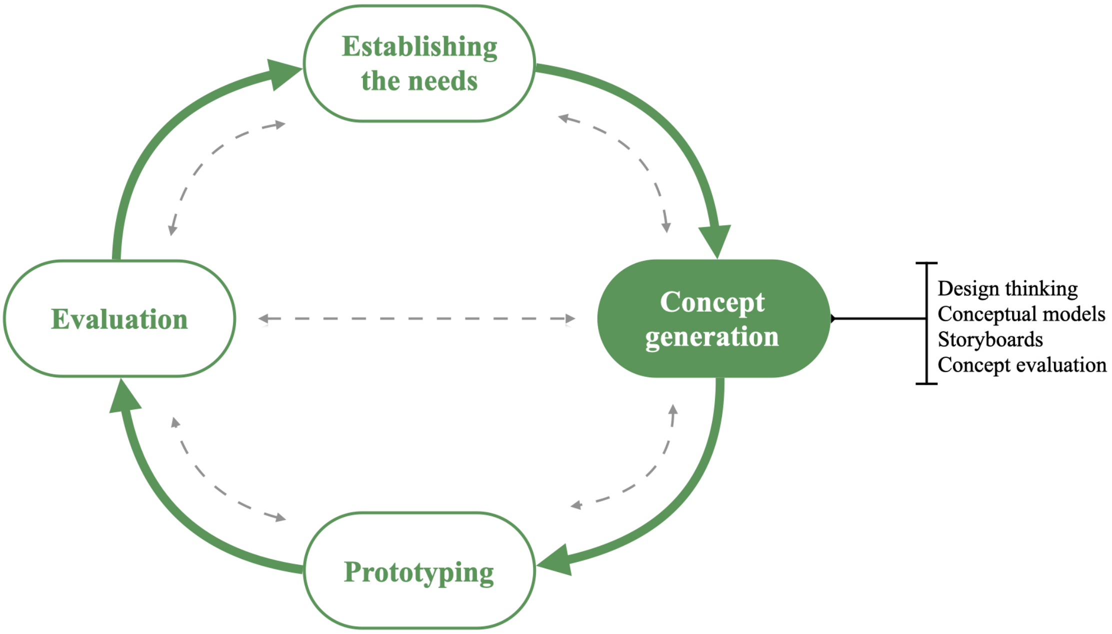
Scenario:
Sune is a proud man who does not want to admit that he has a difficulty walking. He should use a walker, but rarely does. His children are worried that he will fall and would not be able to pull himself up again. They would prefer if he moved into an elderly home to feel less worried, but Sune doesn't want to lose his independence so he refuses to move from his lovely house. They do not know how to leave him alone without diminishing Sune's dignity.

Goal with product use:
Sunes children buy this product to feel more safe leaving their father alone in his home. Sune is happy that he can still live at home and his children are satisfied that Sune has some kind of help.

Chapter 5

Concept generation

This chapter presents the second step of the design process, where different design alternatives are developed. Conceptual models and storyboards were used during the ideation phase, which generated six different concepts described below.



5.1 Ideation

5.1.1 Method for concept generation

Conceptual models

During the ideation process, it was decided that the two designers should develop four design concepts, each on their own. This was mainly due to the risk of influencing each other's ideas in this early stage. A conceptual model is a high-level description of a system or product and depicts how it works. It tells what the user can do with the product and what metaphors or concepts are needed to understand how it works. Before creating prototypes, this model can be developed to clarify the product's function for the user instead of how it appears. It is a way of finding possible metaphors and functions that should be included in the product to make it more intuitive [29].

After developing four conceptual models each, the eight concepts were presented to each other and explored, discussed, combined and changed. They were finally refined into six final concepts. The refinement of ideas was done by comparing each concept with the functions described as necessary in Table 4.3 and the established goals in Table 4.2. The aim was that all necessary functions and goals had to be covered by each concept. Though the camera function was delimited, it was agreed that the camera would be assumed to be placed high up on a wall or ceiling to ensure maximum visual range in all concepts. On the contrary, if the camera were to be placed on a table or bookshelf, it would probably have a smaller range; Implying more or bigger blind spots than if placed on the wall or ceiling. In the conceptual models presented in this chapter, all concepts but one have the camera and voice function in two different modules. This will be explained in further detail in the following sections.

Storyboards

Storyboards were created to understand better the interaction between the product and the user for the remaining six concepts. A storyboard consists of a series of images showing how a user would progress through a task using the product. This can be used early on in a design process to consider different design alternatives [29]. The six storyboards and the different scenarios are inspired by the defined goals and functions that were considered necessary. They are also influenced by the personas described in section *4.3.5 Developing personas*.

5.1.2 Generated concepts

In this section the six final generated concepts can be seen. They are presented with first a conceptual model and then the following storyboard to give more structure to the design alternative.

Concept 1 - Smartwatch

In the first concept, the camera and the voice function are separated, meaning they are not in the same device. The concept is based on having cameras in every room and a smartwatch on the user's arm, the interactive object. The user can communicate with the smartwatch with either two-way voice communication or touching the screen. The camera should detect accidents such as falling at home. Nevertheless, if the camera does not detect the fall, for example, if no camera is placed in the room where the fall happened, the user can call the alarm centre by pressing a button on the smartwatch.

By using machine learning, the cameras can learn the user's routines and therefore help with daily tasks or reminders such as medication reminders, scheduled visits from the home care service or music control in the home.

The wearable will be connected to the internet and the user's phone to make calls directly from it. The connection with the cameras in the home is through a wireless connection such as Bluetooth. The watch should notify the user when it needs loading or maintenance. It should also be possible to see when the cameras are activated with light signalling. An application can be downloaded onto one's smartphone to have better control over one's data.

The wearable will have both touch buttons as well as analogue buttons. It should be possible to mute the speaker, be used as a regular smartwatch, and turn on and off the home-assistant service, meaning that voice and camera functions are turned off. The control of the wearable should be performed only with the voice as an input so that persons with visual difficulties or difficulties understanding the touch functions can use it as well. In Figure 5.1, a scenario when using the smartwatch can be seen.

Figure 5.1: Storyboard of Concept 1, the smartwatch. Sofia is out walking.

Concept 2 - All-in-one with including application

The concept is based on a device with the camera and voice function in the same module. They are placed in the top corner of the home's rooms and wirelessly connected. Due to the high-level position of the object, there are no buttons on the device. The only visual interaction between the user and the camera is a light, notifying the user when the camera is on.

There will be a smartphone application connected to the home assistant. From the application, the user will be able to turn the camera on and off, see what the camera is detecting, add events and reminders, and call the alarm centre.

In case of an accident, the camera should detect the accident and call the alarm central. Figure 5.2 shows how the assistant could act when detecting a fall at home. For daily activities, the user can talk to the camera-voice assistant placed in most rooms and should be able to receive a quick response from it. The home assistant should be connected to other products in the home such as the tv, speakers, and lights to execute daily tasks. Daily tasks that include speakers will be connected to the home assistant's voice system, giving it a good speaker quality for music, radio, or television.

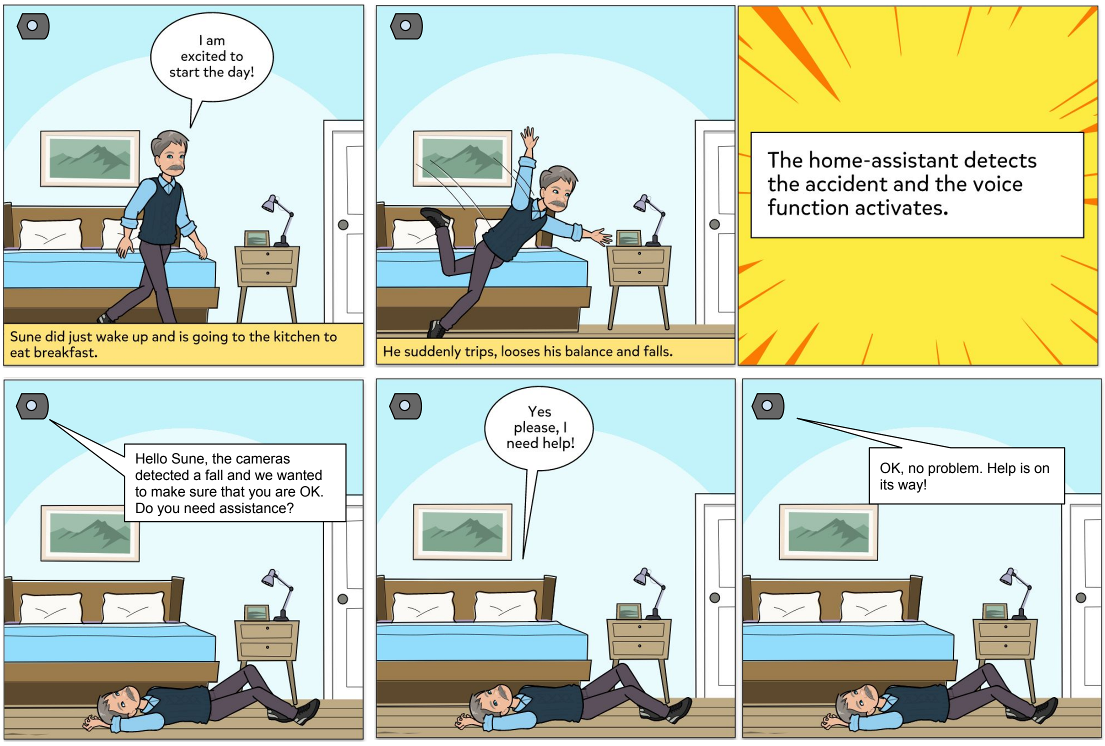


Figure 5.2: Storyboard of Concept 2, All-in-one with including application. Sune falls at home.

Concept 3 - Hub with including application

The concept is based on a device with the camera and voice in two different modules. The cameras are placed in every room in a top corner and connected wirelessly with each other. Due to the high-level position of the cameras, there will not be any buttons on the cameras. They are, simultaneously, also connected to a portable hub where the voice function will be installed. The voice assistant will be a wireless speaker with an on/off button and two volume buttons.

The user will be able to have two-way voice communication with the hub. This service will also have an added mobile application to see what the cameras are detecting. From the application, the user will be able to turn the camera on and off, see what the camera is detecting, add events and reminders, and call the alarm centre. Figure 5.3 shows an example of how a user performs a task. The hub can be placed on a chagrin station. Nevertheless, the device will be portable and can be moved if the user wishes. Due to its portability, it should notify the user when it needs to be charged so that the user does not forget.

In case of an accident, there will be three ways to contact the alarm central: either the camera detects the accident, the user can tell the hub to call for help, or call the alarm central via the phone. For daily routine tasks, the hub will work like similar products today, such as Alexa, Google Home or Siri, which means that the user will talk to a speaker with a microphone installed.

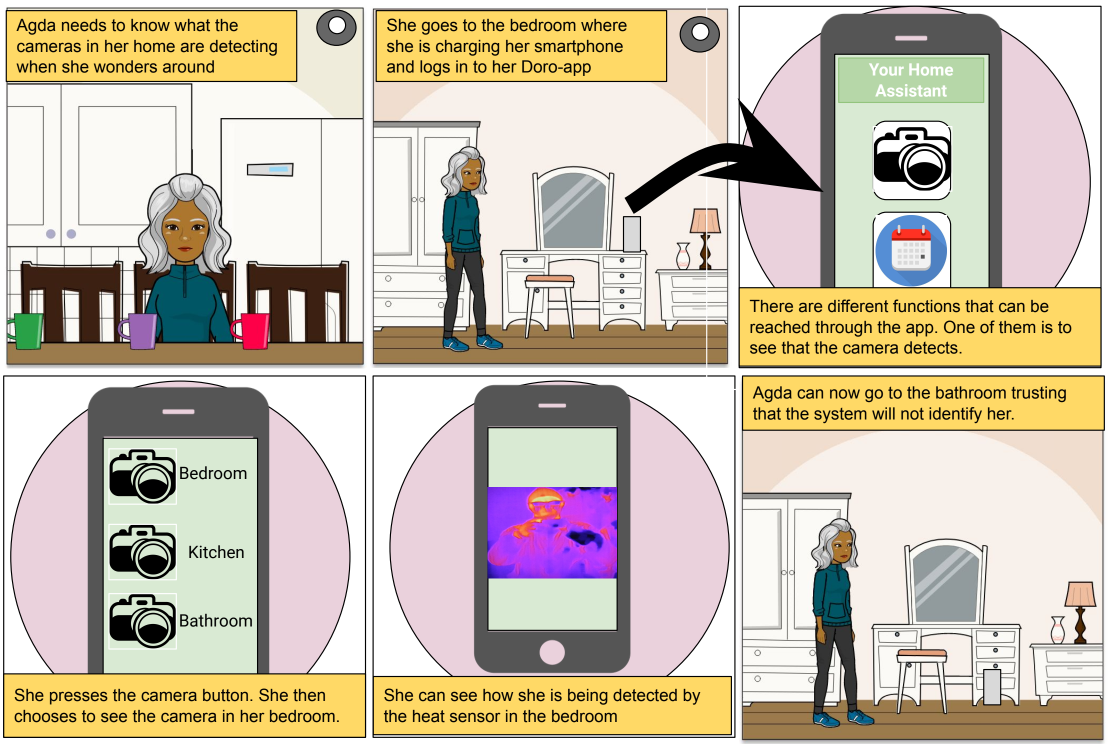


Figure 5.3: Storyboard of Concept 3, a hub with including application. Agda is at home using the application.

Concept 4 - Hub with screen

In the fourth concept, the voice and camera functions are placed in different modules. Cameras are mounted in several rooms to make it possible to detect routines and accidents. These are equipped with a light to show that the cameras are active. The cameras are wirelessly connected to a portable hub. Concept four is similar to concept three, but the hub has an additional touch screen to control one's data, search for information, and control one's home. The user can ask for help by using its voice or by interacting with the screen. If the user is unconscious and the cameras have detected the accident, help will come either way.

There are several buttons placed on the hub, such as on/off and volume buttons. The screen interface is user-friendly, and it is possible to control one's schedule and home from it. When the device is on standby, the user can choose what background to have on the screen. Alternatively, a black screen, a picture or a watch to make it more discrete. To make the hub more interactive and trustable, a picture of a talking person may come up when talking to the hub, giving the interaction a more personal touch. It can also show a picture of the user's medicine when notifying the user. The hub will be charged all the time, but it is possible to move if wished. In Figure 5.4 a scenario when using the hub with a screen can be seen.

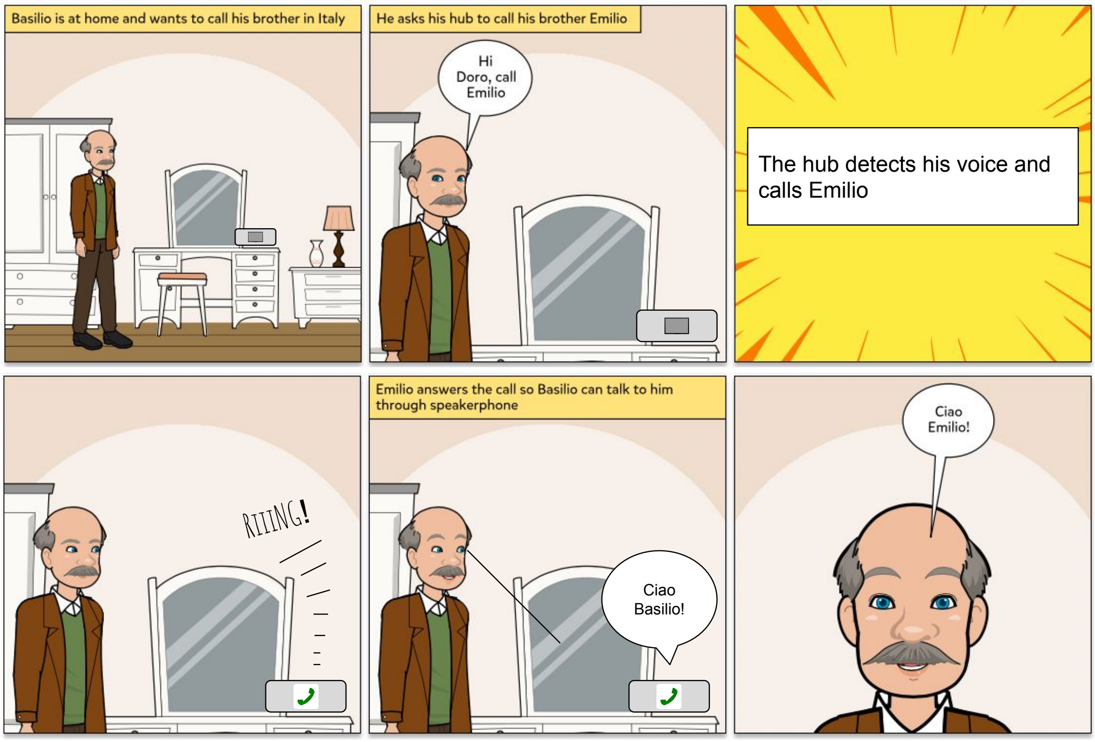


Figure 5.4: Storyboard of Concept 4, a hub with a screen. Brasilio is at home calling his brother.

Concept 5 - Self-going Buddy

Cameras are mounted in every room to detect accidents and routines. A small robot, called Buddy, is connected to the cameras, enabling it to move independently. It can be seen as a robot pet connected to the internet. It can communicate with the user by asking questions, giving reminders and notifications. The Buddy will get notified by the cameras if an accident has occurred and will get to the user's position in the home. When arriving at the user, it can communicate with the user and ask for help if needed to the alarm centre. A similar scenario is shown in Figure 5.5. The voice assistant is portable and self-going. It can charge itself when needed in a docking station without needing help from the user. It is possible to turn it off on a button on the Buddy if the user wants to.

In addition to the Buddy, an application can be downloaded to the smartphone to control one's data, cameras and Buddy. The idea is that the Buddy will be similar to a pet that the user will get an emotional bond to and can be seen as a company for seniors living alone.

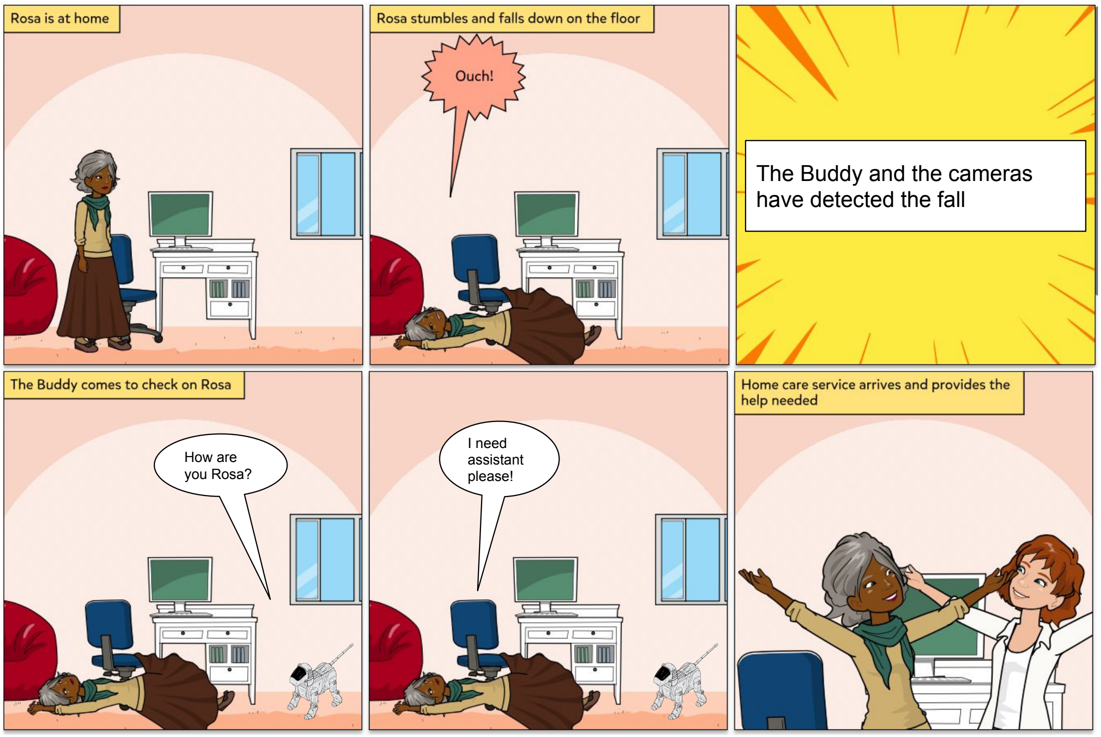


Figure 5.5: Storyboard of Concept 5, a self-going Buddy. Rosa stumbles an falls down on the floor.

Concept 6 - Home Screen

The sixth concept is similar to the other concepts with discrete cameras in every room in the user's residence. A *Home screen* is connected to the cameras and set up at a specific place in the user's home. This concept was inspired by the thesis *Technology based solutions as enablers for active and assisted living (AAL)*, mentioned in section *1.5 Related works*.

The screen must be located someplace where the user often passes to make it easily accessible. As the screen is stationary, the user does not need to worry about charging the screen. On the screen, there is an on/off button. The screen is similar to a photo frame with a touch screen and source to the two-way communication with the voice assistant. It is possible to contact relatives and home care through the screen if needed. The user can, from the screen, manage the data that the home assistant is detecting, such as see what the cameras see and apply filters if necessary.

The cameras have voice recognition to make sure that if something happens in a room where the screen is not mounted, it is possible to communicate with the user. However, the primary communication is through the screen, which works as a control panel where the user can control the cameras, the technical products in the home, search for information and get notifications. Figure 5.6 shows an example of how it would look like interacting with the home screen.

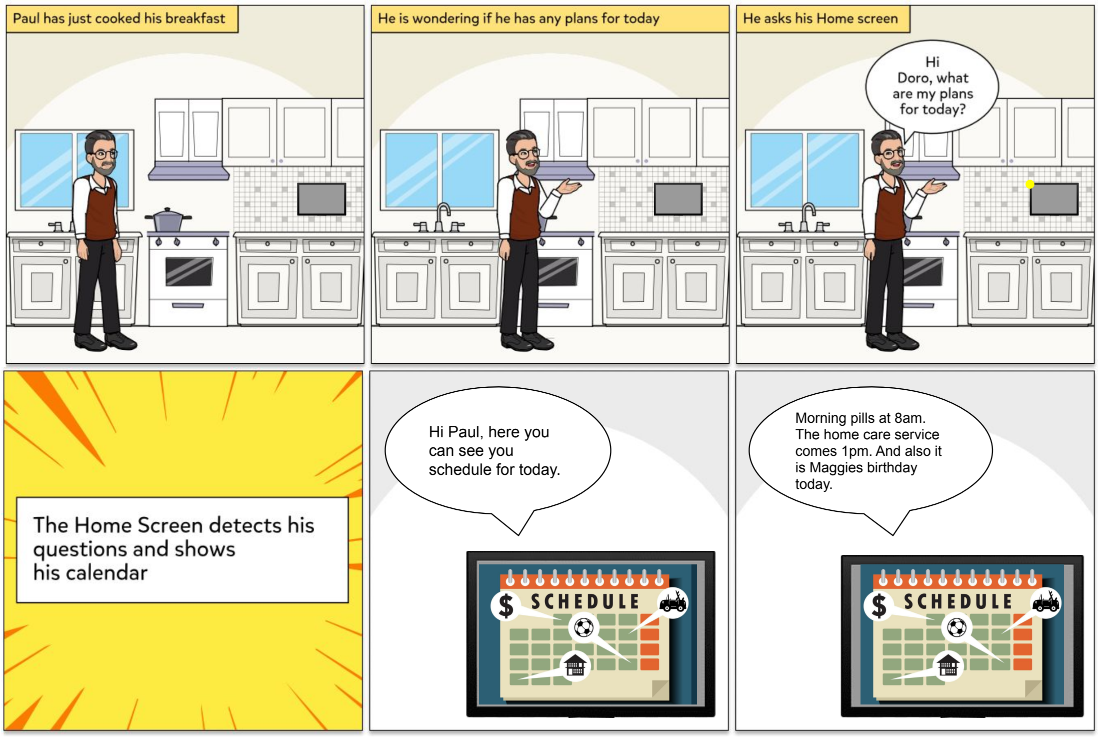


Figure 5.6: Storyboard of Concept 6, a stationer home screen. Paul is checking his calendar.

5.2 Concept Evaluation

The six final concepts fulfilled all the necessary functions, and therefore a weighing of functions as a method of evaluation was believed not to be ideal. Instead, two coordinate systems were created which would serve as an evaluation system. The scale on the axes was determined by considering characteristics that the concepts had in common and having the established goals in mind.

Out of this came the adjectives deemed to be most important for the home assistant and their opposite. The first spectrum determined was *Conspicuous* to *Discrete*, as a product that blends into the home has proven to be of great interest. The other scale is *Omnipresent* to *Bounded*, a spectrum describing how to interact with the product. This system can be seen in Figure 5.7 where all the six concepts have been placed in different locations after much consideration.

Since the *Self-going Buddy* is relatively independent, it was considered noticeable and fairly omnipresent though it can follow the user around. The *All-in-one* concept is omnipresent and almost a godlike presence though it speaks from above. However, this concept was deemed to be most discrete in a home when placed in a top corner of a room. The *Smartwatch* is always present as it is a wearable device. However, it was placed in the middle of the omnipresent-bounded scale as it is optional to wear. The watch is considered to be considerably discrete with a fashionable design. The two different hub-concepts were determined to be almost in the same place on this scale. They are both somewhat restricted to the room they are situated in but not as much as the *Home Screen* concept as the latter is entirely stationary and, therefore, the most bounded concept. The *Hub with screen* is more conspicuous than the standard *Hub with app* as it is both bigger and more visible with an illuminated screen. Nevertheless, the *Home Screen* is considered even more eye-catching with a bigger and stationary screen that can not be put away. The result of this placing can be seen in Figure 5.7.

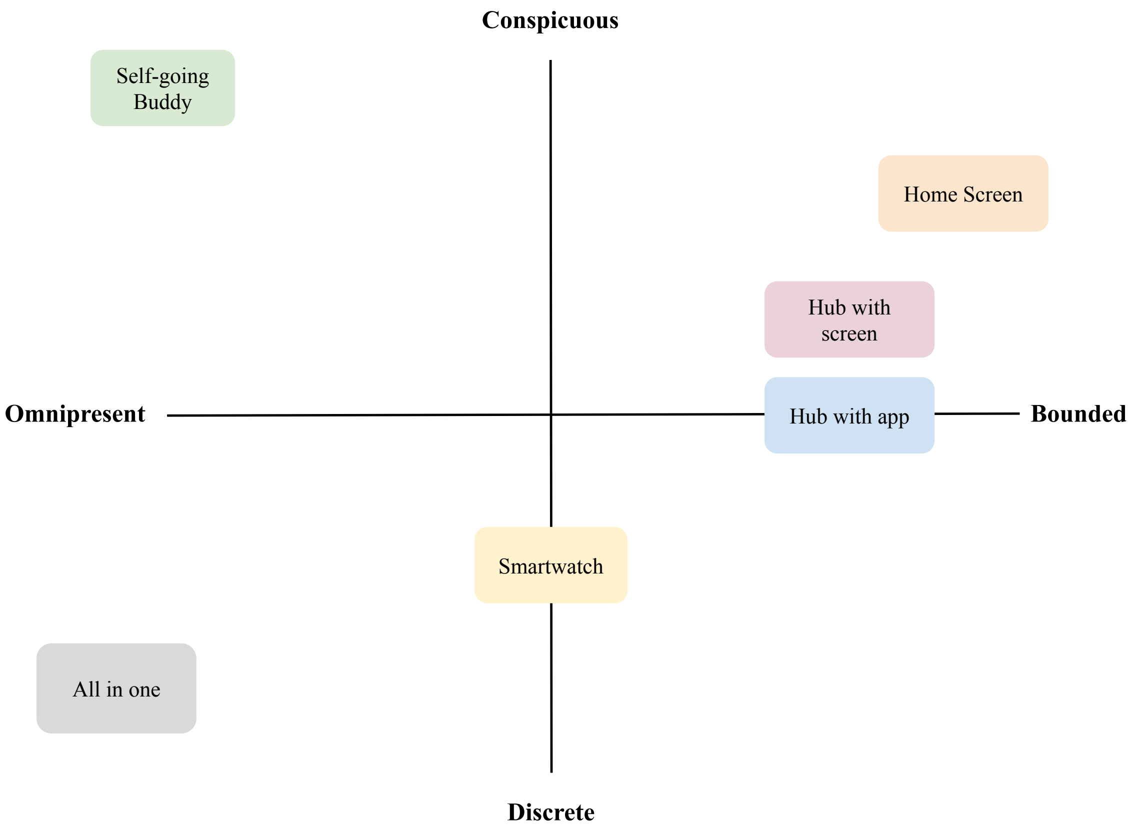


Figure 5.7: The distributed concepts using the axis Omnipresent to Bounded and Conspicuous to Discrete.

Another coordinate system was created to add another perspective to the evaluation. The vertical axis was changed to a scale named *Personality* to *Appliance*. A scale used to estimate how easy it was to get a relationship with the product and how friendly the interaction would be. The x-axis was still a scale between *Omnipresent* to *Bounded*. Figure 5.8 shows the system with the six distributed concepts.

The *Self-going Buddy* was placed on the same spot as in the other system as it was considered to have maximum personality value due to its similarity to a pet. The *All-in-one* concept is hard to build a relationship with and therefore seen more as an appliance. Nevertheless, it is reasonably discrete and was therefore not given the highest appliance value. The *Smartwatch* was placed in the middle as it is a wearable appliance but still has a personal touch making the user feel somewhat connected with it. The two hub concepts were placed in the same spot as in the previous system. The *Hub with screen* was considered easier to concert with as two senses are stimulated when interacting with it. Unlike the *Hub with app* where only the hearing sense is stimulated. Nevertheless, it was deemed the hardest to develop a relation with the concept *Home screen* due to its high technical appliance factor and stationarity.

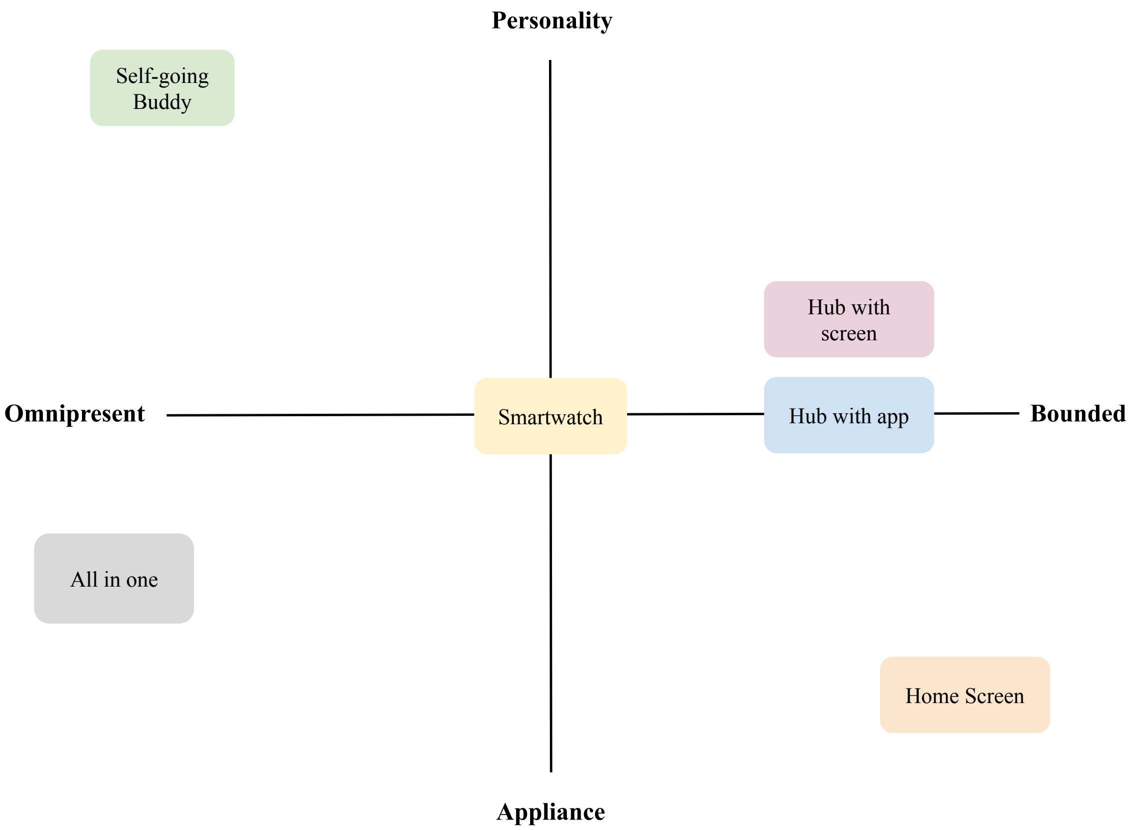


Figure 5.8: The distributed concepts using the axis Omnipresent to Bounded and Personality to Appliance.

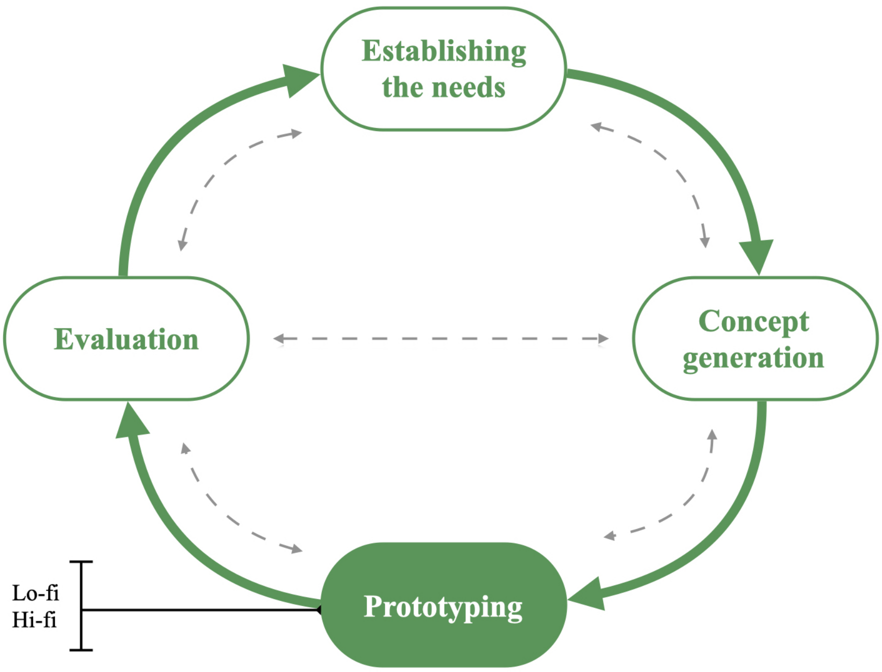
During the evaluation of the concepts, the two generated coordinate systems were compared. Together with the established goals from the data analysis, the conclusion was drawn that the adjectives that should be taken most into account were *Discrete* and *Personality*. This was because it had become known that the user wants a discrete product with which feel some kind of connection. Therefore, only the scale on the y-axis is looked upon and not the x-axis. However, the spectrum on the x-axis was not excluded permanently. The bounded-omnipresent scale will be considered to evaluate the lo-fi prototypes presented in the next step of the design process. Due to the importance of a discrete product, the *Self-going Buddy* was dismissed by looking at the location of the concept on the y-axis in Figure 5.7. The critical factor of personality caused the concept *Home screen* to be excluded, though it is located at the far end of the y-axis in Figure 5.8. It was then decided not to exclude any more concepts as the remaining four did not differ remarkably in the x-axis. Therefore, the following concepts were decided to continue in the design process.

1. All-in-one
2. Hub with app
3. Hub with screen
4. Smartwatch

Chapter 6

Prototyping

In this chapter, the different prototypes are presented, both lo-fi and hi-fi prototypes and the findings and evaluations of the lo-fi prototypes. Four concepts were tested in the lo-fi stage; these were then refined to three concepts later tested as hi-fi prototypes.



6.1 Lo-fi prototypes

Prototypes are usually built to answer different questions and help the designers to choose between different alternatives. Lo-fi prototypes are, as mentioned earlier, simple and quick to create, meaning that they are also easy to modify. This is important; thus, it is crucial for the testers to feel encouraged and welcome to give modification ideas [29]. In this project, the four lo-fi prototypes were created to answer the question: "what does the user prefer talking to?". All concepts include cameras, which should be situated on the wall to detect accidents and routines. The main difference between all concepts is where the voice functions originate from. For this reason, the aim of doing these prototypes was only focused on the voice function of the product.

Before executing the tests, a pilot study was performed. Due to the unnecessary risk of COVID-19 infection, an outsider was not asked to perform the pilot study. Therefore, the pilot test was performed by one of the designers and was mainly done to ensure that the used technology and the questions worked as intended.

6.1.1 Procedure

All tests started by letting the person read the instructions and information on what the data would be used for. They were informed that the information was anonymous and the ability to leave the study at any moment if they wished so. Demographic questions such as gender and age were asked before starting the tests.

Five persons tested all concepts. Due to the pandemic, the target users could not be reached, and the participants were instead all in their twenties. Thereafter, the participants were asked to act as if they were 70 years old and lived alone at home with a home assistant. The participants performed the tests separately. They were given five different tasks which had to be accomplished for each concept, these were:

– Activate the home assistant and ask a question.
– Set an optional reminder.
– Play any music.
– Manage a notification reminding you of medication intake.
– Pretend to fall.

The average age of the five adult participants was 25, where three women and two men participated. The order of the tests varied with each participant, in that way, avoiding bias. The only thing that varied when testing the different concepts was the product itself. All other parameters such as environment and tasks stayed the same so that the comparison of all the concepts could be based on the voice interaction with the product. The participants had to answer a digital SUS survey after testing each concept. The entire test ended with a short interview where the four concepts could be compared. The translated questions in English can be seen in Appendix B.

A smartphone was connected to a Zoom call and integrated into the lo-fi prototype to simulate an AI assistant and, in that way, doing a Wizard of Oz testing. This prototyping method is usually done with software-based prototypes, where the user has to interact with some sort of computer. In reality, a person is operating the software's responses to the user's actions, in that way "playing the role" of the home assistant [29]. The assistant all participants interacted with was called Doro and was activated by saying, "Hi Doro".

The person playing the role of the voice assistant made sure to follow the guidelines of the conversation design mentioned in section *2.4.2 Voice interaction*. Direct and clear responses were given, and follow-up questions and feedback so that the participants felt understood and safe when interacting with the prototypes. The voice interaction was polite, and the responses were designed individually for each participant depending on how they choose to ask and reply to the assistant.

The other designer accompanied the participants during the entire test and annotated what they did, said and asked. The information from this "Thinking aloud" methodology was afterwards used when evaluating the different concepts. The thinking aloud technique is an analysing method used during observations, where the participants are told to say out loud all the thoughts and actions that are thought and done [29].

6.1.2 The 4 lo-fi prototypes

Four different prototypes were built to analyse the voice interaction of the participants. When testing the *All-in-one* concept, a phone was placed over an open door and a window. In that way, simulating the camera and voice function in one object, see Figure 6.1 image A. The camera was instead simulated by a duct tape piece placed on the wall for the remaining concepts, see Figure 6.1 image B. The *Hub with screen* concepts was simulated by attaching a phone to a round speaker. The phone was connected to the Zoom-meeting and showed a PowerPoint presentation with different images and metaphors such as a pill, a calendar, or a telephone calling, see Figure 6.1 image C.

The *Smartwatch* concept was done by placing the phone in a sports bracelet. The smartphone showed the same PowerPoint presentation for the *Hub with screen* concept, see Figure 6.1 image D. The *Hub with app* idea was prototyped by placing the smartphone in a candle holder, Figure 6.1 image E. As mentioned in *Formulated functions and functions hierarchy*, Table 4.3 a necessary function for the home assistant is an additional/ complementary screen to the product. This screen was illustrated by a cardboard phone, see Figure 6.1 image F, and represented an application in a smartphone. This could be used simultaneously or together with *Hub with app* or *All-in-one* and was meant to be used to have additional control of the personal data and control over the cameras and voice assistant.

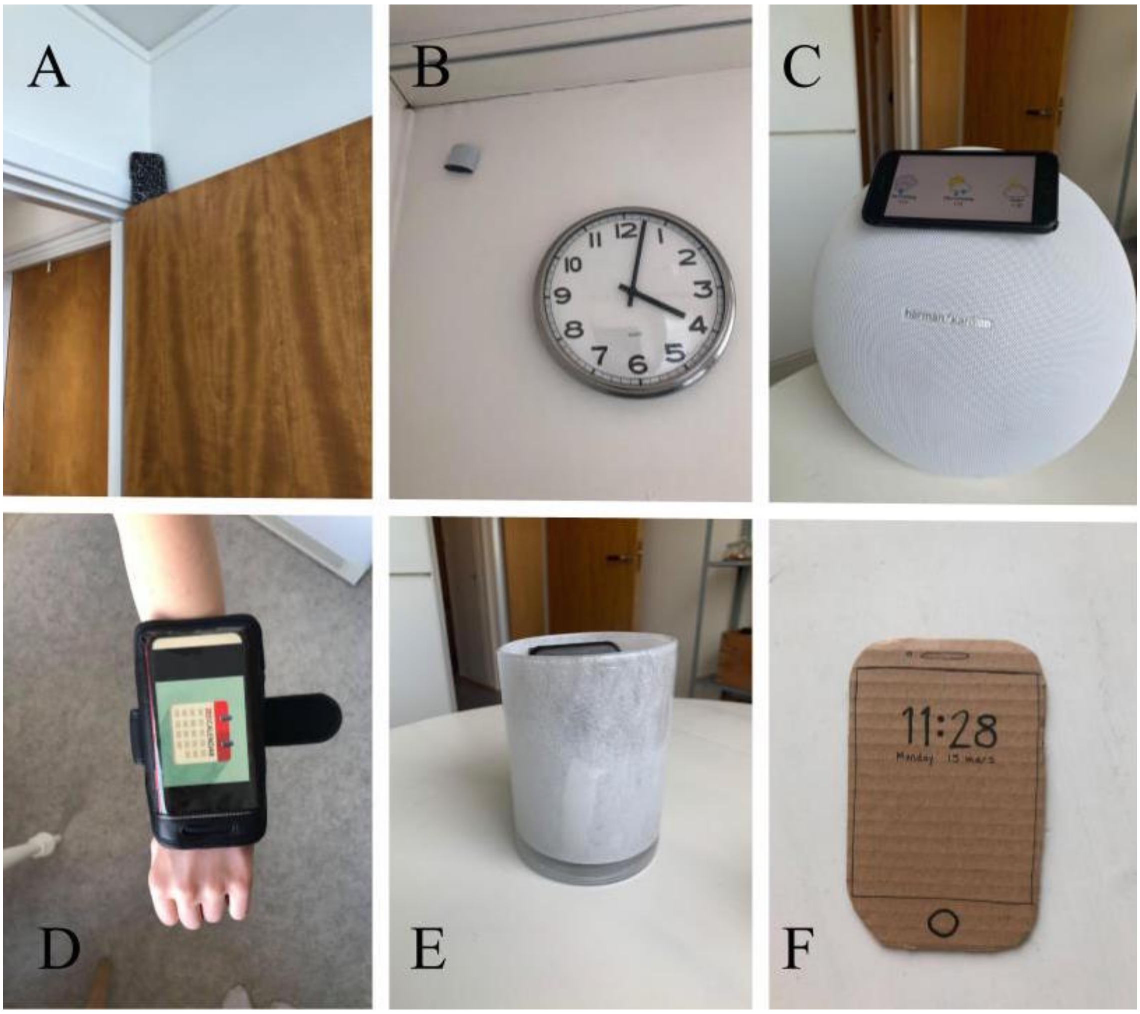


Figure 6.1: The six prototypes used to prototype four concepts. Image A shows the *All-in-one* concept. Image B shows a duct tape piece attached to the wall representing a camera. Image C shows the *Hub with screen* concept. Image D shows the *Smartwatch* concept. Image E shows the concept called *Hub with app*. Lastly, image F shows the smartphone that complements images A and E.

6.1.3 Results from the usability tests

When documenting the participant's actions and thoughts, it was observed that the concepts containing screens should give visual feedback to the user and auditive and touch-based feedback such as dialling sounds and vibrations. In that way, receiving information even though the screen is not in visual range. The concepts based on hubs were more difficult to transport than the remaining concepts and were believed to be difficult for a senior to remember to carry around. It was also pointed out that the hub concepts could not always be seen from the floor and that they tried to move to see them; this movement was thought to be a risk of injury for the elderly users. When testing the *All-in-one* concept, it was seen that the participants talked in a higher volume range because they did not know where to look.

All participants agreed that the easiest concepts to transport were the *Smartwatch* and the *All-in-one* as the last one is not transported at all. However, they all disagreed on what concept was more natural to interact with. Most persons agreed that they want to see what they are talking to, and therefore, 4 out of 5 participants disliked the *All-in-one* concept. They all agreed that the *Smartwatch* was the best concept when they fell on the floor. Thus they were sure that help was on its way and got immediate feedback on what was happening. All participants felt that having the assistant close to them and manually calling for help gave them a sense of security.

A common concern among the participants was the ability of the voice assistant to recognise the user if he or she was under shock or had speech difficulties. According to the study mentioned in section *1.5 Related works*, the technology to recognise users' voice even with disabilities is an up-and-coming technology. In the near future, that will hopefully be available and functional, which is promising for that concern.

The answers differed when asked what concept their older relatives would want to use compared to what concepts they would like to use when they get older. Implying that the design of the home assistant depends on the generation for which the product is aimed at. When asked what product their parents/grandparents would like to use, the answers were the two *Hub* concepts and the *All-in-one*. However, when asking what concept they would like to use when older, the answers were the *Smartwatch* or the *Hub with app* concept. Neither of the participants used a voice assistant daily, and only one had a smartwatch. However, all of them believe that the voice assistant technology will evolve enough until they need a home assistant and believe that their generation will have to get used to the smartwatches and be seen as a standard device in 50 years.

When calculating the average SUS score for the four different concepts, it was observed that the winning concepts were the two variants of hubs. The *Smartwatch* was the concept with the lowest score. The five participants' average scores of the four concepts are shown in Table 6.1.

Table 6.1: The average SUS results for the four concepts tested in the lo-fi prototypes.

Concept	SUS Score
Smartwatch	68,5
All-in-one	69
Hub with app	76,5
Hub with screen	78,5

6.1.4 Conclusions from the lo-fi testing

From the SUS, it was clear that the hubs were the winning concepts due to their higher scores. As mentioned in section *2.5.7 System Usability Scale*, five answers are minimal to get a somewhat reliable answer. The lo-fi tests explained in this section were executed by five persons, which fulfilled the SUS requirements according to Smyk [34]. However, it can be discussed that as five answers are the minimum, more answers would be needed to get more accurate scores according to the two designers. The fact that the participants had to answer four SUS surveys each can also be a factor that affected the different scores. Therefore the SUS score was regarded as only an indication of the test's performance and was not the only factor considered by the designers when going forward.

The scores were therefore combined with the answers from the interviews. From the interview, there was unanimity that the *Smartwatch* gave the participants an increased sense of security. Based on the SUS and the interviews, three concepts were decided to be kept in the design process. The two hubs and the *Smartwatch*. However, some changes were made to all concepts based on the feedback gathered during the tests.

Due to the mobility difficulties of the hubs, it was decided that the number of hubs in the home could be optional. For optimal voice interaction, there should be one hub in each room of the user's home. In that way, avoiding the displacement of the product around the home.

Even though the *Smartwatch* did not get a high SUS score, it was the most popular concept seen in the interviews. This concept was believed to have potential and was therefore decided to be kept in the design process. However, it was pointed out in the interview that even though the participants liked the idea of smartwatches, they were uncertain if their older relatives would be comfortable using them. Due to what is believed to be a generational issue, the *Smartwatch* idea was discarded and instead changed to a *Wearable hub* with the same additional application as the concept *Hub with app*. A wearable product that will not replace a smartphone rather be a complement to it. From now on, the *Smartwatch* concept has been replaced and renamed to *Wearable hub with app*.

6.2 Hi-fi prototypes

As mentioned earlier, all concepts have a screen that the user can interact with. For this reason, three 3D images were designed as well as a UI. Presented below are the iterative design process for the test procedure, 3D images, and the UI. These iterations occurred due to received feedback within the design group and meetings with the thesis supervisors. The supervisors considered experts in the field.

6.2.1 Development of the testing procedure

Iteration 1

How the test would be performed was a considerable difficulty due to the COVID-19 pandemic. The testing procedure was changed several times and is a good example of the iterative process and is therefore presented in this chapter. The first idea was to perform the tests in real life and let the participants interact with the prototype using their voice, similarly to the lo-fi prototypes. The idea was to 3D print the prototypes and make the participants perform several tasks. As done in the lo-fi testing, the voice was meant to be performed by the Wizard of Oz method through a phone or other device connected to the 3D printed design. This idea was quickly discarded as it was believed to be unsafe to meet people due to the pandemic.

Iteration 2

A digital test had to be developed to test the prototypes on more and older persons. The idea was to make the participants perform different tasks by speaking to a screen showing 3D images of the three concepts. The assistant's voice speaking to the participants would be computerised to make the prototype as similar to the final product as possible. While interacting with the image on their screens, they would have access to the complimentary UI through their smartphone. The smartphone's screen would have had to be shared to show where they would click on the UI. As can be guessed, this test would require a great deal of digital knowledge, good internet connections and the possession of two digital screens. It was also assumed that due to the digital complexity of the test, only a young demographic would be able to participate. Therefore, it was decided to redesign the testing process again, making it more available for an older demographic.

Iteration 3

Due to the digital complexity of the testing method some changes had to be made to make it more available for an older population. Consequently, it was decided to start the tests with a short presentation showing the product's design. The presentation would be followed by several tasks that would be read out loud. The participants would choose which, out of the three concepts, they preferred during each task. This testing method was believed to be easy enough for an older demographic. After some expert assistance, it was pointed out that the participants may not get enough context when choosing between the products. Therefore, the tasks were decided to be shown as video clips where the 3D images (created in the online platform Vectary [37]) would be placed in different spots in a home with the help of Vectary's AR function. A recording of a computerised voice, created on the online platform TTSMP3 [38] was added to the videos. In that way, illustrating the voice interaction with the concepts and improving the voice prototype from the lo-fi test.

6.2.2 Development of the 3D images

Since the testing procedure was opted to be digital, the three hi-fi prototypes were decided to be developed as 3D images. Vectary was the online platform used to create the 3D designed and augmented Reality videos for the testing [37]. The iterative process of the development of these concepts can be seen below in this section.

Hub with screen

Iteration 1 - First design

As seen in Figure 6.1 image C, a mobile screen was used in the lo-fi prototypes. The same screen size was therefore continued within the first iteration of the *Hub with screen* concept. As seen in Figure 6.2, a mobile screen was placed on a hub; the screen was tilted some degrees enabling visualisation of the screen from a high or low position. Following the design principle *Affordance* described in section *2.5.5 Design principles*, a handle was placed on the back of the product, illustrating the possibility of moving. Following the same design principle, two volume-buttons were placed on top of the product, illustrated as plus-minus signs. Following the design principle of *Consistency*, a texture with several holes resembling the texture of a speaker was applied on the hub. The colour grey was chosen, in that way following the need of having a discrete product.

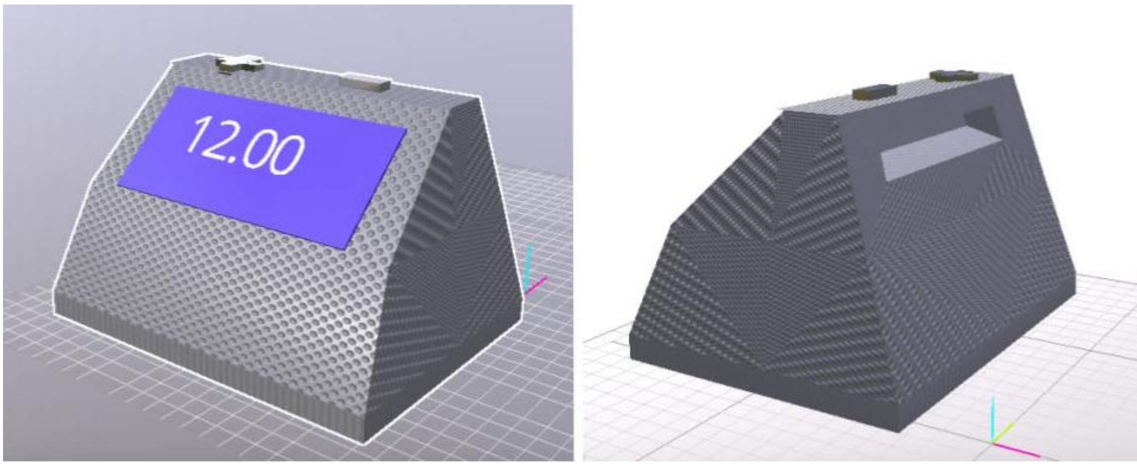


Figure 6.2: The first design on the *Hub with Screen* concept.

This design was shown to two experts. After discussing the mobility of the product and the existence of the volume buttons, a new design following more design principles was created, see Figure 6.3.

Iteration 2 - Second design

The feedback regarding the mobility issues with the first design was taken into consideration. As the concept is mainly based on a screen, the screen should be the dominant part of the design. It was also decided to go forward with a more minimalistic design as the first design was considered "clumsy".

Fulfilling the design principle of *Consistency*, inspiration was taken from similar products in the market such as tablets and Google Nest hub [39]. Therefore, a new design, with a bigger screen on a smaller hub was created. The volume buttons were decided to be kept as they increased the *Affordance* of the design.

The idea of a handle was kept in the second design and placed on the support by doing two parallel straight indentations. In that way, enabling a grip where one indentation is meant for the thumb and the other for the rest of the fingers. A white textile texture on the hub was now chosen to illustrate the material of a speaker as it was believed to be more aesthetically pleasing, minimalistic, and´ more discrete in the context of a home.

The second iteration on the concept *Hub with screen* is shown in Figure 6.3, where the two volume buttons were placed under the tilted screen. Support was added behind the screen to add stability when touching the screen. The two experts gave their tips and opinions on the second iteration. Such as adding the UI to the screen of the 3D images. They also provided a tip regarding the addition of a charger to the 3D image.

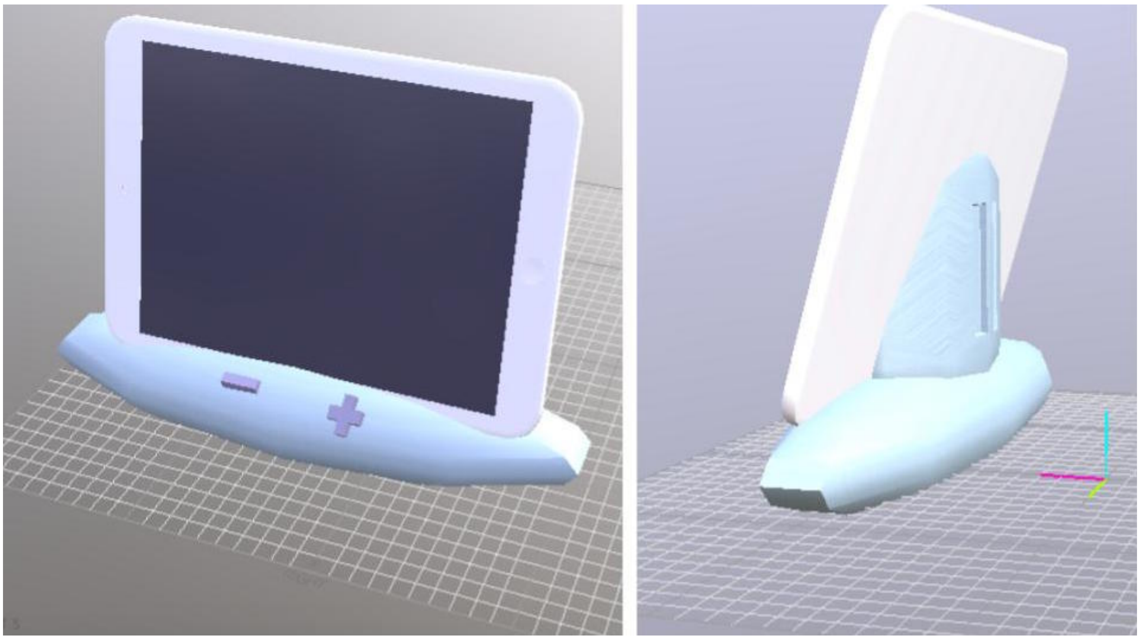


Figure 6.3: The design of the product after the second iteration.

Iteration 3 - Third design

The screen was decided to be turned 90 degrees in that way, fitting the UI onto the screen. A charger was added to the design to give the understanding of needing to be charged from time to time. The hub and the support on which the screen is placed was polished to make it more smooth and aesthetically pleasing.

The handle was removed as it was believed that it would not help carry around the product. It was also believed that the product was small and light enough not to need one. The third design is shown in Figure 6.4 and is the design used during the tests.

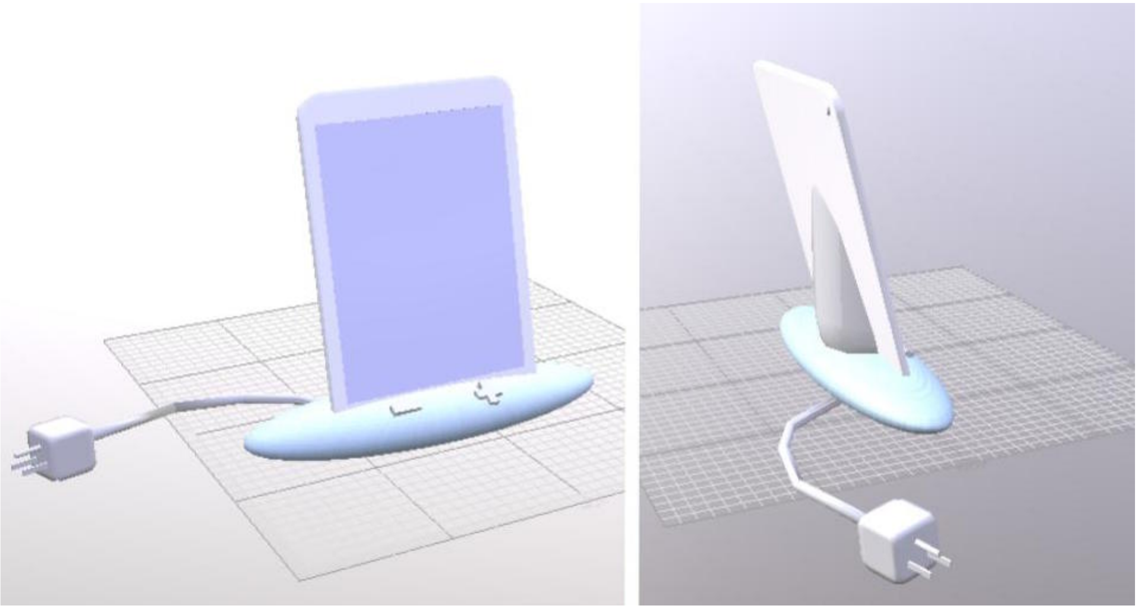


Figure 6.4: The third design iteration of the *Hub with screen* concept

Hub with app

Iteration 1 - First design

The design of the hub was inspired by the design of mobile speakers out in the market today. An oval shape was given to the hub to increase the product's visibility throughout the room. In that way, being able to see the product from a further distance. As seen in Figure 6.5 two volume buttons were placed on the side, and a button for activating Doro was placed on the top.

The volume buttons and the activation buttons were formed differently to distinguish them in that way following the design principle of *Visibility*, described in section *2.5.5 Design principles*. The volume buttons were squared, and the activation button was round. This, combined with a slight protrude, was believed to increase their visibility. As this concept does not have a screen attached to it, it was believed that the need to have analogue buttons had to be given more importance. The colour white was given to it as it is believed to be a discrete colour in the context of a home. A bracelet was placed on the button of the product, making it easier to transport. A ruffled texture was given to the hub illustrating the material of a speaker.

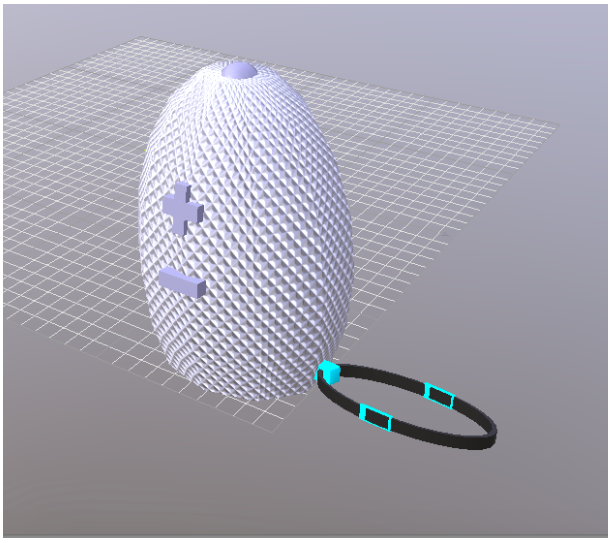


Figure 6.5: The first design of the concept *Hub with app*.

The feedback given from the two experts focused mainly on the fact that the volume buttons were placed on the side of the product. These were believed to be difficult to press without making the hub overturn. The volume buttons were also questioned if necessary due to the voice function.

Iteration 2 - Second design

As reasoned earlier, the volume buttons were believed to be a standard and were therefore kept in the design. The buttons on the side of the product had to be changed after the experts' feedback. The button to activate Doro and the volume buttons were therefore decided to be placed on the top of the product. Therefore, the top of the hub had to become broader to fit the three buttons. There was a decision to make: Either keeping the same height or making the product smaller. Keeping the same height would mean more significant visibility in the room. A smaller design would mean a more discrete product. After discussion in the group and following the *Consistency principle*, a smaller design was created, inspired by existing products such as Google's Nest mini [40].

As seen in Figure 6.6, the volume buttons were separated by the activation button. This was done as a *Constraint*, increasing the distance between the two volume buttons and, in that way, minimising the risk of pressing the wrong volume button. The texture of the hub was changed, becoming that way more discrete. Figure 6.6 shows the second design of the concept *Hub with app*.

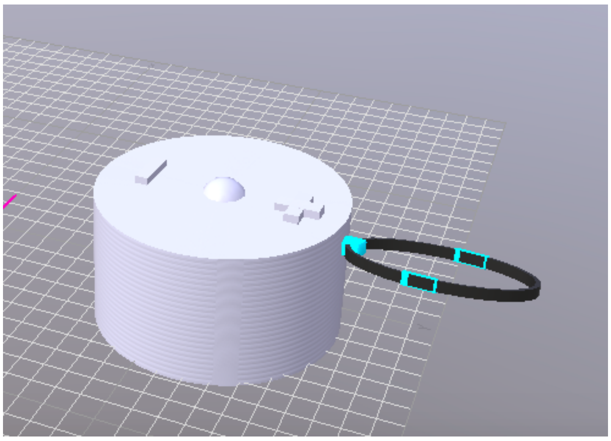


Figure 6.6: The second design of the concept *Hub with app*.

Iteration 3 - Third design

The feedback received from the experts regarding the visual feedback combined with the users' needs regarding light signalling (see Table 4.3) resulted in the final design changes before testing the prototype.

The hub needed to give some visual feedback regarding its status to the user. A light was added to the top of the hub that would shine green if the active listening was activated and shine red if the mute mode was on. The light would be turned off if the hub was not being used, meaning it was on standby and passive listening activated. The light around the top is slightly tilted to be seen from a high or low position. Adding a light would enhance the product's visibility and give the user visual *Feedback* on their commands and the device's status.

The button in the middle, activation of Doro, was redesigned. Instead of protruding, a small and round curvature downwards was created. This was done because the said button would not be frequently used as the assistant could be activated by voice. The volume buttons were decided to be the most important ones out of the three buttons and needed to be more visible. The third design is shown in Figure 6.7, where the three different modes are illustrated.

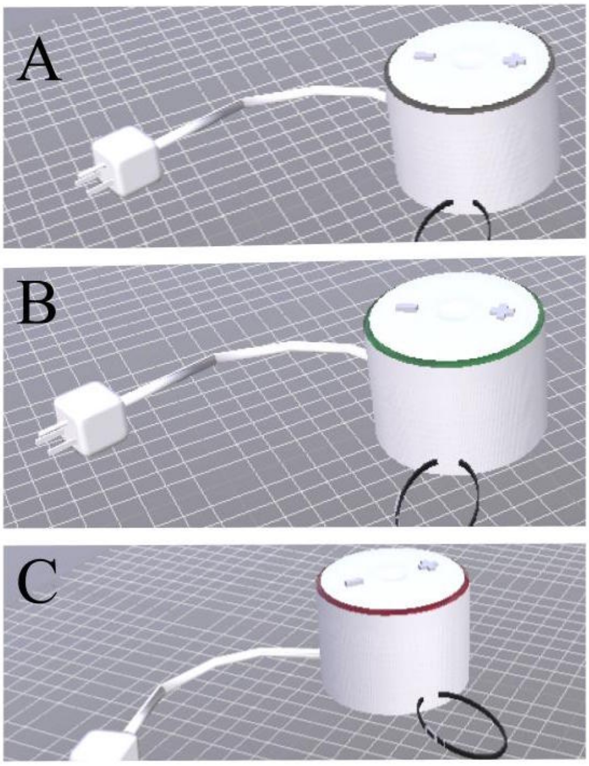


Figure 6.7: The third design of the concept *Hub with app*. The top image shows the hub in standby mode with a deactivated light. The image in the middle shows an activated hub with a green light. And the lower image shows a muted hub

Wearable hub with app

Iteration 1 - First design

An already created 3D model of a fitness tracker, included in Vectary, was used as a template. Four buttons were placed on the *Wearable hub with app* due to the necessity of having analogue buttons on the product. According to the lo-fi testers, analogue buttons gave them a feeling of safety and assurance that help was on its way. A button to activate the assistant, a mute button and two volume buttons were added to the template, as seen in Figure 6.8. The mute and the volume buttons were placed on the same side of the hub, as they are all related to the volume levels of the voice assistant.

All buttons had different forms so that they would be easily identified and harder to mix up. Following the design principle of *Constraint* described in section *2.5.5 Design principles*, three out of four buttons were similar to buttons found on smartphones today. The volume buttons were placed together, looking like one long button. Similar to the mute function on some smartphones, the mute button could be switched up or down like a regulated button. When switched up, the mute function would be activated. A red background under the button was shown to give feedback to the user about the hub's status.

The fourth and last button, the activation of Doro, was placed on the other side of the hub. It was designed to be round and bigger than the other buttons to differentiate it from the rest. The first design of the *Wearable hub with app* is shown in Figure 6.8.

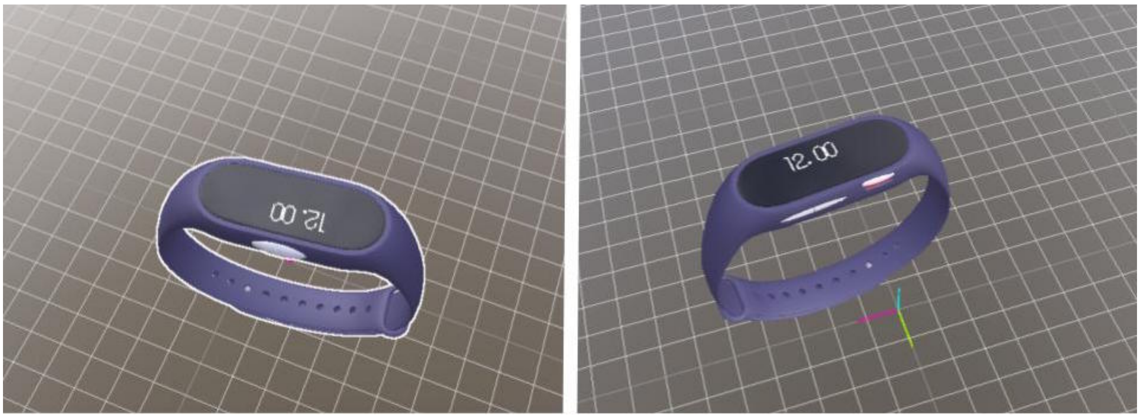


Figure 6.8: The first design of the concept *Wearable hub with app*.

Iteration 2 - Second design

The possible removal of the mute button was discussed based on the feedback received from the experts. Persons with dementia could indeed forget to deactivate the mute function. It is, however, believed that the function offers sufficient feedback (the red marking) to notice if the mute function is activated. Individuals today are used to smartphones which all have mute buttons. Thus it comes in handy to quickly mute a device in a given situation, such as a library. The mute button was kept in the design following the design principle of *Consistency*, the need for a discrete device, and the wish for analogue buttons.

After further observation of the design, it was noticed that the time on the hub would be challenging to see if one would use it as a watch. Therefore, the text on the display was rotated 90 degrees in that way, understanding the text when placing the device around the wrist, see Figure 6.9. To increase the *Affordance* of the *Wearable hub with app*, three dots were placed on one side of the display representing the microphone and the speakers, this can be seen in Figure 6.9.

Figure 6.9: The hi-fi prototype of the *Wearable hub with app* used during the testing procedure.

Iteration 3 - Third design

A third design was never created due to the belief that no more changes were needed before the hi-fi tests.

6.2.3 Development of the user interface

As mentioned, all three concepts have a user interface in common. The *Hub with app* and the *Wearable hub with app* has an application to a smartphone, and the *Hub with Screen* has the same UI on its screen. A hi-fi prototype of the UI was created to complete the concepts and test them fairly.

When deciding what functions should be possible to do in the UI, the designers looked at the established needs and the necessary functions. The focus laid on the importance of controlling the data and the wish for an on/off possibility. Therefore, it was decided that the app's primary function should be to turn on and off cameras or hubs. The control of the cameras could only be done through the UI. This was seen as a safety precaution as the deactivation of the cameras should not be easy from a safety point of view.

Still, the opportunity to turn it off was of interest; consequently, the function was decided to be implemented in the UI. No other function was deemed necessary to implement in the prototype, but symbols were added as indications of what can be done in the application. Examples of other functions are calendar, contact home care service, and control of home devices such as lighting and music.

Iteration 1 - First design

The user interface was created in Figma [41]. Since the development from the lo-fi prototype to the hi-fi of the UI was quite big, a meeting was held between the designers. Possible design alternatives were discussed with the design principles from section *2.5.5 Design principles* in mind. With inspiration from similar applications to fulfil the design principle of *Consistency*, the first prototype of the UI was developed and can be seen in figure U1. The two designers got free rein to design the UI since Doro Care does not have any existing user interfaces.

The dark green colour found in Doro's logo was chosen as the interface's primary colour. The colour psychology of the colour green is also beneficial in this case as it is associated with tranquillity, good luck and health [42]. To keep a simple and stylish interface, white, black and light grey were added to the selected colour palette. However, some details were decided to be given the colour blue to gain some contrast. The font called *Roboto* was used throughout the UI with font size 15. Headers were, however, enlarged with font size 18 or 28.

A "hamburger menu" was placed on the header to gather standard requirements for an application such as Settings, Help, My profile, About and START. To fulfil the design principle of *Visibility*, relatable symbols were placed beside their title to make it easy to identify the functionality. The title of the functionality was placed beside the icon to easily interpret the icons [29]. Examples of these symbols are a house, a telephone and a gearwheel seen in Figure 6.10.

Following the design principle of *Consistency*, a search field was placed on the top of every page of the app in that way, making it accessible at all times. The design principles of *Feedback* and *Visibility* were strictly kept in mind when designing the camera's control page. Visual feedback was given by turning the on/off button red and darken the screen when deactivating the camera function. Respectively, turning the buttons green and showing the view of the camera when activating the camera. To fulfil the design principle of *Affordance*, buttons and icons were shadowed, hinting that they were clickable. Arrows were added, indicating the ability to move forward and backwards. On the calendar page, arrows can be seen by the month "April 2021", indicating changing months when clicking on them.

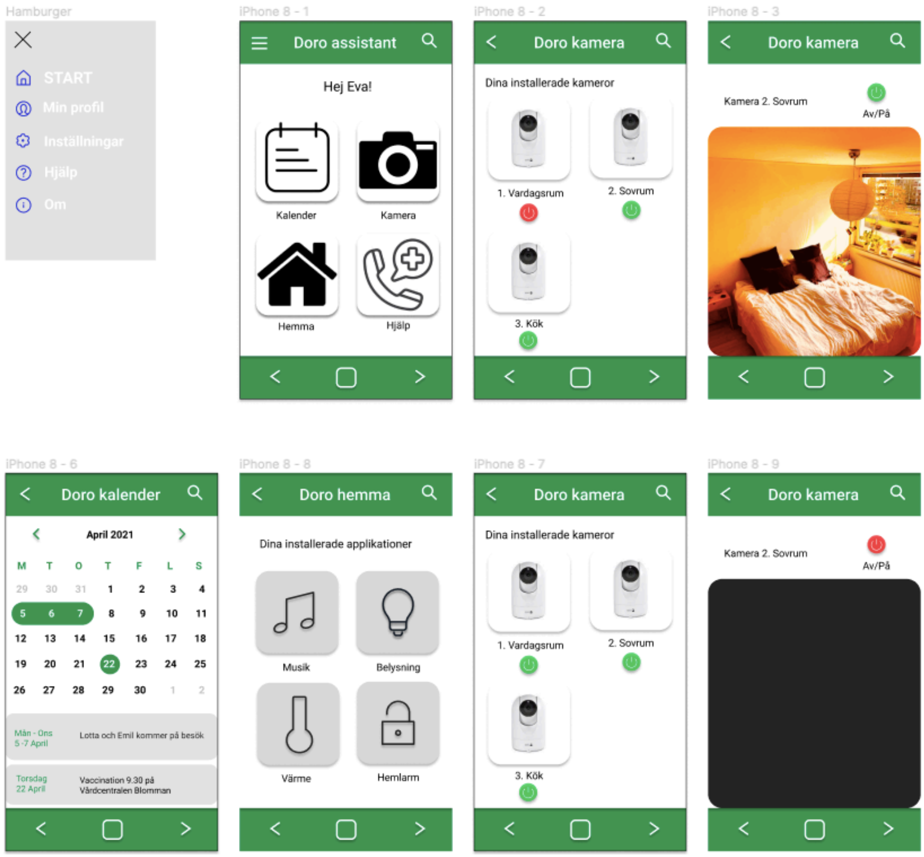


Figure 6.10: The first design of the user interface.

The interface was shown to the experts, and feedback was received. A navigation panel was suggested instead of the current green line with three buttons at the bottom of the screen. It was pointed out that Doro's name should be removed from the header as it gives a feeling of marketing if kept in the interface. Tabs were proposed to replace the current four category buttons on the home page, giving it a fresher look and making it easier to navigate.

The arrows in the bottom line were meant to be used to navigate back and forward. These were questioned as it was unclear what was back and forward when navigating through the app. The double arrows in the calendar layout were also considered a problem as there was a risk of clicking the wrong arrow. This problem could be fixed with the suggested tab layout and deleting the arrows. The title on the health care button "Hjälp/Help" was also suggested to be reconsidered as it could be confused with the help function of the application.

Iteration 2 - Second design

All received feedback was accepted and worked on. The green bottom line was redesigned to a navigation panel, and the arrows were deleted. On the navigation panel, four functions were placed: Settings, Notifications, Mute mode and Care. A green START button was placed in the middle of the navigation panel to get back to the home page quickly, see Figure 6.11. The previous "Hjälp/Help" button is now found in this panel and renamed to Care. Doro's name was erased from all pages except the home page to preserve some association.

As can be seen in Figure 6.11, a tab layout was implemented with three windows; "Start/Start", "Bostad/Residence", and "Kalender/Calendar". The daily schedule, reminders, events, date and weather are presented on the start page. Under the tab "Bostad/Residence", the installed applications can be seen, such as the cameras, the hubs, music and lightning. If the camera button is pressed, the camera page would be shown. The page is similar to the first design except for two changes. Red or green dots have been added to the camera button to inform about the system's status, following the principle of *Visibility*. The headlines have been bolded to fulfil the need for high readability.

The tab menu's background is white, and the main background is grey. Different colours were chosen to visualise the tabs. The open window's title was coloured green, underlined and shaded, giving feedback to the user regarding their position in the application. The two remaining window's titles were coloured with light grey.

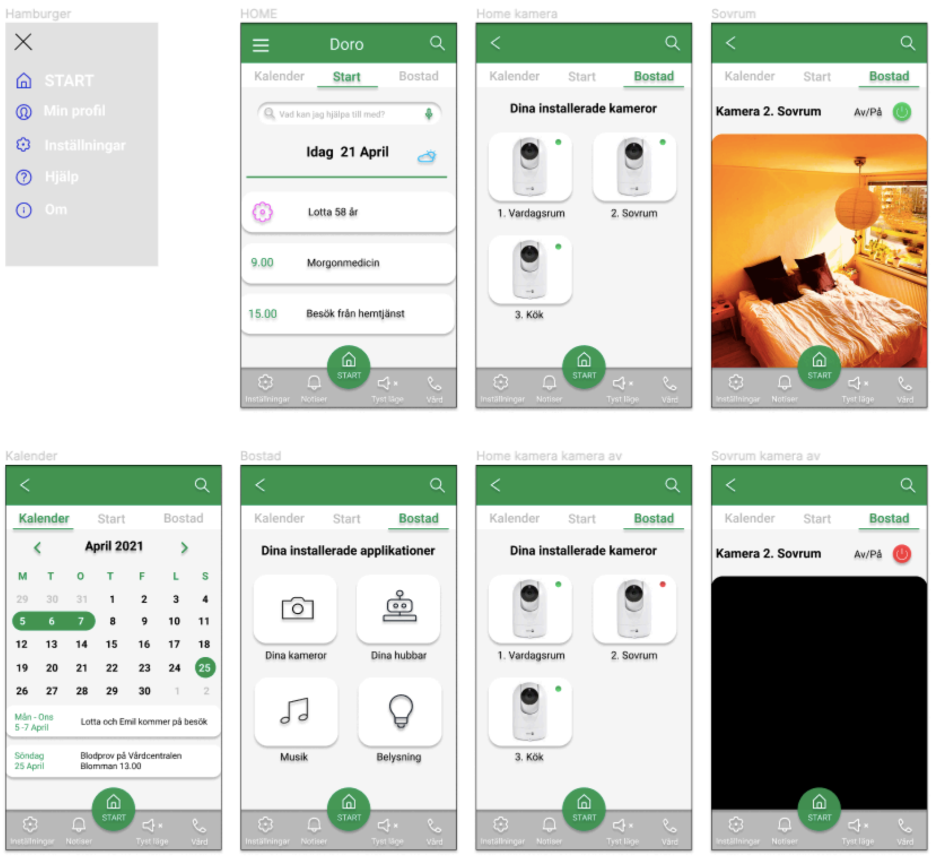


Figure 6.11: The second iteration of the user interface.

A second expert interview was held where the new iteration was shown. According to the experts, a clear improvement had been made. The only suggestion was regarding the colour pallet in the hamburger menu. Colourblind users would have difficulties differentiating dark blue from green or distinguishing white from light grey.

Iteration 3 - Third design

Once again, the feedback was taken into consideration by the designers. Figure 6.12 shows the final hi-fi prototype of the interface, with a redesigned hamburger menu. The green spectrum was kept in the design. The buttons were differentiated with a dark green colour, and the blue icons were changed to white to match the titles. In the calendar, the S for Sunday was changed to red to follow the design principle of *Consistency*. Thus, Sundays are often coloured red in analogue calendars.

Following the design principle of *Affordance*, an arrow pointing down indicates the existence of a drop-down menu. Therefore, such an arrow was added on the calendar page, beside the year, to indicate the possibility to change the year quickly, see Figure 6.12.

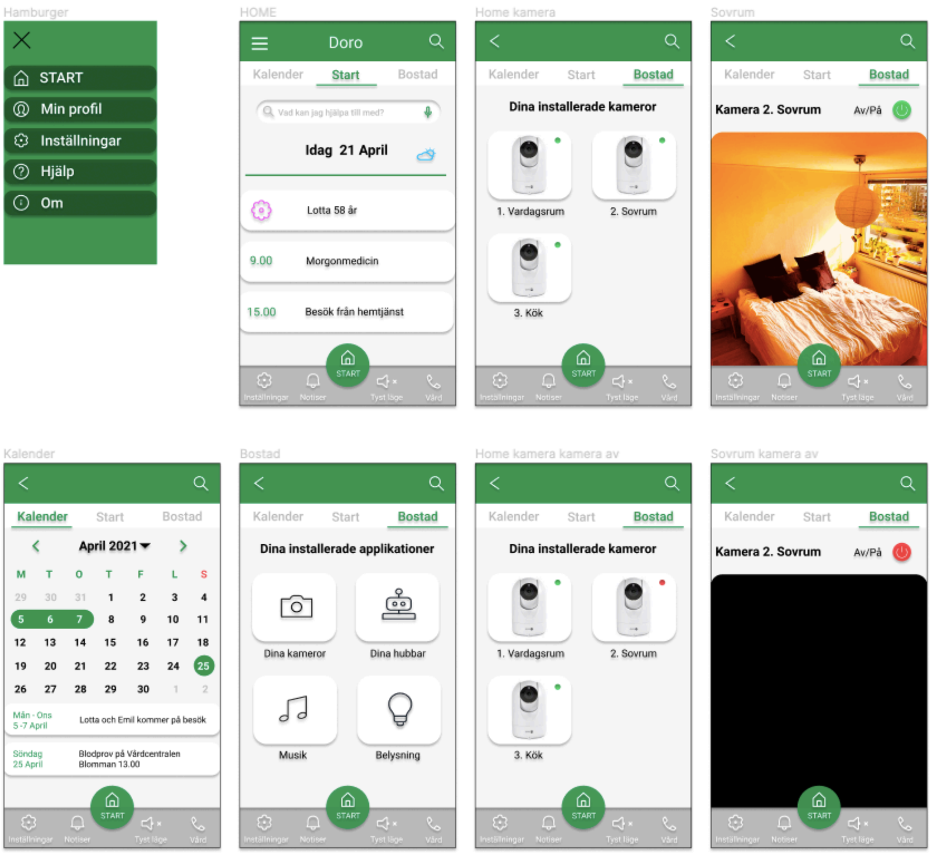
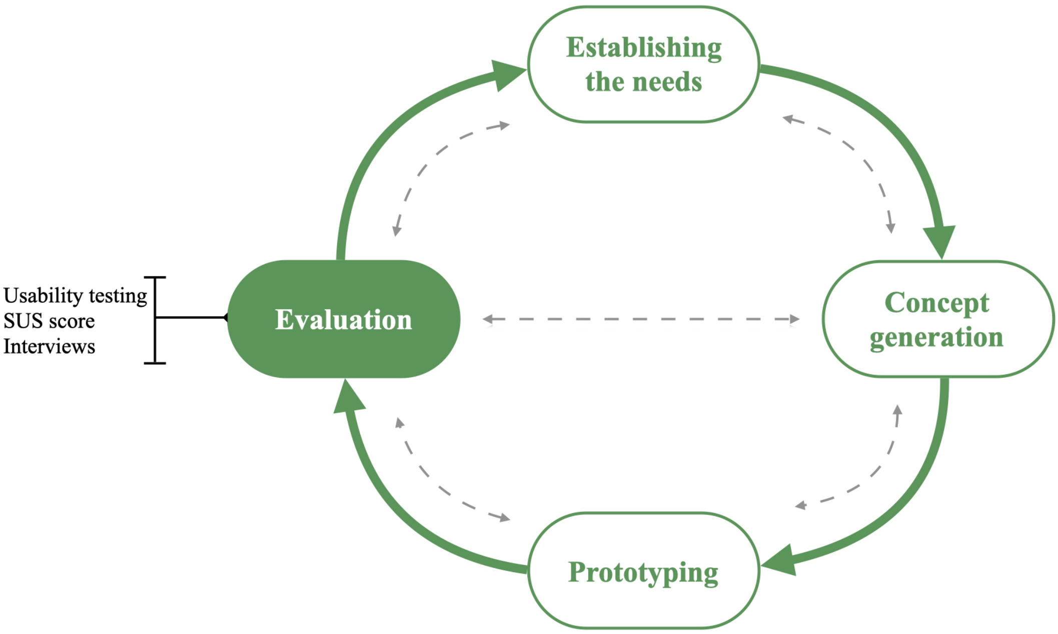


Figure 6.12: The third iteration and the final hi-fi prototype of the user interface.

Chapter 7

Evaluation of hi-fi

This chapter describes the last step of the design process, evaluating the hi-fi prototype described in the chapter before. The evaluation was done by 24 participants doing usability tests and participating in an interview. The methodology of this test is described in detail below and resulted in both quantitative and qualitative data.



7.1 Usability testing

7.1.1 Participants

The digital usability test was conducted with 24 participants who were recruited from the two designers' family and friends. Three of them had been involved from the start by taking part in the first interview, where the needs were identified (see chapter *4. Establishing the needs*). Five other participants were also involved in the lo-fi test (see section *6.1 Lo-fi prototypes*). The aim was to contact seniors and elders, but due to the pandemic and the time restraint, only nine persons over 55 were recruited, six of whom were seniors. The remaining 15 participants were under 30 years old.

The participants were divided into three equally sized groups A, B, and C, which can be seen in Table 7.1. Each group tested two different concepts out of the three final ones. Group A tested the concepts: *Hub with Screen* and *Hub with app*, group B tested *Hub with app* and *Wearable hub with app*. Lastly, group C tested *Hub with Screen* and *Wearable hub with app*. The participants were only allowed to choose between two concepts instead of all three concepts due to two main reasons: The foreseen long test duration of showing three concept alternatives for the five tasks. Moreover, due to the believed similarity between the concepts *Hub with app* and *Hub with screen*. There was a fear of the participants choosing the "hub"-concepts without specifically choosing between one of the two concepts, if presented with all three concepts.When allowing them to choose between only two concepts, they would be forced to make a specific choice. This methods was believed to give more accurate results. As described in section *2.5.4 Usability testing*, this method can be called A/B testing and is used when having to choose one solution among several alternatives. In this test, every concept was in total tested by 16 persons, therefore, fulfiling the recommendation for usability testing explained in the same chapter.

In each group, an equal gender distribution was achieved as well as the same number of old respective young adults in each group. In every group, three adults over 55 years old participated and five younger persons under 30. Table 7.1 shows the age and gender together with the gender of the participant.

Table 7.1: The participants in the test divided into the three different testing groups A, B and C. Group A tested *Hub with Screen* and *Hub with app*, group B *Hub with app* and *Wearable hub with app* and the last group C tested *Hub with Screen* and *Wearable hub with app*.

Group A		Group B		Group C	
Age	**Gender**	**Age**	**Gender**	**Age**	**Gender**
70	Female	77	Female	67	Female
65	Male	65	Male	70	Male
64	Female	56	Female	57	Male
26	Female	26	Female	26	Female
28	Male	28	Male	27	Male
25	Female	25	Female	25	Female
22	Male	26	Male	24	Male
26	Male	27	Male	26	Female

7.1.2 Setup

The preparations for the test consisted of first making a presentation introducing the thesis, its scope, and the test process. The presentations included a detailed description of the two home assistants the participants had to choose between, where the service, the 3D images and the UI were presented and explained.

Six different tasks were given to the participants, five of them shown as AR videos and one task to interact with the UI. Scenarios 1, 3 and 4 were classified as "daily life" tasks, and scenarios 2, 5 and 6 were classified as "out-of-the-ordinary" tasks. This classification was made as it was observed in the lo-fi test that the choice of concept depended on the context it was used. The six scenarios were:

– Scenario 1: Activate Doro and ask for the weather forecast.
– Scenario 2: You have fallen and are contacted by the home assistant.
– Scenario 3: Activate the mute function.
– Scenario 4: Add a reminder for a blood test tomorrow.
– Scenario 5: You can not get out of bed; ask the home assistant for help.
– Scenario 6: Use the UI to deactivate the camera in the bedroom.

The preparations consisted of recording 15 AR videos of the prototypes used in the five different scenarios. The designers took turns acting the different tasks and recording the video. An example of how the three different prototypes could look in AR videos is shown in Figure 7.1. The sound was added in the video clips afterwards, as the AR videos could not be recorded with sound. The computerised voice of the home assistant was created on the online platform TTSMP3 [38]. By computerising the voice function, the voice "prototype" was improved compared to the lo-fi test, making the scenarios more realistic. An example of how the dialogue between the user and the prototype unfolded in the video clip in scenario 4 is shown below.

– User: *Hi Doro, add a reminder for a blood test tomorrow at 12 pm.*
– Home Assistant: *A reminder for a blood test tomorrow at 12 pm has been added to your calendar. Is this correct?*
– User: *Yes!*

The responses from the home assistant were brought up after consideration and research on how voice assistants work. The guidelines for conversation design mentioned in section *2.4.2 Voice interaction* were kept in mind when creating the computerised voice responses. Every scenario had direct and clear answers, follow-up questions and feedback to make the user feel understood and safe. In the example above, the assistant is repeating the request following the design principle of *Feedback*. This ensures that the correct information has been collected and makes the user feel understood by the assistant. The question *"Is this correct?"* in the example goes along with the design principle *Constraints*. Asking this last question prevents mistakes by double-checking if the correct information has been recorded.

Three different presentations were created with the respective two concepts for group A, B and C. The correct videos for the scenarios were added in the respective presentation. The final presentation and scenarios for the concepts *Hub with Screen* and *Wearable hub with app* can be seen in the following link:
`https://drive.google.com/file/d/1YuVF4n4utcKoohQZ6ogUFOV-iBdIlYjI/view?usp=sharing.`

The participants were asked, after each scenario, which concept they would have preferred. After executing the six scenarios, a semistructured interview was held, allowing the participants to elaborate their answers and give the designers feedback regarding the service, the product design and the UI.

A pilot test was performed on a twenty-year-old woman before introducing the test to the 24 participants. The pilot tester gave feedback, and some minor rephrasing and clarification in the presentation were done. An image of the *Hub with app* in standby mode was added to the presentation to clarify the description of the concepts. This can be seen in image A in Figure 6.7.

7.1.3 Procedure

Different communication platforms were used, such as Google Meets, Zoom or Teams. As often as possible, both designers were present during the digital tests. However, some tests were performed individually by the designers if schedules collided. This is considered to be *Investigator triangulation*, a triangulation method described in section *2.5.3 Triangulation.*

Background information was presented to the participant before starting the test. The participants were informed about their anonymity and the management of the recovered data, informing them that the data would only be used for this thesis. They were informed about their ability to interrupt the test at any time. It was clarified that the test's purpose was to evaluate the products' usability and preferred interaction and not test the participants' performance.

Figure 7.1: AR images of the three different concepts located in a home. The *Wearable hub with app* is to the right, *Hub with app* in the bottom and *Hub with Screen* in the top left corner.

The designers followed a script while screen-sharing the presentation. The participants were encouraged to interrupt and ask at any time if there were any questions. The scenarios started after explaining the service and the two prototypes in detail. Two concept alternatives were shown for each scenario; what concept alternatives depended on the participant's group (A, B or C). After every scenario, the person had to choose which concept he or she preferred. If the participant was young, he or she was asked to reflect upon what his or her older relatives would have preferred.

In scenario 6, the UI was tested. A link was shared redirecting the participants to the UI prototype. They were asked to share their screen to observe their actions simultaneously as they were asked to think aloud (method described in section *2.5.4 Usability testing*). The noticed wrong turns, questions and feedback were noted to be analysed in the next step.

A semi-structured interview was held to finalise the test. Questions regarding possible improvements of the service, 3D prototypes and the UI were asked. The participants were asked to rate the privacy intrusion the service offered. Lastly, they were asked to motivate which concept they would prefer to purchase and if combining them could be an attractive solution. The test lasted between 30 minutes and one hour, depending on how many difficulties they had with the digital platform and the eagerness to contribute with feedback.

7.2 Results from the usability tests

7.2.1 Quantitative results

When analysing what concepts the participants preferred, a consistent result was observed. Out of the 24 votes, *Hub with screen* got 10, *Wearable hub with app* 8 and *Hub with app* 6 votes. This is reflected in Figure 7.2. Similar results were shown regarding what the young adults believed their older relatives preferred. The *Hub with screen* got 10, *Hub with app* 8 and *Wearable hub with app* 6. From these results, the concept *Hub with screen* can be called the winner by a small margin.

The result was considered inconclusive. Consequently, subgroups were investigated to explore if other conclusions could be drawn. The choice of concept between scenarios, age group and gender were investigated.

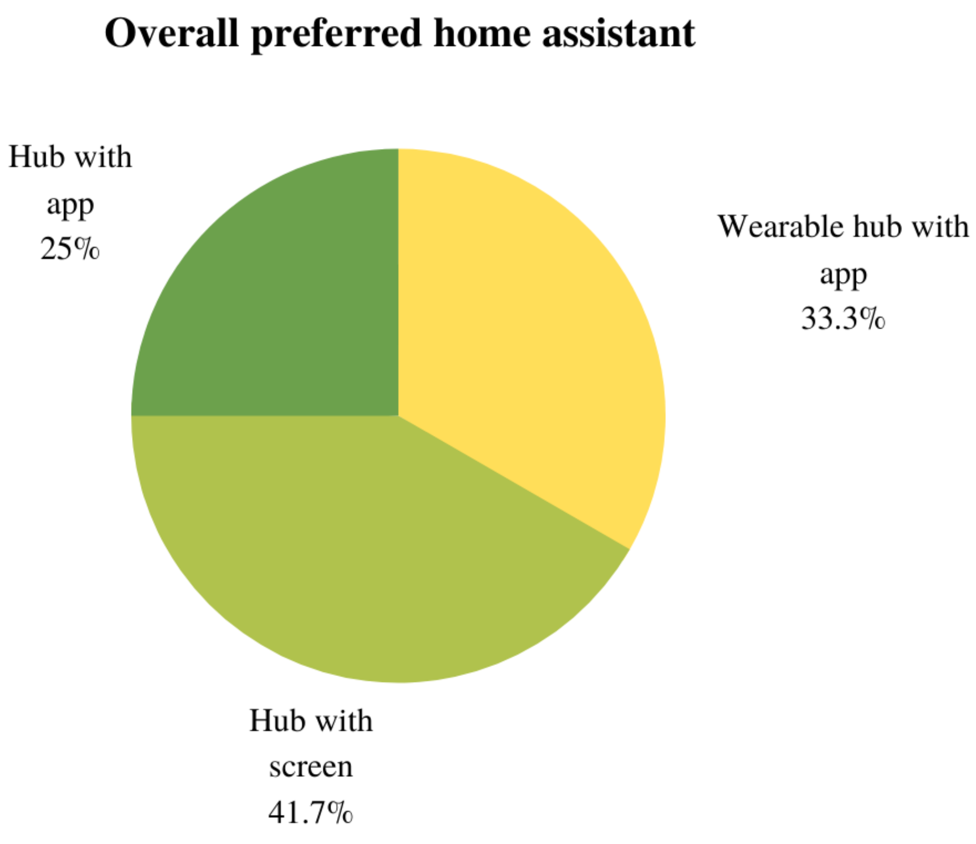


Figure 7.2: The concept *Hub with Screen* was the preferred home assistant with a small margin.

When comparing the choice of concept in each scenario, the result was similar to the general result. Only the first five scenarios were compared as the UI was tested in the sixth scenario. The *Hub with screen* was the most voted concept in three scenarios 1, 4, and 5, which can be seen in Figure 7.3. *Hub with app* won in Scenario 3 when the user activates the mute function. Only in one scenario did all concepts get the same number of votes, in scenario 2, where the user has fallen and calls for help. The *Wearable hub with app* did not get enough votes in any scenario to win. Accordingly, the *Hub with screen* won 60% of the scenarios even though it could still be considered even.

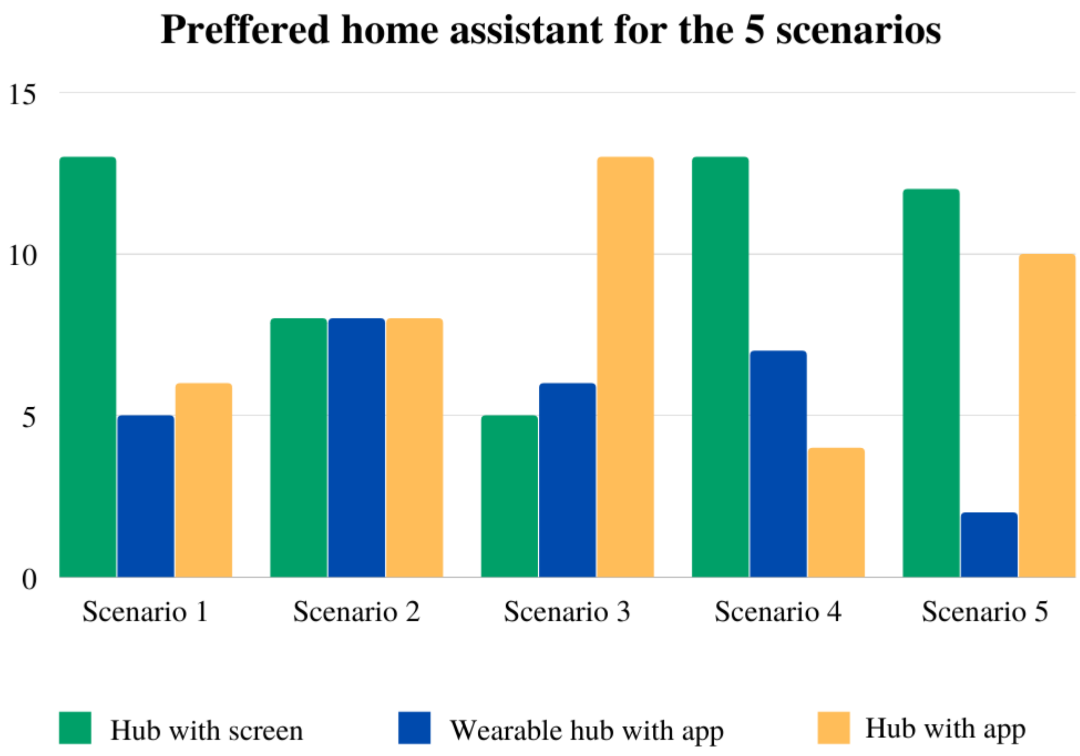


Figure 7.3: Preferred home assistant by the participants for the five scenarios. The number of votes is the unit of the y-axis.

Figure 7.4 shows how many women respectively men preferred each concept. According to these results, men preferred the *Wearable hub with app* and women the *Hub with screen*. The exact number of females and males chose the concept *Hub with app*. In Figure 7.4, it can once again be seen that the results are considerably even and regarded as inconclusive.

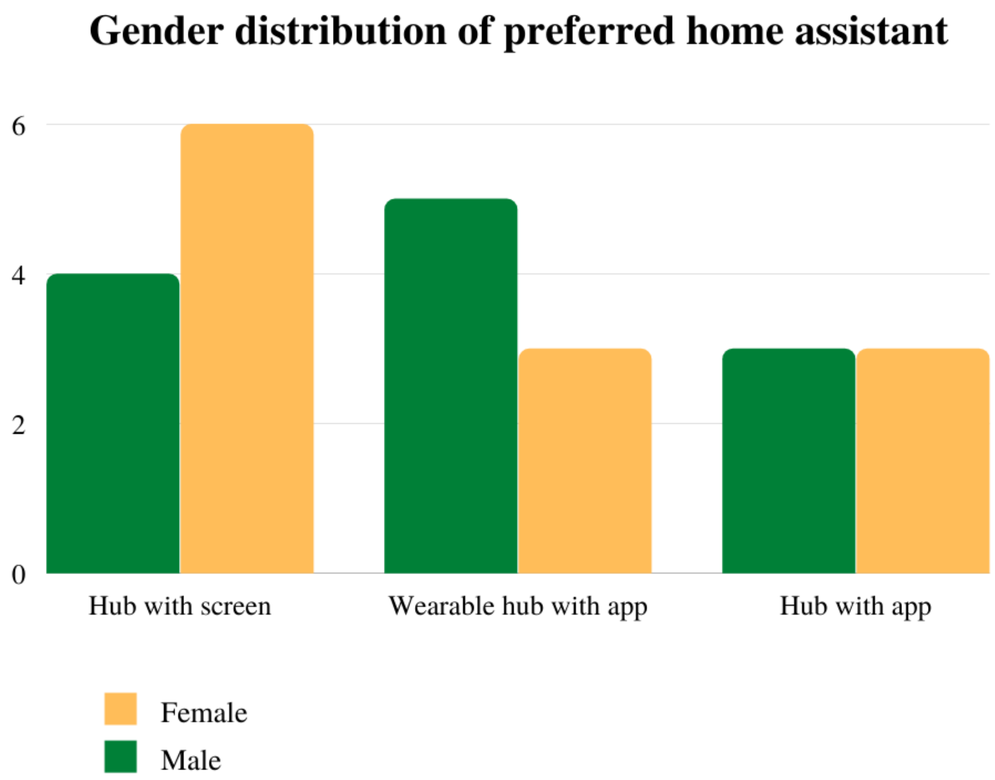


Figure 7.4: Gender distribution of preferred home assistant. The y-axis shows the number of votes.

The target group for the home assistant are seniors; that is why it was interesting to compare if the few older adults that participated in the usability test voted differently compared to the younger participants. Figure 7.5 shows, in the orange left diagram, the responses of the 15 participants under 30. The blue diagram to the right shows the results from the 9 participants over 55 years old. It can be seen that the older generation prefers the concept *Hub with screen* quite considerably as it got five votes compared to the other two concepts, which got two votes each. The younger group voted, on the other hand, relatively even. The *Wearable hub with app* won with just one vote over *Hub with screen*.

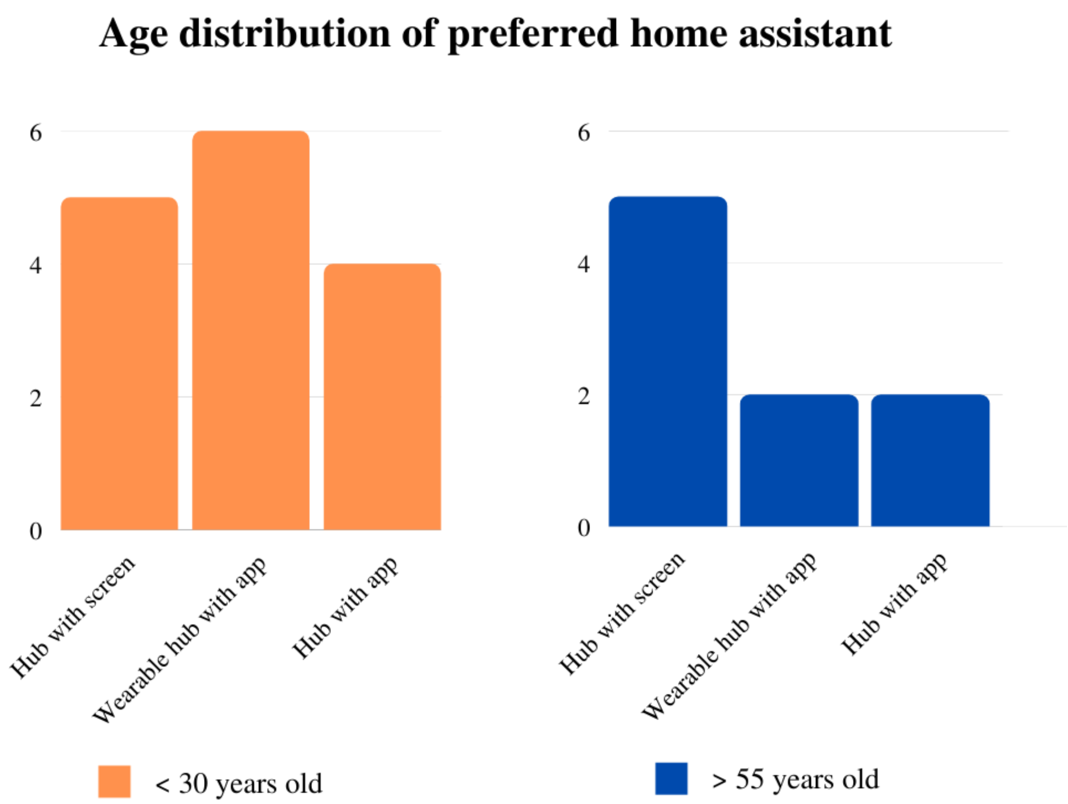


Figure 7.5: Age distribution of preferred home assistant with participants under 30 to the left and over 55 years old to the right. The number of votes is the unit of the y-axis.

As mentioned, the participants were asked if they would like to combine the products. Some considered this to be a great idea, and 15 out of 24 said that they could imagine themself doing that. The participants who did not want to combine the products believed that it would be too much technology to keep track of as well as expensive. The participants were also asked to rate, from 1 to 5, the privacy protection the service gives. One is that the user feels to have no control over his or her data. Five is the user being comfortable with the product´s management of personal data. The average score was 3.3. The participants who rated the privacy management with low numbers mainly distrusted having cameras at home. However, all agreed that when old and in need of help, the distrust would probably disappear. Many participants voted 4 and 5 as they did not see the product as a privacy intrusion as the user probably chose to install the home assistant.

In this study, quantitative results on solely the UI were not collected. It was deemed not to be relevant when investigating the preference of voice interaction. The UI is included in the concepts and, therefore, is a part of the quantitative result presented. To test the performance of the UI by, for example, counting the number of clicks needed to turn off the camera was not considered relevant. The aim was to test the complete concepts and not the design details in neither the 3D images nor the UI.

7.2.2 Qualitative results

The qualitative results were gathered from when the participants were thinking aloud and during the post-interviews. Four feedback capture grids were used to compile the large amount of data. One grid for each prototype (the three concepts and the UI) was created to arrange the respective feedback. The feedback was divided into *Likes*, *Dislikes*, *Questions*, and *Ideas*. The category *Likes* and *Dislikes* involved positive feedback, respectively, criticism. In the category *Question*, confusions and uncertainties were presented. Under the category, *Ideas*, possible improvements were listed. The complete feedback grids can be seen in Appendix C. A summary of these and the result of the hi-fi testing can be seen below.

Hub with Screen

During the usability test, mixed feelings were described regarding the screen. Some participants thought it was excellent with visual feedback, giving the sense of talking to a person rather than a device. Others expressed that the screen made the assistant too visible and inflexible as the user has to be close to the product to see the screen. One participant brought up the concern of big screens being out of style in perhaps 20 years, making the *Hub with app* more relevant in the future. Nevertheless, the concept received positive feedback, such as consisting of only one gadget and not being connected to a smartphone. Moreover, the learning curve was assumed to be small as seniors are getting used to interacting with touch screens. Combining this concept with the others was considered very beneficial though too many screens in a home may not be optimal for the homely feeling and the economic aspect

The participants gave several suggestions: Adding a camera on the front, making it possible to contact the home care by video call and enabling the removal of the screen from the hub using it as a regular tablet. However, the latest suggestion was believed to be a good idea if the user was in good health; otherwise, there could be a risk of forgetting to charge the tablet.

Hub with App

Many of the participants liked the minimalistic design of the concept *Hub with app*. It was considered to be a good size in case the user wants to move it. The application was also received well, especially contacting the home assistant from outside the home. Future seniors are used to smartphones and will probably expect a complementary app for the product. Both in this concept and with the *Hub with screen*, the participants liked the small risk of forgetting to charge it as it could always be plugged in. A dislike that those concepts had in common was the feeling of a need to scream if an accident happens far away, which was not perceived with the *Wearable hub with app*. However, it is believed that the lack of a screen is the reasons why participants felt the *Hub with app* to be an excellent device to have in the bathroom or on the nightstand.

Some questions were asked concerning the microphone range, the hub's material, and how bright the light signal is. Changing the colour of the red light to another colour was suggested as the colour red suggests that the product is running out of battery. Adding an analogue mute button and a direct button to the home care service was also suggested. In general, it was believed that the concept was perfect to be combined with both the other concepts due to its minimalist design.

Wearable hub with app

A general perception was that this device was the most healthcare-adapted due to its similarity with a safety alarm. The fact that the device was wearable gave the user a sense of security. A possible improvement was suggested to add pulse measurement, blood pressure, GPS, and a pedometer to adapt more health care. The only big concern asked was what would happen if the user fell on his or her arm. Would the microphone hear the user?

Some participants believed it unnatural to talk to the wrist, not a discrete product and a product that only patients would use. Concerns about the small display and buttons were expressed as hard to handle and put on when old. However, the main concern regarding this product was the risk of misplacing it or forgetting to charge it. The hygiene and water-resistance of the product were questioned, and offering different bracelet colours was suggested to make it a fashionable product.

User interface

The UI design was perceived as simple and user-friendly. The ability to control the hubs and cameras from the UI was received well, as one felt control over one's data. One concern was the number of steps to reach the control of the cameras, suggesting that the activations and deactivations of the cameras could be done from the homepage.

Some participants believed the tab “Bostad/Residence” to be unclear and did not understand that the cameras could be found there. Many participants believed that the control of the camera was found under “Inställningar/Settings”. However, the settings function was aimed at the settings of the application and not the home assistant.

The fact that one could see the daily activities on the home page was well-liked. However, it was suggested that the “Care” button be more visible, making it stand out from the rest of the buttons. It was also pointed out that a checklist could be added to the same page helping persons with dementia to go through their day. A video-call function was as well suggested so that care providers and relatives could easily be contacted.

In general, all concepts were received well. Some recurring questions and doubts were mainly about the service itself. Participants wondered who would have access to the cameras and access the application. Some wanted the assistant to use voice recognition to protect the users' privacy even more as it only would respond to the user's voice.

Participants asked if they could change devices as their needs would change when getting older. For example, starting with the *Hub with app* and when getting older change to *Wearable hub with app*. As mentioned, the possibility to combine the concepts was also considered a great idea. In general, the participants showed great curiosity and optimism towards the product. Some of the quotes during the test can be seen in Figure 7.6.

"Very exciting for me as a nurse."

"What a super product, I want it NOW!"

"Seems fantastic, when can I get mine?"

"I am impressed, solid work!"

"I would prefer this device before a human in my home"

Figure 7.6: Quotes said during the usability test from optimistic participants.

Chapter 8
Discussion

This chapter discusses different stages of the reports, such as the design process, the results, limitations, future work, and reflection on what has been done.

8.1 Design process

8.1.1 Establishing the needs

Two data gathering methods, interviews and questionnaires, were used to triangulate the user's needs. One could argue that one more data gathering method could have been used to get more accurate data, such as observations. Observations is a technique used in the early stages of design developments that helps the observer understand the user's needs, goals, and actions [29]. Today's elders living alone were interviewed; two out of six used digital elderly care. It is suspected that the interviewees were not entirely honest when asked if they had difficulties at home as it can be a sensitive subject. Therefore, observations as another data gathering method could have contributed with important information but were not done due to the pandemic.

The survey aimed to understand the view on the technology of the future seniors and their relatives. The questionnaire was randomly distributed. However, an alternative could have been to gather more controlled answers by sending it to today's secondary users (close relatives to the elders). Even though a young demographic was the predominant group of respondents, they are believed to have enough knowledge of their elder's situations to give an accurate response. Given the current circumstances and the large number of answers gathered in one week, a questionnaire is assumed to be a suitable data gathering method for this study. It would have been desirable to contact more home care receivers and providers to understand the target user better. However, several analysing methods were used, which clarified the users' needs and resulted in well-established goals and functions.

8.1.2 Concept generation

During the concept generation, the two designers came up with concepts separately before discussing and refining them to six concepts. One could wonder if the concepts would have turned out differently if a brainstorming session would have been performed or if the care provides' perspective would have been considered. Furthermore, several persons could have been involved in the brainstorming session to generate additional ideas.

The concepts were brought up with the personas in mind. If other personas had been generated, it could have resulted in different concepts. The four personas had different difficulties and therefore considered to cover most possible users and design possibilities. In retrospect, the conceptual models could be improved and clarified with more possible metaphors and functions that could later be used in the prototype generation.

Storyboards can be seen as lo-fi prototypes [29]. The generated storyboards and conceptual models could have been presented and tested similar to the hi-fi by potential users. Instead, two coordinate systems were used (see Figure 5.8 and Figure 5.7) as this gave the authors a better structure. Changing the evaluations method could affect which concepts to exclude, leading to the questions, were the right concepts eliminated?

8.1.3 Prototyping

Throughout the entire prototype stage, a recurring thought has been the difficulty of prototyping several concepts compared to only prototyping one product based on one concept. This was not the idea at the beginning of the thesis, as it was then believed that only one concept would be overwhelmingly preferred over the rest of the concepts. Even though the camera function was dismissed early on in the process, three different things were still prototyped: the voice assistant, 3D pictures, and a UI. This led to time-consuming prototype generations as well as long-lasting tests.

The lo-fi prototypes were built as tangible prototypes as the main question was: what does the user prefer talking to? This resulted in one of the four concepts being discarded after the lo-fi test, but one cannot dismiss the fact that the tests were performed on a young population. Leading to the question, would the results have looked different if the participants were older? As the target group could not participate in the lo-fi test, the young participants' answers could not be used as the only source of information before making a decision. That is the reason why a SUS survey was used as a complement to the qualitative data.

Nevertheless, the SUS could not be trusted fully either due to the low number of participants. These two evaluation methods were not 100% reliable for this test. Due to this reason, the designers decided only to dismiss one concept, all-in-one, since it was expressed to be most unnatural to interact with. It was decided to keep the remaining concepts in the design process as the quantitative data, and the SUS scores could not be resolved to one clear answer.

During the hi-fi generation, all design iterations were done based on either the designers' feedback or the experts' opinion. One could argue why no users were questioned during these iterations. Although this perhaps would have given other sorts of feedback, it was not done due to time restraints and because the designers did not want to "waste" the few senior participants. The focus was on recruiting as many seniors as possible in the evaluation process, which meant only relying on the experts' opinion during the 3D images and UI iterations.

As shown in section *6.2 Hi-fi prototypes*, the testing method was discussed and iterated several times. The advantage regarding a digital test is the lower risk of COVID-19 exposure both to the designers and the participants. Another advantage was the time efficiency; thus, 24 persons participated in the hi-fi test in just one week. The apparent disadvantage of digital tests was that the participants were not able to interact with the prototypes.

As the participants were never able to test the devices, they could not answer a SUS survey. A SUS survey evaluates the product's usability by rating its effectiveness, efficiency, and satisfaction. However, these terms cannot be evaluated if the user is not interacting with the device. Regarding the number of participants, the SUS survey would be more relevant in this test than the lo-fi test. These two arguments were the most substantial cases against doing a digital test.

Without a pandemic, the test method would be guided by the hi-fi prototype. Interestingly enough, this was not the case. The narrow testing possibilities decided the construction and appearance of the prototypes. In retrospect, a test where the participants could physically interact with the product and where the designers could observe from a distance (either physical or digital distance) would have been the ideal option.

8.2 Evaluation

Usability tests were conducted to evaluate the prototypes. However, the tests had to be performed digitally, which may have given other results than if the test had been performed physically. However, digital testing made it possible for older adults to participate. The test was therefore constructed so it could be performed with as little technical knowledge as possible. This is why the A/B testing was conducted and the presentation with prerecorded scenarios. It would have been desirable to contact more persons over 55 years old as they are considered primary and secondary users today.

Nevertheless, looking at Figure 7.5, the Hub with screen was the most popular concept of the participants over 55 years old. The same result was obtained in the overall preferred home assistant in Figure 7.2. Therefore, it can be concluded that it was not necessary to spend time finding more senior participants.

As mentioned in section *7.1.1 Participants*, interviewees from chapter *4.2.1 Interview* and participants from the lo-fi test participated in the hi-fi test. As they have been part of this study twice, there is a possibility of them being biased during the last test. This would be the case if they had any favourite concepts. Hopefully, they entered the second test with an open mind. The prototypes and the test procedure had changed remarkably compared to the last time both groups participated in the study.

To divide the participants into three groups proved to be a good decision. As mentioned, the duration of the test was between 30 minutes and one hour. Implying that if all three concepts had been shown in one test, its durations would have been longer, and the participant would probably have lost focus. The same duration problem is observed if more scenarios would have been shown. An interesting scenario to test is the interaction between the user and the assistant in a bathroom. In that way, testing a sensible scenario.

The observant might have noticed that the final prototypes of the two hubs in Figure 6.4 and 6.7 are white, but in the AR images in Figure 7.1, they are grey. This colour change happened when transforming the 3D images to AR simulation. This can be seen as a source of error as the participants only saw the grey versions and not the pretended designs. However, the prototypes receive many compliments, and the source of error has not affected the prototypes or the testing procedure in any problematic way.

8.2.1 Usability test results

Quantitative results

According to the evaluation result, most participants wanted to interact with the concept *Hub with screen.* Still, this concept won with a small margin, and the result was considered inconclusive. The even distribution of preference is an interesting result and was not expected. The designers believed one of the concepts would be overrepresented and the others could be delimited, but that was not the case. This must be due to the heterogeneous group tested and underlined the problem of a board target group. Every person is unique, making it challenging to design a product that fits all primary users.

The main issue brought from the lo-fi testing to the hi-fi testing was whether the user prefers different concepts depending on the scenario's level of urgency. When looking at the most critical scenario, number 2 (the user has fallen and needs help), the result was entirely even, as shown in Figure 7.3. This was not expected as the smartwatch was the clear favourite in the same scenario at the lo-fi test. These inconclusive answers show that the questions regarding the scenario's level of urgency could not be answered. Scenario 5 (cannot get out of bed) is also considered a scenario with a higher level of urgency. However, no connection could be seen between the results between scenario 2 and 5. *Hub with Screen* got a few more votes in scenario 6, indicating that it could be the preferred concept in that situation. Regardless of the high level of urgency of scenario 6, few participants liked the idea of wearing the *Wearable hub with app* when sleeping.

In the remaining scenarios, considered daily tasks, a connection could be seen between scenario 1 and 4, shown in Figure 7.3. In these tasks, the user asked about the weather and added a reminder to the calendar respectively. The visual feedback received from the screen is believed to be why *Hub with screen* was overrepresented in both scenarios.

In scenario 3 (muting the device), *Hub with app* was the clear favourite. The reason being its discreetness and appreciated light signal. The *Wearable hub with app* was believed not to give enough feedback, and *Hub with screen* was believed to be too visible with a mute symbol on the screen.

Overall, no conclusion could be drawn depending on the level of urgency of the scenario more than that one of the hubs may be to prefer. In scenarios when visual feedback is beneficial, as seeing the weather forecast, a screen on the hub is favourable. The screen was also said to make the hub feel more like a buddy and not a device; this is favourable when thinking of the loneliness perspective. Leading to the questions, is the screen on the device making the product more welcoming and user friendly?

Why men preferred the *Wearable hub with app* more than female is an intriguing finding, this could be further explored but is considered difficult to draw any conclusion about. When looking at the age distribution in Figure 7.4, it can be seen that older generations prefer *Hub with screen*, seeing as they are familiar with screens and is believed to have a short learning curve. The younger group of participants had more scattered preferences. This could be because of their open mind towards new technology. For example, a *Wearable hub with app*, similar to a smartwatch, is a relatively new invention and could feel strange for elders but exciting for a younger generation. Nevertheless, voice interaction is still not an established technology; it is unfamiliar among the younger participants as well. Still, the threshold of using it will probably be higher for the older generation, and therefore a familiar product is to be recommended if elders want to use the product.

The 15 participants who wanted to combine the concepts were excited over the idea; some suggested it themself. Though the participants only got to see two of the three concepts, it is hard to conclude what combination would be best. Some wanted one *Hub with screen* and several small hubs to cover all the home but reduce the number of screens. A wish to contact the assistant from the garden was expressed, insinuating that the *Wearable hub with app* could be combined with one of the other two concepts.

The participants who were reluctant to combine were either persons who did not want to have a wearable device or felt that there were too many gadgets to keep track of. The economic aspect was also brought up, meaning that too many gadgets could be expensive for the home care system. Nevertheless, the designers believe that combining the concepts is a good idea based on the even results shown in Figure 7.2. Another solution could be to let the user choose between the three formats of the assistant. This would of course mean a lot of work market-, developing- and manufacturing-wise.

Lastly, the average privacy protection was rated 3.3 out of 5, mainly due to the cameras function and not as much due to the voice function, indicating a potential for accepting voice interaction in healthcare. This would be promising for the study mentioned in section *1.5 Related works* where they explore the capability to diagnose diseases by analysing the patients' voice. In the future, combining this technology with the camera-voice assistant would be ideal.

It is worth exploring all alternatives that would make the installations of the product more acceptable. It would be interesting to investigate further how privacy is affected by cameras. Potential research could be to see if other sensors, apart from cameras, could be a better option to ensure the user's privacy. Ideas on sensors are: motions sensors or radars studied a bit in the thesis *Technology based solutions as enablers for active and assisted living (AAL)*, mentioned in section *1.5 Related works*. It would also be interesting to look at the data management and security of this service as some participants expressed concern about being hacked. In conclusion, the quantitative results indicate that the preferred concept depends on age, gender, and task type and is why the results are so even.

Qualitative results

The qualitative feedback from the interviews came with the same spread as the quantitative result. What one person liked another person dislikes, which once again relates to the heterogeneous target group. The target user's need also changes over time due to the generation gap. Therefore, it is hard to be sure of what will work in ten to twenty years when this product is established on the market. *Hub with screen* was in the present-day the favourite but would another concept be preferred in ten years?

The participants expressed that the choice of assistant would depend on their health status. If they are ill, they would want one and if they are lively elders, the other. Sometimes, an explanation of why they choose one alternative over the other could not be given, as the participants sometimes followed their gut feeling. This shows that the preference can depend on just the overall attitude, experience and perception.

Hub with screen was believed to be easiest to learn and easy to remember how to use, which is two of the six usability goals described in section *2.5.1 Interaction design*. The *Wearable hub with app* was described to be the one concept that felt the least safe to use. Many concerns regarding the tiny buttons and accidentally pressing on buttons or the mute button were expressed. This does not go along with the usability goals of Safe to use and is why the designer would take that feedback into account and redesign the *Wearable hub with app*. Otherwise, the device was believed to have good utility and being effective and efficient to use, according to the participants. This was mainly because of the voice interaction, which was believed to be very straightforward.

Several redesigning ideas were gathered and are shown in the feedback grids in Appendix C under the label *Ideas*; these would have been implemented if it were not for the time constraint. Changes such as changing the red light to orange on the *Hub with app*, adding an analogue mute button on the two hubs, or minor changes on the UI. However, it is essential to point out that this thesis aims not to design the best possible home assistant but to investigate how the best interaction looks. Nevertheless, more time could have been spent on design choices and would be interesting to continue exploring.

The ethical aspect of a home assistant like this can also be discussed. Though this service is aimed at persons who see the need for it, they have to choose to implement it in their home. If they, themselves, choose to install it: there should not be any primer ethical issue. However, there are questions to be asked if a secondary user arranges the installations of such a service: Is it ethically correct to install this in someone else's home? Moreover, is it ethically correct to install this without the user's knowledge, for example, if the user has dementia?

In conclusion, the qualitative result indicates that the users' preferred assistant depends on: their health status, experience, and attitude towards technology. As mentioned, combining or choosing between the concepts could be a solution that should be further explored to ensure that all possible target users could be satisfied and met with their needs.

8.3 Limitations

The COVID-19 pandemic is the biggest and most recurring obstacle that has been encountered during the entire process. It prevented the encounter with the target demographic and determined the way to test the prototypes. At the beginning of the thesis, there was the hope of the Swedish senior citizens being vaccinated. More seniors could have been recruited during the need-finding and prototype testing stages. As this thesis mainly focuses on the interaction between a user and a camera-voice assistant, an optimal way of testing this interaction would have been in real life. The pandemic played a significant factor at this stage as well. Even though it is believed that a suitable testing method was obtained given the circumstances, more accurate results are believed to have been obtained if the test was tested on today's seniors in person.

Another limitation that was found early on was the heterogeneity of the target group. It was impossible to satisfy all the users' needs; thus, these are contradictory to each other and constantly changing regarding their technological demands. The unique needs of elders depend on their age, background, digital knowledge, and difficulties or diseases. Therefore, the needs of specific groups had sometimes to be dismissed during the decision making.

8.4 Future work

The next step would be to apply the suggestions gathered during the hi-fi test and make the changes to create final prototypes. Additional tests should be performed, and if possible, in real life with the future target group. It would be interesting to further elaborate on the UI by adding more features. An investigation on how the devices could be combined and how this combination should look like is a future step, offering the users different interaction alternatives. A more technical prototype would not only enable the participants to interact with a tangible prototype. However, it would also investigate the technical and economic viability of the service, exploring if the prototypes are technologically possible and/or profitable.

A more in-depth study should be done regarding the image sensor (cameras). Answering questions regarding the design, the sensor range, the type of image sensor, its placement in the home, etc. As privacy has been a big part of this thesis, it should also be considered to opt for other sensors, such as motions, smoke, or radars, to either be combined or substitute the cameras.

Lastly, it would be interesting to involve healthcare providers in the design process to make sure that the device can help them. Studying if and how the service could minimise the professionals' workload and making sure that specific functions are added in the service to enable its implementation in elderly care.

Chapter 9
Conclusion

In the final chapter of this thesis, the conclusions drawn and generated during the project are described. They are presented as answers to the research questions mentioned in the section 1.3 Scope.

Which are the requirements a camera-voice assistant should cover according to today's and tomorrow's seniors?
Many requirements were found. Such as the need for privacy protection as well as having easy access to help. From a design perspective, the device should be discrete and have some sort of screen, giving the service a short learning curve as it should be user friendly and intuitive to use. However, it is important to point out that the requirement will differ depending on the user's difficulties, technological knowledge and background.

What characterises a good and safe interaction with a home assistant consisting of camera and voice interaction? Does the preference of interaction depend on the context the service is being used in?
Users want to talk to a real person rather than interacting with AI in an emergency. What characterises a good voice interaction is a standard response time as well as good speech recognition. The voice assistant should recognise a user's voice without him or her needing to scream or standing precisely next to the product.

The design of such a service should resemble products already on the market. The data gathered in this thesis shows that a big screen is an attractive concept for today's seniors. However, it is unclear what kind of interaction is wished for in an emergency or accident and would be exciting to study further.

How to make a user trust the technology in their home without invading their privacy?
There is a balance between creating a discrete device that does not draw too much attention and giving enough feedback such as light signals to signal its activation mode. The user needs to feel that he or she has control over the situation and the information that is being generated. The main function invading the user's privacy is considered to be the camera. However,

this invasion is minimised by letting the user have control over the camera and letting them, for example, control its activation through an application.

How can this service help a range of target groups, such as people suffering from cognitive disorders, loneliness, or motor skills difficulties?
The device should facilitate connection with health care services in case of emergency. It should also be used as a companion to help against the user's loneliness. People with motor skills difficulties can advantageously use this as they only have to use their voice. The same goes for people with cognitive disorders such as dementia, where this assistant can make sure that the user does not forget their daily tasks. The service has the potential to not only help the target group but other users such as care providers.

In conclusion, this study can be seen as a foundation for future work, welcoming further investigations regarding the health care perspective, the voice interaction, and the camera function. Visual feedback has shown to be very important. It shows that even though the voice function is the primary source of interaction, users are today used to screens and therefore require visual feedback. The study shows that a camera voice assistant has potential in the market and could be a great asset in users' homes and possibly health care.

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Appendices

Appendix A
Establishing the needs questions

Below the questions asked to establish the users' needs can bee seen. Both the questions from the semi-structured interview and the questionnaire.

Interview questions:
1. What does your living situation look like today?
2. Do you live alone or with others?
3. On a scale of 1-4, how open minded are you to try new technology?
4. How do you view the increasing supervision of technology in society? Is your privacy affected? (mobile cameras, internet, etc.)
5. What kind of digital technology do you have at home? (computer, smartphone etc)
6. Do you know what a voice assistant is?
7. Do you know what a social camera is?
8. Do you have any difficulties remembering things when you are at home?
9. Would you like a camera and voice assistant to help you with the difficulties you mentioned before?
10. Could you imagine having such a service at home to make you, your children or other relatives feel safer? Why / Why not?
11. Suppose you have a camera voice assistant at home, how often can the product be activated without you feeling that it would affect your privacy?
    a. Would you want to see the camera?
    b. Would you rather have a human being behind the camera or machine learning (computer)?
12. Do you want to be able to talk to the service or that it only talks to you / you only with it?
    a. How important is the mother tongue? Scale 1-6
    b. Do you have gender preferences regarding help?
13. How can the information generated by the assistant be handled to gain your trust?
    a. Contact the alarm center if something happens

b. Contact relatives if something happens
c. Contact both alarm center and relatives
d. No information should be stored
e. The information is only stored locally in the product
14. What would you have preferred the product to look like?
15. Other general thoughts?

Questionnaire questions:
1. Age?
2. Gender?
3. What does your living situation look like today? How many people do you live with?
4. What kind of digital technology do you have at home?
5. Do you use any voice assistants?
6. If you answered Yes to question 5, what do you use it for?
6. If you answered No to question 5, why not?
7. On a scale of 1-4, how open minded are you to try new technology?
8. On a scale of 1-4, how much do you feel your privacy is affected by today's technology at home and in society?
9. In what way do you feel your privacy being affected?
10. Suppose you have a camera-voice assistant at home, how often can the product be activated without you feeling that it would affect your privacy?
11. Would you like to be able to communicate with the assistant like Siri, Google Home and Alexa services?
12. How can the information generated by the assistant be handled to gain your trust?
13. In your opinion, what qualities should a camera-voice assistant have?
14. Other general thoughts?

Appendix B
Lo-fi usability test questions

Interview questions asked in the post-interview in the usability test of the lo-fi prototypes ca be seen below.

Interview questions:
1. Which home assistant was easiest to move with?
2. Which concept was most natural to interact with?
3. What concept did you prefer to interact with when you "fell"?
4. Was there any task that was uncomfortable to perform with the voice function?
5. Which home assistant would you want your parents/grandparents to use?
6. Which concept would you like to use when you get older?
7. In an ideal world, what would be a perfect camera-voice assistant for you?
8. Do you have an idea on how the home assistant could look?
9. Other comments/thoughts?

Appendix C
Feedback grids from evaluation

Below the four feedback capture grids from the usability testing of the hi-fi prototypes can be seen.

Feedback grid of Hub with screen

Likes	Dislikes
• Naturally to talk to something stationary, knows where to look at. • Product design. • Short learning curve. • Visual feedback, gives a sense of security. • Easy access to a calendar, resembling a paper calendar. • Good solution if you are not used to smartphones. • Can be used as an alarm clock. • No risk of forgetting to charge it. • The screen automatically shows what has been talked about. • Advantage when the users suffer declining motor and visual skills. • Good speaker function. • Has potential to be combined with other concepts. • Feels like a home assistant rather than an accessory. • Only one gadget to have in mind.	• The weather forecast shown was too small. • The user may get into a strange position when trying to force visual contact with the screen. • The mute symbol on the screen is not discrete. • The product is tied to the home. Cannot be used outside. • Unable to separate the screen from the base. • The user needs to scream if an accident occurs far away from the hub. • Not optimal if the user lives in a house: too big of an area to cover. • Expensive if many hubs are needed in the home. • Difficult to hide the product when inviting guests. • Dislikes the touchscreen. • For seniors in 20 years, the screen may not be topical. • The low level of discreteness of the product. • Having to go to the screen if something has to be checked.

Questions	Ideas
• Does the screen have to be touched to be activated? • Is the screen attached to the rest of the product? • Is it possible to zoom-in on the screen? • Can the user call home care services if feeling lonely? • Is it possible to change products? Use one alternative first and later change to another? • If I changed products would my personal information automatically get transferred or would I have to do it manually? • Can my children look at what my infrared cameras is detecting? • Can anybody interact with my home assistant?	• Add an analogue mute button on the product. • Turn off the screen when the mute function is activated. • Add a video call function to the screen. • Add a camera on the screen with a cover to avoid feeling observed. • Add more support behind the screen. • Add adhesive material under the product to avoid overturning the hub. • Make it possible to separate the screen from the rest of the product. • Add an "alarm button" to directly contact home care professionals. • Changing the touch screen to a display. • No need for a password to use the service.

Feedback grid of Hub with app

Likes	Dislikes
• Small, light, and discrete with a minimalistic style. • Small risk of misplacement or forgetting to charge it. • Short learning curve. • Similarities with common technology e.g. an alarm clock or speaker. • Not having a mute button that can accidentally be pressed. • A good gadget to have in the bathroom and at the night stand. • Discrete mute light. • Easy to move. • Ability to bring the home assistant outside of the home (on the phone). • Not being forced to interact with a screen if it is not wished. • Good to control the hub from a distance with the complimentary app.	• Feeling a need to scream if an accident happens far away from the hub and phone. • The insecurity of not wearing the hub when an accident occurs. • Not enough visual feedback could be difficult to use by persons with hearing difficulties.

Questions	Ideas
• Will the microphone hear me wherever I am in the room? • What material is the hub made of? • How bright is the light? Is there a possibility of dimming the light? • Do I always have to use voice interaction? • Does the hub identify my voice? • Is the hub shock resistant? • Will the relatives have access to the app? • Can I call home care services from the app? • What will happen if the user has a stroke and cannot talk?	• Ability to combine it with the other concepts. • Change the red light to orange. The red light gives the idea of the device running out of battery. • Make the hub identify the user's voice to secure the user's privacy. • Add a mute button and a button to directly call home care services. • Add symbols on the buttons to make it more intuitive.

Feedback grid of Wearable hub with app

Likes	Dislikes
• Similarities to a watch. • Close to the sound source. • Feeling of safety wearing the device. • Ability to wear it outside the home. • Complementary app in the smartphone. • Similarities to a safety alarm. • Good device for users with hearing difficulties. • Feels most healthcare-adapted. • No need to scream when interacting with the product. • Feels natural to talk to one's wrist.	• Difficulties to be heard if the user falls on the arm. • Gives the user a feeling of being a patient. • Risk of forgetting to charge or misplacing it. • Feeling of privacy intrusion as continuously wearing the device. • Talking to one's wrist. • Lack of discreteness as the user has to continuously wear the device. • The small buttons and small display could be problematic for older user. • Having to sleep with the product to maximize the security. • The risk of accidentally activating the mute button.

Questions	Ideas
• Is the Wearable hub with app waterproof? • How hygienic is it? • Will it get warm under the bracelet? • What if you have a favorite watch you always wear? • Do you have two then? • Can the home care assistant help me charge it? • What happens if I suffer from an accident when it is loading in another room? • Could this be combined with similar products such as Apple Watch? • What happens if I fall on my arm with the Wearable hub with app under me? • How difficult is it to put it on?	• Combine this to the other concepts. • Make it possible to measure pulse, sleep habits, blood pressure and so on. • Make the display round, making it more similar to an analog watch. • Add a direct button to the larm central. • Make it more fashionable by offering different colours of the product. • Add symbols on the buttons to make it more intuitive. • Make the display and buttons bigger. • Make the mute button a press button instead of a regulate button. • Add a pedometer, a GPS and make it possible to detect falls outside. • Have an elastic band as a bracelet. • Making a mute button appear on the display.

Feedback grid of User interface

Likes	**Dislikes**
• The green colour. • The start screen with information about today's events. • The search field and the ability to use voice to search. • The simple and user-friendly design. • The calendar function. • Ability to control the cameras and see what they see. • The icons and big letters. • Have one place to control and collect everything you need. • The mute button. • Ability to check if what was said through voice was correctly understood. • Similarities to other interfaces from other apps.	• Feels irrelevant to have music and lightning in a health application. • Several menus. • Adding another password for the user to remember. • The tab "Bostad/Residence" feels diffuse. • Too many steps to turn off the cameras. • That the green start button is always green. • Having 2 start buttons when opening the hamburger menu. • The flower symbol that signifies someone's birthday. • The help button is not sufficiently visible.

Questions	Ideas
• Why are there two search buttons on the start page? • What happens if the user does not have a smartphone? • Is it possible to manually add an event/reminder to the calendar? • Why is it necessary for many clicks to reach the cameras if that is the main function? • Why is there a mute button on the start page but no button to turn off the cameras? • Can the user's relatives see this information and download the app? • Is it possible to press the weather symbol? • Is it possible to chat with the home care assistants via the app? • Is it possible to reschedule appointments? • Is the care button a speed-dials to the user's home care assistant or to a larm central?	• Add a function to start the TV. • Making the app as an optional add-on. • Replacing the camera settings under the title "Inställningar/Settings". • Adding a checklist with everyday tasks for people with dementia. • Possibility to call video-calls with family and friends. • Possibility to turn off the cameras with voice. • Possibility to easily change the volume on the hub. • Add cameras under the hamburger menu. • Ability to see the charging status on your hubs. • Change the name of "Start" to "Today". • Write "today's agenda" on the home page. • Show the degrees outside beside the weather symbol. • Make the "Care" button more visible.