FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

Analysis, design, and evaluation of a contextual information system for older adults

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Mestrado Integrado em Engenharia Informática e Computação

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Abstract

Nowadays, population is consuming more technology than ever before. The internet has revolutionized our ability to create, store and recover information in a moment. It has become an essential part of our society.

On an average day, a person is in contact with thousands of information items from various sources. There is more information available than we can comfortably process and because this information is so varied, it brings many issues such as how to represent it in a more useful manner so the user can use it efficiently. Also, such vast quantities of information lead to a large number of choices and possible confusion which can result in decision paralysis. With this project, we aim to study an application developed at Fraunhofer Portugal AICOS, the SmartCompanion, and show how we can create meaningful information for the user and how best to present it. A constant challenge for this project is also to discover something we did not know about the users before, and how technology fits into their lives.

Smart Companion (SC) is an Android launcher that was created to address senior's goals and needs. It aims to be a permanently available companion, bringing seniors closer to their caregivers at all times by being remotely connected (in and outdoors), allowing caregivers to be aware and prevent risky situations (such as the risk of isolation, fall risk calculation, activity monitoring and fall detection) and consequently improving seniors' self-confidence and sense of protection. This Android launcher collects different data on the usage that the elderly make of smartphones, such as communications, locations, and activity, among others. This information is spread over several applications and is made available to the user without any cross-linking of data from different sources. So the goal of this project is to understand how we can process this information so that it has the maximum meaning to the user.

To achieve these goals, a User-Centered Design methodology was followed, to focus on older adults' specificities and therefore to create an adequate product that is easy to use by them. The final result was a contextual information system prototype that shows the information available in SC in a way that is more relevant to the user, and which has been co-designed and tested by them.

Resumo

Atualmente, a população está em contato com tecnologia mais do que nunca. A internet revolucionou a nossa capacidade de criar, armazenar e recuperar informação. Tornou-se uma parte essencial da nossa sociedade.

Num dia normal, uma pessoa está em contato com informação de diversas fontes. Há mais informação disponível do que a que conseguimos processar e uma vez que essa informação é tão variada, acaba por levantar algumas questões, como, por exemplo, qual a melhor forma de representação para que o utilizador possa utilizar a informação de forma mais eficiente. Adicionalmente, esta quantidade de informação cria a uma grande quantidade de escolhas e possíveis confusões que podem resultar numa paralisia na tomada de decisão. Com este projeto, procuramos estudar uma aplicação desenvolvida na Fraunhofer Portugal AICOS, o SmartCompanion e mostrar como podemos criar informação significativas para os utilizadores e a qual a melhor maneira de a representar.

O Smart Companion (SC) é uma aplicação Android que foi criada para satisfazer os objetivos e necessidades dos idosos. Esta aplicação pretende ser um companheiro permanentemente disponível, aproximando os idosos dos seus cuidadores em todos os momentos permitindo que os cuidadores conheçam e possam evitar situações de risco (como o risco de isolamento, cálculo de risco de queda, monitorização de atividades e detecção de quedas) e, consequentemente, melhorar a autoconfiança dos idosos e a sua sensação de proteção. Esta aplicação Android recolhe diversos dados sobre o uso que os idosos fazem dos smartphones, tais como: comunicações, localizações, atividades, entre outros. Esta informação encontra-se espalhada por diversas funcionalidades e é disponibilizada ao utilizador sem qualquer cruzamento de informação de diferentes fontes. Portanto, o objetivo deste projeto foi entender como processar a informação de diferentes fontes para que tenha significado máximo para o utilizador.

Para alcançar estes objetivos, será seguida uma metodologia de design centrado no utilizador, para que se possa criar um produto adequado e fácil de usar para os seus utilizadores. O resultado final é um sistema contextual que mostra a informação disponível no SC, de uma maneira mais relevante para o utilizador e que foi projetada e testada por ele.

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Thank You!

Inês Carneiro

"Research is to see what everybody else has seen,
and to think what nobody else has thought"

Albert Szent-Gyorgyi

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Abbreviations

HCI	Human Computer Interaction
PA	Personal Assistant
SC	Smart Companion
UCD	User-Centered Design
ICT	Information and Communication Technology

Chapter 1

Introduction

As time goes by more and more information is generated from various sources with various types and formats. It has become an essential part of human life, which can bring new ways to think and evolve. As an individual on an average day, we can go through thousands of information from emails, to chats, to schedules, news, etc. [KSFN08] Since this information is so versatile, it brings many issues in how to represent it in the most useful manner so the user can efficiently use it.

With population aging being more and more a reality worldwide, this brings one to think in what is the best way to represent this massive data for the user to understand and extract knowledge from it, without never forgetting the needs of these users.

1.1 Contextualization

Technology has brought many benefits to our society. Studies estimate that by the year of 2020 smartphones with internet access will increase in number, from two to six billion, resulting in two-to-three times more smartphones in use than PCs, along with an explosion of related applications [staa, stab].

Over the last few decades, computing and the internet have revolutionized the ability to create, store and recover information in an instant. A global economy and instant communication have created an explosion in the amounts of data to which we are exposed. Still, this quantity of data leads to a large number of choices and possible confusion which can result in decision paralysis. There's more data available than we can comfortably process. So there is also the need to make sense of it all. Information visualization is the art of representing data in a way that it is easy to understand and to manipulate. It is used to make sense of information and thus make it useful in our lives [OB08]. Information and communication technologies can bring numerous benefits to seniors enabling them and their caregivers to improve their quality of life.

Despite the great advantages of such applications, their adoption and acceptance are dependent on the skill for handling and understanding digital media. Devices such as smartphones are incorporated with touchscreens that provide a more natural and intuitive method of interaction with the user interface [Muf17], which may ultimately enable a more natural and intuitive interaction.

This project is part an existing project at Fraunhofer AICOS named Smart Companion (SC), which consists of an Android launcher that was specially designed to address seniors' goals and needs [Sma]. Its main goal is to ease the use of a smartphone by reducing its complexity. It includes a set of applications that range from simple calls and messages to more complex ones, such as activity monitoring and fall detection. It seeks to support older adults in areas such as prevention of isolation, promotion of autonomy and quality of life, and improvement of health conditions.

This work is the result of an opportunity for improvement in the Smart Companions launcher. It is within the area of information visualization, concerning information visualization in smartphones. The development will be made at Fraunhofer Portugal Research Centre for Assistive Information and Communication Solutions (AICOS). This research center concentrates its activity in the area of information and communication solutions, working to improve end-user experience and the usability of its applications [Fra].

1.2 Motivation and Objectives

All the applications developed for SC gather a suitable amount of data. This creates the opportunity to analyse how can this data play an important role for their user. Therefore, the main goals for this work are:

- To study what information is relevant to the user
- Understand the context of this information
- Show the data in a simple and meaningful way, centered around the user
- Study and understand how and when we can show the information so that it has the maximum meaning for the user

To accomplish these goals the project followed a User-Centered Design methodology where we studied the best way to show the information to the users. The users were involved at all times from requirements gathering to prototyping and finally testing the implemented solutions.

The outcome of this project was a prototype of an Android application which will allow the user to get the most critical information at a glance depending on their context. By simplifying their decision making process we expect to identify an improvement in the way seniors rely on technology in their day-to-day life.

1.3 Document Structure

This document is structured in 6 chapters. Chapter 1 introduces the context of this research, as well as its background, goals and contribution, and this section outlining the structure of the document.

Chapter 2 presents the literature review, showing some of the older adult's problems such as the age-related changes. Then it also presents the challenges of designing to seniors. We also discuss potential formats of displaying information and some examples are presented and discussed.

Chapter 3 presents the methodology used in the development of this project to design an application suitable for the older adults; and a review of the novel devices concerning HCI.

The fourth chapter (4) contains the solution proposal and all the steps that lead to the conclusion of this project. Chapter 5 presents the final validation conducted with the users and discusses the overall research process. Furthermore, it presents some lessons learned from working with seniors as well as some lessons learned throughout this thesis development.

Lastly, chapter 6 reflects on the conclusions of our work identifying some improvements that can be object of future research.

Chapter 2

Background and State of the Art

With aging, many changes start to appear. Some are visible, such as changes at the physical level but others are not such as the decrease at the cognitive level. Moreover, all of these changes will ultimately affect senior 's self-esteem and ability to be independent in performing essential activities. This chapter is intended to give an overview of the changes that are related to aging. It is also given an overview of the topic of mobile information visualization and the challenges related to senior designing. Additionally, this chapter presents some examples of design projects of three different ways to processed and present information to the user so he can take more informed decisions such as personal assistants (PA), dashboards, and trackers for the mainstream audience and in specific for seniors. After understanding of what this three main at-a-glance views of information consist of we will decide which is more appropriate for the context of this application.

2.1 Age-related changes

Older adults in most developed countries are defined as people of 65 or more years old. However, there is no general agreement on the age at which a person becomes classified as old [WHO16]. In high-resource countries, older age is defined in relation to retirement from paid employment, at 60 or 65 years. As people grow older, many changes start to appear. Society's view of "old age" has not always been accurate with the truth. There are many myths surrounding aging, however often these myths are incorrect. One common belief is that an old person cannot learn a new skill later in life, but the reality is that, even though it might take longer than younger adults, everyone is always capable of learning new skills regardless of age. Another common belief is that mental diseases such as depression and dementia are a normal part of aging. However, most older adults are found to have lower rates of diagnosable depression compared with younger adults, and successfully adjust to the challenges of aging, living happy and productive lives. This can be explained by the fact that as people age they tend to concentrate on the most satisfying and humanly rich relationships striving for an emotional balance (managing their affective states and

avoiding sadness or anxiety) [Cou06]. Nevertheless, the majority of older adults do experience regular, age-related changes which may affect their lifestyle. These changes can be divided into three categories: cognitive, perceptual and psychosocial.

2.1.1 Cognitive Changes

Just as age-related changes in general, cognitive changes are not uniform across all cognitive domains or all older individuals. The most affected cognitive changes are attention and memory, with evidence suggesting that even though some aspects of attention and memory are maintained with aging others show a significant decline. Higher-level cognitive functions such as language processing and decision making may also be affected by age. [oM15] The greatest declines with age are in the domain of attention, working memory (also known as short-term memory), long-term Memory, speech and language, and lastly decision making and executive control [Gli07].

Some form of attention is involved in virtually all these cognitive domains. Declines in attention make the execution of tasks that are not regular or automatic, such as learning and making a decision, a lot more complicated[MRM+10]. The working memory can be defined as the ability to store, focus attention on, and manipulating information for a relatively short period of time. With aging the process of encoding, storing and retrieving information, tends to get slower, which ends up affecting the ability to learn new information, and ultimately the power to perform everyday tasks [EVL+16]. Furthermore, with aging signs losses in long-term memory start to appear in something called the episodic memory, which is the ability to remember specific events or experiences that happened in the past. Even though most older adults believe they have a better capacity to remember remote events than recent ones, the reality is that they end up only retaining the core information about the event but lacking the details, the spatial and temporal context. This affects their capacity to remember the context or source of information: where and when something was heard or read, or even whether something happened or was just thought about (what is called "reality monitoring") [MRM+10]. Regarding perception, most older adults face a decrease in their sensory and perceptual abilities, causing essential implications in their everyday lives.

Sometimes when connections between ideas are not made explicit, older adults can have difficulties understanding words and images [Rid07]. So, complex interfaces that require the user to find buttons or other elements in the display became a hazardous activity. So, interfaces, where they are faced with the need to find buttons or other elements in the display, became a hazardous activity. Older adults also have difficulties distinguishing essential from non-important information, and increasing the number of distraction will only cause them to get more confused and overwhelmed. Speech and language processing is mostly intact in older adults under normal conditions, although processing time may be somewhat slower than in young adults. Older adults also show a more extensive vocabulary [Rid07]. When making decisions seniors tend to rely on prior knowledge about the domain in question and less on new information, contrary to younger people [MRM+10]. They also tend to rely on experts' opinions more than young adults, possibly because of working memory limitations.

2.1.2 Perceptual Changes

At the perceptual level, according to the American Phycological Association [Ame17], most of the physical changes that appear in older adults are related to vision, earing, physical abilities and reactions that tend to get slower.

The leading visual changes among aging adults result in difficulties such as slower reading speed and reading the small print and in dim light, as well as difficulty while driving at night. [Ows11] According to the American Psychological Association [Ame17], hearing impairment among older adults is widespread. However, it is often mild or moderate. Regarding physical and reaction abilities most older adults have slower reactions needing more time to respond to alterations in the environment once those are detected. [Ame17]. So, it is crucial to implement interfaces that give the user enough time to slowly and clearly understand what should be done and in what manner small targets and moving interface elements are challenging for older people and should be avoided [WNDP07].

2.1.3 Psychosocial Changes

The American Psychological Association [Ame17] mentioned that one in four older adults experience some kind of mental health problem. It points on dementia as an essential psychosocial change that affects 5% of individuals between 71 and 79, and 37% of the population above the age of 90. People with dementia are also prone to suffer from other mental diseases such as depression, anxiety, and paranoia, leading to impairment in social function. The APA defines depression as a collective and severe medical illness that negatively affects how one feels, the way one thinks and acts. It is identified by feelings of sadness, sense of loss, burden, and helplessness. In older people, but not only, causes are mainly the loss of their loved ones or their new limitations [Ame17, BEVh+14]. When depressed, older adults tend to avoid mingling with their relatives and friends, isolating themselves in their own houses. For many people, regular exercise helps create a positive feeling and improve mood. Getting enough quality sleep on a regular basis, eating a healthy diet and talking to other people can help reduce symptoms of depression [Ame17]. So, when designing a product these factors should be considered.

2.1.4 Interaction with Technology

It is a common belief that older adults do not know how to use ICTs, have a disinterest in them and don't want to learn about them [GASZ15]. However, this is nothing but a myth, according to the APA, older adults are capable of learning new skills, though they will take longer to learn them [Ame17]. Older adults have quite a considerable interest in learning about and using new ICTs (especially mobile phones), but the very little adaption of these technologies to their needs and the high prices are considerable barriers for broader use. [GFL+10] According to Rice and Katz [Hoc03] and Castells et al., [SR07] the use of ICTs among seniors varies based on different social factors, such as social class, education, gender, country of origin, belonging to subcultural groups, and place of residence. It might have a direct or indirect influence on people's manner to use ITCs

and their experiences using mobile ITCs. Gascón et al. [GASZ15] conducted a research with the aim to understand whether and how age influences the abilities to use, the uses and perceptions of, and the experiences with newest applications (ICTs) and what are their needs regarding these technologies. Richard Ling [Lin08] and also Ling and Thrane [LT02] have proved that the difference in the way older adults perceive technology has to do with the social meaning of different forms of communication. For example: while "younger elderly have a much more familiar relationship to the mobile telephone" [Lin08] and may use short messaging as a means to communicate, older elders avoid it. An explanation may lay in the fact that they do not understand the need to use a limited written format to communicate when there is an option to call. With the increased usage of computers, this social group could significantly benefit from these high-tech products, and their social interaction, healthcare and education could potentially be enhanced. However, such devices are far from being designed to their needs. In the hardware domain, most devices (e.g., keyboards, printers, speakers, smartphones, etc.) have tiny buttons making it difficult to see and manipulate by seniors. Furthermore, software applications usually demand a steep learning curve making it challenging to learn for an older person compared to a younger one. Wagner and Hassanein point out reasons, as to why older adults are not interested in using computers or the internet [WHH10]:

- The costs of technology
- Barriers due to physical limitations
- Lack of knowledge
- Lack of interest or motivation
- Lack of understanding the benefits

Seniors' emotions towards applications can influence their perception of its usefulness and their evaluation of it. Negative emotions regarding an application could make the user feel incapable, ashamed, or angry and that might create a more negative attitude to similar technologies [GASZ15]. Declines in working memory may make it difficult for seniors to understand new concepts or recall complex procedures. Declines in attention may also complicate tasks where a constant change in focus between several displays of information is needed. In a study conducted by Gregor and Dickinson [GD07], they noted that, in an accessible and commonly used e-mail client program, Microsoft Outlook, there are 250 possible operations and five panels on the first page! Such large amounts of options can make the user feel overwhelmed when using it, even for advanced users. In this study, 50% of a group of beginner seniors failed to complete basic e-mail tasks. These findings can be seen as a clear call for a better adaption of apps to elders' special needs at the physical level, such as larger font size; clear, non-ambiguous symbols, at the content level, being adapted to their everyday life needs. By eliminating these complexities, we can open the access, both to seniors and younger people alike, to technology. However, available studies [GASZ15] indicate that seniors are in fact receptive and interested in using computers and, as they become more experienced, their attitude and motivation also increase [CL07]. In a study, they

concluded that elders learned from and with each other and that they felt less ashamed when other elders were teaching them. Nevertheless, their past experiences, and their support when learning new technologies can be determinant factors for their receptivity.

2.2 Mobile information visualization

By the year of 2019, there will be one billion more mobile phone users worldwide than in the year of 2017, and this number is expected to grow even more in the future [staa, stab]. However, mobile phones still have many constraints such as limited screen size, limited input capabilities (e.g., small keyboard), constraints in the physical environment (e.g., noisy location, awkward position of use), and these are not only constraints for users but for developers too.

Nowadays, information visualization technology evolved from an advanced research topic to general acceptance for both commercial and personal use.

The primary purpose of this technology is to efficiently give to the user the mental models of the information [AEYN11] on the domain he is analyzing, as easier as possible. It can be defined as a mental image or visual representation of an object or scene that is similar to visual perception. This powerful tool can be used for different cognitive processes such as explore, analyze, discover and communicate information in a well understandable form, with a significant insight into the information. Many visualization techniques are available to use in different situations to deliver different levels of understanding to the user [Spe14] to interpret vast and complex amounts of information.

When designing a product, visualization of information will depend on many factors, such as what kind of information, its representation in a specific information space, and the specific task or goal of a user. According to Chittaro [Chi06], there are six different steps to follow to aim for precise and error-free design:

- **Mapping** — which is related to how to visualize and encode information in a visual way. A good mapping produces an exact visual representation. It can be achieved when there is an accurate relationship between data objects and visual objects. It is only possible with a well-defined algorithm.

- **Selection** — It is associated with the process of selecting the data needed for the given task or job. Selection is one of the most crucial tasks because the wrong selecting of data can mislead the user in important decisions and create negative consequences and losses (financial, time). The inclusion of unnecessary data should be avoided at all costs.

- **Presentation** — it is the process of managing and organizing the information in the space available in an efficient way.

- **Interactivity** — It relates to the abilities to organize, explore and rearrange the visualization. Good interactivity enables the user to explore and understand the information in the best way.

- **Usability** — It involves adaptation and accessibility factors making the visualization easy to use by the end users but also by people with special needs.

- **Evaluation** — Evaluation is also an important step when creating a visualization interface. It will allow determining if the goals were achieved or not and how effective is the visualization interface.

However, creating the perfect visualization method is a significant challenge to fulfill all the user requirements. The most critical issues for visualization is usability that is defined by how easy it is to use the product and how efficient it can be. It is also necessary to understand the user and his perceptual, cognitive tasks, and have prior knowledge about the methods and how to operate with it. Information visualization itself is much more difficult than scientific visualization and includes many unsolved problems [TC09]. There is no accepted answer to which visual representation is more suitable for the kind of information under consideration for a specific goal. In addition, one of the most significant problems with mobile devices is their screen since it is much smaller than a computer. Moreover, making insight of data visually appealing to the user is essential. The aesthetics are very difficult to maintain and a big challenge for visualization engineers since aesthetic is defined as a philosophical theory that deals with the beauty and taste, which are very subjective.

In this project, the chosen methodology is a more general model of software creation where we will start by identifying the characteristics of the users' life to understand what aspects of the design are more likely to be barriers for the users – such as using too much text or having too many movements. Afterward, we will look at the goal of the system to improve the user experience and be creative about how SC can improve seniors' lives. So we can understand which is the best way for users to interact with our system, meaning which is the best modality or combinations of modalities to be adopted in SC.

In the context of human-computer interaction, modality is a particular mode in which something is experienced, on a sensory level. Modality is an approach where communication and representation are more than about language. It is the input/output between a computer and a human. [KASA08] And a system can be unimodal if only has one modality or multimodal if it has more than one modality implemented. Multimodalities tend to be used to provide more intuitive ways of integration between the system and the user. Multimodalities are divided between modalities computer-human and human-computer depending if they are used to send information from the machine to the user or the other way around. When designing for seniors, their characteristics play an enormous role when deciding which are the more suitable modalities to use [HM06, MS17, TC09].

According to Pak and McLaughlin [CL07] there are some general guidelines that we can follow to attend some of these users needs such as: allowing for sufficient time in inputs, guiding or limiting movement for users with motor control deficiencies, simplifying features, by reducing the number of features, renaming features so they can meet their function, not the companies

name. An example of this is "Microsoft Excel" that can be confusing when the users search for the product on their computer.

Another thing to be aware is to preferably use words compared to images and icons since these can be confusing for the user, and increasing the target size and providing accurate targeting devices. Moreover, offering feedback (through audio, vision or touch) or combinations of them, preferably matching their intensity to the environment of the user. Combinations of multimodalities, such as visual and audible displays of information, can be used to complement each other and help the users with sensory limitations. For users with some problems of cognitive attention, multiple modalities can help them to switch between different tasks. For example: when a user is typing a list of groceries and can say something like "remind me to call daughter" the software will create a reminder to call her daughter, and when she is finished creating the groceries list it will notify the user [HM06, MS17].

An application that can change from a graphical and audible display to speech displays can be beneficial to users with perception deficiencies. For users with motor limitations, a display with fewer movements and more clicks on the screen can be beneficial. Some users may also have difficulties when articulating words which can be a problem for systems that depend on speech to work, so making them speech free can improve this users interaction with the system. Lastly, systems that can provide the user with easy access to chats and reminders to call their loved one are also necessary [HM06, MS17].

Some of the formats in which the information can be organized and presented to the user and also some examples of applications are treated in the next sections.

2.3 Mobile personal assistants, dashboards and trackers

With this project, we aim to create a system that will complement the application already on the market. The idea behind the system is to use the information SC already has about the usage that the elderly make of their smartphones and show it to the user and to assist him with difficulties that he might have throughout the day. Since this project aims at the same time to assist the user, by providing him with the best information available in different contexts. One of the most used ways to display information is through the use of dashboards. Trackers are also valuable when our main goal is to record information about the user. A last method that is being widely used is through personal assistants. In the next section we will explain what these methods are, and what we can learn from them.

2.4 Related projects

Over the years many applications have been built using different multimodalities available in mobile devices. These applications can vary in the way they present the information to the user, such as Personal Assistants, Dashboards, and Trackers.

Personal assistants are software agents used to perform tasks or services for the users. They are sometimes, also referred to as chatbots and are very useful for treating information to be shown to the user. Personal Assistants make use of different modalities such as Text, Voice or Image. They interpreted the information the users want to access to, perform the activities related to such tasks and show it to the user in the best way possible, taking control of the interface. An example of this is when the user asks the device for the next events in his calendar, and the PA understands this request, searches the calendar and then replies to the user with a list of scheduled events [PMPN11]. A survey conducted in May of 2017 showed that the biggest used personal assistants are Apple's Siri with 34% of users followed by Google Assistant with 19% of users in the US [Gra17].

Despite all the apparent benefits of using personal assistants, according to a study [Dis] made in the United States in 2017 the most significant dangers of the increasing popularity of virtual assistants are the difficulty in increasing human contact and our everyday life becoming less private. This leaves one thinking that when developing a contextually based system, we should always promote human contact and security above all.

Another useful way to deliver information to users is by using Dashboards. They are generically a visual display of the most critical information that the users need to fulfill his goals. It is arranged to show on a single screen all the information that can be monitored at a glance. Because the available information can be so different from each other, before they are shown to the user they are treated, meaning that they are abbreviated to summaries and exceptions. So the user can quickly see which information needs attention and may require some action. To get the full information dashboards to make use of navigational models. They assemble concise, clear and intuitive display mechanisms. They are usually customizable and when information is of extreme importance they can alert the user so he can take actions as fast as possible. Making dashboards so valuable nowadays. There is no longer needed to seek and examine the data so exhaustively because all the information is gathered in only one screen [Few06]. By making use of dashboards we would be able to recreate scenarios of use that the elderly make of their smartphones and learn from it. To help them achieve their goals. Dashboards, when presented to the users, could help them feel more motivated throughout their day, identify patterns and help them end them, for example: showing the user that the longer he stays at home, the sadder he will feel and less motivated to do something, and suggesting him to go outside for a change.

Another method to deliver information to users is trackers. These systems are used to log the users' information, such as the locations he has been. They only display the information to the users [WMY08, trc]. This method of displaying information could help the user remembering old trips he has been to, or help them navigate and prevent them from getting lost.

By combining these three methods, we could create a system that would assist older adults in their everyday life. We can track and monitor users information (such as locations, heart rate, messages, events, etc.), treat this information and making use of it to assist older adults in their everyday life and help them delay the effects of aging. Also, lastly, create dashboards with the aggregated information that could be used by them and by their caregiver in the future.

2.4.1 For the mainstream audience

Personal Assistants have become widely available commercially, especially in mobile form, with recent reports of increased market interest in their adoption by older adults. Most commercially available personal assistants are limited in their multimodal capabilities, typically offering a combination of touch and speech input [HM06, MS17]. The most significant examples for the general audience are Siri, developed by Apple Inc., Echo, developed by Amazon Inc. and lastly Google Now, developed by Google Inc.

As for dashboards some of the applications available in the market are Morning for iPad, an application that gives the user easy access to information such as upcoming events, weather forecasts, to-dos for the day and it is customizable. For Android, the most significant example is Google Now that gives the user quick access to all the information available on his Google account.

For tracking of information some examples are the fitness applications available such as Google Fit, that also has integration with some wearables to track the heart rate. In addiction, Google Maps that tracks the location of the device at all times.

Smart Companion in a way does some of this functionalities. However, it could take advantage of even more information and cross-link them together to assist users and predict what information they will need at different times of day and different locations.

2.4.2 For seniors

For seniors, some examples of applications are the iCare that is a mobile health monitoring system. It makes use of the mobile device and body sensors to track the users. It also monitors emergency situations that in this case, they alert preassigned people of what is happening. It also offers medical guidance to the elders. This application is part of the domain of health-care that according to Rodriguez et al. [RGI05] is divided into three groups: applications that record signals and take action off-line, apps that make remote real-time processing and lastly apps that provide local real-time processing and take into account the levels of mobility. iCare also plays a role as a living assistant, by including activities such as regular reminders, quick alarms, etc. This application is mostly based on a touch interface.

As a different example of a project developed for seniors, there is Brian. An assistive interactive robot that assists adults in their daily tasks. It has a multisensor system with a speech-based interface, and it also shows some emotions through gestures, which induces the user to engage more in the interaction. As examples of personal assistants, there are some applications such as vAssist a European research project funded by the Ambient Assisted Living Joint Program. It is a multilingual voice controlled service for seniors with chronic diseases. Its interface is mostly based on speech interaction.

As a final example that aims to provide a sense of connection between the elders and their loved one, there is InTouch. It provides real-time video communication and photo and text messaging. The curious fact about this application is that it is entirely text free. Making use of only icons,

swipe gestures, and voice message input. Which is beneficial for seniors that don't feel very comfortable using smartphones since the interface and methods to communicate will not be so confusing to them.

Chapter 3

Methodology

Sharp, Rogers, and Preece in their book [SRP07] define HCI as the job of designing interactive products to support people in their every day and working lives. Interaction is in everything that surrounds us, from the most basic thing as using our tv to the most complicated ones such as mobile phones. However, when some of these products are being developed, they are developed from an engineering perspective where the most important aspect is if the product works or not. One significant example of this perspective of development was the error message that was shown to the users when they tried to run too many programs at the same time on Windows, where the message merely said: "Ran out of memory while trying to allocate 0 bytes". An incomprehensible message for a typical user. With the evolution of technology, its complexity is also growing, making it "worthless unless they can be used properly by men," as Karray et al. said [KASA08]. As developers, we must talk to the actual users that will use the product at the end of the day.

When designing a product, we should take into account two terms: functionality and usability [TCZ05]. Being the functionality of a system the features of the system, what it can do. Usability is defined as the degree in which a system is efficiently and accurately used by a user to complete a specific task. It is crucial to understand that when designing a product, a golden rule must be followed: the users must be involved in the design process [DFAB03]. It is no longer enough that products have a rich amount of functionality. It is also fundamental that users will be able to efficiently use it. To create an adequate product that meets the characteristics of the users, a Human-Computer Interaction (HCI) methodology was followed. HCI is defined as the d̈iscipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them [SIG, HBC+92].

HCI should not be seen as equivalent to testing, to check whether people can use the system and fixing problems, but rather a field that allows us to make sure they can use it from the beginning. In HCI it is necessary to consider several aspects such as the user requirements and their characteristics when using the system, recognizing the importance of functionality and usability in

the system [DFAB03]. When interacting with a system the levels of activities involved between the user and the machine can be divided into three [KASA08] different aspects:

1. The physical aspect is related to the mechanics of interaction between human and computer,

2. The cognitive aspect is associated with the way users can understand the system and interact with it and

3. The affective aspect tries to make the interaction a pleasurable experience for the user and change the attitude of the user in a way that he will continue to use the system.

Also, this should be thoroughly thought when developing a system [KASA08]. By considering these aspects, we intend to build a product that has in consideration senior's characteristics and provide them an app to improve their daily lives.

3.1 User-Centered Design

The main approaches of HCI in the software development are Usability Engineering (UE), Participatory Design (PD) and User-Centered Design (UCD) [GLB99, MNAA12].

The UE methodology has as a central concern the evaluation of the usability of the software. Faulkner [FC00] defines it, as being an approach that involves the users from the start, in the development of software systems, and guarantees the efficacy of the product with a set of usability specification and metrics. There are three types of usability evaluation depending on the evaluation itself. The first, name exploratory evaluation is done before the interface development. It is followed by the formative evaluation during the development of the interface and lastly, the summative evaluation after the interface development is finished. These concepts are associated with the definition given by Seffah and Metzker [SM08] that the UE method is a software development method prioritizing the usability of the system developed.

Participatory Design (PD), initially co-operative design, now often co-design, is a method that attempts to actively involve all stakeholders in the design process to help ensure that the result meets their needs. It is important because most of the knowledge of the application area is only accessible to the end users. The concept of PD is embracing the users in the development process so the requirements and needs of the user can be achieved without discussions about the system characteristics, using prototypes to simulate and test the system [Kyn91].

In this project, the design methodology chosen to be followed was a combination of User-Centered Design (also known as Human-Centered Design) with Participatory Design. UCD was first introduced in a book by Norman and Draper [ND86]. Contrary to PD, in UCD methodology the product is developed considering the user, however, he is not a member of the designer team. This methodology emphasizes the user's needs by including him in as many steps of the design and evaluation process as possible, from the requirements gathering in the development phase, to the final use of the system.

Norman and Draper define UCD as an ideology based on the needs and interests of the users, which will make use of the system, making it usable and understandable. In this methodology, a lot of information and analysis is conducted to understand the characteristics, needs and different types of interaction of the users that will influence the system's design [HRRS08].

According to the ISO 13407 a UCD project involves four essential activities:

- **Requirements gathering** — To understand and specify the context for use
- **Requirements specification** — To specify the user and organizational requirements
- **Design** —Where we produce designs and prototypes
- **Evaluation** — Where we evaluate the designs against requirements

These steps should be planned and executed to incorporate usability requirements into the development process. In this approach the users should always be present, focusing intensely on understanding their characteristics and needs, context and goals to deliver a solution that meets every requirement. This project followed the UCD method phases and, as a first step, user research about older adults was made. This was followed by an informal interview with the target audience of this project. As a second stage, a transcription of the interviews was made followed by card sorting sessions with users. Based on the results of these two phases, a prototype was created with the help of the users. This is where the PD method was incorporated with the UCD, since users helped and co-designed the system. Also, as a final step, the created prototypes were tested and changed according to user feedback. The next diagram describes how these phases were planned to happen.

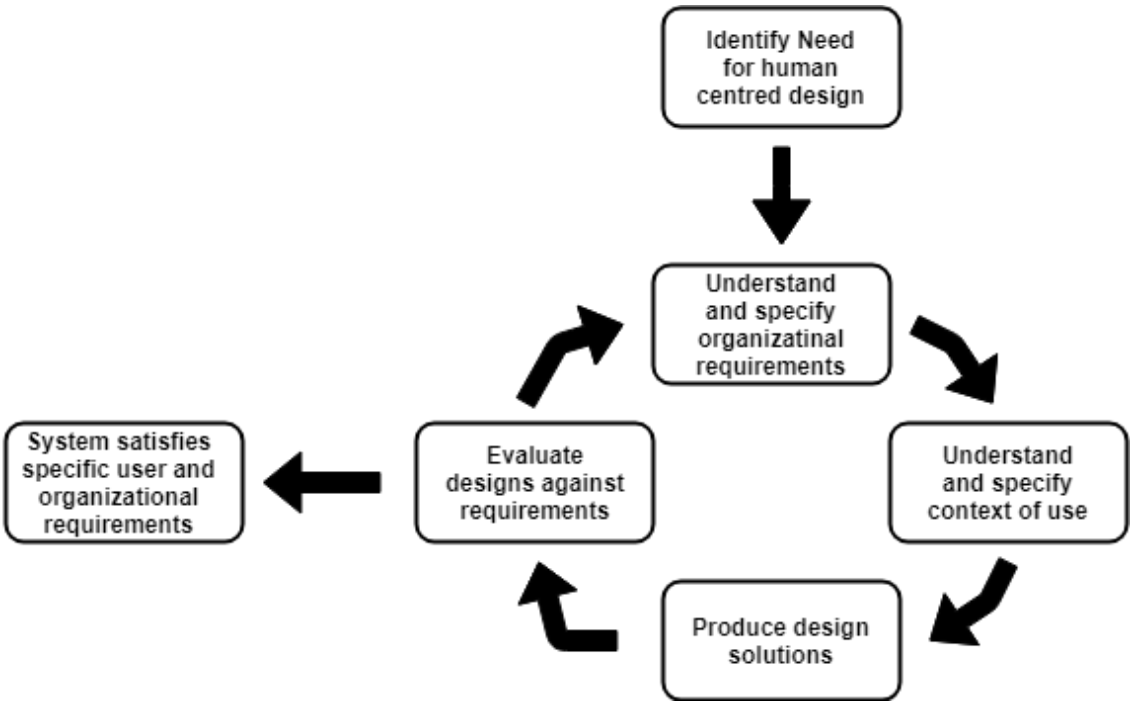

Figure 3.1: ISO 9241-210:2010 for User-centered design methodology

1. **Identification for the need of a human centred design** — The characteristics of this social group and research made in this topic are sufficient to understand the need for this methodology

2. **Understand and specify organizational requirements** — The requirements were defined with the users

3. **Understand and specify the context of use** — Analysing the results from the previous phase, helped to assess which informations are most important to show depending on requirements.

4. **Produce design solutions** — In this phase, in collaboration with the participants in this project, a prototype for the design was created to the target audience to have a positive impact in their life.

5. **Evaluation of design against requirements** — Prototypes for the designed android application were co-designed and tested with the users to ensure the project is considering the needs and characteristics of the end-users.

6. **Final Evaluation** — One final evaluation was made to the prototypes making sure all their functionalities and proposed goals are guaranteed.

3.2 Specifying the Context of Use

The first step of an UCD process is to understand the user, its characteristics, their problems with the system, the tasks that they will perform and the environment in which users will use it [SRP07].

It is also essential to understand their level of experience, needs that are not being met by the current system and which are their frequent or desired tasks. For this initial stage, we started by making user research, based on literature analysis, and informal interviews with users and caretakers. Some information was also gathered from other sources, that did not involve the user directly, such as reports from public sources and books specialized in these types of users. With data collected from these methods, we were able to reveal patterns and trends to create new ideas, to incrementally improve the product experience for the users and to measure success with users. The output of these steps of the UCD method is a description of the user with rich detail to allow the designer or evaluator to understand the user's capabilities and limitations better. The two traditional ways to do structure this information is through user profiles and personas. In the following section, an explanation is given on some of the techniques that could have been used and some that were used in the specification of the context of use.

3.2.1 Questionnaires

One approach we could have used was to ask the users a predefined set of written or oral questions. Questionnaires can have multiple choice questions or open text questions where users can add their personal comment. It is generally used to understand users needs but also to test the services in the end. Questionnaires have the benefit [Adv, MD95] of being cost and time efficient since the candidates can respond at their one time. Anonymity is also a big plus for this method since it allows responses to maintain their anonymity and the users can be more comfortable answering certain questions. There is also the likelihood of a high return rate since they can be sent to multiple users and lastly, all topics are covered. However, it has some disadvantages too, such as dishonesty, different understanding and interpretation, with all emotions (facial expressions and overall body language) and reactions lost. Some questions can be difficult to understand and analyse. In the case of this project, the biggest downside is accessibility so the methodology ended up by not being used.

3.2.2 Interviews

Another approach to understand the user in order to specify the context in which the application will be used can be through a conversation with a purpose talking with the users one at a time, with the help of an interviewer. A set of questions and tasks with different levels of technology experience were prepared for the user, allowing us to get to know in detail the users' point of view and to understand their everyday life, their activities, what kind of conversations they usually have and with whom, and their main problems. Interviews can be broadly classified as structured, unstructured or semistructured [SRP07] depending on how strict the interviewer is to stick to the

prepared set of questions. In this project we will use semistructured interviews, that allow for the interviewer to ignore the set of questions when the topic that the interviewed is talking is of interest but was not on the set of questions prepared. Another advantage of semi-structured interviews is that they provide with both quantitative and qualitative data. [BCC15] Interviews compared to Focus Groups have the benefit of allowing to collect more detail about the individual experience, marking different questions as follow-ups depending on the answers and pairing them with observations of the task. Even though this method as a drawback since it takes some additional time to analyze. Following the interviews some time was taken to do the transcript of the meeting and to examine which information could be taken from it. After balancing the advantages and disadvantages of this method we opted to follow it since we were looking for a more individual insight into the users life.

3.2.3 User Profiles

Are presented in a tabular form and serve to remind the design and evaluation team of the the users specific needs. It illustrates their capabilities, limitations, needs, and motivations. According to Kuniavsky [GKM12] some of the categories that should be present are: demographics (age, gender, etc.), level and type of experience, environment in which they typically use the system, lifestyle, roles (responsibility), goals regarding the product (long and short term), needs and wants, and lastly the tasks (main low-level tasks the users accomplishes with the product). User Profiles are specially important when recruiting new participants for usability testing sessions and interviews.

3.2.4 Personas

Personas are a fictional characterization of a user and help to make the users seem more real in through the design process. They are similar to a profile on a social media platform where the "user" has a name, an image, a background associated with her and their information. It represents a user in a group of users and is created based on complex user data. They put a name, face, and characteristics on users to keep the users in the forefront of design decisions. They are represented in a format that is meaningful and creates empathy among the development team. They range from a paragraph to a full page with specific information (characteristics, demographics, and experience levels) from a user profile. Further information in personas is personal details such as behaviors, attitudes, motivations, and goals [FCR+09]. This helps designers and evaluators to have realistic ideas of users through the design process, from meetings, cognitive walk-throughs, storyboarding, role-playing to other user research activities. They also help new team members to quickly understand the end user. However, when creating a persona, there are a few risks one should be aware of [BCC15]. Firstly while generalizing data about the users to create a persona some information is lost, we can miss out the exception cases that can be important. When recruiting based on personas some valid users can end-up by being excluded. Thirdly they must be updated at all times to reflect the changes that users needs might face over time. Lastly

they should never replace ongoing user research. Personas were used in this project as inspiration for the development process.

3.3 Specifying the User Requirements

Following the context of use, the user requirements were gathered. Preece et al. [SRP07] define a requirement as a statement that specifies what an intended product should do and how it should work, which is remarkable given the fact that we need to know how the application could have a positive impact on the seniors' lives. In this section, we will present some methods, their primary goals and how we could use them to gather information to establish the user requirements.

3.3.1 User observations

User Observation consist of literally observing how users act in the environment where the application will be used. It is essential to spend time with users without disturbing them to keep the context as natural as possible. The results collected by this method can contribute to the initial design specifications, reducing the iterations required for the last design evaluation. As benefits, this method can contribute considerably to initial design specifications and usually reduce the number of iterations required for usability testing. This method was not followed since, considering the objectives of the project (presented in section 1.2 it would make sense to use it.

3.3.2 Focus groups

In this methodology we encourage a group of older adults to share their thoughts, feelings, attitudes, and ideas about the application. The results gathered using this method can be used later in usability tests [RCC+02]. The value of this method is the depth of the discussions that can come from it. Generally, when people hear others responses to questions they start discussing the topic among themselves. In this structured interviews, the users should not know each other well and a list of topics to cover should be present. The group should have as much diversity as possible. When applying this methodology with seniors some drawbacks can be encountered. By its nature, focus group research is not fully confidential or anonymous, since the information is shared among others in the group. Since some of the elders used in this study their privacy has already been compromised by living in a group setting, sharing some of their opinions could result in loss of respect among their peers. And from what was observed during the interviews, where seniors would ask for opinion in their responses, a big disadvantage would be that the participants' responses could not be independent of one another which could lead to the generalization of results.

3.3.3 Scenarios

According to Baxter, Courage and Caine [BCC15] scenarios are a story that describes how a persona completes a task or behaves in a given situation. It helps to bring the users to life and to test the product to see if it meets the requirements and lastly it helps to create tasks that can

be used for usability tests. In order to create a scenario there are some things that are necessary to define, such as who is the individual user (or persona), the task itself, what is the desired outcome for the task, procedure and task flow, a time interval and lastly which are the envisioned features/functionalities that the user will need in the future.

3.4 Iterative and Incremental Prototyping

After collecting all the user's requirements, it was time to start designing the prototypes for the application. The first prototypes should meet the user's requirements and were later tested by the users to check if all requirements were met. A prototype is the materialization of an idea in a simple model, to be discussed between designers and stakeholders and developed if approved. Prototypes are good for early validations and validation of ideas between designer. They should be created using simple materials like paper, soaps, and cards [SIG]. Prototyping also helps the designer to identify the problems, to improve in future versions and also encourages them to reflect about the product. It relies on a collaboration between researcher and users, and on thoughtful conversations and close observation.

There are two main types of prototypes:

- **Low-fidelity prototypes:** used for quick and early design. They usually are sketches, mock-ups, PowerPoint presentations, storyboards, etc. They have a little or none interactive functionality. The most crucial purpose of low-fidelity prototypes is to verify and test functionality rather. The visual appearance of the product is refined later [Mur18].

- **High-fidelity prototypes:** are more elaborative and take longer to be built and changed. However, they provide a look and feel of the final product and can be static HTML, flash prototypes, switchable photo gallery, etc.

In this project, we will opted to create low-fidelity prototypes using paper, and software prototypes. They were a way to obtain quick feedback about how a users engages with an interface during the execution of a task.

Prototypes can be implemented in several ways and following we will present the methods used:

3.4.1 Card Sorting

Cardsorting is a method for suggesting intuitive concepts. It is a quick, inexpensive, and reliable method, which serves as input into your information design process. There are two types of card sorting [BCC15] close and open card sorting, depending of the level of freedom given to the users in the cards and categories of information. For the purpose of this project we opt for the closed card sorting since it is more appropriate when we are trying to improve the structural design of shared information of an existing product. A user is presented with an unsorted pack of index cards with information to sort into categories that make sense to them [Sti]. The participant was

asked to sort these cards into groups. The results of multiple individual sorts were then combined and analyzed statistically. All cards used were physical so no other barrier is added for the users. In this project, this method was used to decide some of the interface content according to older adults' preferences.

3.4.2 WireFrames

WireFrames are a visual guide that represents the skeletal framework of a user interface, like a web page, a screen or dialog box. It provides the general layout of the controls, graphics, and text of the user interface and some provide a description of the task flow of the application [usa].

This method was used to complement the paper prototypes so the users could understand some prototypes more easily. The clickable wireframe was created using the tool Quant-UX [qua]. With this tool ideas are transformed easily into dynamic prototypes, where the user can click and navigate between screens.

3.4.3 Mockups

Mockups are used so designers can collect feedback about the design or ideas in the early stages of the design process. Made of cardboard, soap or other low-fidelity materials. It relies on the user's imagination that the product works so he can provide with valuable feedback on functionality, usability, and understandability of the basic idea of the product. It has many benefits such as inciting criticism from users given their low-cost. Given their informal materials, the user and designer can collectively improve the design using familiar tools. It also helps the discussion among team members. It enables usability testing at the beginning of the development process [moc]. Lastly it focuses on content and functionality and ignores details of graphic design. For all these reasons we opted to create paper prototypes that were later validated by the user.

3.5 Evaluating the Design

After each development iteration, there is a need to evaluate the designed solution. In this process, the participants performed one usability tests, where they completed specific tasks with the product while being watched by one observer. In this phase of the process some measure could be taken on their time-to-learn a specific function, time-on-task, success rate, how much information they retain over time, their errors and subjective opinion of satisfaction [FRC+09]. However, since the project is in an initial state no measures were taken. According to the International Organization for Standardization (ISO9241-11) the definition for usability testing consists on: " The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. "

Effectiveness, efficiency and satisfaction are the three critical measures of usability .Effectiveness and efficiency are related with he value-added part of usability in which the product adds

value to the user meaning it allows the user to achieve his goals faster, easily and most of all better than the existing products. Lack of efficiency may cause the user to reject a product/feature because he doesn't see the value in it. Satisfaction is only related with the user's perception with satisfaction with the product.

Usability evaluations are divided into two groups: formative and summative. [BCC15] Formative evaluations are done early in the development lifecycle. They are used to give insights and shape the design direction taken, and consist of a set of usability inspection methods or usability tests with low-fidelity prototypes. On the other hand, summative evaluations are typically done at the end of the development life-cycle, and, consist in comparing high-fidelity prototypes or the final product itself against a set of metrics such as time-on-task, success rate, etc.

The techniques to be followed to evaluate the design will be the Wizard of Oz and the Think Aloud Protocol.

3.5.1 Wizard of Oz

The name of this method is based on the famous story of "The Wonderful Wizard of Oz", where an ordinary man hides behind a curtain and pretends to be a powerful wizard (The Wizard of Oz) using sound effects to do so [Mol04]. In this technique, designers simulate reactions of the system with users to study their expectations and specifications [usa]. This method was applied to find out the kinds of obstacles people had with the devices. They can be technical, linguistic or visual. [usa]. This method allied with the paper prototypes was very useful to understand the main problems with the interface.

3.5.2 Think Aloud Protocol

In this second protocol, a test participant thinks aloud while interacting with the product. It can be used to evaluate systems by making use of the paper prototypes [FRC+09]. This approach was used to understand what the older adults thought about each functionality and their reasoning while navigating through the system.

Chapter 4

Solution development

After the literature review and methodology definition, there is a need to specify the users' requirements and design solutions. This chapter presents an overview of the Smart Companion project, the results from the conducted user research, followed by a detailed presentation of the proposed solution including the iterative design process of the user interfaces. In the end, a comprehensive overview of the final evaluation using high-fidelity prototype is made.

4.1 Smart Companion: an overview

As mentioned before this project is associated with a project developed at Fraunhofer Portugal called Smart Companion (SC).

Smart Companion is an Android customization that was specially designed to address seniors' requirements and empower older adults to live their lives to the fullest. It replaces the default Android Launcher and it tries to be a permanently available companion to support them in their daily activities using numerous tools, from messaging to medication reminder applications. It was designed for two users: the seniors and their informal caregivers (children, family, friends). Thanks to its easy interface Smart Companion allows inexperienced users to master general mobile phone features, such as making calls and sending voice and text messages. Other important features are the ability to receive medication reminders and to call the emergency line from the home screen in just one click. However, the most important feature to remark is the fact that SC allows seniors to have a better experience by allowing them to have a personalized experience by using a customized unlocker, home screen, and settings. It is composed of many applications, such as:

- **How are you** — application that allows the user to monitor their mental health by enabling them to check in their emotions.
- **Questionnaires** — application to answer questionnaires related to their physical conditions, feeding habits, a scale of fear of falls and sleeping habits.

- **Medication remainder** — medication reminders that help them remember to take their medication.
- **Calendar and Agenda** — agenda so they can insert events, for example, doctor's appointments.
- **Activity Monitoring** — application that contains activity monitoring to track movement and classify activities performed as laying, sitting, standing, walking, cycling or running.
- **Navigation** — application that helps the user with navigation and alerts their caregivers when their family members become disoriented or lost
- **Camera and Gallery** — Camera and gallery that let users to effortlessly take pictures and share them with their friends and family offering little moments of social interaction.

4.2 Requirements definition

Once the literature review phase was over, the next step was to proceed with the interview stage of this project.

The interviews were conducted in two distinct places with 18 people varying from 69 to 90 years old: the first ones took place at a daycare center and the second ones took place at the Living labs at Fraunhofer AICOS. Both environments in which the interviews took place were relaxed, being that the first one was a place already known to the users and the second one simulates a living room so that users feel more at home and comfortable to talk about their life. The setting appears appropriate given the fact that this project aims to be used in their day-to-day life. With these interviews it was important to understand three crucial pieces of information: their everyday routines, what it is that worries them, and which information is more relevant for them in their day-to-day life. These two groups of older adults differed a lot in their routine. For people at the daycare center their routine is centered around the daycare center activities. However, for the other set of people, their routine can vary on the day of the week and most importantly the people with whom they interact. It is not only the routine that varies in these two groups of people. The environment observed at daycare centers was also completely different from the one described by other users. People at the center were less energetic, more quiet. Many were asleep when we went there. Other were sitting on table playing games or just watching. During the interviews at the day center people would get more distracted during the interview and ended up referring situations that were not relevant for the interview, which might reveal their lack of concentration. It was clear from the first contact that the majority of seniors that attended the center had their physical and psychological capacities more limited than the ones interviewed in living labs.

4.2.1 Interview analysis

Upon conducting the interviews, some conclusions were taken in a first empirical analysis of the information. At the daycare center when talking about their routine, the majority revealed that

they use pill boxes for their medication. These boxes are refiled every single week by them or their caregivers. Regarding their medical exams, the bulk admitted that they prefer to be notified by other people and curiously they like to keep the paper of the appointment to read it later and take it with them. To evaluate the weather the majority revealed to only look out the window. When it comes to moving from a place to another, when they do not previously know the way most of them revealed to ask for directions to take while they are on the move. And a few revealed that they do not get out of their usual routes alone. One thing that was noticed in every interview was the constant worry about their family members. When asked about the objects that they forget more often they were sparse. However, some were pretty serious such as forgetting to take insulin and eating meals. When it comes to valuable information some admitted to not take notes, only keeping the information in their mind and eventually forgetting it. Also, when it comes to shopping, making a shopping list depends on the type of shopping. If it is for the month, the list is needed, however for the smaller things they admitted to not needing a list but ending up forgetting something. Only for things of real importance, they would write it on a piece of paper. The majority also revealed that their finances are taken care of by other people, so they do not feel the need to use the computer to do so. The majority revealed that they like to be informed about the world and use newspapers or television to do so. When going to bed, the majority revealed that they leave the mobile phone on the bedside table in case of an emergency, by them or other people. As the first activity of the day, the most significant portion of people says that they start by thinking what they have to do that day. The most significant difference however between these two sets of people is on how they perceive exercise. People at the day center, even though they are aware of the importance of exercise and diet reveal not liking it or making an effort to do it. Other differences are related with navigation, since people that leave on their own, are not afraid to use their mobile phone, or navigate the streets only by asking for directions to people. Another difference is in relation to meteorology where the second set of people use their phone or watch the weather forecast on television. In general they are more active and make an effort for being busy and excise their minds, by doing cross word games, going out with friends, walking outside, reading, etc.

Followed by an empirical analysis four, personas were drawn (appendix B) to be considered during the design phase of the project. Two of them are more active and exercise more, however one is more experienced with mobile phones than the other. Others are less active and again differ in their level of experience with mobile phones. We used these personas as inspiration during the design phase.

The interviews were conducted in two sets. The first one was with people that attend a day center and people living on their own. After this set of interviews it was clear to understand that the information collected wasn't enough to extract the context in which the system will be used by the user. So a new set of interviews was done with people outside the center, that live on their own, as a couple or alone. In the second section of interviews we had interviewed 8 persons that lived with the spouse and three were widow. This second sections of interviews made clear that users like to wake-up early and do everything in the morning. They try not to isolate themselves,

they like to plan what to do in the day and to keep busy. They also make shopping lists at certain times of the month. They have some forgetfulness, like objects and some thoughts. They make an effort to keep themselves informed by watching TV and reading the news. More conclusions from the interviews will be discussed later.

In the end, a transcription of the interviews was done followed by the use of thematic analysis to obtain the patterns within the data collected from both sets of interviews. Transcriptions are divided in three ways: verbatim, where the transcription captures everything exactly as the interviewee and interviewer did; edited, used in cases such as this project, where word crutches are not important; and edited and summarized transcripts that usually include an edited and condensed version of the questions asked and topics raised by the interviewer. [BCC15] For these interviews, an edited transcription was done, where misstatements were omitted. As referenced in section 3.2 a semi-structured interview was followed and to analyze the data collected a qualitative content analysis, called thematic analysis, was followed. This is one of the most common forms of analysis in qualitative research. It highlights recognizing patterns (or "themes") within data [BC06]. According to Virginia Braun and Victoria Clarke, a theme seizes something important about the data, representing some level of patterned response.

For the thematic analysis, I used a framework called "Scrivener" to help me with the organization and conception of themes. To analyze the content from the transcriptions of the interviews I started by reading and rereading interviews responses, then I generated a scheme to categorize the answers [BCC15]. A lot of themes emerged, though they were all related to three main groups.

1. **Forgetful practices:** related with the difficulties the elderly have in their routine regarding things they tend to forget. For example: remembering to take their meds.

2. **Practices to not forget:** related with their strategies not to forget or lose something. Such as enumerating the objects mentally that they need to have with them before leaving the house.

3. **Planning:** related with the preparation older people make of their day. This can be divided into three categories:

    - daily tasks, such as making the bed, preparing meals, cleaning the house, etc.
    - extraordinary activities, were seniors have events they need to attend to, activities that are not part of their routine.
    - activities to fill the day, such as watching TV, going out with friends, walking in the park, things they are not obligatory to do. They do them so they don't feel so isolated.

When analyzing the themes it was also important to understand the context in which the information would be used. Even though the interviews were created with the intent to understand users' everyday life, what their concerns are, and which information is more relevant to them, the goal was also to understand the contexts around each information.

During this stage of the project, it was possible to conclude that the main challenges faced by the users are forgetting medication, medical appointments, and prescriptions. Forgetting where they left some objects such as umbrellas, mobile phones or forgetting to make a shopping list before going shopping. Other problems reside with how to know the weather so they can select their clothing appropriately. Many revealed to not leave the house for new places alone or unprepared, and several indicated that they study the routes beforehand. Only a few use the GPS to navigate while others rely on indications from other people that they encounter while navigating.

When it comes to making notes, several seniors revealed to use a piece of paper and carrying it around while the subject in the note has not been taken care of. Others admitted to forgetting the notes, or not writing them down because they believe they are not important, and forgetting about them later on. Only two people out of the eighteen I interviewed added them to their mobile phone. For this theme, a context was difficult to extract because there was no special time of day or place when these situations would happen. They could occur in the morning, afternoon, night, in the street, at the doctors' office or outside the house.

The second big theme that emerged was strategies that seniors used to avoid the difficulties and forgetfulness that they feel during their day. Some of them are as simple as connecting the initials of each word and form a word of objects to not forget, for example: if they are going shopping and need to bring Eggs, Almonds and Tomatoes, they memorize the word "EAT" so they don't forget anything.

As mentioned, to find their way to a new place some ask for directions when moving from one place to another, take someone else to help them with directions or study the routes beforehand. Still, regarding navigation, many revealed to not knowing public transportation maps and times from memory and just wait for the transportation to arrive. Another strategy used is to take notes. In a medical context, some revealed to keep the pills together inside boxes for the week. Or even keeping the pills together to take them along the day, or making marks in the boxes while they use them. For appointments, many said that they kept the paper from consultations together and organized by date so they can easily check the dates of the medical appointments. Only six people out of the eighteen use their phones to keep everything organized and to receive notifications with the dates.

To not forget anything before leaving the house a participant stated that she makes a mental list of things before exiting the door. And when the weather is not that nice, diverse people admitted to carrying their umbrellas for days because it might rain with various users reporting to forgetting their umbrellas everywhere. Since this events are planned beforehand seniors have time to prepare for them. Mostly in the morning and night, depending if they will leave the house in the morning or afternoon, inside the house.

When it comes to planning, seniors typically take care of their obligations and look for activities to stay entertained throughout the week. They go to the gym, go out with friends, go shopping, in sum, they look for being busy. Many admitted that the reason for this is because they don't like to be alone and when they start to feel like they are getting lonely and nostalgic they reach for friends and family members for help. They keep following their routine schedules, such as taking

care of the garden, cleaning the house, clothing, baking, cooking, and try to be occupied as much as possible. For planning, it is mostly done in the morning and at night. Morning because after waking up many think about what they have to do in their day, and at night because this is the period when many would feel more alone and would reach for family and friends to communicate.

4.2.2 Card sorting

Following the interviews and their thematic analysis, an idea of a product started to appear. However, more information was needed to conceptualize the contexts in which the seniors will use the application. Therefore, a new set of sessions using card sorting - as shown in figures 4.2, 4.3 , 4.4, 4.5, 4.6, 4.7 and 4.8 - was conducted with the help of thirteen people with the age between 68 and 83 years old. It took place at two different locations: Fraunhofer AICOS' living lab, and a daycare center. The environment, at Fraunhofer, was relaxed and simulated a living room so that users would feel more at home, the daycare was already known to the users so they also felt relaxed and comfortable to talk.

With this technique, we aim to understand three crucial aspects of this project to be used in the components development proposal:

- which information is more relevant to the user in their day-to-day life
- which is the interaction modality that they prefer to use in each case
- understand how the information being displayed can vary throughout the day

.

The results from this session are our starting point for the paper prototypes that will come after. As specified in the followed protocol (see Appendix C), three scenarios were tested. In every situation, notes were taken using a camera and a recorder.

The first task consisted of displaying in front of the users a set of cards with sketches of possible information that can be presented. For example, his events for the week, his tasks, etc, as seen in chart 4.1 the user was asked to say if this information was something useful to him or not, by answering 'yes' or 'no.' No solution was considered correct or wrong, and the experiment ended when there were no more sketches for the user to see. No time limit was imposed on the user.

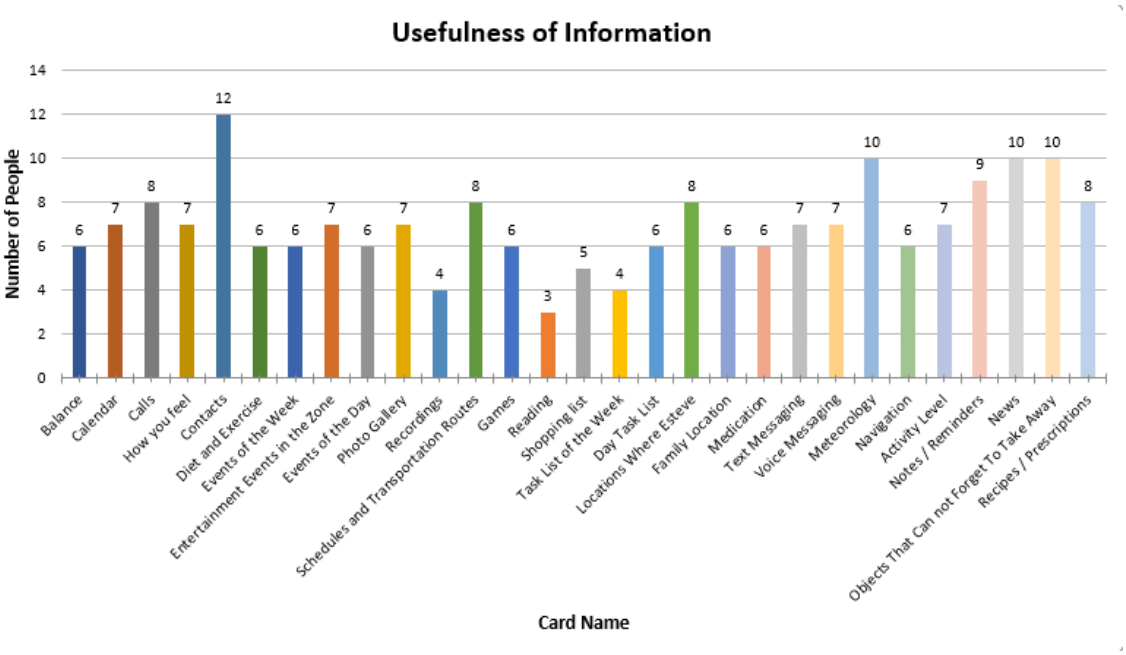

Figure 4.1: Chart with the most useful information for the user

From here, we noticed that when asked to select the cards that are useful for them, the majority of users selected these following cards 4.1: contacts, meteorology, news, list of objects they can not forget, notes/reminders, transportation schedule, calendar, places you've been, calls, prescriptions.

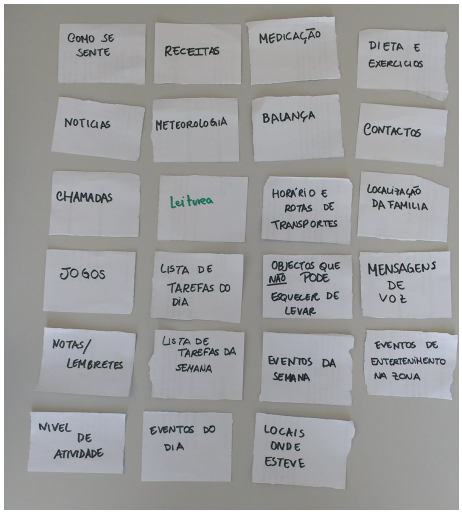

Figure 4.2: Example of response for useful Information

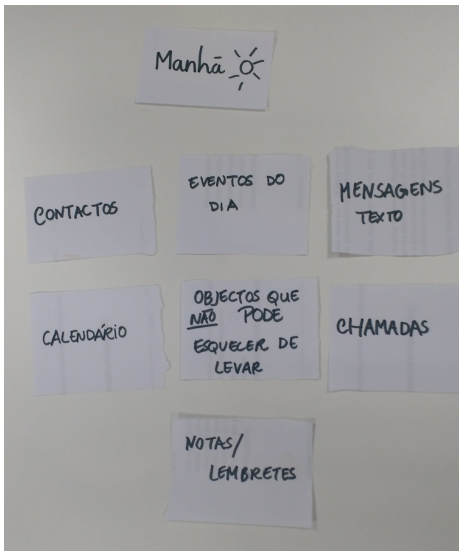

Figure 4.3: Example of response for Morning

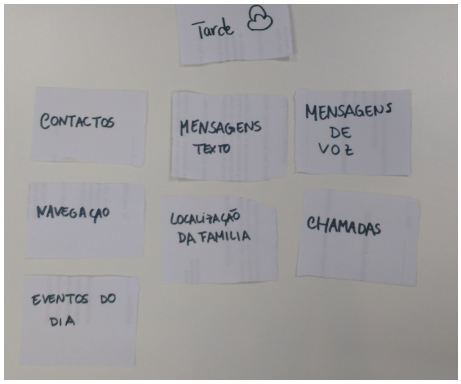

Figure 4.4: Example of response for Afternoon

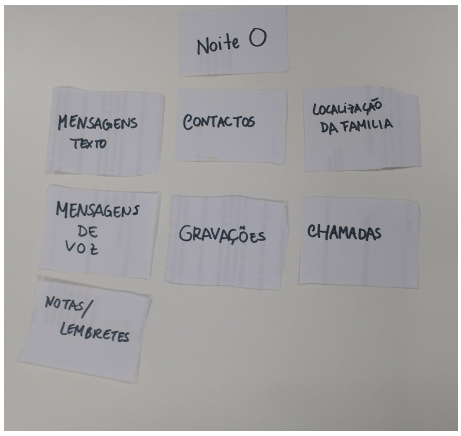

Figure 4.5: Example of response for Night

Figure 4.6: Example of response for Home

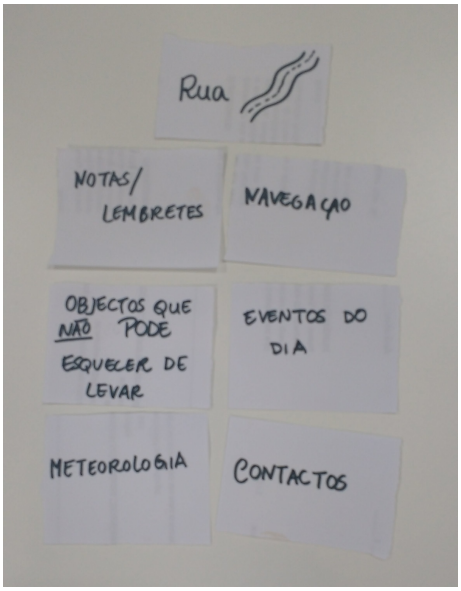

Figure 4.7: Example of response for Outside

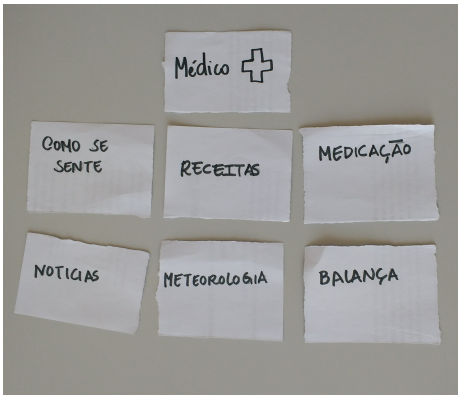

Figure 4.8: Example of response for doctor

In the second task, the user was asked to order the information, according to its importance during the morning, afternoon and night, as seen in chart 4.9. Again, no time limit was imposed. Given the results, it is easy to conclude that in the morning the most useful information for the users is: meteorology, news, notes/reminders, tasks of the day, transportation schedule and family location.

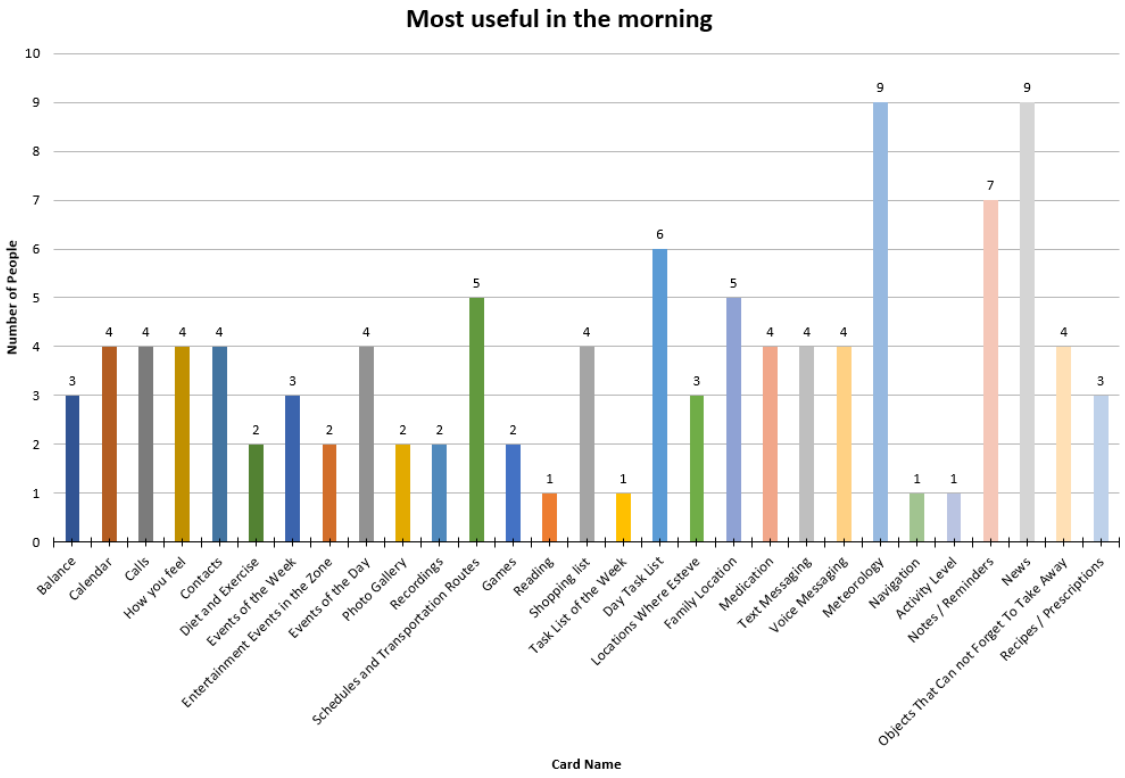

Figure 4.9: Chart with the most useful information in the morning for the user

During the afternoon (see chart 4.10) the most useful information for the users is contacts, news, notes/reminders, calls, transportation schedule, family location, and level of activity.

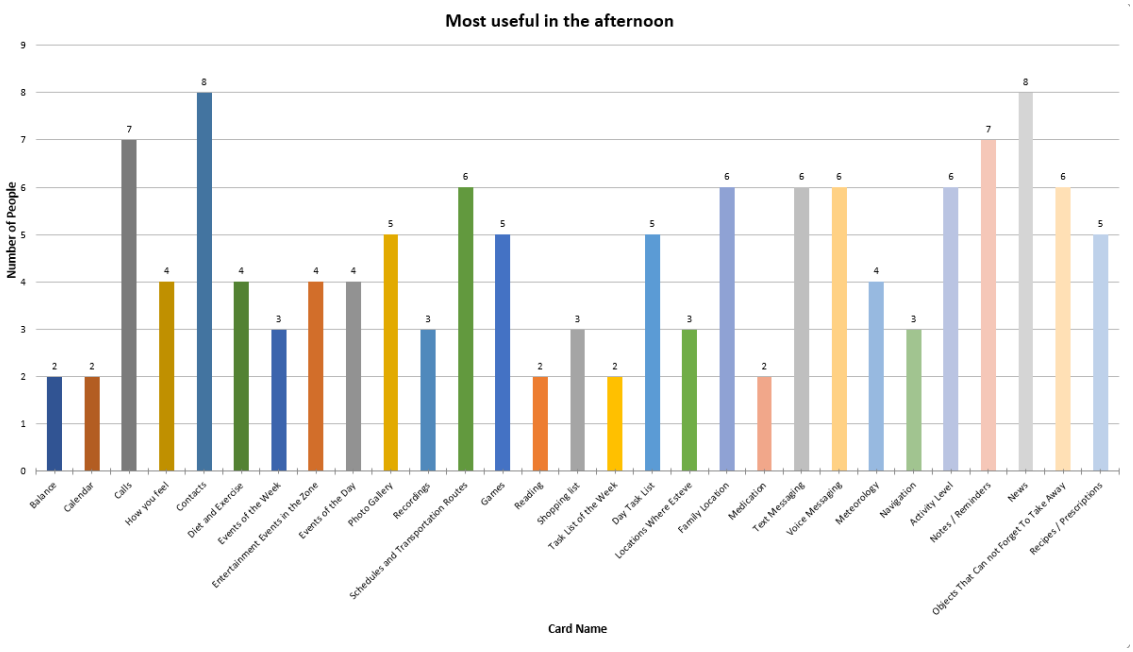

Figure 4.10: Chart with the most useful information in the afternoon for the user

At night the most useful information (see chart 4.11) for the users is news, text messages, calls, voice messages, games, how are you feeling, contacts, family location, medication, and meteorology, although most users prefer to see it in the morning. These results are not surprising since from the interviews, coding, and analysis we realize that during the day they try to be busier and at night is when they try to stay at home talking with family and friends or playing games before going to sleep.

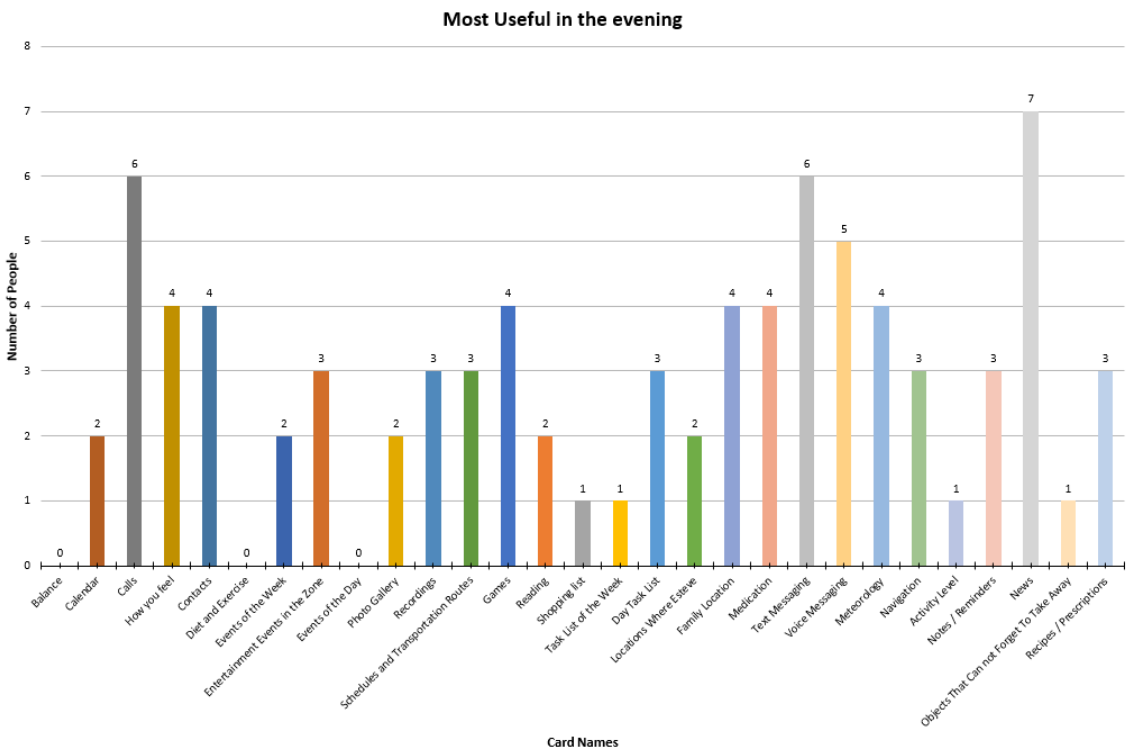

Figure 4.11: Chart with the most useful information at night for the user

In the last task, the user was asked to do the same however categorize the information according to its importance at a certain location. Meaning, if he is at home, at an event or outside the house, as seen in images 4.12, 4.13, and 4.14. Again, no time limit was imposed. Given the results, it is easy to conclude that at home the most useful information for the users is: contacts, notes/reminders, calls, meteorology, how are you feeling, and news. In a specific context such as going to the doctor, the most useful information for the users is: how are you feeling, medication, notes/reminders, prescriptions, and objects they can not forget. Lastly, when outside the most useful information for the users is: contacts, transportation schedule, notes/reminders, and objects they can not forget.

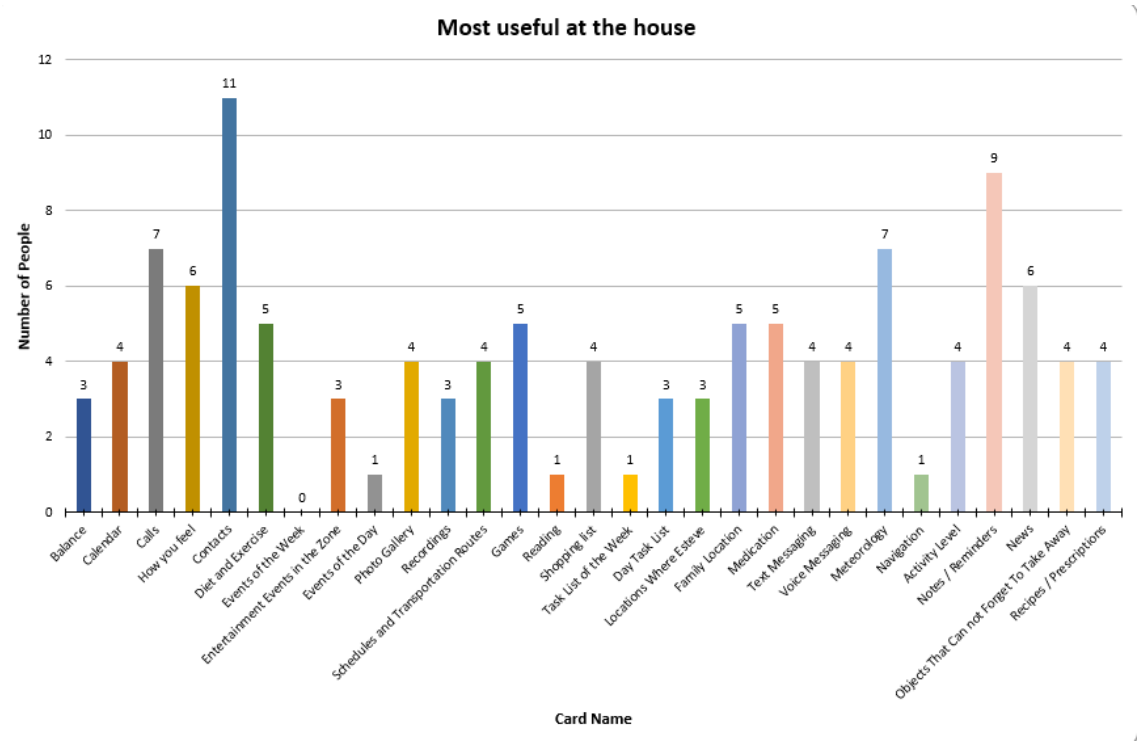

Figure 4.12: Chart with the most useful information when the user is at home

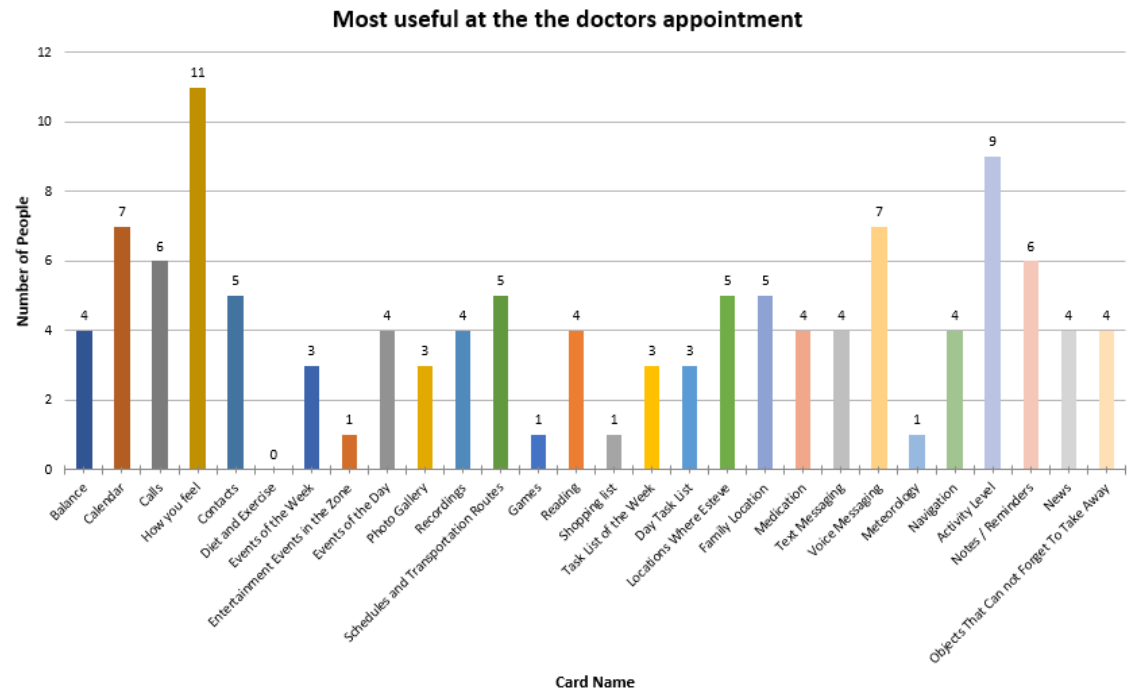

Figure 4.13: Chart with the most useful information during a doctors appointment for the user

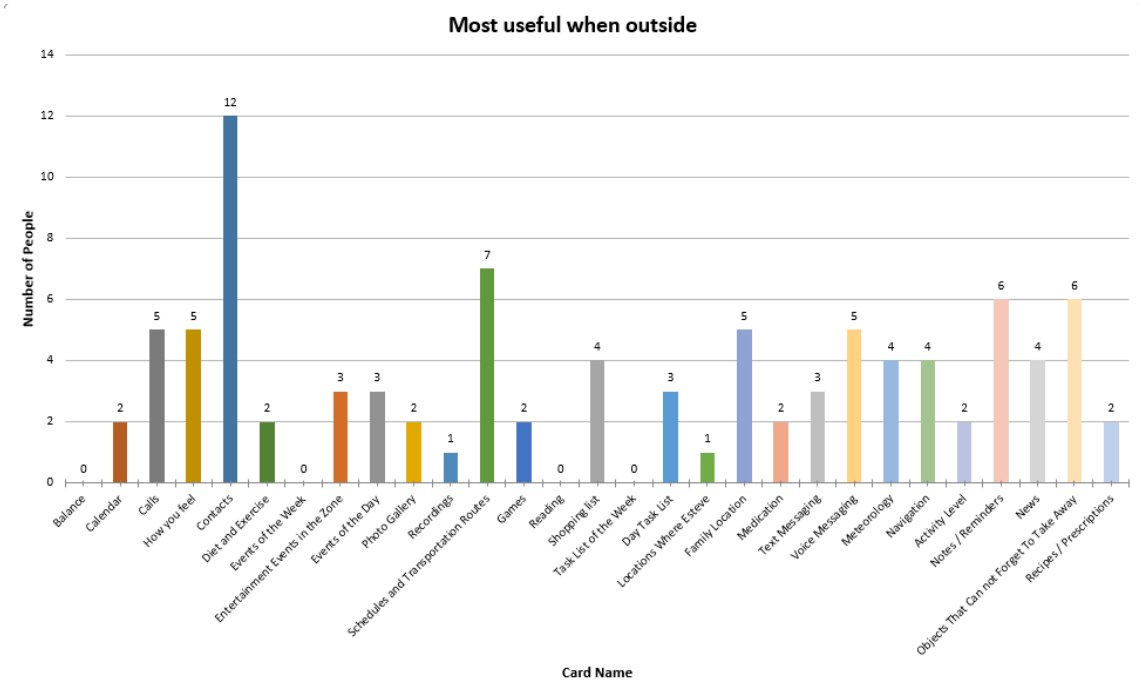

Figure 4.14: Chart with the most useful information when the user is outside

On a quick note, I would like to say that throughout the test, I encountered some problems with the information written in the cards. Many of the users were having issues with the "navigation" card because some were interpreting it as navigation on the Internet, others as GPS navigation, and others as both. Another card with which I encountered some problems was the "recipes" because in Portuguese this words, contrary to English, has the same meaning when referring to cooking recipes and medical recipes (prescriptions). And the overall users was associating it with medicines and others with culinary recipes.

At the end of the test and after analyzing the answers obtained, it is understood that between morning and afternoon the information that the users indicate has many similarities which may suggest, together with the recordings collected, that in fact the nuance between morning and afternoon is not relevant in the day-to-day of users and varies significantly with their tasks.

4.3 Solution proposal - prototyping

As stated before (in section 3) our solution is based on the use of information that Smart Companion already collects about the usage that seniors do of their smartphone. The primary goal was to design an application for older adults that displays information useful to them and related to their context.

Since what we were looking for in this project in a first phase was to test an initial concept, in the development phase we used paper prototypes. Only later we created a prototype already displayed in a smartphone.

The user interface prototyping phase began with a meticulous mapping of all the information from the interviews and the card sorting exercise which lead us six different contexts: morning, afternoon, night, home, outside and at the doctor.

However, before we start, although the the card "calls," "contacts," "text messages" and "voice" were the most voted, given the problem of this project that we are trying to answer, we will not focus on the design of these cards. Since, we would not add anything to what the system already does by default.

4.3.1 Paper Prototypes

All user interfaces were prototyped at 100% of their real size to enable a faster and flexible process. Having an overview of the users' characteristics, daily life, difficulties and ways they overcome them proved to be very useful when prioritizing the system functionalities and, as a result, the succeeding low-fidelity prototypes. All the six prototypes shown in the next sections follow the same structure of a list of cards that change according to the time of day and location of the user.

4.3.1.1 Morning Prototype Context

In this context, a set of cards is designed on the screen, see chart 4.15, according to what was extracted from the interviews and then proven by the card sorting exercise. The first card refers to meteorology. The card tries to inform the user about three things, the forecast for the day, suggest some clothing the user should take and also an icon representing the average of the weather. To see more information regarding the meteorology the user could touch in the card.

The second card refers to the news of the day. This is an important aspect of the system since many users referenced they like to be informed and read the news first thing in the morning. This card intends to inform the user of the multiple news of the day, but only showing the title of the news given they also mentioned during the interviews that they read the titles and only if it is interesting to them they will read the rest. To see the different news available, the user could use both arrows or gesture to navigate with a swipe.

The third card refers to the events/tasks the user has in their day. This is an essential card because users stated that they think about their tasks and chores first thing in the morning and end up forgetting some of them throughout the day. To see more information regarding the activities the user can touches anywhere and the system will take him to the Smart Companion calendar app.

The last card is a replacement for notes that the seniors stated to carry with them, including important things to not forget, such as numbers to call later on the day, and places to go to. This is a crucial card because users confessed to getting lost in their papers and losing some, which can result in losing important information. To see the different notes and reminders available, the user could use both arrows or a gesture to navigate.

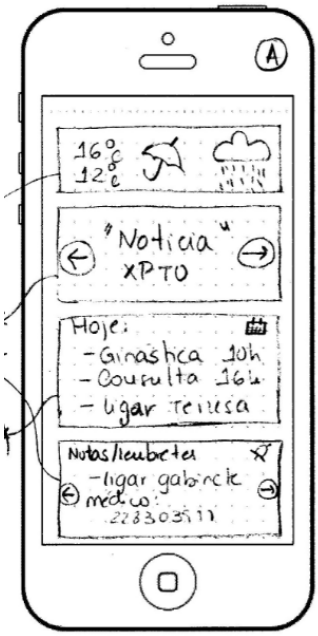

Figure 4.15: morning prototype

4.3.1.2 Afternoon Prototype Context

In the second prototype (chart 4.16) the user is shown three different cards. The first one is another layout for the Notes/Reminders card (see chart 4.15), however, if the user touches the card he will see more Notes/Reminders. The second card is one of the most challenging cards to design because from it the user is expected to understand eight things: the time the transportation leaves, from where it will leave, the type of transportation he will use, the route to take, the time he needs to leave the place he is at and what time he will get to the destination, the total duration of the trip and lastly to where he is trying to go. To get the directions and start the transit the user needs to touch the card. As shown in the card at the top we can see the time and from where the transportation leaves, followed by the route to take, in this case, 5 minutes walking to the metro and then a 10-minute walk. After it is represented the time the user needs to leave the place he is at and what time he will get to the destination, the duration of the trip and at the bottom, it is the name of the destination.

The last card is a simple card that helps the user to keep on track with his level of activity. Here we are trying to represent the different activities the user does along the day and what is his goal for the day.

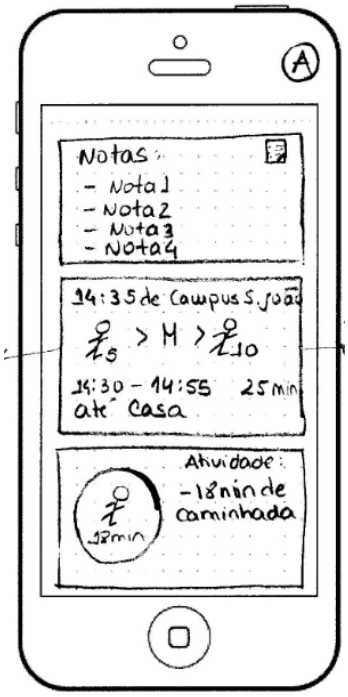

Figure 4.16: afternoon prototype

4.3.1.3 Night Prototype Context

The third prototype has three cards (see chart 4.17). At night, according to what the interviews revealed, the users prefer to watch TV, play games on a tablet and call their relatives. Therefore, there is not much required from the system. The first one is equal to the news card in the first prototype (see chart 4.15). The second card is something that some users commented to think about at night and is associated with an application already available in Smart Companion that asks the user how he is feeling. This will appear in case the user hasn't replied yet. With this application, we aim to gather historical information about the user so we can use it in the future.

The last card intends to make suggestions to the users using information from multiple sources. In chart 4.17 the card is suggesting the user to call his daughter considering she has arrived home 18 min ago. This is a card that can have multiple suggestions varying from the information the system has about the user.

This card was so appreciated among the participants that the users made some suggestions that they would like to see are reminders for anniversaries, events related with gallery expositions and paintings, events to go to, parties, and movies to watch. A participant was so enthusiastic about this idea that he shared how good this would be for him in the future when he is older.

Figure 4.17: night prototype

4.3.1.4 Home Prototype Context

The fourth prototype (see chart 4.18) is representing a context in which the user is at home. This was a difficult context for the users to understand because they had difficulties separating the days when they have something to do, from those they don't leave the house. The bulk of the users said they don't do much in the house, except for the usual chores, that they know from memory, and watching TV or playing some games. As such, this prototype has only two cards. The first one is another design for the notes and reminders card. The last card is another suggestion made to the user based on the fact the system has knowledge of the user's feeling from previous entries. The question about how he is feeling will only appear if the user has not yet answered it. After the user touches in a smile to answer a pop-up will appear for the user to give a justification with the reason for the selection. Associated with the answer the system also records the events and places the user has visited that day.

Figure 4.18: house prototype

4.3.1.5 Outside Prototype Context

The last paper prototype (see chart 4.19) is based on the cases where the user leaves the house. Here, the system will be based on the tasks and events the user has that day and the place he is at or needs to go to.

Although many reported to not use the phone very often when leaving the house, they also revealed a desire for the phone to help them remember notes and tasks, such as shopping lists. And to help them with navigation. However, the most important feature is the list of objects the user cannot forget. They all admitted this is something they wish to have because it is really useful and would help them with some memory-related changes that start to appear with age.

So this prototype has all these three cards. The first one is again the navigation card, the second one is a note taken by the user with a grocery shopping list and the last one is a list of objects the user cannot forget before leaving the house.

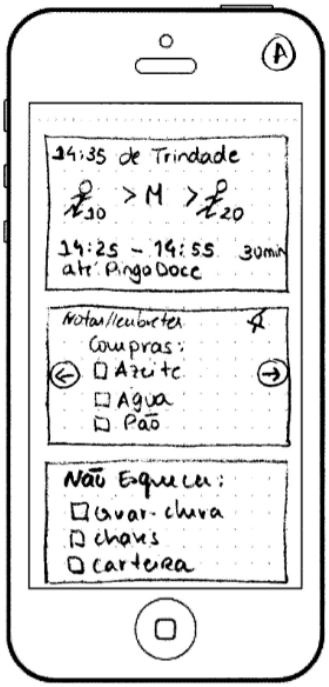

Figure 4.19: Outside prototype

4.3.2 Medium-fidelity prototype - Medical Context Prototype

The medium-fidelity prototype was developed based on the paper prototypes and designed for an Android phone with a 5-inch display. Only one of the contexts was developed since it was the only one with the majority of the consensus between users. Maybe because this is one of the only aspects of their routine that is more similar to all of them.

For this context the design is based on the four main questions asked during a doctors appointment. The prototype in chart 4.20 has two cards and two buttons that give access to the most important information during an appointment. The first card has a chart representing the history of emotions of the user in a week which can be used to answer the question the doctor makes, when he wants to know how the patient has been feeling. The second card has a list of questions the user intends to ask the doctor. Users could read through them when the doctors asks if they have any questions. This information can be stored in a text format or image. To see the different doubts created the user could use both arrows or use a swipe gesture. The first button when touched will take the user to a screen (see chart 4.21) with his medication history, containing a list of medication he is currently taking, a list with the dates where he forgot to take the medication and lastly a list with the dates he is not sure if he took. The last button will take the user to a screen (see chart 4.22) with a list of prescriptions to ask the doctor for. This last two buttons can be accessed when the doctor wants to know which medication he is on and if there are any prescriptions needed.

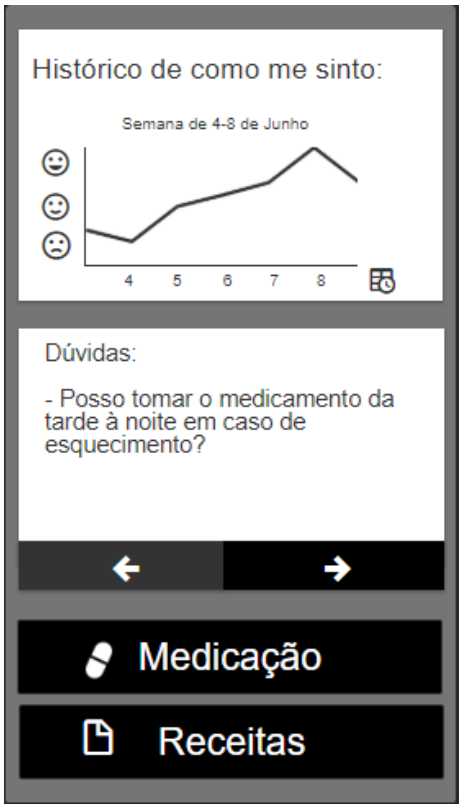

Figure 4.20: Medical prototype

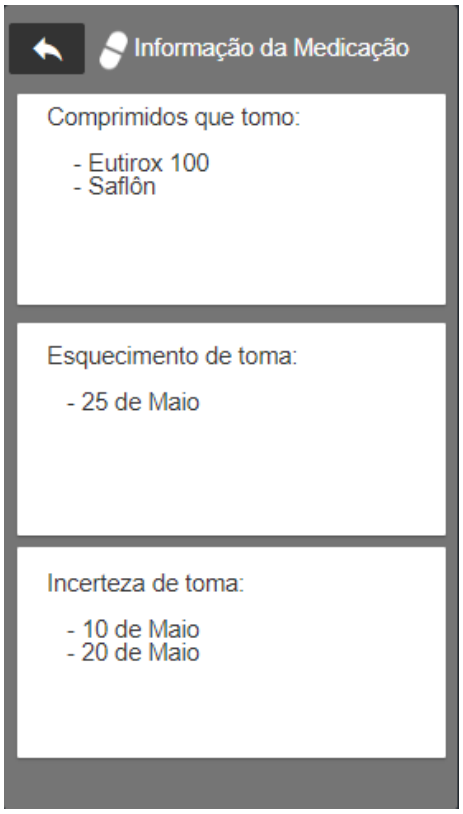

Figure 4.21: Medical history prototype

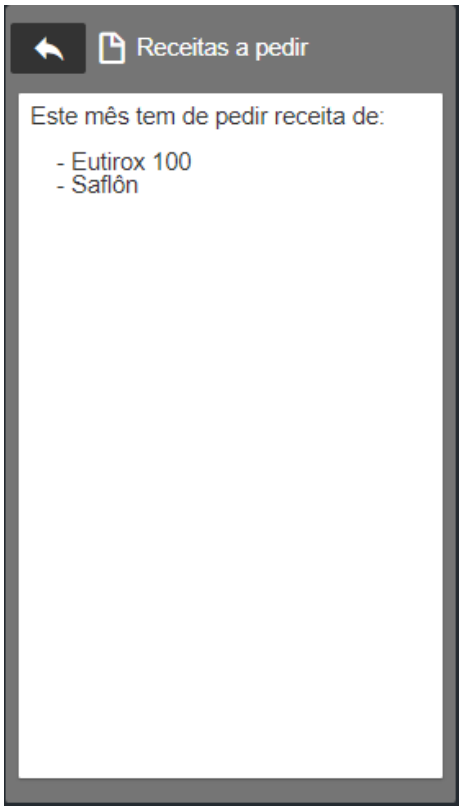

Figure 4.22: Prescriptions prototype

All the icons used in this prototypes were not tested with the user, however, during the test, they were asked about them. However, it would be useful to test this extensively. The order in what the cards appear in the multiple prototypes is not relevant since it was decided that reordering them could be a feature in the future system.

4.4 Conclusion

With these six prototypes, we try to answer the three major challenges presented by the elderly related with their forgetful practices, practices to not forget and the planning they do (see section 4.2). By making use of the contextual information that Smart Companion has access to it seeks to help seniors not forgetting anything by replicating the practices that they already use (see section 4.2). The system also seeks, above all, to help the elderly to stay busy with various activities, by offering varied suggestions (as shown in the image see figure 4.23) in order to prevent, in a way, age-related changes, such as isolation.

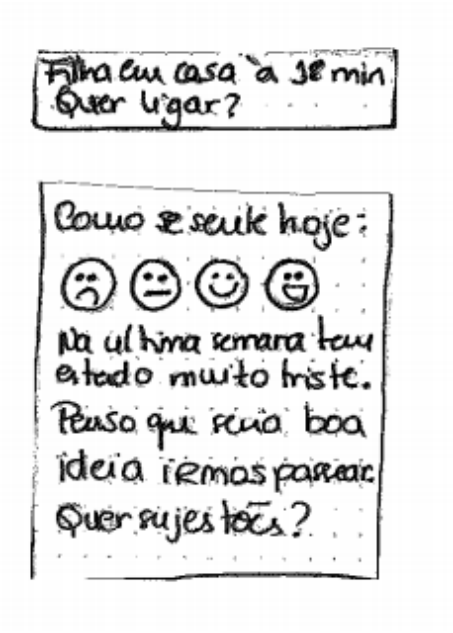

Figure 4.23: Two examples of the card with suggestions

Finally, the use of paper prototypes allowed us to have a faster response on the users' adhesion to the application, but it was also a challenge since it required the user to imagine that he was interacting with a real system. Contrary to the use of medium-fidelity prototypes, that made simpler for the users to predict the application's responses because the prototype was more dynamic.

Chapter 5

Evaluation and Discussion of results

Designing user interfaces is a challenging task, especially in the case of applications designed for an older audience. Designing for groups with so specific characteristics, as the senior population, makes it much more challenging than creating a system for the mainstream audience. With this group, a lot of information was needed to be taken into account and evaluation was a constant in every stage of the process. In this chapter we will explain the final assessment done to the system and a discussion will be made around the methodologies used and the results gathered.

5.1 Final Validation

The final and last stage of this process was the final evaluation. Due to limited time available, it was only possible to do an iteration, which required a very agile approach between tests. As such, designs were continuously being improved based on the results from previous users. This final test of the project took place at Fraunhofer AICOS with seven users with the age between 63 to 72, 4 man and 3 woman. The primary goal was not only to evaluate the system's usability and features but also know if, in fact, older adults would find it useful. Similarly to every test mentioned in this document, this evaluation followed a pre-established protocol (see appendix D) in which every task was described in detail. There were two types of prototypes used during the test: paper prototypes and a prototype tested using a mobile phone as previously described in sections 4. Even though this last prototype was fully functional, the options available were limited to the number of scenarios tested. With these prototypes, we aim to understand if the information is understood, which interaction is more suitable for each card, and, lastly, which layout is more appropriate for some cards. In a first approach it is considered that this system already knows the information shown to the users, i.e., we are not testing a system where users input information. Only in future work the system will be used not only to see but also to manage information.

5.1.1 Paper prototypes

The first part of the test was done using paper prototypes. The designs were as simple as possible, since due to age-related changes in working memory, older adults may find it challenging to interpret a significant amount of information at a time or handling complex interfaces. The test started by displaying a set of cards in front of the user, as shown in figure 5.1. The user was asked to read every card carefully and to separate them according to the time of day (morning, afternoon and night) in which the information of the cards was most useful to them. Even though no time limit was given, 4 users were having problems separating some cards because they mentioned they needed the information in the morning and afternoon. This confirms one more time, as seen in chapter 4.2.2, that the distinction between morning and afternoon is almost none. After dividing the cards, the users were asked, depending on the cards chosen, predefined questions. (see questions in appendix E). Which helped assess how much of the information was understood from the cards.

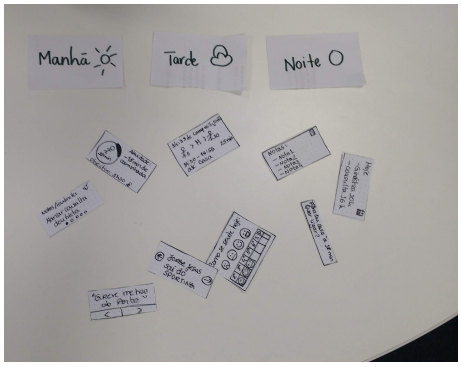

Figure 5.1: Initial phase of the test

Even though all participants were able to answer every question with no big difficulty, the card that was the most challenging for them to understand was the card with the routes and schedules of the transportations, see Figure 5.2. For this reason, this card was the one that suffered the biggest transformation (see Figure 5.3) throughout the test, being that the final version, see figure 5.4, was the one preferred by the users.

The main problems with the first prototype relied on the fact that in the route to take with the icon with ten on the bottom was confused since it did not mean anything to the user. The hours to leave and to take the transportation were also confusing. The only aspect that didn't confuse the users was the time the transportation leaves, from where it will leave, the type of transportation he will use, the total duration of the trip and lastly to where he is trying to go. So we started by removing the time he needs to leave the place he is at and what time he will get to the destination since the users admitted that they calculated this from memory using the time to catch the metro and the time they know they take to get to the metro stop. After this, we converted the route to take from a view with icons and numbers to a view using only text.

Nevertheless, 3 participants mentioned that they prefer text information to icons because, even though it would take more time to understand, it would be more clear to them. Still, icons should be considered if we want to include users that don't know how to read.

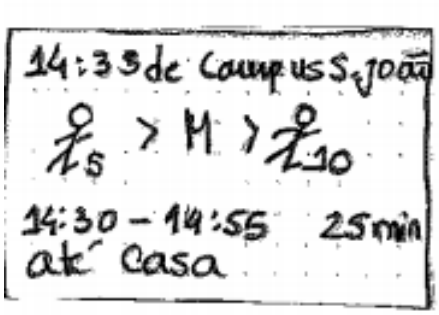

Figure 5.2: First version of routes and schedules of the transportations card

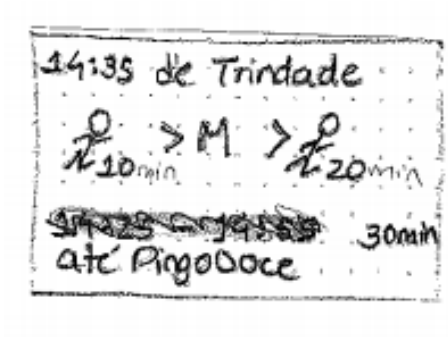

Figure 5.3: Second version of routes and schedules of the transportations card

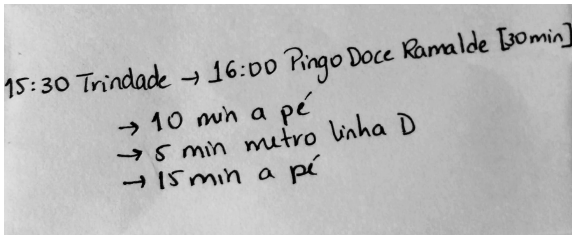

Figure 5.4: Final version of routes and schedules of the transportations card

Next, users were asked to divide this information according to a location, depending on if they were at home or outside the house.

Later on, users were asked about the layout of information in the cards and the methods of interaction in order to understand which layout they considered more intuitive.

Starting from the cards with meteorology (see figure 5.5) 3 participants admitted, that they prefer the information in the middle to be displayed in text since the icons can sometimes be

confusing to interpret. Two users said that the icons or text were unnecessary because given the temperature they could easily access the clothing to wear.

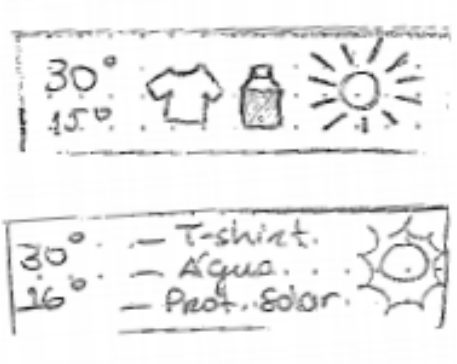

Figure 5.5: Two versions for the meteorology card with different layouts

Following the meteorology card, for the news card, 2 participants confessed that the news provider before the news title (see figure 5.6) was a plus because having a provider the reader can know if it is something of trust or not. When asked about how they would see more news 5 participants said they would scroll vertically.

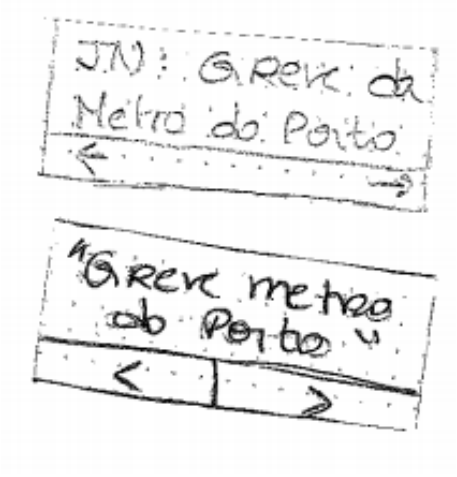

Figure 5.6: Two versions for the news card with different layouts

Even though the activity card (see figure 5.7) was not something we would focus on since Smart Companion already has this functionality, 2 participants revealed not to pay attention to the icon of the man walking and that the icon itself was unnecessarily and not helpful. They also mentioned that the objective and the time were confusing, they could not understand if there was missing one hour and a half to conclude the objective and if 18 was what was done or if 18 was what was missing to conclude the objective for one hour and a half. As an improvement, they suggested substituting the word "Activity" of "Activity done"

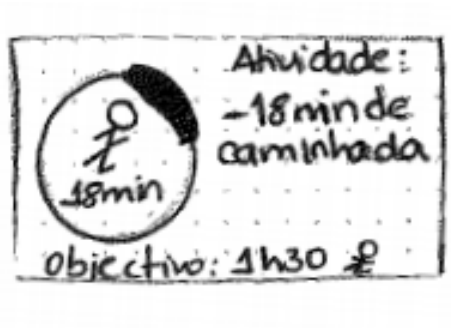

Figure 5.7: Activity card layout

When analyzing the calendar card (see figure 5.8) 6 participants admitted that the most intuitive and useful layout and interaction was the one with all the daily events listed and not the one with only one event that required the user to use a horizontal arrow navigation interface.

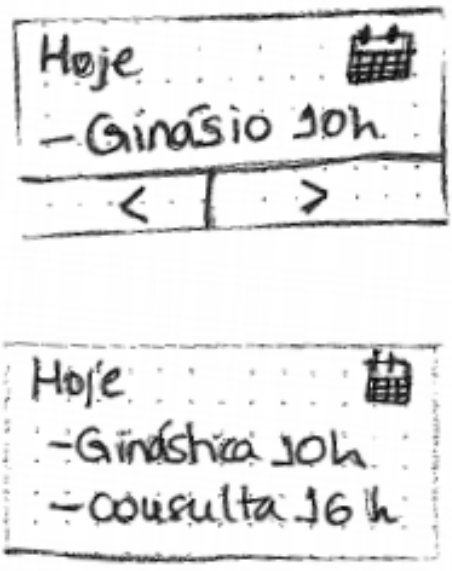

Figure 5.8: Two versions for the calendar card with different layouts

Another card that was defined by the users as something beneficial is the list of objects not to forget (see figure 5.9). When interacting with this card, all the participants agreed that it is unnecessary to mark the objects, by touching on their name, as taken. The list of the items would be enough.

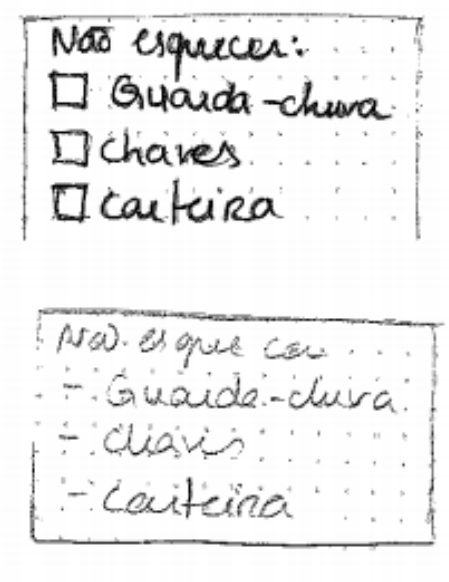

Figure 5.9: Two versions for the list of objects to not forget card with different layouts

With the notes/reminders card (see figure 5.10) a participant commented that the most appropriate icon, for him, was the one with the paper with bullet points, in the last version of figure 5.10. Other 4 participants said that seeing the notes in a list format where they could click on the titles to see the notes was more intuitive to use than the horizontal arrow navigation system. When the note is for a shopping list being able to cross the item from the list was very useful.

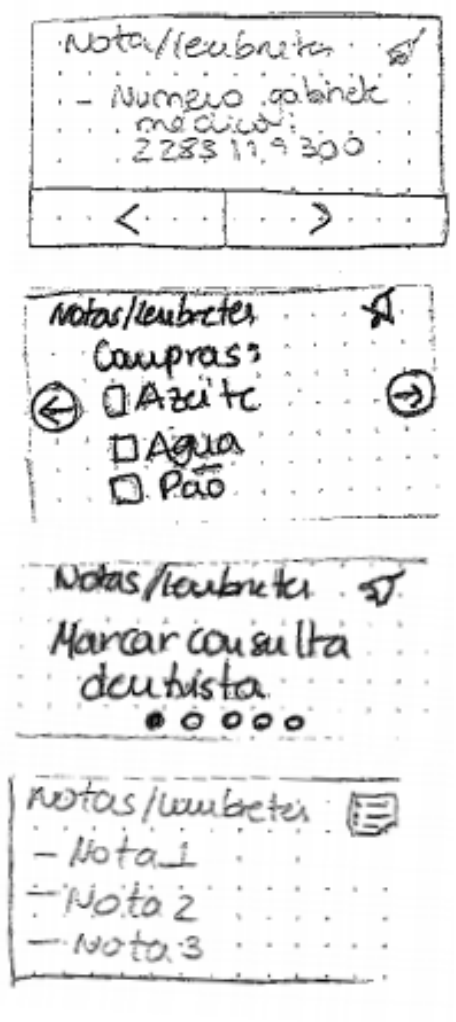

Figure 5.10: Four versions for the notes/reminders card with different layouts

Overall it was clear that, depending on the level of how comfortable the user is with smartphones, the desired iteration method differs. When asked about cards that involved lists of thing such as figures 5.6, 5.8, and 5.10 The users who had more experience with smartphones (5 users), admitted that they preferred to scroll vertically to see the information than using horizontal arrow navigation to see more content of the same type. Contrary, users with less experience (2 users) felt indifferent and said that the two models were equally intuitive for them.

5.1.2 Medium-fidelity prototype

The second part of the test was conducted using a mobile phone. After, we used a role-playing approach and asked them to imagine they were at a medical appointment, where I played the part of a doctor and asked the participant the questions stated in the appendix D. With this last test, we aimed to understand how much of the information is interpreted, if the order in which it appears

is relevant for the user, and if the older adults would be able to interact with the system and find it useful.

We decided to go into more detail in this context because most users agreed with the information needed during medical appointments and indicated it as the most useful. At the beginning of the test, the users were informed of how they could interact with the application, however, during the test, they would sometimes get confused.

This prototype started with a version (see Figure 5.11) where the medication button was at the top, followed by a chart with the emotions history of the users and a card with their prescriptions and doubts to ask the doctor. When users touched the medication button, they would go to a screen (see figure 4.21) that indicated their medication and additional info such as days where they forgot to take their medication and days they were not sure if they took it or not. This first version had many issues, starting with the medication button. The first 3 participants were having issues understanding that it was a bottom, according to a participant having the button in that place made it difficult to reach and made the user occupy all the screen which could in users unintentionally touch one of the options with their hand or wrist. With help, they would end-up by clicking on the button.

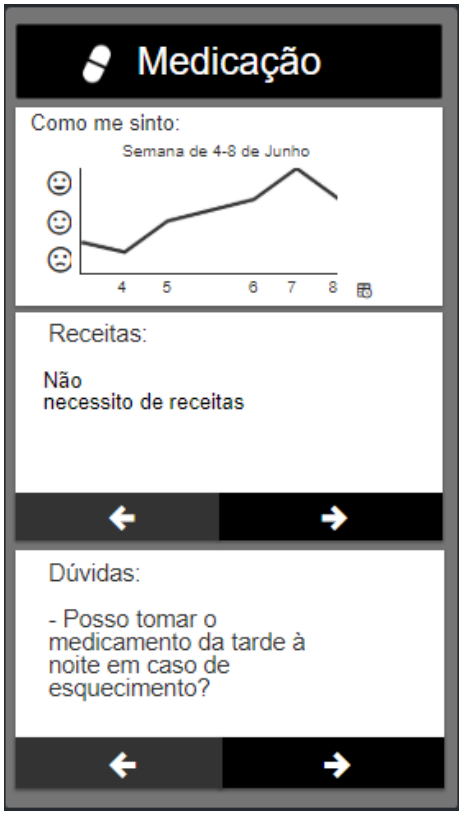

Figure 5.11: First version of the home screen for the medical prototype

The list of prescriptions was not intuitive to use since all three users would touch the prescriptions sections hoping to see their prescriptions. With help, they would understand the arrow

navigation system. However, all 3 participants admitted that it was not easy to use. When asked about the doubts section users, would carry their knowledge from the prescriptions section and navigate the doubts section without any problems. Five users praised the fact that they could be able to make notes by taking a picture of the medication and agreed that using both, text and images, was a very convenient way to create notes. With this version, the three users were always having problems and asking for help in every question.

After this first round of tests a second version (see figures 4.20, 4.21, and 4.22) of the prototype was created and tested with the help of more 4 participants. A more detailed explanation of the second version prototype is written in section 4.3.2. Many of the issues were resolved with this version.

When asked about the medication they were taking, the rest of the participants were able to accomplish the task very quickly. However, when asked about the "Doubts" section 3 participants got confused about what to do after asking the first question. Which indicated a problem in the interface design: the users were trying to touch the card and expected it to expand to the next questions or open another page with every question. However, what was expected of them was to click on the arrows at the bottom of the card. It showed us the importance of having a consistent interface design since with the "medication" and "prescriptions" button this was the interaction used. When asked about how they were feeling, according to the data in the application, users were quick to provide the needed information, which reveals that the graph was enough on its own.

If more time was granted a second iteration of this system should have been done, to evaluate a more proper size and complexity of all icons, texts, and images used.

5.1.3 Conclusion

At the end of every test users were asked if they liked the experience and all participants answered positively. Concerning challenges with the prototypes, a lot of users found the card regarding transportation to be difficult to read. The only icon that confuses some of the users was the icon of a man walking used in two cards (see Figure 4.16). Concerning the challenges encountered, only one participant found that 1 or 2 tasks were more challenging to perform. As to the utility, the participants would give the system, only one person revealed not to use it, since he was already comfortable with his iPhone. This shows that the product could have a good acceptance among seniors. However, it is also evident that the system is still a work in progress and that a long way is needed to reach a final product.

5.2 Discussion

5.2.1 Expected results

Since the beginning of the project, it was known that designing for a specific audience such as this one would be daring compared with applying the same method with the mainstream audience. For

this reason, using UCD together with a PD approach was crucial to keep the users' characteristics and constraints in mind throughout all the development process. Starting with the literature review on aging we were able to achieve the knowledge needed to identify an extensive range of age-related changes that could impose barriers to our design (see chapter 2 for more information). With the help of interviews, at a daycare center and Fraunhofer AICOS, and their codification it was possible to establish a more accurate definition of the audience's characteristics and context. The results from the codification were a valuable asset for this project since it gave us the three pillars that we used to guide the development phase, which aligned with the card sorting test, was a valuable insight into the daily life of our users. It gave us a deep insight into seniors preferences and difficulties regarding specific contexts throughout the day. With all of the information gathered from these techniques, the development phase began, with the creation of low-fidelity prototypes of five contexts of use and the creating of a medium-fidelity prototype for the medical setting. Both prototypes were tested with older adults' that were invited to come to Fraunhofer. Regarding the medium-fidelity prototype, testing with the users was a valuable experience because their feedback allowed us to achieve results that indeed consider their characteristics and preferences. The use of low-fidelity prototypes, although challenging, proved to be a good choice since it allowed a bigger exploration of ideas and encouraged users' feedback regarding essential aspects and not only the aesthetics of the prototypes. The next step is to develop a series of high-fidelity prototypes to test the usability of the system as a whole, with functionalities, naming conventions, icons, element positions and interaction methods. As expected the project proved that a context-based system is something older adults would appreciate having and it would be without a doubt something beneficial for them. It demonstrates that the project has the potential to be well accepted by older adults, implying that the assumptions on which this project was proposed upon were in fact correct.

5.2.2 Working with older adults

Along the way, this project presented some challenges, however, the biggest one, and at the same time the biggeste privilege, was to perform interviews and validations with older adults. First of all, without the help of the COLABORAR [col] network, the access to this audience would be almost impossible. They allowed me to work in partnership with a daycare center and other seniors that came to Fraunhofer voluntarily, providing me a direct contact with this audience. But there were some constraints regarding the time we spent with seniors due to their routines, and, for that reason, the sessions performed had a total duration of two hours each. Managing a session in itself was defying because depending on older adults' daily disposition, some could go better than others. It was imperative to understand and ask them at the beginning of every session if they were in the mood to help us that day. Throughout the sessions, it was also important not to fatigue them, that is why it is crucial to inform them at the beginning that the session can end when needed. Another aspect that was difficult to manage was when older adults were eager to share their life stories or daily event which increased the time needed to perform a session. Attending to their needs and adapting our speech was also important due to regular age-related changes in speech, language, and hearing. Doing it with a patronizing speech can make the participant

feel frustrated or irritable with the session, asking to leave earlier [BCC15]. Therefore, we paid particular attention to literature that provides guidelines on how to communicate with older adults [BCC15] as well as more general guidelines for working with this audience that I got the chance to learn with the COLABORAR network. Given all these circumstances, the number of users that I had the pleasure to work with was more than expected. In the end, the project counted with the help of more than 15 older adults which, considering this is a project that is in a primary stage, should be enough to prove this project has a future ahead.

5.2.3 Lessons Learned

Throughout the development of this project a number of interesting findings appeared. The lessons learned that should be carried to future projects are:

- when it comes to interaction, seniors prefer vertical scrolling to horizontal arrow navigation systems.
- they also prefer interfaces where they can touch a button to see more information.
- using pictures to make notes is an idea that amused participants. Since it was more visual and faster to take written notes. Complementing communication with images revealed to be a plus.
- letting users customize the order in which the information in the screen appears is something the participants considered a plus. After analyzing the results of the tests, it is clear that making these kinds of applications personal for the user is something that could help with the adaptation to the system.
- the interfaces should be as easy and as direct as possible or the goal to assist the user with contextual information will be unsuccessful.

Chapter 6

Conclusion and future work

With the continually growing use of smartphones, thousands of data are created and stored every day. To generate information from this data is becoming increasingly important to provide people with simpler mechanisms to represent it and interact with it. When the recipient of the information are older adults the importance of providing them with a set of conditions that promote better decision making increases. The advantages that the use of technology affords to seniors are undeniable, they could help prevent and mitigate the many changes that come with aging. It gives seniors an opportunity to enhance their quality-of-life through the use of a variety of mechanisms and promotes successful aging. These systems can be a tool to increase their overall well-being and assist them throughout the aging process.

As such, designing systems that can meet older adults' needs and that consider their characteristics and capabilities, while considering some personalization, such as their preferences, has the potential to revolutionize their lives. It is crutial to always make sure not to add too much complexity, making them impossible to use. User-Centered Design along with Participatory Design was used to focus on older adults creating a design that can easily be used by them.

This thesis had the primary goal of analyzing, designing and evaluating a contextual information system for older adults. Through an extensive understanding of the target audience, as well as a profound study of the context of use, of not only smartphones but also other techniques revealed to us by the users, we were able to propose a solution that we believe to have the potential of acting as a first step towards including contexted-based technology, which provides the user with more natural and intuitive interactions while increasing their overall well-being through the use of environmental information. The fact that there are no similar products to this one, and after hearing the feedback from the participants, we believe this solution is a valuable contribution and the foundation for future research and implementation of similar products.

The goals defined at the beginning of this project were successfully achieved. To investigate the older adults' specificities and gather which information is relevant to them, we conducted interviews with the users. Besides this, a thorough study using thematic analysis helped create a

more in-depth description of the user and the contexts related to this information. To design the data in a simple and meaningful way, centered around the user, many prototypes were created and iterated based on the users' feedback. This helped us understand how and when the information needs to be shown to the user so that he can take the most benefit from it.

In the future, some improvements could be made to the developed solution. In a first stage, it is essential to study the incorporation of different types of interactions besides touch, since using multiple modalities could make it usable for a broader group of users. Also, if more time was available, a second iteration of this system could have been done, to evaluate a more proper size and complexity of all icons, texts, and images used. More metrics could be added during the tests using high-fidelity prototypes so the usability of the system could be properly measured. A long-term evaluation of this application could also be done by delivering mobile devices to a group of older adults during several months to understand if, on a daily basis, these systems would add value to their lives and assist them when needed. Since one of the long-term objectives of this project is to also achieve a mainstream audience, it is suggested that besides the long-term evaluation, some evaluations can be done with other populations. This evaluation could help us analyze how easy it is to adapt an application's design for older adults to other age groups and gather the benefits of this choice. On the last note, something suggested by the older adults, concerning the suggestion card, would be to create suggestions based on the preferences of the user. This could be achieved with the use of machine learning.

Finally, the preliminary results gathered from this project indicate that the system satisfies its objectives, as it is perceived to be very useful by older adults. However, for a final project, more work needs to be done.

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Appendix A

Script

A.1 Objective

Collect information on a personal level to perceive the day-to-day life of the participants.

A.2 Purpose of Interview

- Understand the most important information for users
- In what does their day-to-day routine consist.
- What are their main concerns
- How they manage their health, namely in taking medication and medical consultations.
- How do they get around in their daily lives?
- How much they use their mobile devices and how they can help deal with some day-to-day problems.
- If it is possible for them to have more autonomy in their management.

A.3 Questions

1. When you wake up, which is the first one you want to try to know/think about?
2. And how is your day-to-day? Can you describe a day in your life?
3. How do you know when to take your medication, and how do you know if you already had it or not?
4. How do you keep track of your medical appointments? - Do you expect them to remember (message) or keep a calendar?

5. What do you think about before you leave home? - how do you know what to take with you, what to wear, how to reach the destination?
6. When you need to go to a place you didn't know before, do you the search the rote before? How? Do you ask for help along the way?
7. How do you know the transportation routes and schedules?
8. During the day what is your biggest concern?
9. Is there any particular object you often forget?
10. If you receive a call and are given important information, where do you record it? If you only remember something in the middle of the day, how do you do it?
11. Do you often receive important emails? Can you give me examples.
12. Do you usually read the news? At where?
13. Do you usually accompany any sports team? How do you keep up with the news?
14. How do you maintain contact with your family? In particular, if you have relatives outside the country?
15. Do you usually make a shopping list? Whenever something ends or immediately before going shopping?
16. Do you travel? Who / how do you manage with the associated markings?
17. Do you take many pictures? To what?
18. When you are going to sleep, where do you leave your cell phone? Why?
19. Do you use a mobile phone? What do you consider to be the top 5 features of your mobile phone?

Appendix B

Personas

António Manuel

Age: 79

Job: Retired

Previous job: Mechanical followed by Owner of a small business

Education: bachelor

Location: Braga

Disabilities: partial memory loss

Family: no children

Hobbies: Reading

civil status: Married

Context

Antonio is a 79 year old man. He owned a small business that he sold after getting injured in an accident 2 years ago. He now lives only with his wife. that is the one that looks after him. He attended and graduated college. He is a very communicative person and has a lot of friends.

Routine

A normal day in Antonios' life is spent more or less like this: He wakes up, followed by taking the meds his wife prepared for him. Then he dresses and takes a bath if needed and after he is all cleaned and ready he goes outside to the garden and reads the news in his mobile phone.while his wife prepares them something to eat. When they finish he likes to go outside to have a walk and talk with the neighbors. After lunch he likes to read something new and browse on his computer about topics of interest. Sometimes they also go drink coffee to theirs friends house and stay there the afternoon. They have dinner alone at their house. And sometimes they go to dinner. At night and after the kitchen is clean they prepare for bed and sit on the couch and watch television until they start to get tired.

Health Information

Antonio doesn't have many mind health related issues, in part, because he is a very communicative person. He is forgetful and depends on his wife to give him his meds. However he has been feeling some challenges when climbing stairs or walking for long periods of time.

Technical knowledge

He owns a computer and a smartphone that he uses regularly. Given his previous job he had to learn how to use computers and soon he understood the power of these technologies when understood. He likes technology and enjoys to learn how to use it better. He also has a land phone, however he doesn't use it very often.

Fears and trust

His biggest fear are forgetting to close doors and windows or objects and to take his medications. He feels his health declining, which causes him to face old age in a very negative way.

Motivation

Antonio would really like to improve her overall health.

Emilia Santos

Age: 72
Job: Retired
Previous job: dressmaker
Education: fourth year
Location: Porto
Disabilities: Diabetes
Family: 2 kids and 3 grandchildren
Hobbies: nitting and sweing
civil status: Widowed

Context Emilia Santos is a 86 year old grandmother that loves to be surrounded by people. She has two children that she loves very much. She can lives in Porto in the same building as her daughter. She is a very social person and enjoys going out with her friends. She is also a religious person and goes to church every sunday morning. She only has the primary class in terms of literacy. Because of diabetes she needs to be very careful with her medication and her meals. She cooks for her and sometimes her kids. She loves to help with everything that she can and helps her children by taking care of her grandchildren.

Routine A normal day in Emilia life is spend more or less like this: she wakes up, and starts by thinking about what she has to do in her day, followed by taking her meds because some need to be taken before breakfast. Then she prepares a cup of coffee and something to eat. After she likes to take care of the house and tidy everything she can. However given her condition she now takes

longer to perform these tasks. Then she takes a bath and exits the house to take a walk outside and take to her neighbors. when she is back she starts preparing her lunch, for her and sometimes her grandchildren. After this depending on the weather she likes to go back outside and get some fresh air. when she is back she likes to read and do some sewing work. When her daughter comes home, she goes to her house which is in the same building and they go to the kitchen to talk while making dinner. At night and after the kitchen is clean they sit on the couch and watch soap operas until they get tired and fell asleep. She also likes to listen to music, radio and watch the news on TV.

Health Information Emilia's main concern is related with diabetes because she needs to monitor not only her blood sugar but also tracking the blood pressure, weight, and foot health, as well as the number of steps walked throughout the day. She normally goes to the doctor which is time consuming. She also complains that sometimes it is tiring to manage these diseases.

Technical knowledge Emilia doesn't like to use computer. She does not want to learn how to work with them, although she sees the benefits. She has a smartphone and her daughter is teaching her how to use it better. She uses her mobile phone mainly to call her friends and family and send text messages. She also has a cable line phone that she also uses. Her finances are taken care by her children.

Fears and trust Emilia's biggest fear is that something happens to her kids. And that because of diabetes she might lose a leg or other parts of her body and became a burden to her family.

Motivation Emilia would really like prevent her disease from escalating. She would like to manage her health better and get more motivated and motivate her friends and family to take care of their health.

José Alberto
Age: 64
Job: Retired
Previous job: Goldsmith for a few years followed by master builder
Education: fourth year
Location: Porto
Disabilities: None
Family: one daughter and 2 boy grandchildren
Hobbies: Running
civil status: Married

Context José Alberto is a 64 year old grandfather that loves to be active. He lives alone in Porto. With his and his wife retirement they can afford to live in a spacious house for the both

of them. Last year they moved to a house closer to their daughter. José is a man that likes to be informed, so he reads the news in the paper and lots of different books. He also enjoys to be active not only mentally but also physically. He goes run at least once a week. when he can't run he likes to take long walks with his wife. One of the best things he likes to do is learn new things.

Routine A normal day in Joses' life is spent more or less like this: He wakes up, followed by taking his meds because some need to be taken before breakfast. Then he dresses and takes a bath if needed and after he is all cleaned and ready he goes outside to buy the newspaper while his wife to prepared them something to eat. While he is eating he likes to read the newspaper. when hey finish he likes to go outside to have a walk and talk with the neighbors. If there is still time before breakfast, and if the weather is favorable, he likes to go for a run. After lunch he likes to read something new and browse on his computer about topics of interest. Sometimes they also go to their daughters house and stay there the afternoon watching TV and making company to the boys. Dinner is served at their daughters house and very occasionally they have dinner alone at their house. At night and after the kitchen is clean they sits on the couch and watch television until they start to get tired. when they are ready they prepare and go to bed. While in they daughters house he talks with people and discusses topics that he has read.

Health Information Jose doesn't have many health related issues because he is a very active and communicative person.

Technical knowledge He owns a computer and a smartphone that he uses regularly. Given his previous job he had to learn how to use computers and soon he understood the power of these technologies when understood. He likes technology and enjoys to learn how to use it better. He also has a land phone, however he doesn't use it very often.

Fears and trust Given the fact that his wife is getting more forgetful over the years and less active. His biggest fear is that his health may start to decline, especially when it comes to memory.

Motivation Jose would like to keep on being this healthy for the rest of his life. and he makes an effort to keep on track with dieting as well.

Maria Teresa
Age: 88
Job: Retired
Previous job: Secretary
Education: fourth year
Location: Ovar
Disabilities: Spinal problems, can't bend; memory a little debilitated; wears glasses
Family: 1 Children
Hobbies: jewelry

civil status: Widowed

Context Maria Teresa is a 88 year old grandmother that enjoys people. She lives alone in Ovar. She lives out of her retirement payment of 1000 euros. Which after paying her meds is not that much. She likes to interact with people, however she admits to feel a little lonely. She enjoys having everything clean however her health problems keep her from doing it as she would like. So when she needs help she calls her son.

Routine A normal day in Maias' life is spent more or less like this: she wakes up, however she likes to stay a little bit in bed, followed by taking her meds because some need to be taken before breakfast. Then she prepares something to eat. After she likes to take care of the house and tidy everything she can. However she gets chess pains which do not allow her to keep on cleaning for longer. Then she takes a bath and if needed she exits the house. When she is back she starts preparing her lunch for her. Other times she goes to have lunch at her sons house. After this depending on the her motivation she likes to make some jewelry, listening to the radio or watching TV. During the afternoon she, sometimes calls some of her friends and family. When is time she goes to the kitchen to talk while making dinner. Some nights she might go to her sons house. At night and after the kitchen is clean she sits on the couch and watch soap operas until she feels tired. Because she doesn't like to be alone she likes to fell asleep with the radio on. She also likes to read the newspaper every time she can.

Health Information Maria's main concern is related with her spine. She feels tired really fast, and can't do some moviments.

Technical knowledge Maria doesn't like to use computer. She would like to learn how to work with them, though she doesn't have the money to buy one. She has a smartphone that she uses mainly to call her friends and family and send text messages. She also has a cable line phone that she also uses. Her finances are taken care by her son.

Fears and trust Maria's main concern is related with robaries and car accidents. she is always worried that something might happen to her son or her grandchildren. She is always worried about losing things.

Motivation Maria would like to be more independent. even though her health does not help.

Appendix C

Card sorting Protocol

C.1 Users

We expect to recruit 13 senior users, aged 65+. Participants are characterized by having an active lifestyle and do not attend care centers or live at retirement homes.

C.2 Context of product use

C.2.1 Facility

The sessions will take place at Fraunhofer AICOS, in the living lab. The environment is relaxed and simulates a living room, so that users feel more at home and comfortable to talk about their life. The setting seems appropriate given the fact that this project aims to be used in their day-to-day life. With this session, we aim to understand three crucial aspect of this project:

- which information is more relevant for the user in their day-to-day life,
- which is the interaction modality that they prefer to use in different cases and,
- to understand how the information being displayed can vary throughout the day.

C.2.2 Participant's computing environment

No computers will be used in this session.

C.2.3 Display devices

Given the goal of the session in this first phase no device will be used, however, we will use paper prototypes.

C.3 Test procedure

C.3.1 Scenarios to be tested

The first task to be made consists of displaying in front of the users a set of cards with sketches of possible information that can be presented to the user. For example, his events of the week, his tasks, etc. The user will be asked to say if this information is something useful to him or not, by answering 'yes' or 'no'. In this primary task, no solution will be considered correct or wrong, and it will end when there are no more sketches for the user to see. No time limit will be imposed on the user. In the second task, the user will be asked to order the information, meaning the cards he said 'yes' to, according to its importance in his morning, afternoon and night. Again, no time limit will be imposed. Lastly, the user will be asked to do the same however varying from the location. Meaning, if he is at home, at an event or outside the house. And again, no time limit will be given.

C.3.2 Participant general instructions

Introduction:

"Hi my name is Inês, and I would like to thank you for time. Today I want your help with a project I'm developing here at Fraunhofer. I'm developing an application to assist seniors in their daily life. Here I have some elements (show sketches) that I will be using in the application, and I need your help to evaluate if they are appropriate for you. Don't worry if you don't know something about what I ask you, and it is not you that I am evaluating but the elements. Here we are trying to understand if they are adapted to you, not the other way around. If you have any question or don't understand what I ask, ask me to clarify it."

C.3.3 Participant task instructions

a) "Can you please read all these cards out loud and tell me if they are useful to you? By answering 'yes' or 'no'?"

- Present the cards

b) "Now imagine that you have woken up and you look at your phone. Which information would you say is of most interest to you in the morning?"

- Let the participant choose the cards.

c) "Ok, good choices. Now, can you explain why you chose those cards?"

- Keep them in sight

d) "Now imagine that is the afternoon and you look at your phone. Which information would you say is of most interest to you in the afternoon?"

- Let the participant choose the cards.

e) "Ok, good choices. Now, can you explain why you chose those cards?"

- Keep them in sight

f) "Now imagine that is night and you look at your phone. Which information would you say is of most interest to you at night?"

- Let the participant choose the cards.

g) “Ok, good choices. Now, can you explain why you chose those cards?”

- Keep them in sight

h) “Now let us imagine that you divided them according to the place you are at. For instance, you are at home. Which information would you say is of most interest to at home?”

- Let the participant choose the cards.

i) “Ok, good choices. Now, can you explain why you chose those cards?”

- Keep them in sight

j) “And now let us imagine that you are at the doctors’ office. Which information would you say is of most interest to there?”

- Let the participant choose the cards.

k) “Ok, good choices. Now, can you explain why you chose those cards?”

- Keep them in sight

l) “And now let us imagine that you are generically outside. Shopping or just walking. Can you tell me which information would is of most interest to you?”

- Let the participant choose the cards

m) “Ok, good choices. Now, can you explain why you chose those cards?”

- Keep them in sight

Appendix D

Usability Test Protocol

D.1 Users

We expect to recruit 7 senior users, aged 62+. Participants are characterized by having an active lifestyle and do not attend care centers or live in retirement homes.

D.2 Context of product use in the test

D.2.1 Test Facility

The tests will take place in Fraunhofer AICOS, in the living lab. The environment is relaxed and simulates a living room so that users feel more at home and comfortable to take the test. The setting seems appropriate given the fact that this project aims to be used in their day-to-day life. With this test, we aim to understand four crucial aspects that are critical for this project:

- Understand if the information is well organized
- If it is understood
- Which interaction is more suitable for each card
- And, lastly, which layout is more appropriate

D.2.2 Participant's computing environment

Only for one of the test will a device be used. The device is an Android version 7.1.2. The rest of the tests will be conducted using paper only.

D.2.3 Display devices

The device to be used is Nexus with a 5-inch display. With IPS LCD capacitive touchscreen, and 16M colors. Lastly, its resolution is of 720 x 1280 pixels, 16:9 ratio (294 ppi density).

D.3 Test procedure

D.3.1 Scenarios to be tested

The first test to be made consists of displaying in front of the users a set of cards with sketches of cards to use on the screens. For example, a card with the weather for the day, the news of the day, etc. The user will be asked to divide this information into morning, afternoon and night. In this primary test, no solution will be considered correct or wrong, and the test will end when there are no more sketches for the user to divide. No time limit will be imposed on the user. In the second test, the user will be asked specific questions, depending on the cards chosen, to access how much of the information he can understand from the cards. Again, no time limit will be imposed. Following this the user will be asked to divide this information according to a location if he is at is at home or outside the house. No time limit will be imposed in this step of the test. After this, the user will be asked to select for certain cards which layout he finds more intuitive. Again, no time limit will be imposed and some question will be asked depending on the cards chosen. Lastly, the user will be asked to imagine he is at a medical appointment, where the interviewer will play the part of a doctor and ask the participant the questions stated in the appendix A. And again, no time limit will be given. The last test aims to understand how much of the information is understood and if the order in which appears is relevant for the user. This last test is conducted using a mobile phone.

D.3.2 Participant general instructions

Introduction: “Hi my name is Inês, and I would like to thank you for time. Today I want your help with a project I’m developing here at Fraunhofer. I’m developing an application to assist seniors in their daily life. Here I have some elements (show sketches) that I will be using in the application, and I need your help to evaluate them. Don’t worry if you don’t know something about what I ask you. It is not you that I am evaluating but the elements. Here we are trying to understand if they are adapted to you, not the other way around. If you have any question or don’t understand what I ask, ask me to clarify it.”

D.3.3 Participant task instructions

a) “Can you please read all these cards out loud and divide them according to this categories?”

1. Present the cards
2. Show categories (morning, afternoon and night)

b) Ok, good choices. Now, I will ask you a few questions related to the information in those cards, okay? If you have any questions don’t hesitate to ask me to clarify.”

1. Present the cards

c) “Can you please read all these cards out loud and divide them according to this categories?”

1. Present the cards
2. Show categories (home, outside)

d) "Ok, good choices. Now, I will ask you a few questions related to the information in those cards, okay? If you have any questions don't hesitate to ask me to clarify."

1. Present the cards

e) "Now, I will show you some layout and different interactions for the cards can you tell me which you prefer and find more intuitive? If you have any questions don't hesitate to ask me to clarify."

1. Present the cards

e) "Now, we are going to do something a little bit different. Here is a mobile phone with the information that you would see on your phone when you would be at the doctors' office. I will play the role of your doctor and ask you a few questions that you will get the information to reply from the mobile phone. If you have any questions please don't hesitate to tell me."

1. Hand over the phone
2. Start Role Play:

a) "Hello good afternoon. How have you been feeling these past few days?"
b) "Can you tell me what medication you are taking at the moment?"
c) "Do you need any prescriptions?"
d) "Do you have any questions that you would like me to clarify to you?"

Appendix E

Questions for cards

E.1 Meteorology card

1. Can you tell me what temperature is indicated on the screen?
2. According to what is on this screen, is any indication given to the user of some object that they should take with him? Which one?

E.2 News card

1. What is the title of the news that appears on the screen?
2. How would you do to see more news?

E.3 Events/Calendar card

1. According to what appears on the screen what events does the user have to do?
2. What time are the events?
3. How would you do to see more events?

E.4 Notes/Reminders card

1. What note/reminder are they indicated on the screen?
2. How would you do to see more notes/reminders?

E.5 Routes and transportation card

1. Looking at the screen, let's pretend you are getting a means of transport in a bit, can you identify which transport you will have to pick up?

2. At what time and from where does the transport depart?
3. How long will the trip take?
4. How many minutes will you have to walk?
5. How far will you go?

E.6 Activity card

1. How many minutes was the users' activity?
2. What is the objective indicated on the screen?

E.7 How are you card

1. Let's imagine that you are thrilled because you came here to talk to me. Looking at this screen how would you indicate that you are thrilled?
2. Can you understand from this screen how the user has felt throughout the week?
3. What days were him the happiest?

E.8 List of objects to not forget card

1. Looking at this screen can you indicate which objects are meant for the person to remember to take before leaving the house?

E.9 Suggestions card

1. Did you find this card useful?
2. What other suggestions would you like to see?

E.10 In the end

1. Do you have any suggestions or alterations you would like to make to this sketches?