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Technologies for Supporting Social Participation

With a Focus on Intergenerational Interactions

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Abstract

Loneliness increases mortality risk by 50% and is one of the main causes of depression. Several factors like living far away from the family, not being able to move much due to physical problems, or being unable to use communication technologies favor the likeliness of feeling lonely, especially in later life. We propose Lifehsare, a system for intergenerational communications that facilitates connecting people, enabling them to participate in the life of each other either in an active (synchronous interactions) or passive (asynchronous interactions) way. Current proposals for intergenerational communication do not address the problems related to the lack of time to share and lack of topic to talk that young usually have when interacting with their older relatives. Our proposal addresses these problems by implementing a method that requires no effort to share on the side of the young and by automatically enhancing the shared information. Furthermore, our experience with the evaluation of our proposal was translated into design recommendations that extend the current literature on design guidelines for applications for older adults.

Keywords

Social Wellbeing, Older adults, Interaction design, Intergenerational communication, Design guidelines

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Chapter 1

Introduction

Social interactions affect our health and wellbeing. People that are socially active usually have a happy life [28, 47, 21], while people who lack social interactions are vulnerable to loneliness, which can derive in depression [8, 27] and an increased mortality risk [30]. Our work leverages on the advancements in communication technologies to help the people that are vulnerable to loneliness by reconnecting them with the people that they care the most, enabling them to participate in life again and consequently, improve their social life and their general wellbeing.

1.1 Social interactions

Social interactions are an important part of our life. It is important to take care of our social health the same way as we take care of our physical and mental health. Moreover, social interactions are a good predictor of life satisfaction [28] and have a positive association with subjective wellbeing [47], that is, having a good social life is associated with having a happy life.

On the other hand, loneliness is a feeling caused mainly by a perceived lack on the quantity and quality of social interactions. Regardless of being a subjective emotion, loneliness has a negative effect on our physical

and mental health [8], increasing mortality risks the same way as abusing alcohol and smoking does, and more than obesity and physical inactivity [30], and it is one of the factors that cause depression, inflammation, and cardiovascular disease [12, 25, 52] in middle-aged and older adults. People in later life are more vulnerable to loneliness than other age groups as their social network tend to decrease [20, 28] for reasons like family and friends moving away, going to pension, moving out from their homes to a care facility, and the declines in physical and cognitive abilities that come with ageing that make interaction with others more difficult.

Studies around the world show that a significant part of the population, especially to those in later life, are affected by social isolation and loneliness (Figure 1.1). Tilvis et al. [54] studied more than 3,800 community-dwelling older adults in Finland (aged 75+) and found that 46.1% of them were affected by social isolation and 37% of them were affected by loneliness. Yang et al. [59] studied age and loneliness in 25 european countries (for people aged 60+) and found that this target population is the most affected by loneliness in eastern european countries (19 - 34%), while is less affected in southern european countries (10 - 15%), and northern european countries (3 - 8%). Steed et al. [51] studied the demographics of loneliness among older people in Perth, Western Australia (aged 65 - 85) and found that 39.3% of them were affected by loneliness. Perceived social isolation has also been increasing (from 20% to 35%) in the US (for people aged 45+) in just a decade [18], and similarly (from 15% to 29%) in China (for people aged 60+) in 8 years [60].

1.2 Communication technologies

Modern technology makes it easy to remain socially active, however, these advances in communication do not reach everyone. People in later life,

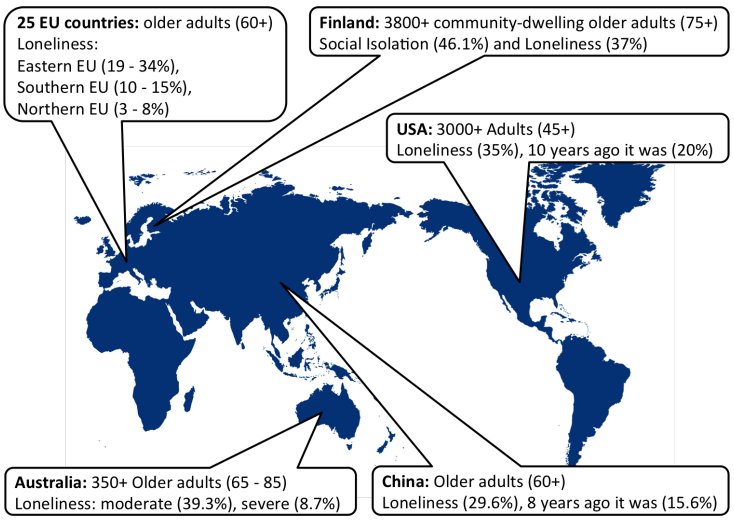

Figure 1.1: People affected by loneliness around the world according to several studies.

people with no experience with technology, and people affected by physical and cognitive disabilities may find these advances in communication difficult to use. The problem is on the one hand related to the **difficulty in using social networking technology** (usually a design issue), and on the other hand there is the **difficulty in understanding the context and content of items shared by their dear ones**, which is intended for their "peers" (such as their same- age friends) that share a different language and context than older adults [31]. In addition, younger family members do not always wish to spend a lot of time interacting or updating older family members on where they are or what they do. Sometimes this is due to a lack of interest from the young, but very often it is just a matter of **not finding the time** or the will to make the effort to share [7].

Researchers, and the industry, proposed intergenerational communication systems with the goal of keeping older adults socially active and better connected to their families by facilitating interactions between older adults and their family members [38]. Intergenerational communication tools attempt to appeal older adults by proposing a user interface with uncluttered views, less interaction elements, and the use of touch interaction, which are

found to be more intuitive for older adults than other peripherals [31, 42]. These systems usually support a closed social network where only members of a family are connected with each other, offering a private and common space for its members to share, and consequently, making the system more trustworthy, especially to the eyes of older adults.

Current systems for intergenerational communications require an intention to interact from the user, that is, from older adults it requires some **ability to use the system** and from young it requires **taking some time out** (could be just seconds) from a usually busy life [7] to either share or find a topic to talk about. This usually creates in the young users a sense of **obligation to communicate** with their older relatives [7], which in turn could discourage adoption of this type of systems.

1.3 Life participation

Our goal is to identify if and how we can design technologies that **facilitate connecting people**, enabling them to participate in the life of each other either in an active (synchronous interactions) or passive (asynchronous interactions) way. We focus on people that cannot interact anymore with their dear ones, with an especial focus on intergenerational interactions based on zero-touch design.

These considerations motivated us to assess the opportunity and viability, and later to design and validate a system that enables *effortless communication*, that is, that lets younger adults to share some aspects of their life with older relatives - and enables older adults to consume this information - in a way that requires no interaction with technology - other than looking at the shared information.

To achieve our goal we had to:

1. Understand **preferences**, **desires**, and **concerns** of young adults

when they **share** with their friends and family (especially with their older family)

2. Study and **analyze** the **coverage**, **clarity** and **consensus** of **design guidelines** for implementing usable and inclusive applications
3. **Propose technological interventions** that can improve the social life of **people vulnerable to loneliness**, and
4. **Understand how** we can **evaluate the effectiveness** of such a proposal.

Communication technologies like tools for instant messaging, video calls, and social network systems are usually based on the premise of passing messages, following the traditional idea that communication comprises the only purpose of information exchange. Nevertheless, communication has other purposes that go beyond the simple exchange of messages, it can also be the mean for curating or reinforcing a relationship. We focus in this work on communication from younger adults to older adults, and therefore on giving the possibility to physically isolated older adults to experience and be part, even in a passive way, of the life of younger family members. Older adults show more interest in knowing the activities of their family and they can sense more positive feelings from these interactions than their young relatives [37].

We target a very specific category of persons, those that: i) are physically isolated from family members and as such have few occasions to see and hear stories from them, ii) are not overly familiar with technologies (for example they would not be able to search images, information and maps on the internet), and iii) have a desire to hear from family members and know what they are up to in life. Many older adults fit this category and thus, we use the rather generic term "older adult" for simplicity when we refer to our target group.

1.4 Structure of the Thesis

The rest of this work has the following structure. Chapter 2 introduces the state of the art, the reasons for the low adoption of technologies by older adults, the research done so far to make applications more usable to older adults, and a review of applications for intergenerational interactions. Chapter 3 describes the problems and limitations extracted from the state of the art related to adoption of technology for intergenerational interactions. Chapter 4 presents the results of our studies to learn more about the sharing behavior and preferences of young adults. Chapter 5 shows the results of our literature review about design guidelines for older adults. Chapter 6 explains the design and implementation of our proposal for facilitating interactions between young and old family members. Chapter 7 presents the results of the studies conducted to evaluate our proposal. Finally, chapter 8 highlights the findings of our work, mentions the limitations that it has, and introduces the future directions that it can take.

Chapter 2

State of the Art

Older adults are less likely to adopt new technologies than are younger adults [49]. This fact led us to ask ourselves the following question: What affects the use of communication technologies (like Facebook, Skype, etc.) by people in later life? To answer this question we searched in the literature for articles that analyze the aspects that motivate older adults to use (or not use) technology, with a special focus on communication technology, and the challenges that they need to overcome for using it. We also analyzed what have been done so far in the field of human-computer interaction to make new technologies more usable and accessible for the older population. Furthermore, we also reviewed technologies that specifically aim at facilitating social interactions for older adults to see what others did to improve the social life of this population. This chapter presents the works in the literature related to these three aspects related to the use of communication technologies by older adults.

2.1 Technology use in later life

With the intention of making our lives easier, technology has come to our homes with the introduction of personal computers and since then it has been evolving up to the point of becoming a seamless part of our

lives. Some of these technologies are already familiar for older adults, like desktop computers, mobile phones and browser applications, while others that are more recent, like smartphones, tablets, and surface computers, still feel alien or unnecessary.

Technology adoption in the older adult population is lower than the young counterpart and in this section we highlight, based on the studied literature, the different causes that could explain this situation. We focus on the factors that cause technology rejection as well as pointing out activities that motivate technology adoption.

The work of [57] surveyed 198 older adults to learn about their technology-based activities, their experience with technology, and their socio-personal characteristics to examine how these factors correlate with technology adoption. Results of the study showed that maintaining social relationships and searching for health information were the most performed activities, other activities also involve searching information about products and services, and online shopping. On the other hand, feelings of anxiety with technology and a lack of motivation were the main factors for non use. At the same time Rogers et al. [49] found that older adults show willingness to adopt technology if they perceive their utility but physical and cognitive factors associated with ageing prevent the adoption.

With a different perspective, we have the work by Sun et al. [53] where authors studied 17 older adults in china that adopted ICT for reasons different than assistive technology. In this work two types of social factors emerged as motivators for adoption of ICT. The first one is ICTs as tools for facilitating social interactions. The other one is "social pressure" from friends and family members that comes in the form of encouragement and support received to learn and use new technologies.

The work in [10] studied patterns of use and reasons for non use of computers among 324 residents of a retirement community. Results sug-

gest that the most common reason for computer use is to stay in touch with friends and family (81% of the respondents indicated this reason), other uses are related with entertainment, managing finances, information search and work. Reasons for non use include the high cost of computers and internet access, the complexity in using the internet and computer applications, the different declines in physical and cognitive abilities that make computer use more difficult, and lack of interest.

The literature review made by Wagner et al. [58] found that the most common use of computers by older adults is for communicating with others, other reasons for use include entertainment, information search associated to health and educational areas, and for productivity or work. The common reasons for non-use are lack of motivation, perceived lack of utility, and high costs of new technologies, other reasons for non use are no experience with computer, difficulty in accessing one and perceived barriers associated with physical declines.

After reviewing the literature about older adults and technology adoption, we summarize the factors that motivate use and non-use of technology as follows.

Factors that motivate technology rejection can be summarised as follows:

- Declines in physical and cognitive abilities: age-related declines in vision, motor, and cognitive abilities make more difficult and frustrating the use of new technologies by older adults, for example, interfaces with small text are difficult to read for people with low vision and mouse-based tasks are frustrating for people with motor problems (20

- Lack of motivation: sometimes older adults just do not finding any purpose or utility for new technologies, they do not see how technology can help them with their lives (52

- Difficult access: some older adults cannot afford to buy a computer or pay for internet access, and is not common to find places (like a public library) that offer free (or affordable) computer and internet access (15
- Technology complexity: many older adults find computer and the internet confusing and difficult to use. This is usually caused by a lack of previous experience with technology or by technology anxiety (27.5

Factors that motivate technology adoption can be summarised as follows:

- Social interactions: older users perceive that the most useful feature of new technologies is that they facilitate communication and staying in touch with people, especially family and friends. Moreover, older adults mention that they feel motivated to learn and use new technologies when they receive encouragement and support from their family and other peers. (74.5
- information access: older adults use new technologies to access the web to search for information, mostly about health and education. Other searched topics include information about traveling, products, and services (58
- Entertainment: older adults use technologies to play games (51.5
- Productivity: other uses of technology are related to work, managing finances, paying for services, and online shopping (42.5

After reviewing the literature and extracting the factors we can say that all the factors that prevent technology adoption are, approximately, equally mentioned by the literature (lack of motivation is mentioned slightly more

than the rest). Among the factors that motivate technology adoption we have that social interactions is the most mentioned and the most important factor according to the reviewed literature.

2.2 Design guidelines and older adults

Older adults can benefit from the advantages that offer new technologies, but unfortunately, this population is less motivated to adopt them due to usability and accessibility problems [10, 45, 4, 11, 17, 57], as we have mentioned in the previous section. Research in the field of human-computer interaction for older adults is expanding, offering a wide range of contributions in the the form of design methods and guidelines for making technologies usable and accessible for this population. Unfortunately, a large part of these research lacks a connection with the industry and among each other. In this section we give an overview of the reasons that contribute to this gap.

On the designers end of the gap, we found that sometimes the problem are related to:

- Technologies still being designed with the young population in mind, that is, young users are usually the main target of the technology [22, 48].

- Designers not being aware of the importance of guidelines, or if they do, they do not know which ones they should enforce [43].

- Designers not having a realistic picture of the abilities and preferences of older adults [26], usually treating them as an homogeneous group that is affected by a common set of physical and cognitive declines [Dickinson 2007], that is, designers design applications for the

"stereotypical" older adult and thus, applications will only cater to the needs of the older adults that match this stereotype.

On the guidelines end of the gap, we found that the problems are several:

- Sometimes guidelines are defined using concepts that are familiar to accessibility experts but are foreign to designers [34], that is, designers and developers are not considered as the end user of the guidelines.

- Guidelines that relate to interface and interaction elements should not be technology independent. Taking for example the design guidelines proposed by the Web Accessibility Initiative[1], which are focused on the design of web applications that will be accessed through a personal computer (usually with a mouse and keyboard). Therefore, this guidelines cannot simply be applied in the design of applications for other devices (like touchscreen-based applications) due to the different way of interacting with them in comparison to traditional computers [44]. Moreover, websites that are already compliant with accessibility rules cannot be considered compliant anymore if they are accessed from a touchscreen device. These websites require some adaptations to be compliant again, like the change in the size of interaction elements, which are usually prepared for the size of a pointer and not for the size of a finger [23].

- Some guidelines do not explain the problem that they address, making it difficult to relate them to a specific ability or decline, which is useful when selecting guidelines for targeting a specific group [48].

- In general, guidelines can be confusing, contradictory, obsolete (due to the advances of technology), or just too many, as it was experienced

[1] https://www.w3.org/WAI/guid-tech.html

by the authors of [1] during their work with their tool for evaluating accessibility of websites based on guidelines.

There has been some work in order to solve the abovementioned issues. The literature has emphasized the importance of design guidelines for older adults and several recent studies investigating them have been carried out in order to reduce "the gap between a designer's conceptual model and a user's mental model of the design", as stated by the authors of [41].

There also have been attempts to propose guidelines addressing both specific abilities and design categories related to them, for instance vision and small screens of handheld computers [15], as well as general recommendations for touchscreen applications for older adults [24].

But all these works are centered on the functional categorization of guidelines, not on abilities users have. Also, some works focus on HCI in general without considering older adults as a specific target group. Also, there has been no detailed investigation of guidelines matching severity of each ability or that would identify which categories of abilities are covered poorly. Overall, the research in the literature can be categorized as following:

- Works that propose guidelines that target a specific decline or ability [15], e.g. making an application accessible for blind, or alleviating the cognitive process for writing an email.

- Works that propose guidelines for older adults in general, targeting several declines but without any specific classification, e.g., they recommend the use of a specific font size but don't define the benefits for people with visual declines, or recommend the use of simple language and an uncluttered view without stating how it helps with the cognitive load of the user [61].

- Literature reviews [14], limited in their contribution to merging the guidelines that were analyzed without any further classification.

2.3 Tools for intergenerational interactions

Universal design was proposed to make technologies accessible for everyone, nevertheless, despite the advances in this field, most applications are still not accessible by the older population, and this is not the exception even for communication technologies. Researchers, and the industry, proposed intergenerational interaction systems with the goal of keeping older adults socially active and better connected to their families by facilitating interactions between older adults and their family members [38]. In this section we will overview, in chronological order, several of these proposals, which were selected based on the similarities with our own proposal, that is, the goal is to connect distant family members and content is shared to a fixed display.

The first proposal for intergenerational interaction that we overview is Palaver Tree Online (2001) [19]. It is a desktop-based application that allowed forum type conversations between students and older adults. The topic of the conversations were based on homeworks that students received in the school. This proposal is very different to ours, nevertheless, we decided to mention it because is one of the earliest proposals for a tool for intergenerational interactions and it connects people that lives remotely from each other.

The next proposal that we present is the Vodafone 520 Photo Frame (2008), which is a digital photo frame that is connected to the internet. Photos could be sent to the photoframe either by MMS or from a website. The Vodafone 520 was used in a study [56] to evaluate the effects on connectedness that photos sent by family members to the photo frame can

have on people with spinal cord injuries and elders in a care-home.

Then we have Tapestry[2] (2010), which is an application for tablets that was designed specifically for older adults and people that have difficulties using new technologies. Family members can shared content to the Tapestry application through email or from other social networks like Facebook, Google+, etc. The Tapestry application also offers communication through an instant messaging feature, but only with other members of the closed social network.

The next proposal that we present is PersonCards (2011) [16], which is a touch-enabled digital photo frame that communicates its users through asynchronous communications. The photo frame is installed in the house of the older adult and sends an email to his/her family members when touched, asking them to communicate with him/her. Family members can record or upload a video to a website that sends the video to the photo frame. At this point, the older adult can watch the videos by touching again the photo frame.

Another proposal is Wayve (2012)[36], which is a touch-based messaging system for the whole family that works in a touch-based device called wayve and that can also be used as a situated display. Wayve offers asynchronous interactions among family members, which usually form a closed social network. The exchanged messages can be either text, photos, or drawings and can come from and be send to emails, phones and other wayves. Authors of wayve observed that asynchronous interactions were more convenient than synchronous interactions because it made easier to work around the busy schedule of some members of the family, usually the younger family members.

A proposal that leverages old technology is Sentab[3] (2013), which is

[2]https://www.tapestry.net/
[3]https://www.sentab.com/

a device that turns a TV in a communication and entertainment system. Users can see pictures, make and receive video calls, meet new people, play games, and watch tv-shows that are curated to their interests; everything with a simple user interface that is usable even by people with no experience with new technologies.

Other proposals are the GrandPad[4] and Unaxone[5] (2014). Both proposals are applications for tablet computers for communicating older adults with their family members. Both applications offer the possibility to make calls, video calls and send voice emails, watch photos and videos, listen to music, and play games. Family members form a closed social network.

The last proposal that we present is Bloom[6] (2015) which is a system for facilitating family communication. Bloom uses a tablet application with features that are very similar to the previous proposals, what makes it different is that it also uses a wristband (wearable sensor) that the older adults needs to wear. The wristband, besides being an activity tracker and a fall detector, also acts as an authentication device, login the user when he/she is near the tablet. Thanks to this, the system can prescind from the traditional user/password authentication method that is very confusing and frustrating for older adults [13].

This overview gives us a glimpse on the evolution of the tools for intergenerational interactions, each of them taking advantage of the technological advances of their time. Starting from a desktop computer with internet connection, then passing through digital photo frames and touch-based computers, to tablet computers and wearable sensors. We can notice that most proposals favor touch-based interactions, this could be due to the findings that suggest that older adults prefer this type of interactions [42]. We can also notice that most proposals support closed social networks, as

[4]https://www.grandpad.net/

[5]https://designit.com/happening/news/bridging-the-digital-family-gap-through-design

[6]https://bloomcloser.com/

these are more valued by family members because they feel more free to share [36]. The following tables show the distribution of proposals based on the mentioned aspects

Table 2.1 shows the distribution of proposals by the year they were proposed and by the sector that proposed them.

Table 2.1: Distribution of proposals by year and sector.

	Year	Research-based	Industry
Palaver Tree Online	2001	X	
Vodafone 520 photo frame	2008		X
Tapestry	2010		X
PersonCards	2011	X	
Wave	2012	X	
Sentab	2013		X
GrandPad	2014		X
Unaxone	2014		X
Bloom	2015		X

Table 2.2 shows the distribution of proposals by the type of social network that they implement.

Table 2.2: Distribution of proposals by type of social network.

	Open	Closed
Palaver Tree Online	X	
Vodafone 520 photo frame		X
Tapestry		X
PersonCards		X
Wave		X
Sentab	X	
GrandPad		X
Unaxone		X
Bloom		X

Table 2.3 shows the distribution of proposals according to the type of

information that they share.

Table 2.3: Distribution of proposals by year and sector.

	Asynchronous			Synchronous	
	Picture	Text	Video	Call	Video Call
Palaver Tree Online	X	X			
Vodafone 520 photo frame	X				
Tapestry	X	X			
PersonCards	X		X		
Wave	X	X			
Sentab	X	X	X		X
GrandPad	X	X	X	X	X
Unaxone	X	X	X	X	X
Bloom	X	X	X	X	X

Table 2.4 shows the distribution of proposals according to the type of device that they support.

Table 2.4: Distribution of proposals by type of device.

	Personal Computer	Digital Photo Frame	Tablet	TV
Palaver Tree Online	X			
Vodafone 520 photo frame		X		
Tapestry			X	
PersonCards		X		
Wave			X	
Sentab				X
GrandPad			X	
Unaxone			X	
Bloom			X	

Chapter 3

Problem statement

In this chapter we will highlight the barriers and challenges that we identified in the literature and that we have to overcome to achieve our main goal of designing an application for facilitating social interactions with an especial focus on improving the social life of people vulnerable to loneliness. We found that lack of motivation, and usability issues are the main problem for adoption of new technologies by the older population. We also found on the young side hints to problems with sharing with their older relatives. This problems are related to privacy issues [55], lack of time to share [38], and, in some cases, the feeling of having the obligation to share [7].

3.1 About technology adoption

In Section 2.1 we identified several barriers for technology adoption among older adults: **declines in physical and cognitive abilities, lack of motivation, technology complexity**, and difficult access. With our work we will address the first three problems, as the last one does is out of the scope of our field.

The goal of our work (facilitating social interactions) implicitly addresses the barrier related to lack of motivation. In the previous section

we found that connecting with people, especially family members, was one of the best motivators for adopting new technologies and was among the top activities associated with computer use.

We propose a zero-touch design and a very simple interface to make the application accessible to people with declines in physical and cognitive abilities, as well as making it usable and understandable for the people with no previous experience with new technologies. Our proposal works in a completely no-touch mode, and yet allows the users to be aware of what's happening in their family.

3.2 About design guidelines

In Section 2.2 we noticed that **the usefulness of guidelines is inversely proportional to their generality** as it becomes more difficult to relate them to a target population. The authors in [14] noticed this issue and realized that in this case guidelines are not enough to make an application usable and suggested to involve older adults in the design process of products to overcome this limitation. However, this solution increases the costs of the product and, moreover, is not even a guarantee of a good design as it is not simple, or straightforward, to involve older adults in the design process of a product [26]. This is usually because there is a miscommunication between designers and older adults, that is, for older adults the design terminology is foreign and for designers is difficult to interpret the needs and preferences of older adults.

To overcome these limitations, this work improves the existing research-based guidelines by classifying them using a fine-grained capability model that better represents the diversity of the older adult population. The guidelines are also extended with information related to the technologies that can apply them, the methodology used to obtain them and if they

were validated.

The overall goal is to make current guidelines more useful for designers and developers, so they can have a better understanding on the importance of each guideline, know how trustworthy they are, and which of them they need to enforce according to the target population and to the technology that will be used to run the application. Furthermore, an increase in the adoption of guidelines will result in more usable and accessible applications, and thus, benefiting older adults and people in general.

3.3 About intergenerational interactions

In Section 2.3 we presented several applications for intergenerational interactions that were proposed by researchers and the industry. Common characteristics of these proposals are that they attempt to appeal older adults by proposing a user interface with uncluttered views, less interaction elements, and the use of touch interaction, which are found to be more intuitive for older adults than other peripherals [31, 42]. These systems usually support a closed social network where only members of a family are connected with each other, offering a private and common space for its members to share, and consequently, making the system more trustworthy, especially to the eyes of older adults.

Current systems for intergenerational communications require an intention to interact from the user, that is, from older adults it requires some ability to use the system and from young it requires taking some time out (could be just seconds) from a usually busy life [7] to either share or find a topic to talk about. This usually creates in the young users a sense of obligation to communicate with their older relatives [7], which in turn could discourage adoption and use of this type of systems.

The major problem of current tools for intergenerational interactions

is that they **require adoption from both old and young users**, and usually the pressure to interact is on the side of the young users, as older adults tend to think that their young family members are too busy to be contacted [38], so in most cases interactions depend on the initiative of the young. Therefore, If the young users are not interested in using the tool, then older adults will soon follow, losing the interest in using it too.

These considerations motivated us to design a system that enables effortless communication, that is, that lets younger adults to share some aspects of their life with older relatives - and enables older adults to consume this information - in a way that requires zero touch - other than looking at the shared information.

Chapter 4

Facilitating interactions

The first objective of our work is "Understand **preferences**, **desires**, and **concerns** of young adults when they **share** with their friends and family (especially with their older family)". To achieve this goal we designed and conducted two surveys. The first one had the goal of learning what type of information young adults like to share, and with which group of people they feel more comfortable sharing. The second survey had the objective of learning the frequency with which young adults communicate with their older family members, if they felt satisfied with that frequency, and in the case of infrequent communications, the reasons that led to that situation.

4.1 Exploratory study to learn sharing preferences

We started the work by conducting a study to investigate the preferences of people when sharing with older relatives. For this we designed a survey where we asked people questions related to what information they think that would be interesting to share, how comfortable they feel sharing with friends and family, and how they would like to control the sharing process.

For this study we used a convenience sample, that is, we created an online survey (`http://goo.gl/forms/jggs011xQs`) and distributed it through social networks and mailing lists. The first part of the survey included in-

formation on the project and a concept video of how an effortless life sharing application could operate, the second part contained questions about sharing, the third part asked questions about receiving shared information, and the last part collected demographic data. We got 94 respondents (45 female). Figure 4.1 shows the age distribution of the respondents.

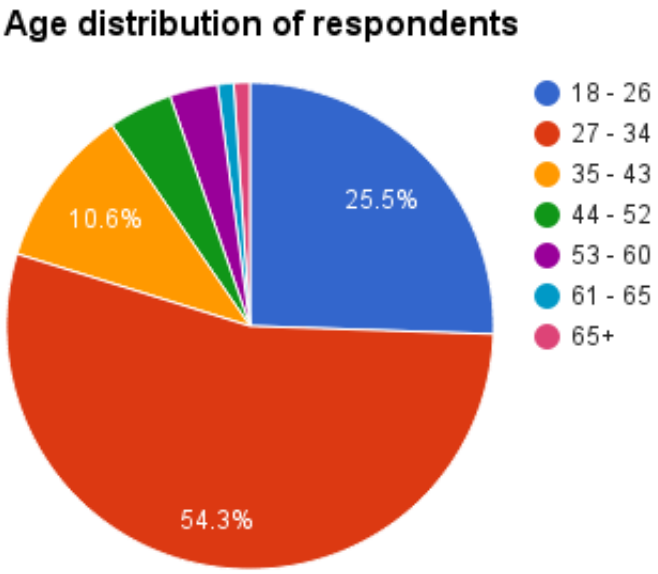

Figure 4.1: Age distribution of the participants.

For the questions related to sharing preferences we asked: "How interesting do you find sharing the following types of information?" Results are shown in Figure 4.2. A very high percentage of respondents think that pictures are an interesting type to share. Respondents also found interesting to share text message, and location. The types time, weather, and activity are considered interesting but only to a little more than 50% of the respondents.

Furthermore we asked: "What is your comfort level when sharing your context information with the following groups?" Results are shown in Figure 4.3. We got that most people feel comfortable when sharing with their close family and friends. Notice that the group of other relatives

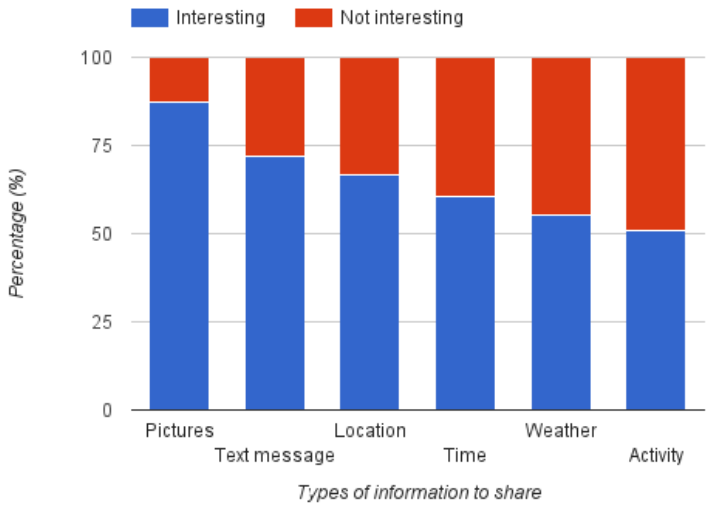

Figure 4.2: Results to the question: *How interesting do you find sharing the following types of information?* The x-axis reports the answer categories; the y-axis reports, for each category, the percentage of respondents that find sharing this category "interesting" or "not interesting".

(cousins, uncles, aunts) was still considered comfortable to share with but less than the other groups.

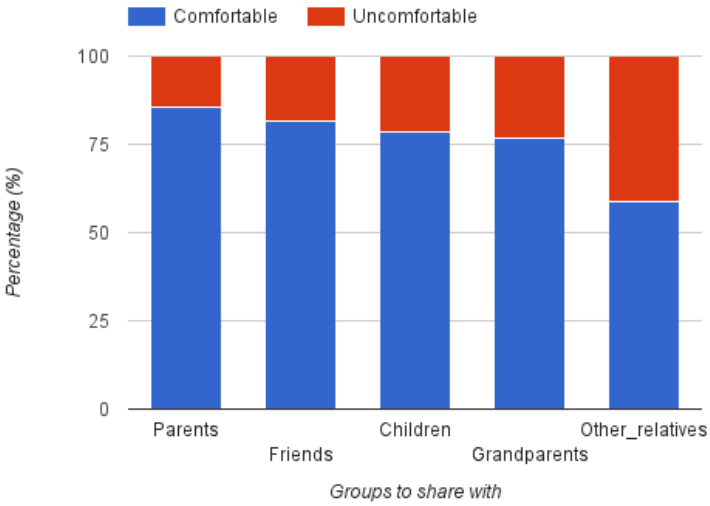

Figure 4.3: Results to the question: *What is your comfort level when sharing your context information with the following groups?* The x-axis reports the answer categories; the y-axis reports, for each category, the percentage of respondents that find sharing this category "comfortable" or "not comfortable".

In relation with the level of control of the sharing process we asked: "What type of control would you like to have on the sharing of location?" Results, shown in Figure 4.4, clearly indicate that people want to remain in control of the sharing process.

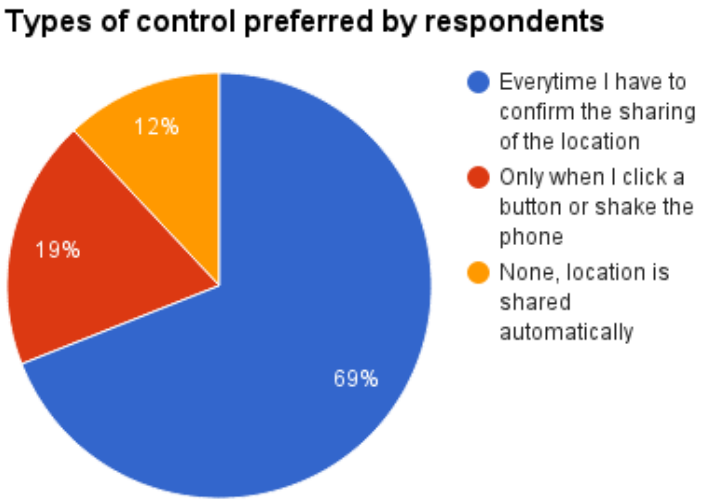

Figure 4.4: Results to the question: *What type of control would you like to have on the sharing of location?*

The results from the questions related to receiving shared information are not reported here because they were not used to design the sharing application.

4.2 Exploratory study to understand the communication behavior of young adults

We conducted a second study with the purpose of improving our understanding of the interactions (and, specifically, the reasons for the lack of them) between young adults and their older relatives. We used a convenience sample for this survey and collected answers from 86 participants (59 female), mostly university students in Trento - Italy, with an age range: 17 - 45, mean (SD) = 24.84 (9.08)).

At the beginning of the questionnaire the respondent had to choose one of his/her grandparents and then answer questions considering the interactions with him/her. For the questions related to the frequency of interactions we asked: "Think about the last month, How many times did you communicate by phone with your grandparent?" Results, shown in Figure 4.5, indicate that the majority of young adults have rather infrequent contact with their older relatives (82% report physical and phone contacts of less than once a week, 52% reports no contact at all in the last month).

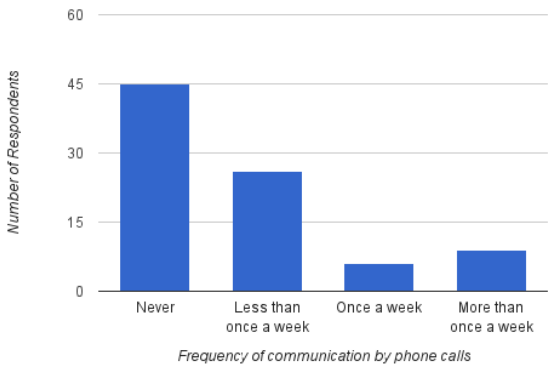

Figure 4.5: Results to the question: *How many times did you communicate by phone with your grandparent? (in the last month).* The x-axis reports the answer categories; the y-axis reports, for each category, the number of respondents.

Furthermore, we asked questions related to the reasons of such infrequent contact. Results, shown in Figure 4.6, indicate that the reasons for infrequent phone contact are lack of time (55% of the participants mentioned this reason) and lack of common topics to talk about (also 55% mentioned this). Other barriers for interaction are related to the cognitive declines that affect the older relatives and the uncomfortable feeling associated with the idea of having the older relative in a physically or cognitively challenged condition (23% of the participants reported these reasons).

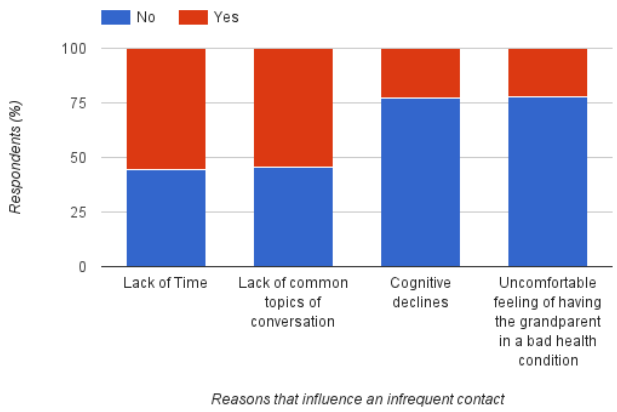

Figure 4.6: Reasons that influence an infrequent interaction. The x-axis reports the different reasons that can lead to infrequent contacts; the y-axis reports the percentage of respondents that find each category as a reason "Yes" or not "No" for avoiding contact.

4.3 What we learned from the studies

From our first survey we learned that people, and especially young adults:

- Think that pictures are the most interesting thing to share
- Feel relatively comfortable sharing their information with their close family and friends, and
- Want to be able to control the sharing process

From the second survey we learned that the main barriers for interaction between young adults and their older relatives are:

- Young adults cannot find the time to interact (call). This result supports a similar finding in [38] that says that older adults see their grandchildren as too busy for contact
- Young adults have difficulty finding a topic of conversation
- Cognitive declines that affect the older relative and make interactions more difficult

- Negative feelings associated with the idea of the older relative in a difficult condition

Chapter 5

Literature review of design guidelines for older adults

The second objective of our work "Study and analyze the **coverage**, **clarity** and **consensus** of **design guidelines** for implementing usable and inclusive applications" aims at bridging the gap between the idea that designers have of user's interaction capabilities and the actual users' expectations about the interface.

In this chapter we describe our literature review of design guidelines for older adults, which is the method that we chose to achieve our objective, a method that will allow us to outline the existing literature in a thorough and unbiased manner. Literature review is a well-established approach in the field of human-computer interaction, it can be applied in order to identify, evaluate, and interpret the state of the art on a given research topic and analyse what has been done, to which extent, and what needs more work [33].

For our this literature review we collected and analyzed a set of design guidelines under paradigms, such as universal and inclusive design, to address general usability problems of older adults, as well as the declines that they might experience. One of the greatest challenges we had was to compile overlapping and identify contradicting design guidelines for each ability

and its severity, and at the same time, still consider the interface design category that the guidelines refer to, for example, layout, text, navigation, among others.

This literature review follows a similar process based on the proposal of Kitchenham (2004) [33], and thus, the stages associated with conducting this review are: identification of research, selection of primary studies, study quality assessment, data extraction and monitoring, and data synthesis.

5.1 Selection of works included in the analysis

The first step of the literature review consisted on selecting the most relevant sources (conferences and journals) for papers that cover the areas related to HCI and ageing. The initial list found in Appendix A contained 16 sources from which only 13 were used due to the inability to access to papers of the following sources: International Conference on Computers for Handicapped Persons. Computers Helping People with Special Needs. Special Thematic Session: Human-computer interaction and usability engineering for elderly (HCI4AGING); Mobile HCI; International Journal of Human Computer Interaction (IJHCI). This step corresponded to the identification of research stage.

5.2 Filtering process

The second step of the literature review consisted on identifying papers that could contain guidelines for applications for older adults. To keep the literature manageable and up to date, we defined that the inclusion criteria should include all the papers published in English from 2005 onwards and that their title or abstract should include at least one keyword from

the following topics: older adults (older adults, elderly, elders, ageing), guidelines (guidelines, recommendations, suggestions, principles). The initial search achieve a total of 403 articles that were retrieved through the advanced search feature of the ACM Digital Library and dblp[1]. This step corresponded to the selection of primary studies stage.

The third step of the literature review consisted on a superficial analysis of the 403 filtered papers to identify which of them actually contained guidelines or content that could be interpreted or translated to guidelines. This step identified 103 papers that may contain guidelines, and filtered out 31 papers due to being editorial articles or duplicate works and 269 due to not containing any guidelines or because the guidelines were for a very specific application or device. This step corresponded to a second iteration of the selection of primary studies stage and a first iteration of the study quality assessment stage.

The fourth step of the literature review consisted on a detailed analysis of the 103 papers with the purpose of extracting from them their corresponding guidelines and the details of the studies that either conducted to them and/or validated them. For some papers, the guideline extraction was straightforward as the guidelines were clearly stated in the article. For other papers the guideline extraction required more work as the guidelines were presented as experiment outcomes, future recommendations, and observations, and thus, they had to be interpreted and rewritten. This analysis excluded 30 more articles due to: not proposing actual guidelines, the guidelines were too general or confusing. This step was the last for the filtering process and resulted in 73 papers marked as containing relevant guidelines for applications for older adults. This step corresponded to a second iteration of the study quality assessment stage and the data extraction and monitoring stage. The process for filtering relevant papers can be

[1] `http://dblp.uni-trier.de/`

seen in Figure 5.1.

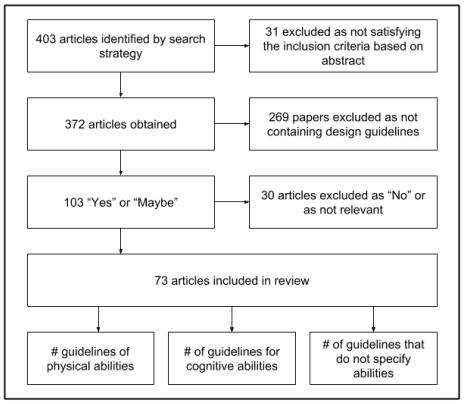

Figure 5.1: Process for obtaining the relevant papers for the literature review.

The result of the process so far is a set of preliminary design guidelines that support the design of solutions that target different declines of abilities of older adults. Moreover, each guideline was annotated with the technology for which it can be applied, like web, smartphone or tablet, which was specified in the paper from which it was extracted. This set was further analyzed, filtered, and then integrated and transcribed to create an operational version of checklists of guidelines.

5.3 Classification of guidelines

Guidelines classification is the step that follows the selection of papers and the extraction of guidelines. The criteria for considering a suggestion or recommendation as a guideline is closely related with the concept of design guidelines. There are a variety of definitions for the term "design guidelines" that have been suggested in literature. Smith and Mosier [50] refer to guidelines as an encapsulation of expert judgment and that their

use varies with the role of the user, for example, for a "manager responsible for user interface software design", guidelines are "means to make the design process more efficient". Sometimes design guidelines are defined as design rules that provide "direction for design, in both general and more concrete terms, in order to enhance the interactive properties of the system" [2]. However, this work will use the definition suggested by *Stewart and Travis (2002)* who state them as "sets of recommendations from software providers or agreed within development organizations to increase consistency of design and to promote good practice within a design process of some kind" because this definition reflects better the idea of guidelines being a valid tool for designing applications, having a focus on rules for designing software without considering the design of the hardware.

The classification of guidelines consisted of an iterative process that classified each particular guideline according to:

- the ability that it targets and its severity, like vision, motor, or cognitive, which were derived from the abilities and declines that the reviewed literature targets, and
- the design category it corresponds to, like interface layout or interaction styles, which were obtained from the original classification of the guidelines.

In the first iteration of the classification, the guidelines were classified and grouped according to the ability targeted by the paper from where they came from. Moreover, in this iteration were excluded single guidelines that targeted declines or abilities that cannot affect older adults.

In the second iteration, the guidelines in each ability group were reevaluated based on the description text of the guidelines themselves to confirm if they belonged to that ability group or to another group. If a guideline was found to fit better another ability, then it was moved to that ability

group.

The third, and last, iteration included the evaluation and coding of guidelines of each ability group, refining their belonging to each ability, and classifying them by design category and subcategory. This iteration was also used to identify and remove repeated guidelines from the list.

The last iteration was used to configure the finalized design guidelines into a heuristic checklist for designing accessible solution for older adults, which could be generalized and applied to different technologies and be easily comprehensible and adopted by software developers and designers.

The list of guidelines, annotated with abilities, design categories, and devices were copied to an online spreadsheet, where the are accessible to anyone, and they can be easily filtered according to any of the annotated dimensions. The spreadsheet, with the annotated guidelines, is a tool that could be useful for designers and developers, and can be used to facilitate the implementation of applications that better cater to the needs of older adults.

5.4 Results and Findings

The reviewed literature was evenly distributed from 2005 to 2015 with a decrease of publications between years of 2006 and 2008 as can be seen in Figure 5.2.

We identified the method that was used in each work to obtain their list of guidelines and annotated the article accordingly using the following tags:

- **Experiment:** a technology was used in an intervention study and guidelines were derived based on the results of the intervention.
- **User studies:** user studies like interviews, focus groups, etc. were

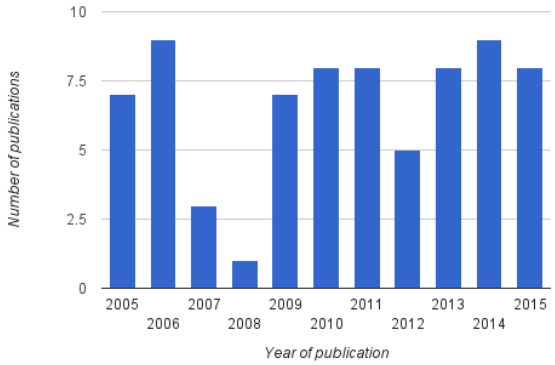

Figure 5.2: Distribution of the publications included in the literature review.

used to collect requirements and needs, which were used later to derive guidelines. These studies do not involve any type intervention.

- **Literature review:** a literature review was conducted to collect and merge guidelines.

- **Official guidelines:** guidelines were extracted or derived from official sources, like the guidelines from the Web Accessibility Initiative (WAI).

- **Experiment+User studies:** guidelines were derived from a combination of intervention and no intervention studies.

- **Literature review+User studies:** guidelines were derived from a combination of literature reviews and no intervention studies.

- **Not available:** there is no information on how the guidelines were derived

Figure 5.3 shows the distribution of the publications according to the method used to obtain their list of guidelines.

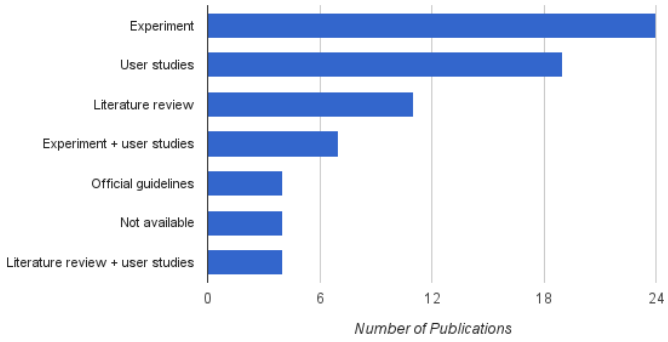

Figure 5.3: Distribution of publications according to the method used to obtain guidelines.

Initially the selected papers were classified based on the ability that they target, that is, the problem or decline the work wants to address. The works were classified with the following tags:

- **Vision:** if the goal is to address problems related to low vision, color blindness or full blindness.
- **Motor:** if the goal is to address problems related to reduced mobility, hand tremors or pain when doing physical movement.
- **Cognitive:** if the goal is to address problems related to lack of experience with technology, social isolation, memory, dementia, attention, among other cognitive problems.
- **Accessibility:** if the goal of the work is to address accessibility issues without focusing in any specific problem in particular. They usually address general problems related to vision, hearing, motor, and cognitive declines.
- **General:** if the goal of the work does not mention explicitly that it addresses a specific decline, or if the problem is a general problem that

is not considered a decline, or if the target user could be anyone, not only older adults.

Guidelines were extracted from the selected papers and were, first classified with the ability of their containing paper, and later evaluated one by one having their ability categories refined by three experts until an agreement was reached on the guideline's ability. The guidelines were classified with the following ability tags that were derived from the conditions that the reviewed literature aims at addressing:

- **Vision - Mild:** conditions that reduce the ability to perceive what is displayed by the application, for example, low vision.
- **Vision - Severe:** conditions that disable the ability to perceive what is displayed by the application, for example, blindness.
- **Motor - Mild:** conditions that reduce the ability to move fingers, hands, or arms, for example, hand tremor.
- **Motor - Severe:** conditions that disable the ability to move fingers, hands, or arms, for example, quadriplegia.
- **Hearing - Mild:** conditions that reduce the ability to hear, for example, ambient noise.
- **Hearing - Severe:** condition that disables the ability to hear, for example, deaf.
- **Physical:** conditions that can produce pain, seizures or fatigue.
- **Cognitive - Mild:** conditions that affect memory, attention, ease of use, etc.
- **Cognitive - Learning:** conditions related to no experience with technologies, or with learning technology-based skills, for example, send email or search for information.

- **Social:** conditions that affect social skills, for example, affect the trust in the system and in the interactions, facilitate communication and sharing, etc.

Table 5.1 shows the distribution of guidelines according to the abilities that they cover.

Table 5.1: Distribution of guidelines by the abilities they target.

General Abilities	Number of Guidelines	%	Abilities	Number of Guidelines	%	Sub-abilities	Number of Guidelines	%
						Vision - Mild	176	23.8
			Vision	205	27.7	Vision - Severe	29	3.9
						Motor - Mild	65	8.8
			Motor	76	10.3	Motor - Severe	11	1.5
						Hearing - Mild	1	0.1
			Hearing	10	1.4	Hearing - Severe	9	1.2
Physical	293	39.6	Physical	2	0.3	Physical	2	0.3
						Cognitive - Mild	391	52.8
Cognitive	412	55.7	Cognitive	412	55.7	Cognitive - Learning	21	2.8
Social	35	4.7	Social	35	4.7	Social	35	4.7

Guidelines were also classified according to the technologies that can apply them. The guidelines were classified with the following ability tags:

- **Touch-based:** guidelines for the implementation of applications for touch-based technologies like smartphones, tablets, or other type of touch surfaces

- **Web:** guidelines for the implementation of websites or web-based applications, independently of the device that will be used to access them.

- **TV:** guidelines for the implementation of applications for TVs and

smart-TVs technologies like smartphones, tablets, or other type of touch surfaces.

- **Desktop:** guidelines for the implementation of applications for "desktop" or personal computers, that is, that require a keyboard and a mouse to work.

- **Others:** if the technology is referred only by a few guidelines and it only targets one ability.

Table 5.2 shows the distribution of guidelines by the abilities that they target and the technologies that they support.

Table 5.2: Distribution of guidelines by the abilities they target and the technologies they support.

	Cognitive		Physical		Social	
Technology	Number of Guidelines	%	Number of Guidelines	%	Number of Guidelines	%
Touch-based	51	12.4	108	36.9	3	8.6
Web	296	71.8	131	44.7	18	51.4
TV	9	2.2	4	1.4	2	5.7
Desktop	6	1.5	3	1.0	2	5.7
Others	50	12.1	47	16.0	10	28.6

5.5 Remarks from the literature review

We have that 44% of the articles consider older adults as a homogeneous group of 65+ people and thus, offer guidelines that aim at addressing a general set of problems that mostly include declines in vision, motor and cognitive abilities. There are also works that aim at addressing very specific issues like improving social interactions, lack of experience with technologies, address the needs of blind users, among others.

Related to the coverage of abilities is worth noticing that we could not find any work that addresses specifically hearing problems. We found guidelines that address hearing problems, but they were just part of a set of guidelines that addresses different types of declines. This could be because new technologies rely mostly on visual interactions, and besides multimedia content, auditive interactions are used normally for notifications, which can be replaced with tactile and/or visual feedback. With respect to social abilities, we have found some articles that specifically address them but only a few offer guidelines that can guide the implementation of applications for facilitating social interactions for older adults.

From the final set of guidelines we identified guidelines that are consistent and well supported, for example, text content should have font size of 12-14 point. We found 2 guidelines that support this:

- "Use san serif type font i.e., Helvetica, Arial of 12-14 point size. Avoid other fancy font types" taken from [62], and
- "Font size: 12-14 point. It could be a problem when same text has to be written in different languages and resultant phrase has different length." taken from [9].

We also found guidelines that aim at disproving previous recommendations, for example, we found a guideline that recommends the use of left justification for text content and 1 guideline that says that this is not necessary:

- "Text should be left justified and text lines should be short in length" taken from [62], and
- "For text justification there were no significant differences in preferences due to any of the variables. So proposing left only justification for older adults has no support from this study for either performance or preference reasons." taken from [46].

Finally, we found guidelines that seem to be contradictory, for example, we found 1 guideline that recommends the use of familiar icons to increase the users' comfort level while another guideline says that standard icons could seem foreign or unfamiliar:

- "The use of familiar icons can increase users' comfort levels and proficiency with new technologies; this should be explored in future studies." taken from [35], and
- "Standard icons may be unfamiliar –use with care or better reinforce with words." taken from [9].

Based on our findings we can see that there is room for research in the area of design guidelines for applications for older adults, some examples could be conducting more research: to propose guidelines for the areas that are not well covered, for validating already existing guidelines, to propose new guidelines for new technologies, etc. The list of classified guidelines is available in this public document: `https://docs.google.com/spreadsheets/d/1FdPDtWuAV15UKCQ1_tyIEBzYSm_wsBaNC7Rfjc_iEes/edit?usp=sharing`.

Chapter 6

Lifeshare: design and implementation

From our surveys we found that young adults cannot find the time to interact with their older relatives or is difficult to find a common topic to talk with them. From the literature we learned that usability issues are one of the barriers that prevent older adults from using communication technologies. However, designing an application that is usable by this population is not simple, as the design guidelines that can be used to guide the implementation are not clear, as we found in our literature review.

To overcome this problems we decided to target the extreme cases of these populations (young and older adults) and propose a system that requires neither the young (the sharing party) nor the older adults (the receiving party) to make any effort to interact, up to the point that none of them is required to do anything or touch anything. We propose the concept of touchless interactions to facilitate the communication between young adults and their old family members.

This chapter presents our proposal for facilitating interactions between young adults and their old family members. It starts by presenting the general idea of our proposal, and then it presents the design and implementation of two applications that realize our proposal.

The basic ideas and principles behind Lifeshare lie in

1. Automatically capturing as much as we can about the young adult's life - through the devices that one brings with him/her, primarily a smartphone

2. Automatically enriching this information to make the context clearer and more understandable from the perspective of the information consumer,

3. Ensuring that the privacy of the young adult is respected so that we do not share more than one would want.

4. Displaying the information on a device at the older adult's side, without requiring any physical interaction with it

The goal of our system is to create stories about the young using the information that we capture. Currently, the system only tell simple things because it focuses on contextual information associated to single location points. However, the storytelling can be improved by extending the system with plugin algorithms that can deduce more information with the captured data. Moreover, the system "sensing" abilities can be extended beyond of that of the smartphone by implementing plugins for other devices (like smartwatches, and wearable sensors) that can capture other types of information.

In the following we describe the design of an application for sharing photos based on places that a person visits, and then we explain the design of the application for receiving the shared photos, both of them based on principles of the Lifeshare system. We later present the general architecture of the system that allows to plug in different devices and reasoning logic to add both information and context.

6.1 Designing the life sharing application

In the following we explain and exemplify Lifeshare with the case of sharing of pictures of places that the young adult visits, where the location is collected via smartphone and pictures are collected from what is available on the internet. Additional context information that we get comprises the weather condition, name of the place (or name of the nearest point of interest), city, country.

The sharing process has 3 modes: automatic, semi-automatic (with confirmation), and manual. We included these sharing modes because the results of the survey showed us that young users would like to control when the sharing happens. The **automatic** (touchless) mode, shown in Figure 6.1a, shares the information each time the phone detects a significant change in the location, i.e., the young user moves to a different place (from one point of interest to another), city, or country. The young user can configure the granularity of the "significant change". The **semi-automatic** mode, shown in Figure 6.1b, asks the user for a confirmation before sharing the information through a phone notification. The **manual** mode, shown in Figure 6.1c, requires the user to open the application and then pressing a button for sharing the information. Notice that we require at most 2 touches from the user to share and thus, keeping the interaction as an almost effortless action.

The user can also choose among different granularity levels for the precision of the location information to have more control over what is shared, even in the touchless mode. Once again this is a result from the initial survey where we derived that touchless systems sharing at a detailed level would have had relatively limited applicability for the general public. The lowest level is **place** (Figure 6.2a), which could be the name of a restaurant, a square, a point of interest, etc. The next levels are **city** (Figure 6.2b),

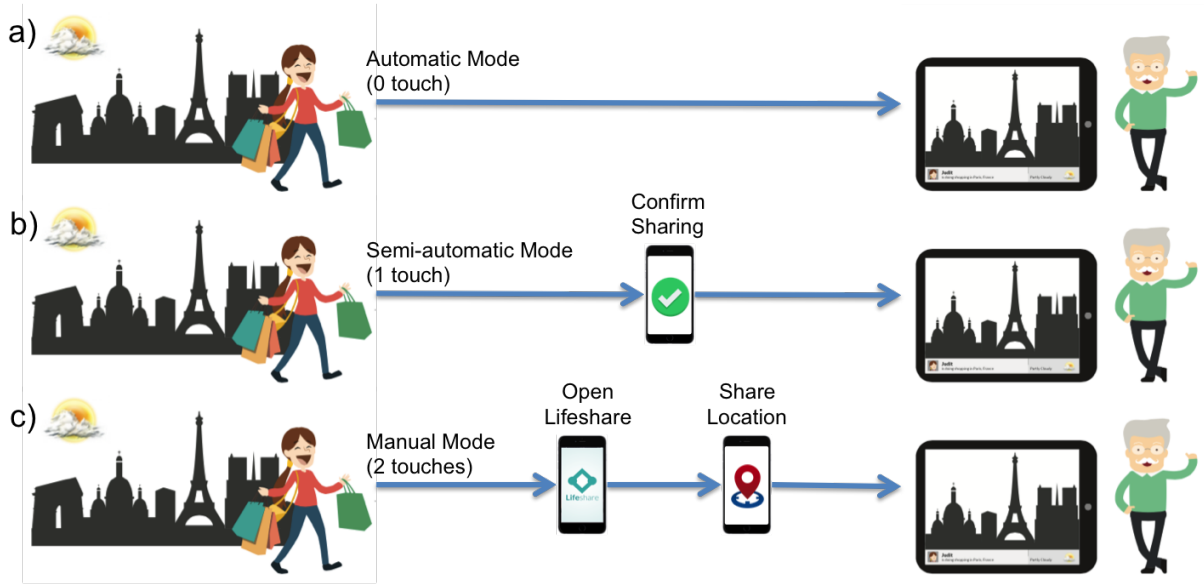

Figure 6.1: Lifeshare sharing modes. (a) Automatic mode, information is shared automatically each time a new location is detected. (b) Semi-automatic mode, similar to automatic mode with the difference that the user needs to authorize the sharing of the information. (c) Manual mode, the user has to open the application and explicitly choose to share.

region (Figure 6.2c), and **country** (Figure 6.2d) where what is shared is only the name of the respective location. Finally, there is the **none** level (Figure 6.2e) for the users that do not want to share any location information. The information is shared only with the people selected by the young user.

The final result is that the Lifeshare application for smartphones requires only three setup (one- time) actions from the users after being installed: setting of the sharing mode, setting of the granularity level of the location information, and adding the recipients of the shared information. After the initial setup the application is ready to work autonomously and the user may never touch it again while still keep sharing his daily moments with his/her dear ones.

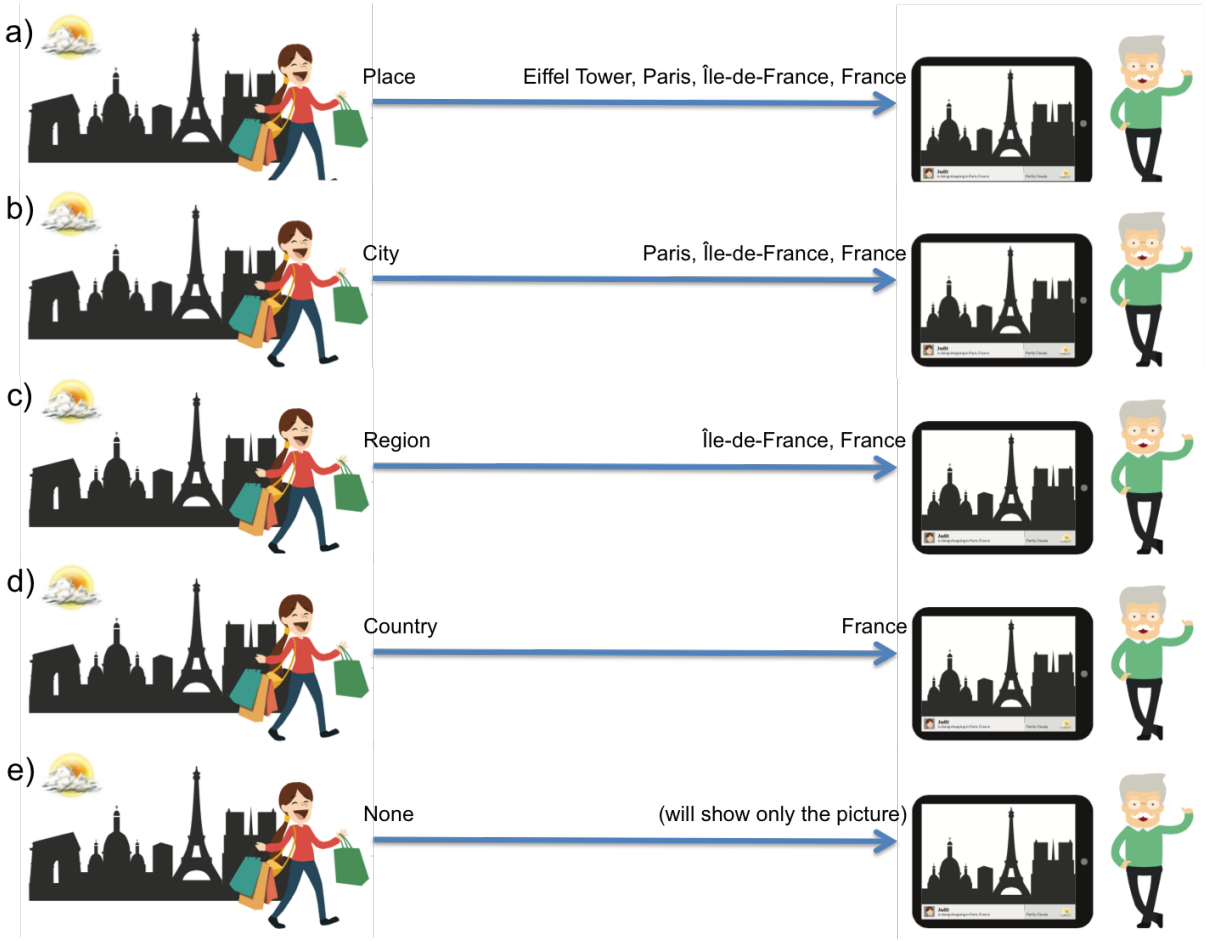

Figure 6.2: Information shared at the different granularity levels. (a) Place. (b) City. (c) Region. (d) Country. (e) None.

6.1.1 Considerations for the design of the sharing application

Our system for intergenerational communications was designed mainly for asynchronous interactions from the young to the older adult. We chose asynchronous interactions because they can be automated and the recipient can see the message whenever it is more comfortable for him/her. It is known that older adults like richer type of interactions like calls [38], and for this reason Lifehsare also offers the possibility of making video calls, which are still touchless from the perspective of the receiving party.

Automating messages and interactions favors ease of use at the expense

of the precision of the information that we can get and share [40]. With full automation we achieve effortless interactions but we limit the information that we get to what we can sense or infer with current devices. The trade-off with precision could come at the cost of sharing incorrect information due to the imprecision of the GPS of the phone in some locations. We also had the problems of sharing photos with snow during summer because we could only get photos according to a position and not to a period of the year. It is very likely that these drawbacks will decrease with time thanks to the advance of sensors and algorithms that are able to capture more information and with better precision than what we currently have.

User privacy was always an issue with communications systems and this holds even more true when it comes to location sharing systems [55]. For this reason we included in the smartphone application three different options for controlling the sharing process: the first option for controlling the sharing mode, the second for controlling the granularity of the location information, and the third option to control who are the recipients of the shared information (these options were explained in the previous section).

As a final comment we want to stress that the purpose of automatic interactions is to fill the gap between "traditional" interactions among people with small fractions of life moments of their dear ones, and not the opposite, to replace the interactions that already exist between them.

6.2 Designing the receiving application

The application for receiving shared information was designed to be used as a fixed display, like a live digital photo frame, where however the information displayed goes beyond that of a photo. We adopted a *postcard* metaphor for showing to older adults the information shared by their younger family members. The rationale behind this decision was that is

easier to understand new concepts (shared information) if presented in a way that resembles a concept that is already known [29].

The postcard metaphor shows (Figure 6.3) a geo-tagged picture of the place, a profile picture of the young that shared the information, the name of the young, the location information (place, city, region or country), how much time passed since the information was shared, and an icon representing the weather in that location at the moment of sharing.

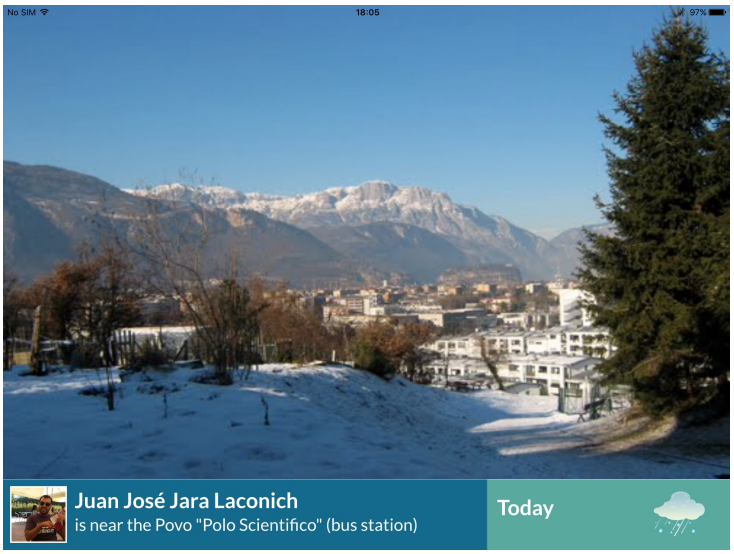

Figure 6.3: The postcard metaphor.

In addition, we included an extra slide (Figure 6.4) that presents, in a different way, the same information from the postcard but replacing the geo-tagged picture with a map that indicates (at a global scale) where is the shared location.

In the receiving application, the shared information is shown as a slideshow, first the postcard, then the corresponding map, iterating through them by showing the last three locations that were shared by each young family member that is connected to the older adult.

We chose tablets as the implementation platform for several reasons: older adults find the touch-based interface of tablets to be more natural

Figure 6.4: The map card.

[42], for the exceptional cases when the older adult has to interact with the application; the screen size of tablets is usually big enough to show the postcards without having a cluttered view; and applications for tablets can stay logged in even after they are closed, so there is no need to sign in if the application is accidentally closed.

The general idea is that the tablet with the Lifeshare receiving application should be located in the room where the older adult spends most of his/her time, so with just giving a glance to the display he/she could have a glimpse on the whereabouts of his/her family.

6.2.1 Considerations for the design of the receiving application

The design of the receiving application was focused on the choice of the metaphor and how to show it. We did not try to also share something automatically from the receiving point because of the difficulty in finding anything interesting that could be captured and shared automatically.

The receiving application can also receive video calls that come from the sharing application. To follow the touchless principle, the video call is

answered automatically when received. We thought that this could create privacy issues in the older adults, therefore, we included an option were older adults could turn on or off the automatic answering of the video call. If turned off, the video call could only be answered after the confirmation from the older adult, which requires 1 touch. All the participants reported that they prefered to turn off the automatic answering of the video call.

Showing both sides of a postcard using a fixed display may create some confusion but it allowed us to have an uncluttered view of the shared information. We saw postcards from places unknown to us during our tests with the system. This motivated us to include a map in the postcard metaphor to make clearer where in the world is located the shared place. We noticed, however, that having the map and the geo-tagged picture at the same time produced a cluttered view. Therefore, we opted for representing the postcard metaphor using both sides of the postcard, which allowed us to keep the map information and have an uncluttered view. All the participants understood the information presented in this way.

Our touchless approach is not limited to enabling older adults that cannot use new technologies to consume shared information, it also seeks to appeal to older adults that enjoy seeing information presented in a simple way.

6.3 Under the hood

This section will describe the architecture of the Lifeshare system that was designed to support the automatic capture, enriching, and sharing of information with the purpose of facilitating interactions between people. Figure 6.5 shows the general architecture of the Lifeshare system.

The components of the architecture work as follows:

1. The **sharing device** represents the applications that automatically

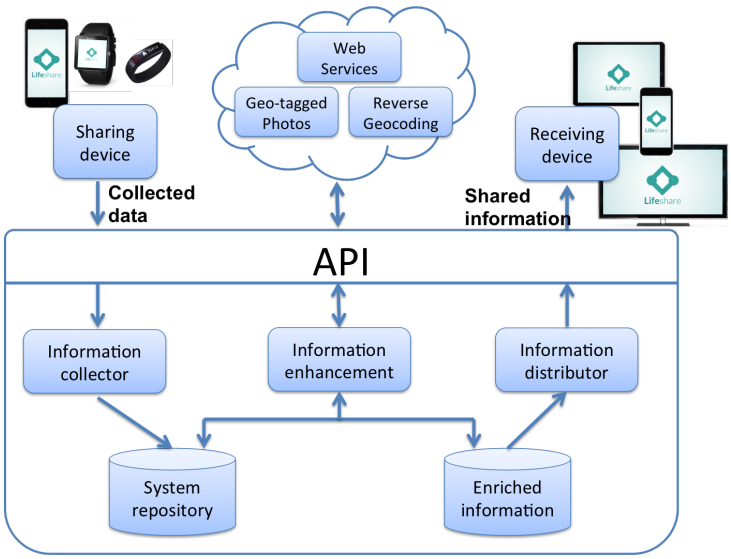

Figure 6.5: Lifeshare general architecture.

collect information and that run on the devices that young adults carry with them. A specialized implementation of this component is needed for each type of the device that the Lifeshare system wants to support. The type of the collected information depends on the type of device, for example, location and step count information can collected from smartphones, heartbeat rate information can be collected from a wearable sensor, etc.

2. The **information collector** serves as the interface between the devices that collect information and the system repository. This component offers one api for each type of information that can be collected.

3. The **information enhancement** contains the different algorithms used to automatically enrich information, for example, to enrich location data with context information like nearby points of interests or geo-tagged pictures, or using location and timestamps to infer places like home, or work, or if someone just arrived from a long flight. This component can be extended with new algorithms that can enrich in-

formation or infer new information based on already collected data, all this independently of the processes that collect information.

4. The **information distributor** serves as the interface between the devices that receive information and the system repository. This component offers one api for each type of information that can be shared and also notifies the different recipients when new interesting information is available

5. The **receiving device** represents the applications that automatically receives and presents shared information. A specialized implementation of this component is needed for each type of the device that the Lifeshare system wants to support.

Based on the case for sharing pictures of visited places, the implementation of the Lifeshare architecture works as follows. The automatic interaction between young and older adults works as follows: Younger people install Lifeshare on their phone;- that's all they need to do. The application in the **smartphone** gets the current location and sends it to the Lifeshare server, this is done each time the young moves to a new location and is done automatically. The server receives the location and gets context information for that location like the weather, name of the place, city, country, and pictures geo-tagged of that location. With the context information the server creates a postcard and sends it to the family members selected by the young. The application for **tablets** is designed to work as a fixed display, it receives the postcards from the server and shows them as a slideshow, all this is done automatically so it does not require any effort from the older adults. Figure 6.6 illustrates at a high level the implementation of the Lifeshare architecture for the case of sharing pictures of visited places.

Notice, therefore, that we get ease of use at the expense of specificity of

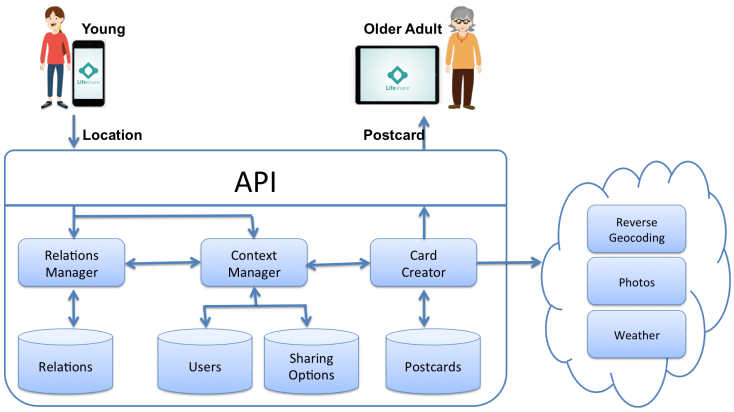

Figure 6.6: Implementation of the Lifeshare architecture for sharing pictures of visited places.

the experience: to achieve zero–touch, what is shared is in essence information on events at and positions of our family members, based on what can be deduced automatically. Moreover, with touchless interactions we aim at promoting sharing among the young family members, as they either cannot find the time to share [7], or are not used to communicate with their older family members.

Finally, Lifeshare supports video calls, where again the older adult does not have to touch anything: it is like their family popping in their homes. In this way, older adults at home always have a "window" open on the world of their family, providing a sense of increased social connectedness.

Chapter 7

Studies and experimental results

This chapter presents the studies that we conducted to validate our work. We conducted two studies. One of the studies had the purpose of investigating the communication behavior of older adults and to evaluate the usability of the receiving application. The other one was a 8-weeks long study and had the purpose of collecting feedback from users in a realistic context and to identify the requirements needed to make a study that can effectively evaluate the impact of our proposal.

7.1 Usability study

We conducted a study to investigate the communication behavior of older adults and to evaluate the usability of the receiving application. The survey, which can be found in Appendix B, contained 14 questions from which four were to investigate the communication behavior, two to collect demographic data, and eight were extracted from the *System usability Scale* (SUS) [6] . Questions 5 and 6 of the scale were excluded due to the fact that in a pre-test phase elderly were not able to understand them, therefore, in our study the score of this scale has a range of 0 to 80 (contrarily to the full 10-item version, which has a range of 0 to 100).

We contacted different centers for the third age in Tomsk, Russia to

invite older adults to participate in the study. We conducted several focus group sessions were older adults tested the receiving application, which showed postcards from different test users (some of the authors). Next, the participants received a video call from one of the authors, and then they completed the survey. We recruited 30 older adults in total (25 female, 5 male; age range: 55 - 78, mean (SD) = 66 (5.71)). Take into consideration that 55 in Russia is considered "old" as it is already the retirement age. The relation between the SUS score and the question "*How often do you communicate with relatives?*" provided the most interesting finding. This relation is shown by figure 7.1.

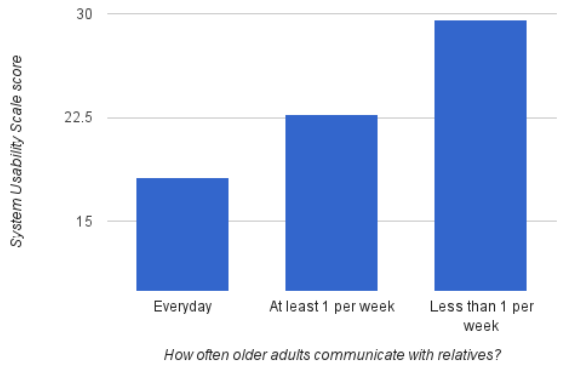

Figure 7.1: Relation between the SUS score and the frequency in which users communicate with their relatives

The mean SUS score is inversely proportional to the number of times that participants communicate with their relatives. In fact, participants that communicate "everyday" had a mean SUS score of 18.13 (30% of the respondents); those communicating "at least once per week" had a score of 22.69 (45% of the respondents); and those communicating "less than once per week" had a score of 29.58 (25% of the respondents). This could be interpreted as that participants either feel an increased need to communicate more or that they think that the application is more usable

as it will help them with this situation. However, due to the small number of participants, this finding does not reach the significance point.

7.2 Pilot study to understand how to evaluate our proposal

We conducted a study to evaluate if older adults and young understand and appreciate the Lifeshare methods of interactions:

- Asynchronous method (postcards) that allows the young to share information on events at and positions relative to where they are without interrupting what they are doing. The shared information is converted as a series of postcards that were designed with the scope of being easy to understand. The postcards arrive to a tablet application that shows them in a continuous slideshow, this way the older relative can consume what is shared without having to do any effort.
- Synchronous method (video calls) that allows the young to call the older relative, but not vice-versa. This way the young will be using a social network without having to be always available, always online, and the older relative will have a method to receive video calls without any effort.

The second objective of this study was to identify the requirements needed to make a study that can effectively evaluate the impact of our proposal. The goal was to observe participants behaviour, what motivated them to complete the study and what made them drop from it. In this case we designed a study for measuring if the Lifeshare methods improve the wellbeing of its users. To do this we planned to periodically collect from the participants self-measurements related to their feelings of happiness, connectedness and loneliness while they use the applications.

7.2.1 Participants

Participants of the study received a tablet with internet connection for 8 weeks (the duration of the study) and with Lifeshare installed and configured. To participate in the study participants had to meet the following requirements:

- Be 55 years old or older, and
- Have at least one young family member living in a different city, that uses a smartphone that can run Lifeshare, and that agrees to participate in the study.

Participants were recruited from different centers for the third age in Tomsk, Russia and their young family members (who had to live in a different city than the older adult) were contacted through email. We recruited 7 older adults and 7 young relatives (older adults: 5 female; age range: 60 - 75, mean (SD) = 69.57 (5.65); young relatives: 4 female; age range: 18 - 51, mean (SD) = 29.43 (13.14)).

7.2.2 Procedure

During the 8 weeks of the study, older adults used the Lifeshare Tablet application and the young the Lifeshare Mobile application. The elderly used the tablet as a fixed display, that is, it was fixed in the room where he/she spent most of the time. The young used the Lifeshare application in automatic sharing mode and, occasionally, made video calls to his/her older relative.

Participants completed a 10-item questionnaire to measure their self perceived happiness, loneliness, and closeness to their corresponding young relative. Questionnaires were completed at the beginning of the study, during the 4th week of the study and at the end of the study (8th week).

The questionnaire was composed of 4 items from the *subjective happiness scale*[39], 3 items from a short version of the *UCLA loneliness scale*[32], 1 item from the *inclusion of other in the self scale (IOS)*[3], and 2 items from the *subjective closeness index scale (SCI)*[5]. The last 2 scales are used to measure perceived closeness to the young relative. All the scales were selected based on their validity, high diffusion in the community, and low number of items that facilitate their completion time.

7.2.3 Results

More than 50% of the participants dropped from the study. Only 3 older adults, and their respective young family members, finished the study. The other 4 older adults dropped the study for the following reasons: One participant traveled to Thailand for a long period of time. Another one had problems with the internet connection, and thus the application could not receive any postcards or video calls. Another participant lost interest, as she was already using Skype to communicate with her grandchild. The remaining participant dropped the study without giving a reason. In our case, we found that mainly motivational and technical issues motivated some of our participants to drop from the study.

With respect to the results of the study about self-assessment of emotion, unfortunately, we are not able to conclude or infer anything from the results due to the low number of participants that finished the study. The 3 participants reported the following scores for their self perceived happiness, loneliness and closeness during the 8 weeks of use of Lifeshare. Figure 7.2 shows the changes in the loneliness score. Figure 7.3 shows the changes in the happiness score. Figure 7.4 shows the changes in the closeness score based on the IOS scale. Figure 7.5 shows the changes in the closeness score based on the SCI scale.

In summary, we can observe the following changes in loneliness, happi-

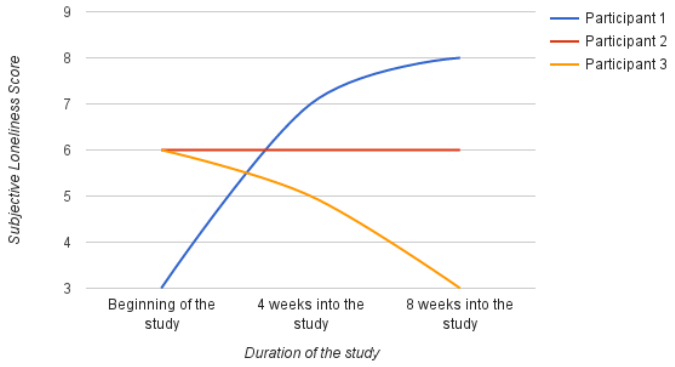

Figure 7.2: Changes in the self perceived loneliness per participant during the 8 weeks of the study

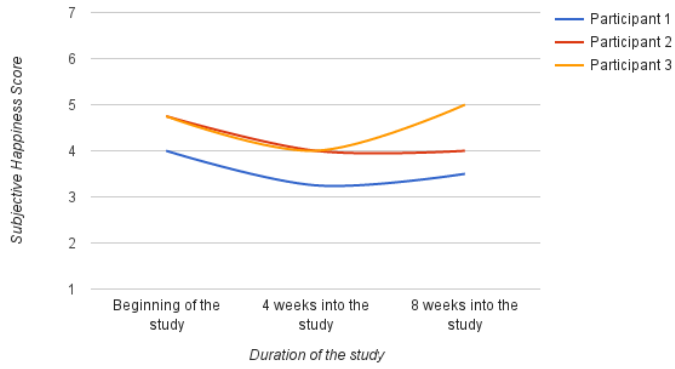

Figure 7.3: Changes in the self perceived happiness per participant during the 8 weeks of the study

ness, and closeness for the 3 participants at the end of the study:

- Participant 1: felt more lonely, slightly less happy, and less close to her grandchild.
- Participant 2: felt no change in loneliness, slightly less happy, and closer to her grandchild.
- Participant 3: felt less lonely, slightly happier, and slightly closer to her grandchild.

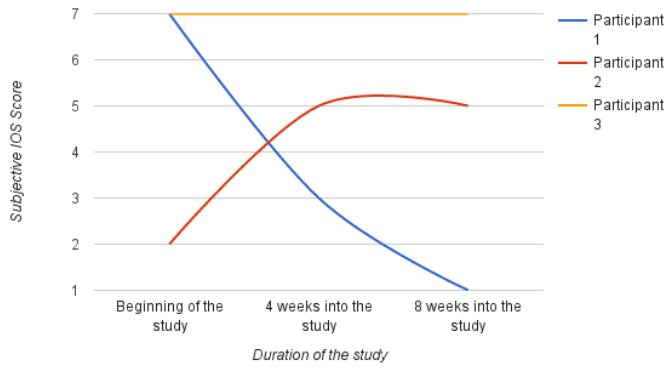

Figure 7.4: Changes in the self perceived closeness to their young relative based on the IOS scale per participant during the 8 weeks of the study

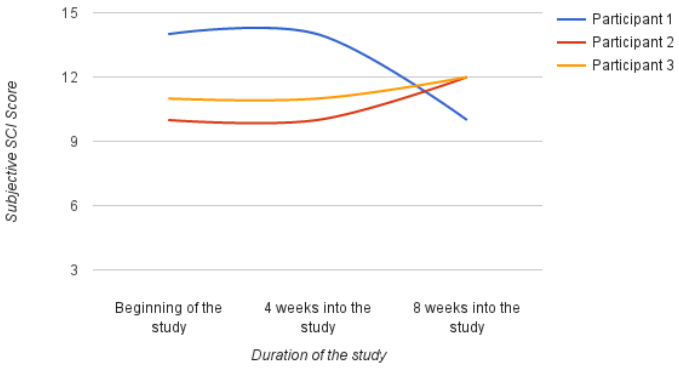

Figure 7.5: Changes in the self perceived closeness to their young relative based on the SCI scale per participant during the 8 weeks of the study

7.3 Feedback from studies

We learned about designing studies the following:

- Adapt the study requirements to facilitate recruitment because is very difficult to recruit participants, especially for longitudinal studies
- Collect automatically as much data as possible because is difficult to contact participants, and

- Use questionnaires with few items to avoid stressing participants

Furthermore, we collected feedback from the participants from both user studies. With respect to the receiving application we have that:

1. Some older adults told us that they wanted to *interact more with the application*. One suggested interaction was to swipe the postcards, either forward or backwards because at times they want to see again a postcard that just passed or they want to see the next one because the current is not interesting

2. Some older adults mentioned that they would like to see more information about the place of the postcards or to get some questions (like trivia) related to the place because the postcards are not interesting anymore after some time. This request also suggests the *addition of more interactions* to the application

3. Most older adults wanted to be able to *call their young family members* (currently only the young can initiate a video call). They also wanted to see a missing call notification if the young called while they were not around.

Older adults, in general, liked the receiving application. The video call was the most interesting feature. Several of them told us that they were waiting anxiously to receive the next video call from their young family members. Some of them called us when they had some problems with the video call,as this was a particularly interesting feature. A couple of older adults that finished the two months pilot study wanted to keep using the application because they enjoyed it so much.

With respect to the sharing application:

1. Most of the young wanted to be able to share photos from their phones and some of them wanted to personalize the message

2. Some of them recommended to optimize the resources because they noticed that the application consumed too much battery.

Young also appreciated the application in general, they also stated that the video call was a nice feature. Some of them liked the idea of the automatic sharing and said that they agreed to participate in the study only because of that feature as they are busy and would not be able to collaborate with something that required more effort. Getting feedback from young users was difficult as they could only be contacted through email.

Chapter 8

Findings and lessons learned

This chapter summarizes the contributions of our work, points out the limitations, and presents some final remarks. We start by presenting our findings from the literature review, we continue by highlighting the most important results from our surveys related to sharing preferences and behaviours of young adults, and finally we talk about the design recommendations that we derived from our experience with Lifeshare and how they can be used to extend the set of guidelines that resulted from our literature review. Then we will point out the limitations of our work and conclude with some final remarks.

8.1 A classification of guidelines by abilities

The list of classified guidelines is available in this document[1]. As a result of our literature review, we found that most abilities that are affected by the ageing process (vision, motor, cognitive) are covered by the literature, with the exception of hearing that was not covered specifically by any article. We found some guidelines that address hearing problems, but they were just part of a set of guidelines that address different types of declines. An

[1] https://docs.google.com/spreadsheets/d/1FdPDtWuAV15UKCQ1_tyIEBzYSm_wsBaNC7Rfjc_iEes/edit?usp=sharing

explanation for this lack of support could be that new technologies rely mostly on visual interactions, and besides multimedia content, auditive interactions are used normally for notifications, which can be replaced with tactile and/or visual feedback. With respect to social abilities, we have found some articles that specifically address them but only a few offer guidelines that can guide the implementation of applications for facilitating social interactions for older adults.

After analyzing the final set of guidelines we found that there are interface aspects like font size that are well supported, there are aspects like text justification that are being dismissed as relevant, and there are aspects like icon design that seem to be contradictory.

Overall, there is room for research in the area of design guidelines for applications for older adults, some examples could be conducting more research: to propose guidelines for the areas that are not well covered, for validating already existing guidelines, to propose new guidelines for new technologies, etc.

8.2 Sharing preferences, desires, and concerns of young adults

We report the following findings from our surveys about sharing preferences and understanding the way that young adults interact with their older relatives:

- Young adults like to share pictures and think that pictures are the most interesting thing to share

- Young adults feel comfortable sharing their information with their close family and friends, and

- Young adults want to be able to control what is shared and the sharing process
- Young adults cannot find the time to communicate with their older family member.
- Young adults have difficulty finding a topic of conversation

These findings give an insight on the what could motivate young adults to interact more with their older relatives and therefore, they could be used as guidelines for the design of intergenerational applications.

8.3 Design recommendations

The experience we earned during the process of design and evaluation of our proposal for intergenerational communications can be translated into the following recommendations:

- *Give room to personalization (go the extra mile)*: include an option that allow users to personalize automatic processes. We designed sharing to be extremely simple to cater with the need of the young that do not have time to share. While we covered this need succesfully, we also fell short when the young had time and wanted to send a personalized postcard (12 young did not take part in the study because they were busy, which indicate that young do not have time to share or communicate with their older relatives).
- *Have clear privacy controls*: give users, especially the ones that share, the possibility to control all the processes. Make these controls clear and visible. In our system, besides the controls that manage the sharing process, we also show to young users the last 3 shared postcards so they can clearly see what we are doing in their behalf (3 young did not participate due to privacy issues, this supports our recommendation).

- *Support video calls*: this feature was a huge success, especially among older adults. If a system wants to appeal older adults it should support video calls (All 44 participants used and liked video calls)

- *Consider the learning effect (go another extra mile)*: include an option that gradually enables more interaction options for older adults. People learn and want more, and that was the case with the older adults that used our system; they wanted to interact more with the application and we felt that the system should provide this possibility, especially for the older adults that are more able. (6 older participants asked for more features that allow them to interact more with the application).

- *Allow reciprocity*: give to older adults the possibility to communicate or share with the young family. Some intergenerational communication systems consider older adults as consumers of information and do not give the possibility to share or contact their family. This was our case too and in our studies we learned that older adults also want to be able to call to their young family members. (17 older participants requested this feature).

8.4 Limitations of our findings

Our work is not exempt of limitations and in this section we will point them out.

8.4.1 Limitations of our literature review

The guidelines classification that resulted from our literature review is limited with respect to the articles that were included in the review as well as the process for classifying the guidelines.

Due to practical constraints, our study was not unable to investigate the entire set of articles with design guidelines for older adults. Articles with actual guidelines could have been left out from the review for the following reasons:

- The article was published in a source that is not among the sources related to HCI and older adults that we included
- Articles did not contain any of the keywords used for the inclusion criteria.

The method to evaluate and classify the guidelines consisted on expert agreement and in this work the classification process was the result of the consensus of only three researchers. More researchers should adopt our classification method to increase (or decrease) its validity.

8.4.2 Limitations of our surveys

We conducted two surveys, one on sharing preferences and the other on communication behaviour of young adults. While the results of the surveys came from a sample of young adults, these results cannot be generalized due to the small size of the sample (94 and 86 respondents respectively) and the limited diversity of the sample (mostly students from the University of Trento).

8.4.3 Limitations of our evaluation studies

To validate our application we conducted a usability study and an intervention study to evaluate to what extent our application affects the feelings of connectedness, happiness and loneliness. The findings of the usability study cannot be generalized as our sample population was constituted from older adults from the city of Tomsk, Russia and were mostly women.

Furthermore, the sample size of the intervention study was very small (only 3 groups of participants finished the study) to even be able to report to a trend. The factor that limited the size of our sample was the particular requirements that participants had to comply to participate in the study. First, the older adult had to live in Tomsk, Russia, and his/her young family member had to live in a different city, the young family member had to agree to participate in the study, and finally the young family member needed to use a smartphone compatible with Lifeshare application.

8.5 Final remarks

In this work we have explored several aspects related to using technology to facilitate social interactions. We have learned about the complexities associated to incorporating design guidelines in one own's design, highlighting the importance of knowing the effect that each adopted guideline has in the final implementation. We have experienced the intricacies of social interactions, especially between actors with different preferences and needs, and we learned that technology can effectively facilitate and support this type of interactions. However, the design of technologies for social interactions is not straightforward and the use of guidelines alone is not enough to guarantee adoption. Therefore, it becomes important to involve each of the actors in the design process to better capture their preferences and to design a technology that appeals to each of the target users.

With our work we have presented our contribution to the field of social interactions and highlighted many other aspects that can still be improved in this field. Moreover, the constant advancement of communication technologies offers new methods to interact, which in turn gives room for new research in this area of technology-mediated social interactions.

As for the next steps, we have that our classification of guidelines will

guide the implementation of applications that will be used by residents of care homes. Furthermore, studies will be conducted to evaluate the usability of these applications, and the results of this study will determine the validity of the guidelines.

The results from the surveys and the architecture of Lifeshare are being used to design and implement more applications for intergenerational communications for a joint project between the university and the industry to improve the social wellbeing of older adults in care homes in the Trentino region of Italy.

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Appendix A

List of sources for articles with design guidelines for older adults

1. Universal Access in the Information Society, http://link.springer.com/journal/volumesAndIssues/10209
2. Gerontechnology, http://www.gerontechnology.info/index.php/journal
3. Computers Helping People with Special Needs, Special Thematic Session "Human-computer interaction and usability engineering for elderly (HCI4AGING)", http://link.springer.com/chapter/10.1007%2F978-3-642-14100-3_83
4. Australian Conference on Human-Computer Interaction (HCI) OZCHI, http://dblp.uni-trier.de/db/conf/ozchi/
5. Human-Computer Interaction INTERACT, http://dblp.uni-trier.de/db/conf/interact/
6. Behaviour & Information Technology, http://www.tandfonline.com/loi/tbit20#.Vd8ajbM5s8o
7. Computer Human Interaction (CHI), http://dblp.uni-trier.de/db/conf/chi/

8. 2nd Workshop on Designing With Older Adults: Towards a Complete Methodology, https://olderadultsmobileinterfaces.wordpress.com/

9. Mobile HCI, http://mobilehci.acm.org/2015/

10. International ACM Conference on Assistive Technologies (Assets), http://dblp.uni-trier.de/db/conf/assets/

11. International Conference on Advances in Computer-Human Interaction (ACHI), http://dblp.uni-trier.de/db/conf/achi/

12. International Journal of Human Computer Interaction (IJHCI), http://www.cscjournals.org/journals/IJHCI/issues-archive.php

13. ACM Transactions on Computer-Human Interaction (TOCHI), http://dl.acm.org/citation.cfm?id=J756&picked=prox

14. BCS conference on Human Computer Interaction, http://dblp.uni-trier.de/db/conf/bcshci/

15. Human-Computer Interaction, http://dblp.uni-trier.de/db/conf/hci/

16. Computers in Human Behavior, http://www.sciencedirect.com/science/journal/07475632/30

Appendix B

Communication behavior and Usability questionnaire

B.1 Lifeshare specific communication behavior questionnaire

In this questionnaire we will ask you questions about your communication behavior with one relative that you will choose. Your answers will help us understand better how people interact with their family. Please try to respond honestly and what you believe is truly correct.

- Your age?
- Your Gender
  ( ) Male
  ( ) Female
- Think about a relative with whom you will like to interact more. What is your relationship with this relative?
  ( ) Son or Daughter
  ( ) Grandson or Granddaughter
  ( ) Other. Please specify .....

  In the following questions we will refer to this relative as "the other".

- How many times would you say you communicate with the other? Please consider visits, telephone, letters, email, or other online communication.
  ( ) Every day or almost every day
  ( ) At least once a week (but not every day)
  ( ) At least once a month (but not every week)
  ( ) Less than once a month

- What forms of communication do you use in everyday life to contact the other? Choose all the forms that you use.
  [ ] Meeting up with others face-to-face
  [ ] Making phone calls.
  [ ] Writing text messages (SMS)
  [ ] Making video calls.
  [ ] Writing emails.
  [ ] Using social networks systems (Facebook, Whatsapp, VK, etc).
  [ ] Other forms, please state: .....

- We would like you to think for a moment about the topics you usually talk about with the other. Please try to list as many as you can think of. Keep your description general (you can write e.g. family, work, vacations, politics etc.)

- How many of these topics you consider deep or important and how many you consider superficial or light?
  ( ) All or almost all of them are deep or important
  ( ) Most of them are deep or important but some are superficial or light
  ( ) Most of them are superficial or light but some are deep or important
  ( ) All or almost all of them are superficial or light

B.2 System usability scale

Items are answered using a 5-point likert scale that goes from Strongly disagree (1) to Strongly agree (5)

- I think that I would like to use this system frequently
- I found the system unnecessarily complex
- I thought the system was easy to use
- I think that I would need the support of a technical person to be able to use this system
- I would imagine that most people would learn to use this system very quickly
- I found the system very cumbersome to use
- I felt very confident using the system
- I needed to learn a lot of things before I could get going with this system