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GUIDELINES TO DESIGN COMPUTER-SUPPORTED TECHNOLOGY FOR MEDIATING
INTERGENERATIONAL COMMUNICATION AND INFORMAL ELDERLY CAREGIVING
IN SOUTHERN CONE FAMILIES

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RESUMEN

La tendencia de usar servicios de redes sociales en línea y mensajería móvil instantánea ha cambiado tanto la forma en que las personas se relacionan como los espacios en los cuales interactúan. En el contexto de comunicación intergeneracional, este nuevo escenario de interacción ha sido poco estudiado y comprendido desde una perspectiva holística, es decir, considerando las actitudes, expectativas, puntos de vista e intereses de todas las partes involucradas en el proceso. Si bien existen perspectivas orientadas a intervenir este escenario de interacción, con un enfoque basado principalmente en gerontología social y antropología, el problema no ha sido profundamente estudiado desde un enfoque computacional.

En términos generales, el diseño de tecnología para apoyar el cuidado de adultos mayores no ha reconocido ampliamente la complejidad y heterogeneidad de dicha actividad. Consecuentemente, esto introduce una brecha entre las necesidades de los adultos mayores y los servicios provistos por sus redes de apoyo. Por ejemplo, la mayoría de los adultos mayores en Latinoamérica no han sido capaces — ni han manifestado interés — en adoptar tecnología digital para interactuar socialmente con sus familias. Esta actitud, junto a un alto grado de compromiso derivado de la fuerte obligación filial característica de las sociedades colectivistas, sobrecarga a los familiares más implicados en el cuidado informal de sus adultos mayores, generando indirectamente tensiones con otros miembros. Luego, en lugar de tecnología más avanzada para apoyar el envejecimiento en el hogar, se requiere de un mejor entendimiento de la complejidad y diversidad de las experiencias de vida y necesidades de cuidado de los adultos mayores, para así apoyar el diseño de soluciones socio-técnicas potencialmente efectivas.

Para abordar el problema presentado, esta tesis estudia empíricamente, a través de un enfoque inductivo basado en Trabajo Cooperativo Asistido por Computador, el escenario de interacción y colaboración en familias del Cono Sur. La finalidad de dichos estudios es modelar — de manera integral — la estructura y dinámica de los procesos de cuidado informal e interacción intergeneracional para comprender sus sutilezas desde un enfoque socio-técnico, y así diseñar nuevos mecanismos basados en computador para intervenirlos. Esto se traduce concretamente en identificar aspectos de diseño claves de dichos procesos, considerando el punto de vista de los adultos mayores y cómo se articulan los distintos miembros de la familia en este contexto. En otras palabras, el entender las implicancias de diseño derivadas del análisis sistemático del escenario de estudio, nos lleva a formular consideraciones de diseño que deben ser tenidas en cuenta a la hora de concebir soluciones que apoyen dichos procesos. Organizandolas estas consideraciones de diseño de acuerdo a su relación con las partes involucradas y las dimensiones que inciden en la arquitectura del software a desarrollar, nos lleva a proponer guías estructuradas para apoyar el proceso de diseño, desarrollo e implantación de sistemas computacionales en el dominio de estudio. Finalmente, esta tesis propone una serie de instrumentos que ayudan, por un lado, a identificar consideraciones y guías de diseño relevantes, y por otro lado, a apoyar a diseñadores de software a tomar decisiones arquitectónicas informadas a través de un proceso guiado en base a evidencia empírica.

Considerando las guías propuestas, investigadores, diseñadores y profesionales trabajando en el área de computación social, podrán entender de mejor manera la complejidad del escenario estudiado con la finalidad de identificar soluciones plausibles para mejorar la experiencia de usuario y la efectividad de estrategias de mediación comunicacional y cuidado informal de adultos mayores asistidas por computador.

ABSTRACT

The current proliferation of social media tools for facilitating interpersonal communication (e.g., social networking services and mobile instant messaging) has inadvertently shifted the way in which people interact with each other, as well as the social spaces through which these interactions are mediated. In the context of intergenerational communication, this interaction paradigm has not been deeply studied from a holistic perspective, i.e., considering the attitudes, expectations, viewpoints, and concerns of all involved stakeholders in the process. Although there are research-oriented approaches—grounded mainly in social gerontology and cultural anthropology—aimed to plan strategies to intervene this interaction space, there is still a broad amount of open research questions in exploring the potential and implications of designing, developing, and deploying computer-supported solutions in this domain.

In general terms, the design of computer-supported caregiving technology has generally not acknowledged the complexity and heterogeneity of the informal care provision to older adults, which produces a gap between the older adult needs and the provided services. For instance, most Latin American older adults have not been capable to—nor shown interest in—adopting digital technology to interact with their family members. This attitude, complemented with a high commitment derived from the strong filial obligation perceived in collectivistic societies, burdens the most engaged family members in the informal care provision to their older adults and indirectly produces tension within the family network. Consequently, rather than more advanced technologies for supporting aging in place, we require a better understanding of the complex and diverse living experiences and care needs of older adults, as a way to help conceive effective socio-technical solutions for each particular caregiving context.

In order to bridge this gap, this dissertation empirically studies, following an inductive research approach under a Computer-Supported Cooperative Work lens, the interaction and collaboration scenario in Southern Cone families. The goal of the conducted studies is to model—in a comprehensive manner—the structure and dynamics of informal elderly caregiving and intergenerational communication, as a way to understand their socio-technical nuances and therefore design new computer-supported mechanisms to mediate these processes. More precisely, this implies identifying key design aspects in those processes, considering the perspective raised by older adults and how other family members articulate themselves in this context. In other words, by understanding the design implications derived from the systematic analysis of the study domain, we formulate a set of design concerns that need to be considered when conceiving computer-based solutions to support such processes. By organizing the proposed design considerations according to their relation with involved stakeholders and software architectural dimensions, we propose structured guidelines to support the design, development, and deployment of computing systems in this study domain. Finally, this dissertation proposes a set of instruments that, on the one hand, help address relevant design concerns and guidelines, and on the other hand, assist software designers in taking informed architectural decisions following a guided process supported by empirical evidence.

By addressing to these guidelines, social computing researchers, designers, and practitioners would be able to better understand the complexity of the studied scenario, and therefore, identify plausible solutions that would improve user experience and the effectiveness of computer-supported mediation strategies in intergenerational communication and informal elderly caregiving.

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1. INTRODUCTION

The World Health Organization has reaffirmed the importance of social interaction in promoting wellbeing [Frie09]. In that respect, the notion of health is not constrained to the absence of diseases or ailments, but instead it refers to being simultaneously physically, mentally, and socially fit [Who06]. Furthermore, several studies grounded in medicine and social psychology show a positive correlation between frequent and meaningful interpersonal exchanges with higher levels of physical and mental health, as well as a reduction in mortality rates [Hous88, Hous01, Seem87, Step13, Umbe10]. Therefore, by improving the social health of people, i.e., the ability to sustain healthy relations with family, friends, neighbors, and colleagues [Alid14], it would be possible to increase their perceived wellbeing.

Previous research shows that as a person gets older, the size of his/her social networks, sense of social connection, and interaction frequency all tend to decrease [Dean92, Hawk06], focusing more on close family members—mainly children and grandchildren [Osor14]. This perceived degradation in social exchanges negatively impacts the physical and mental health of older adults, and therefore, their wellbeing. In that respect, social isolation in older adults seems to be rooted in several causes, such as a lack of relationships and perceived psychological barriers [Nich09], which end up reducing the space for interacting with others. According to the Chilean National Service for Older Adults (Servicio Nacional del Adulto Mayor, SENAMA) [Sena16], *both social isolation and inactivity trigger a deficient social health state in older adults, which affects their physical and psychological health, as well as that of the people surrounding them.* This stresses the need to improve the social health of older adults as a strategy to enhance their own quality of life, hence reducing the burden that close family members usually suffer as a consequence of assuming informal caregiving duties.

As in any culture, the health, physical, and economic state of Latin American older adults determine many of their needs. However, several others are shaped by cultural expectations in favor of these people. For instance, in collectivistic societies—which emphasize the needs of groups over individuals—adult daughters still dedicate a considerable amount of their available time to care for their parents and own children [Gonz10, Tao15]. In particular, literature recognizes this situation as the assumption of a *filial obligation*, which is deeply rooted in Latin America. In some cases, it is further considered as a societal expectation [Barr14] in which family members are prompted to promote social engagement and provide affective care to their older adults [Barr14, Robl14]. Likewise, older adults expect this kind of involvement from their family networks, exposing their needs as caregiving requirements that have to be addressed. Culture also affects the way in which family members deal with this activity. For instance, in Latin America, social interaction with older adults should ideally be conducted in a face-to-face manner, since this has been the traditional way to interact with these people. As a result, a large number of Latin American older adults still prefer to stick to this interaction paradigm [Guti16]. This shapes the way in which family exchanges should be supported, reinforced, or mediated.

In this dissertation, we refer to *informal elderly caregiver* as any family member who engages in providing care and assistance to their older adults, even if the latter do not suffer from chronic or disabling conditions. As it was stated before, Latin American adult children—mainly women—assume a large part of this process due to both cultural expectations derived from a perceived filial obligation [Barr14] and the Latino parenting style [Dome09]. These caregivers assume several informal roles and have different engagement levels toward the process. The

dilemma of simultaneously having to care for their parents and children [Barr14, Guti16, Guti17], as well as unbalanced responsibilities when caring for older adults, stress family caregivers and produce tensions with other members in the family network. Therefore, this situation affects the quality of life of the involved family members, and consequently the results of the caregiving process [Barr14, Guti17, Thum15].

One of the most important duties that informal elderly caregivers are expected to fulfill is ensuring that older adults to sustain a suitable social health, i.e., favoring the social inclusion within the family network and avoiding potential negative effects of social isolation. While until about 20 years ago most of the social exchanges were conducted through face-to-face encounters, handwritten letters, and landline phone calls, current interaction paradigms are strongly reliant on mobile social media services, such as social networking platforms, mobile phone calls, and instant messaging. This, added to increasingly more time-consuming tasks, such as long working shifts and daily commutes, contributes to reduce even more the possible alternatives to mediate the interaction between younger family members and their older relatives. Although face-to-face interaction and phone calls between older adults and their family members still prevail, the frequency, quality, and extension of these interactions seem to decrease [Guti16].

The use of information and communication technology (ICT) is in part responsible of the digital divide that isolates the older adults. However, several researchers state that ICTs are also able to enhance and improve the social integration of the elderly (e.g. [Barb15, Corn13, Gara12, Lind12]). Such technologies can play in favor or against a certain target population depending on the ways in which they are designed and used.

The design of effective domestic computing solutions requires framing the socio-cultural nuances of the interaction scenario where they will be deployed. In other words, software designers in this domain need to deeply understand the contextual viewpoints and concerns of the involved stakeholders that will interact with the conceived social technology support. In that respect, although previous research efforts have been dedicated to design computer-mediated technology to facilitate the social interaction among members within a family network [Neus13], these solutions are not fully transferrable to the case of middle-class Latin American families. In particular, technology appropriation is a noticeable issue in most of Chilean adults, where 70.5% of the population aged over 50 declares that they do not know how to search information online nor send an email [Nati12]. Therefore, it turns relevant in this scenario to systematically study how to improve technology acceptance and adoption among older adults, which based on state-of-the-art solutions, can act as a way to help design and introduce computer-based technology for enhancing their social health through mediating their social interaction space.

In summary, we are faced to a problem that is shaped by human and social factors rooted in our culture. These concerns must be actively considered when aiming to understand the interaction scenario, and later when designing technology that can be accepted and considered as useful by the involved stakeholders in the informal elderly caregiving process. Furthermore, there are additional challenges related to how to deal with intrinsic asymmetries when envisioning to design both human-human and human-computer interaction experiences. These considerations include selecting the appropriate technology support [Guer06] and interaction mechanisms [Eraz14] to be supported through the mediation system. In concrete terms, we can state the following design concerns that should be addressed: support the negotiation process of aligning the communication channel used to mediate the interaction, manage the available time periods, and respect the inherent preferences—and willingness—of both parties to deal with disruptions

caused by the intervention process. Therefore, conceiving a solution to mediate intergenerational family communication in the studied scenario goes beyond than merely facilitating technology adoption by a certain group or population. While today social media seems to be the preferred way to interact among younger people, in the near future it is quite possible that new interaction paradigms will emerge. This situation would then shift the reliance on the technology support for mediating social interaction with current popular services (e.g., email, Facebook, and other social networking services) and rather stick to the lessons learned from understanding the design space and underlying challenges that need to be addressed, both from an organizational and collaborative viewpoint regarding the informal elderly caregiving process, encouraging active aging and facilitating the involvement of the family network.

In that respect, while in Chile the discourses and implications of aging have been mostly studied from an anthropological point of view (e.g., [Osor13, Osor14]), there is currently little research in this area conducted from a Computer-Supported Cooperative Work (CSCW) and a Human-Computer Interaction (HCI) perspective. The lack of knowledge in these areas limits our capability to design technology for positively impacting the informal caregiving space with ICT-based solutions and for encouraging older adults to be active users of computer-mediated technology, as well as effectively mediating the social interaction space shared by the involved parties. These design challenges are also relevant to an emerging branch of Software Engineering, named “Social Software Engineering” [Ahma08], which is focused on studying the social aspects of both software development and developed software.

1.1 Problem Statement

The current social interaction paradigm—mostly relying in social media applications and services—has inadvertently increased the risk of social isolation among older adults, given that family members tend to overlook the traditional interaction spaces that the elderly have historically used for socializing [Gidd98, Neal00, Thom11]. For instance, a recent survey conducted in Chile [Fern14] shows that almost 25% of older adults consider themselves excluded or socially isolated, while 40% declare to miss the company of people around them. Similarly, a study conducted with a random sample of 3,858 older adults in Finland shows that 77% of them suffered from social isolation or continuously feel lonely [Tilv12]. Although the proportion of socially isolated people varies across different cultures and societies, it is clear that this is currently a global issue [Clou11]. Furthermore, if we consider the increasingly aging in population and the accelerated rhythm of technology evolution, it turns evident that we are currently facing a challenging and relevant problem, which progressively turns more complex and requires attention.

Computer-supported solutions to socially integrate older adults to their families is a challenge that is not easy to address, given that these people have variable health and cognitive conditions as well as asymmetric perceptions on cultural expectations about the family caregiving process. These considerations reaffirm the need to reflect on the underlying human values and social factors that influence the design and appropriation of technology by the different stakeholders in family networks. In order to bridge this gap, in this dissertation we conduct contextualized and localized empirical in-the-wild studies, aiming to understand the socio-cultural nuances of intergenerational communication and informal elderly caregiving in Southern Cone families. Building on such broad of knowledge, we contrast with the state-of-the-art discourse on designing social and domestic computing solutions to encourage active aging, which are mainly

rooted in Western Europe and North America. Through understanding the similarities and differences between both socio-cultural scenarios, we derive guidelines to inform the design of computer-supported solutions tailored to the viewpoints, expectations, and concerns of Southern Cone families.

Counting on contextualized guidelines and supporting tools is required given that most of the computer-based technology designed to assist informal family communication with older adults in a certain socio-cultural scenario (e.g., in Western countries), is not fully transferrable to a different interaction scenario (e.g., Latin American families). Therefore, any design proposal or supporting system must explicitly consider the attitudes, needs, and expectations of the involved stakeholders, which in our case correspond to Latin American people participating in the informal elderly caregiving process. In other words, any potential solution to address this problem needs to actively consider the particular cultural nuances of the local studied scenario, which requires conducting socio-technical research in order to structure and understand the viewpoints and concerns of all the involved stakeholders. For instance, in individualistic societies—like Western Europe or the United States—technology acceptance among older adults is much higher than in Latin America, given that the former tend to be more independent, empowered, and more reluctant to ask for assistance to their fellow family members [Nef13, Wayc13]. Besides, their adult children are less available to personally care for their aged parents [Kenn07]. Therefore, computer-supported solutions to increase family connection are more accepted in Western families than in Latin America, which serve more as a way to support informal communication than informal elderly caregiving activities. In particular, although enabling and facilitating intergenerational exchanges are important and meaningful efforts for mitigating the potential social isolation among older adults, existing solutions already reported in the literature do not explicitly cover the attitudes and expectations of adult children acting as informal caregivers, nor the dynamics within family networks to sustain such informal care provision. In Latin American families, these two concerns are significant restrictions that need to be addressed when designing domestic social computing solutions to support family communication and informal caregiving.

To summarize, specific and tailored guidelines are required to design computer-based technology that supports the family caregiving process in the Southern Cone region. These guidelines require understanding the underlying asymmetries among the involved family members, for instance in terms of preferred social media and time periods, as well as the current willingness to interact with other members across the family network. The proposed guidelines should also consider mechanisms for aligning the social interaction spaces of family members, as a way to allow older adults be an active party of the regular family interaction across the network. While the mechanisms used to align these social spaces can be computer-mediated, they must not only be appropriate for older adults, but also need to consider the preferences across the family network to make these interactions suitable.

In order to get useful and reusable knowledge that allows us to define particular design guidelines for developing and deploying computer-supported technology, aiming to facilitate the informal caregiving process for older adults, we state the following research questions:

- *What are the key viewpoints and concerns of family members regarding the informal elderly caregiving process?* Answering this question will allow software designers and researchers to identify particular caregiving activities that recurrently require external support and that could possibly be addressed using an ICT-based system.

- *How can we design computer-mediated technology to seamlessly address the communication asymmetries between older adults and fellow family members?* Answering this question will allow socio-technical designers, researchers, and practitioners to conceive and deploy in the field effective computer-mediated intergenerational communication technology.
- *How can we assist older adults to adopt and embrace computer-mediated technology to support intergenerational communication across the family network?* Answering this question will allow social computing researchers, designers, and practitioners to conceive systems tailored to the perceived needs, attitudes, and expectations of older adults regarding computer-mediated intergenerational communication technology.

To answer these questions, we limit the scope of this dissertation to studying and intervening middle-class Chilean and Argentinian canonical families living in urban settlements, given the high diversity of family configurations and heterogeneity within the population of older adults in terms of access and exposure to ICT-based technology. By canonical families, we mean the most common type of family structure according to socio-demographic reports. These families are usually composed of three generations: older adults, their adult children, and their grandchildren, who do not necessarily share the same household and are usually spread over a limited geographical context. In addition, we limit our sample to older adults not suffering from major physical or psychological impairments to keep regular social interaction with other family members, potentially with the assistance of computer-mediated technology.

In this dissertation, we argue that technology to seamlessly support the communication needs of older adults could help reduce their social isolation and increase the opportunities for conducting face-to-face interaction with other family members, through physical or virtual meetings. These solutions would also assist adult children acting as informal caregivers in balancing the caregiving workload across the family network, and possibly allow older adults to live independently in their homes by keeping a frequent social contact with their family members. However, designing these systems is a challenging task since they have to deal not only with the particularities of the described social interaction and with the typical technology reluctance shown by older adults in the studied socio-cultural context, but also with the technical aspects involved in developing and deploying this kind of software. Therefore, addressing this design challenge requires integrating knowledge from various domains: *Computer-Supported Cooperative Work*, *Social Computing*, *Ubiquitous Computing*, *Interaction Design*, *Engineering of Interactive Computing Systems*, and *Social Software Engineering*.

1.2 Understanding Family Communication and Informal Caregiving

Aging in place is a paradigm that encourages people to live in their homes for as long as possible as they get older [Robe12]. While family members provide more than 95% of the informal care for older adults who do not live in nursing homes [Kaye10b], more than 99% of American adults aged 65 and over have expressed a desire to stay at home as long as possible when aging [Koch05]. Hence, this paradigm is highly praised by governments, since it reduces the impact of older adults on public health services [Lewi10, Myna04]. However, the availability and characteristics of family networks that provide informal elderly care (e.g., size, structure, professionalism, and response capability) depend not only on the needs of older adults, but also on socio-cultural, demographic, and economic aspects, which at the end shape the structure and dynamics of the caregiving process.

Older adults typically do not have broad access to modern technologies, or they find them difficult to use [Kari12, Hope14]. This problem is exacerbated for those with physical or cognitive impairments. As a result, many older adults report feelings of loneliness and an increased longing to communicate or interact with family or friends [Forb96, Newa09]. Moreover, with the proliferation of devices supporting ubiquitous access to communication technologies, and the prevalence of social media for connecting with family and friends, it is likely that older adults face increasing challenges in interacting with their younger relatives who use such technologies [Lind08, Lind09, Moff13]. Therefore, a theoretical understanding of the connection between communication aspects and health indicators will advance human-centered computing, by motivating the design of interfaces and awareness mechanisms that offer wellness and promote interaction opportunities to older adults [Sund11].

For older adults, the rapid technological shift has caused a series of side effects due to the difficulty of having to constantly acquire new knowledge. The natural decline of their biological and mental capacities—such as visual and auditory perception, fine motor control, and some aspects of memory and cognition—does not help them address this problem [Carm99, Hawt00]. As a result, older adults unfortunately lag behind in the adoption of new communication media and they are at risk of falling into social isolation. Therefore, they need support and guidance to face the new communication media in a pleasant way [Roup10], and in finding alternatives to allow them to be part of the intergenerational social space, where digital media play a key role.

Making the older adults active players in this new social scenario becomes mandatory, since Chilean and Argentinian young and adult people have a stressful rhythm of life that pushes them to interact using social media and reduces their spaces for conducting face-to-face interactions. In particular, Chilean adults are usually engaged into quite long working shifts (9–10 hours a day, regulated by law). Chile and Mexico are among the Western countries belonging to the Organization for Economic Co-operation and Development (OECD) with the highest number of worked hours per year [Orga15]. This situation burdens the adult children assuming informal caregiving duties for their older adults, since they must find a work-life balance trying to simultaneously care for their parents and their own children.

1.3 Challenges to Align the Social Interaction Spaces

Besides remote monitoring, one of the ways in which informal elderly caregiving is instantiated is through facilitating the ways to conduct intergenerational exchanges between older adults and other family members. Therefore, understanding the attitudes and preferences of family stakeholders becomes relevant when aiming to intervene their social interaction space.

Through observing and interviewing members in Chilean and Argentinian family networks, we identified that informal communication asymmetries are mainly expressed in terms of: (1) the different media that family members are capable or prefer to use; (2) the available time periods for engaging into social communication with other parties; and (3) the perceived willingness to initiate a particular social interaction with another family member. We propose that these three dimensions shape the social interaction space of an individual [Guti15b]: interaction media, time space and willingness for socializing.

Figure 1 shows these dimensions through visual representations. Circles represent the communication media that an individual is capable to use; octagons represent the available time

periods when a family member is able to engage in social interaction; and squares list the perceived willingness to initiate social interaction with others. However, as depicted in Figure 2, these preferences usually do not match across generations.

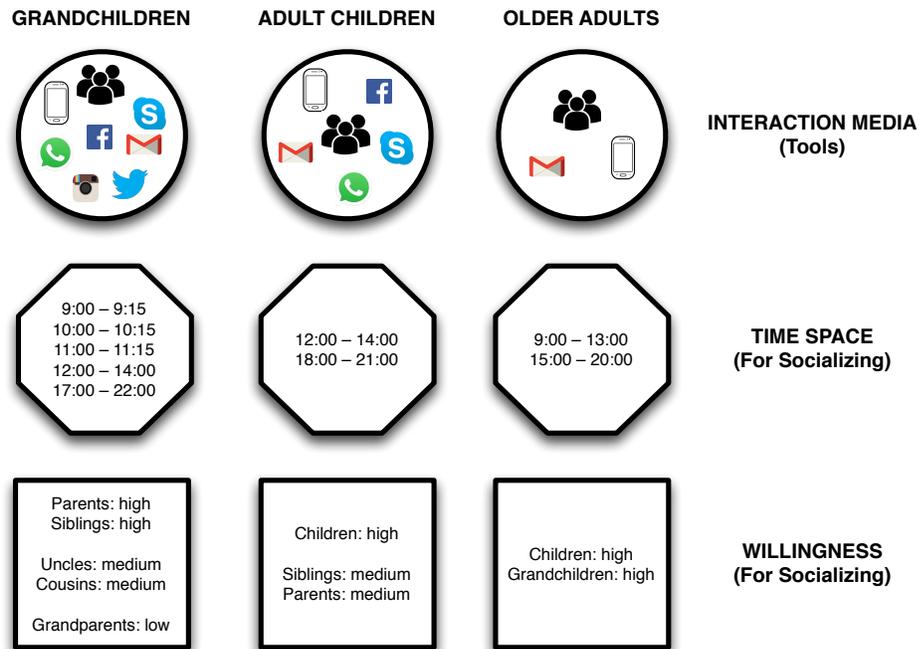


Figure 1: Social interaction spaces across generations within a family network

In Figure 2, the size of each component maps the diversity and/or strength of the attributes expressed in each dimension. In particular, the social interaction space of an individual is usually different whenever s/he takes the role of sender or receiver in a given interaction process.

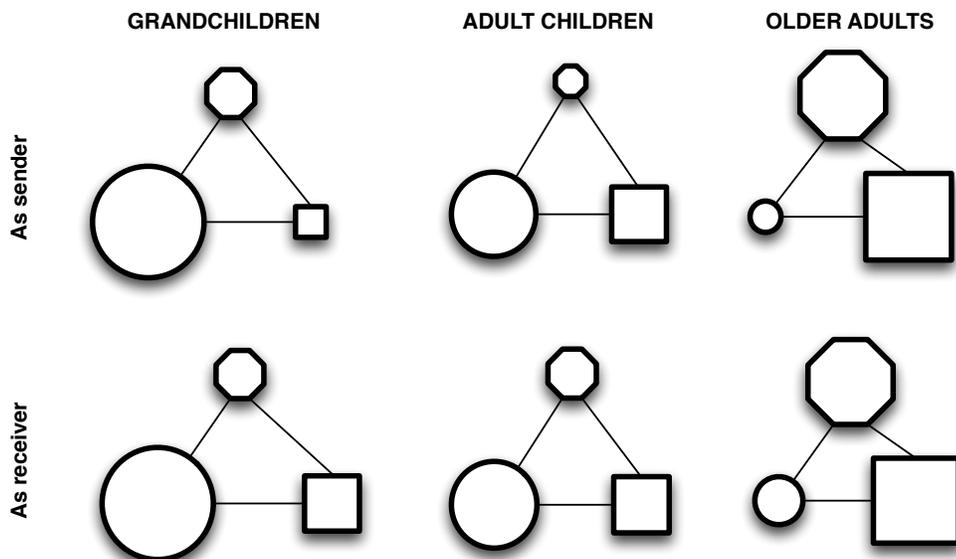


Figure 2: Asymmetry between the social interaction spaces within a family network

Therefore, asymmetries need to be addressed when the social interaction space of one family member (e.g., who takes the initiative to interact) does not match the social interaction space of a fellow family member (i.e., the target people). For instance, different family members usually prefer different communication media to interact; e.g., telephone calls, email, social networking services, or other messaging tools. Respecting these preferences is part of what is required to design accurate and effective ICT-based solutions.

In the case of asynchronous communication, such as email or text messaging, we can use an aligner—a software component—that makes the users perceive that they are interacting with somebody using the same tool, although in fact they are using different ones. For instance, we could align interactions based on text messages, where a participant uses Facebook messages and the other uses email. The challenge then is focused on how to keep the communication paradigm proposed by each mediator, which is usually different among these tools, in order to make the participants feel that they are actually using the communication channel they prefer.

In the case of synchronous communication, the use of mediators is quite difficult because interactions should be in real-time, and the process to adapt the messages (e.g., speech-to-text and reverse) usually takes time that jeopardizes the sense of simultaneity perceived by the participants. Moreover, synchronous communication also requires aligning the time periods in which the participants are available to socialize. Unfortunately, the interaction mechanisms usually preferred by the older adults are synchronous—mainly face-to-face and phone calls—, which are not easy to align. However, instead of aligning these mediators, we could emulate the preferred interaction mechanism of older adults by using services of synchronous communication tools. For instance, we can emulate a regular phone call using Skype or another VoIP service. The challenge here is to determine how to use the current services of synchronous tools, to emulate other communication mechanisms.

All the previous challenges should be addressed by aligning the mechanisms preferred by the people involved in a social interaction. However, in order to encourage family members to engage in social interaction, the system also needs to be proactive, i.e., to prompt them to initiate interactions. For this, it is necessary to align as well the time periods in which the person in need of socializing (socially supported) and the target person (social supporter) have at their disposal, and to prompt one of the parties to initiate a social interaction request to the other. The alignment of socialization periods and the promotion of interaction require intervening into the social interaction space of the involved people.

Existing research about awareness mechanisms in collaborative environments could be helpful in addressing this problem, by making family members aware of the current situation of their elders and other family members. However, it is not clear what awareness mechanisms are effective and in which way they must be used, due to the fact that people usually have different rhythms and patterns (routines) to perform their social interactions [Muno15]. Research into mixed-initiative dialogue systems may contain solutions in the design of interventions that are not considered unnatural or perceived as obtrusive by users. Yet, what approaches would be appropriate to apply in this context of cross-generational family communication, and how to culturally anchor them, are open research questions that border the field of persuasive technologies and behavior change.

Although promoting social interaction among family members is a commendable objective, such interaction must not overwhelm people having little time for socializing. Therefore,

effective mediation strategies should intelligently coordinate all the members in a family community based on specific criteria, such as location, time of the day, and available communication media to support the interaction. This necessarily implies that such mediation process should be adapted to both, the individual's interests and those shared among groups of his/her network. Supporting technology deployed in domestic settings should not be excessively intrusive as well. For instance, computer-based solutions based in habituated objects (e.g., [Brer13, Brer15]) and extending design metaphors of common objects into the physical world (e.g., [Corn13, Gara12, Lind12]) have been proven effective for increasing technology adoption and appropriation by older adults. Similarly, using passive monitoring in lieu of instrumenting the older adults' house with sensors can be effective for dealing with technology reluctance.

Besides, the mediator system should not be too proactive, since people will eventually refuse to react when there is no urgency. In fact, understanding the social and technological context of the involved people is fundamental to ensure the success of the mediation. Furthermore, this coordination process should be able to identify whenever family members need to be persuaded in order to engage in social interaction. We can summarize these ideas as follows:

Design Implication #1

Any technological solution that tries facilitating the social inclusion of older adults must do it in an integral way, trying to minimally intervene the environment of the older adults and the daily routines of other family members.
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In addition, the design of computer-supported caregiving technology has generally not acknowledged the complexity and heterogeneity of the informal care provision to older adults [Proc14], which produces a gap between the older adult needs and the provided services [Bres13, Proc14]. Fischer and Herrmann [Fisc15] refer to this situation as a “Universe of One” problem, in which a solution for one person will rarely generalize to a broader population. Therefore, a plausible option to deal with this situation is to support meta-design, i.e., an approach where users act as designers in a scenario where technology gets embedded into the socio-technical environment where it is intended to be deployed. In consequence, the latent needs of both older adults and their informal caregivers are addressed in the design process.

In that respect, there is a consensus in literature that adult men and women tend to address and prioritize different caring aspects when assuming their roles. However, although these approaches seem to be complementary, there is little to no coordination among them, usually leading to conflict and tension among family members due to the lack of visibility of the fulfillment of caring activities [Guti17]. Besides, informal caregivers are not always aware of opportunities to balance the caring process and involve other family members.

All in all, this information can be used to inform the design of socio-technical systems for increasing the engagement of informal caregivers, thus helping deal with most of the tension and derived conflicts. In other words:

Design Implication #2

We require a better understanding of the complex and diverse living experiences and care needs of older adults and their surrounding family networks, as a way to help conceive effective socio-technical solutions for each particular caregiving context.

Consequently, this dissertation aims to frame the general context of intergenerational family communication in the Southern Cone of Latin America, as well as structuring and understanding the viewpoints and concerns of the stakeholders involved in informal elderly caregiving.

1.4 Hypotheses and Dissertation Goals

Given the current technology shift we experience, older adults are more prone to suffer from social isolation. There is empirical evidence that interventions can be designed to improve the health status and wellbeing of social groups [Coh04]. We are interested in studying the dynamics of the informal elderly caregiving process; in particular, through confronting the viewpoints and concerns of older adults and other family members. Likewise, we envisage to facilitate the participation of older adults in digitally mediated socialization scenarios and actively involve family members. In this case, the differences in age, level of technology appropriation, availability, and intention of socializing produce communication asymmetry.

Understanding the socio-cultural nuances of this particular interaction domain would allow software designers to contextually elicit requirements and take informed architectural decisions to develop computer-supported mechanisms to mediate intergenerational communication and informal elderly caregiving. As any computer-based intervention intended to be mediated in the wild, the conceived software support needs to take into account the human and social factors of the ecosystem in which it will be deployed. In particular, it needs to coordinate and articulate the interests, underlying expectations, viewpoints, and concerns of the involved stakeholders. In the context of this dissertation, the rationale behind the envisaged solutions to reach these stated goals will be captured through empirical studies informing design guidelines to support the process. Based on these premises, this dissertation hypothesizes that:

- (H1) *Computer-supported software abstractions, developed to facilitate intergenerational communication, increase the perceived sense of connection of older adults within their families.*
- (H2) *Computer-supported mechanisms, developed to seamlessly allow people to use their preferred media to communicate, reduce the perceived asymmetries between older adults and the rest of the family.*
- (H3) *The usage of computer-supported software abstractions to mediate family communication by older adults, eases the informal elderly caregiving process.*

As stated above, the main research goal of this dissertation is to develop design guidelines for computer-supported interactive applications, aiming to facilitate the social inclusion of older adults in the digital media age as a way to facilitate intergenerational exchanges through computer-mediated mechanisms. Therefore, such guidelines should help software designers conceive mechanisms aiming to reduce the communication asymmetry—in terms of preferred communication media, time space and willingness to socialize—between family members and increase the social communication from/to older adults, as well as reduce the load of family members acting as informal elderly caregivers. In that respect, and following an inductive research approach, the formulated hypotheses guide the reflection process to empirically derive the proposed design guidelines. Consequently, the specific objectives derived from the general goal are the following:

1. Structure the informal elderly caregiving process, by identifying and characterizing the main viewpoints and concerns of the involved stakeholders. That way, software designers would be able to understand the key factors regarding intergenerational exchanges as a way to make informed architectural decisions for computer-supported systems in this domain.
2. Propose a family communication model that allows software systems to manage (i.e., record, monitor, align, and facilitate) computer-mediated social interactions from/toward older adults, addressing communication asymmetries through synchronous and asynchronous channels. That way, software designers would be able to conceive tailored computer-supported mechanisms to deal with intergenerational communication in the studied socio-cultural context.
3. Define a set of user roles representing the main attitudes, needs, and expectations of older adults in terms of social interaction and care provision according to the Latino culture; particularly considering the case of Chilean and Argentinian families. That way, software designers would be able to specialize the broader interests, viewpoints, and concerns of the involved stakeholders in this domain.
4. Evaluate the pertinence, acceptance and effectiveness of mediating the social interaction space within a family network, through an interactive system aiming to reduce the perceived asymmetries between older adults and the rest of the family. That way, we would be able to contrast the empirical ethnographic work with in-the-wild data, as a way to corroborate and extend the derived design implications so far.
5. Synthesize the inferred design implications from empirical work into a set of concerns and guidelines. That way, we would be able to structure the analyzed data into a reusable framework to assist software designers in taking informed architectural decisions for computer-based interactive systems to mediate intergenerational exchanges and supporting informal elderly caregiving in the studied socio-cultural context.

1.5 Proposed Solution

The envisaged solution spans over two main domains: (1) understanding the social interaction dynamics regarding the informal elderly caregiving process, and (2) using the acquired knowledge to conceive reusable artifacts (e.g., guidelines) for designing mechanisms to mediate the informal interaction across generations, as well as assisting informal caregivers in fulfilling their duties more easily. In both cases, the conducted empirical studies are grounded in the research areas of computer-supported cooperative work and human-computer interaction.

The first work domain considers the non-invasive monitoring of the social activity within a family network. This considers the definition of routines, roles, and interaction flows aiming to understand first-hand how the interaction scenario in the studied families resonates and differs from those already established in the literature. Regarding the second work domain, the main consideration will be in using a cultural lens to fit the analysis as a way to contextualize the envisaged design implications and developed software artifacts. Figure 3 details the successive stages involved in the development of the solution to answer the stated research questions.

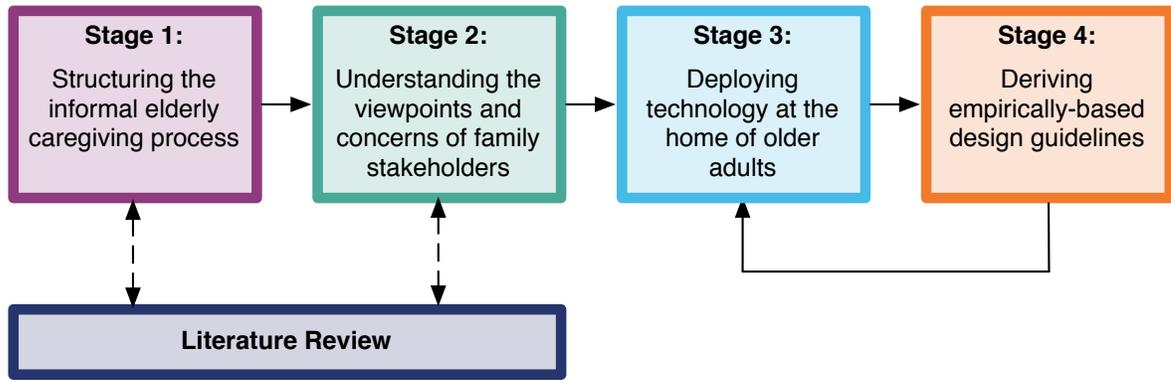


Figure 3: Stages involved in the derivation of design guidelines to support informal elderly caregiving

The proposed solution is composed of the following four main stages:

- **Stage 1:** *Structuring the informal elderly caregiving process*; i.e., modeling the family communication flow and understanding the internal dynamics on how the involved family members coordinate, negotiate, and accomplish their duties.
- **Stage 2:** *Understanding the viewpoints and concerns of family stakeholders*; i.e., characterizing the main attitudes, expectations, and needs of older adults and the other family members acting as informal caregivers.
- **Stage 3:** *Deploying technology at the home of the elderly*; i.e., observing and inquiring through systematic methods how family members interact with each other, involving the mediation of computer-supported mechanisms. A system, called SocialConnector [Muno15b], has been conceived through participatory design with older adults and iterative empirical refinements through continuous lab and field validation.
- **Stage 4:** *Deriving design guidelines to support informal elderly caregiving*; i.e., formulate modular, extensible, and reusable knowledge regarding the design and deployment of computer-based technology to support informal elderly caregiving in Southern Cone families. These guidelines, which extend prior work in Web accessibility (e.g., [Kurn05, W3C08]) are then iteratively introduced into a system prototype and validated through localized and contextualized empirical studies.

1.6 Methodological Framework

Given the nature of the study domain, we opted to follow an inductive research approach modeled after the *Grounded Theory* framework [Glas99]. Grounded Theory—which is widely used in HCI [Blan16, Furn11] and is starting to gain wide recognition in Software Engineering [Stol16]—is a systematic method for inductively developing theory from empirical data. Although in the literature there are several variations and interpretations on how to conduct the method, there is a widespread consensus in that it involves several stages of deep iterative data collection, coding, and constant comparative analysis.

As suggested by Blandford et al. [Blan16], a Grounded Theory research process can be modeled after a funnel. This simplified model represents the breadth and depth of the evolving theory, with iterative cycles of recruitment, data gathering, and analysis (Figure 4).

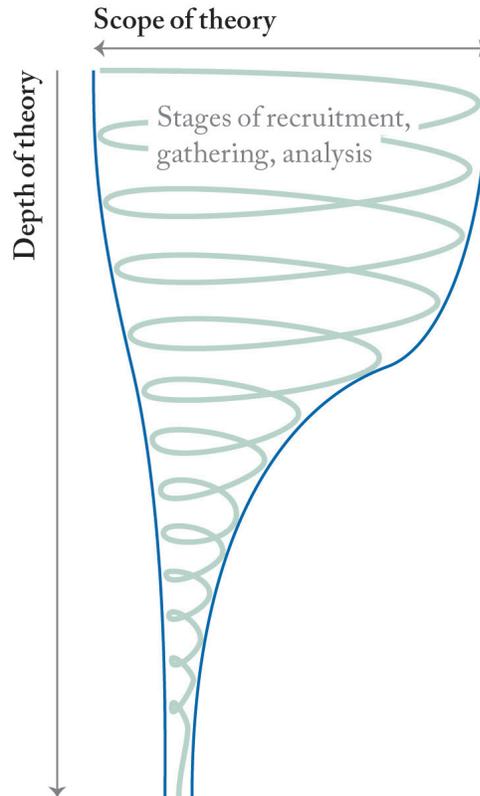


Figure 4: Simplified view of Grounded Theory [Blan16].

In the context of this dissertation, the initial hypotheses for inducing the theory development process are those presented earlier in Section 1.4. The cycles down the funnel correspond to four empirical studies, ranging from an observation and informal interview study (Chapter 3), semi-structured qualitative interview study (Chapter 4), contextual inquiry study (Chapter 5), and mixed-methods in-home deployment study (Chapter 7). In each stage we iteratively reflected upon the initially formulated hypotheses, and refined design implications to systematically analyze, structure, and synthesize, which finally take the form of design guidelines at the bottom of the funnel (Chapter 8).

Each iterative circuit of the followed research process was modeled following the *Action Research* paradigm [Haye11]. This research strategy allows performing one or more active in-the-wild interventions in the studied scenario, and is particularly appreciated when the goal is to observe in depth the effects of introducing a new technology or method in the study population [Blan16]. In this approach, the research is conducted in an inductive way. Particularly, after identifying and characterizing the problem to address, the solution and understanding of this problem is developed and refined through several cycles (Figure 5). This approach also allows researchers to identify particular problems—usually more specialized—derived from the addressed one.

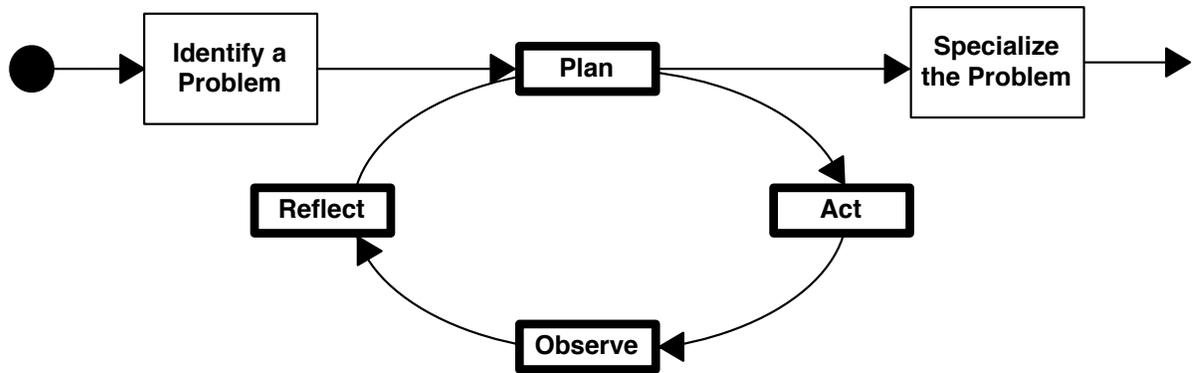


Figure 5: Action research approach

In our case, and as defined in subsection 1.1, the problem to address is to identify key aspects to be considered in the design of computer-supported technology to mediate informal elderly caregiving and provide guidelines to address them, grounded in the contextualized analysis of the interaction paradigm in Latin American families. A specialized problem—to be solved in future work—would be to conceive personalized persuasive triggers to mediate social interaction within a family network. Each action research cycle structures the stages proposed to solve the current problem as follows: (1) plan, (2) act, (3) observe, and (4) reflect. Particularly, these cycles allow us to identify, evaluate, and refine the guidelines proposed for addressing the key design concerns. Next we briefly explain the stages of the followed action research cycles.

- **Plan:** After analyzing in depth the interaction scenario and the problem to address, we plan an intervention to be deployed in such a scenario as a way to get concrete and reusable knowledge; e.g., determining if a preliminary formulation of key design aspects is complete or includes the most relevant concerns of the studied context.
- **Act:** Intervene into a sample of the study scenario, i.e., family networks, according to the plan defined in the previous stage.
- **Observe:** Follow systematic methods to observe, interview, and record the information to be observed in order to gain the expected knowledge.
- **Reflect:** Systematize the acquired knowledge, and based on it formulate and/or adjust the product being evaluated; e.g., the set of design aspects or reusable design guidelines. The obtained results indicate if a new cycle is required to improve or refine the product under study, or if it is already deemed as good enough for moving forward in the development of other components of the final proposal.

As noted above, the development of this thesis work involved several action research cycles, where the first ones were more focused on gaining knowledge in the study area and on identifying key aspects for designing the supporting solutions. Then, the cycles were used to identify and evaluated the set of design guidelines. Finally, there was a last cycle focused on conducting an in-home deployment for verifying in the field the suitability of the proposed guidelines.

1.7 Steps to the Solution

Below we describe the main steps followed to build the solution proposed in Figure 3. This helped us answer the research questions stated in this dissertation.

1. Review of the literature on family communication and informal elderly caregiving, contrasting the views on the key topics in Western countries (e.g., United States, United Kingdom, and Canada) with those in Latin American countries. *This work is presented in Chapter 2.*
2. Inductively structure the informal elderly caregiving ecosystem and model communication asymmetries in family settings. This is achieved by conducting empirical qualitative studies and model-driven engineering formalizations. *This work is reported in Chapter 3.*
3. Study in depth the attitudes, needs, and expectations of older adults and informal caregivers, in order to formulate a set of informal caregiving and intergenerational communication family roles. *This work is presented in Chapter 4 and further developed in Chapter 5.*
4. Deploy in the homes of a sample of families the interactive system named SocialConnector, aiming to monitor and mediate intergenerational family communication between older adults and the rest of the family network. By analyzing automatically generated system reports, and conducting semi-structured interviews with relevant stakeholders, we study using a mixed-methods design the usage and user perception on the system. *The design of SocialConnector is reported in Chapter 6 and the results from the study in Chapter 7.*
5. Systematically observe and conduct interviews to the key stakeholders in the informal caregiving process as a way to contextualize their usage, current expectations and user perception when interacting with computer-supported technology to mediate family communication in their homes. *This work is presented in the second half of Chapter 7.*
6. Derive, analyze, and formalize design guidelines to inform future computer-mediated communication interactive systems, aiming to bridge family asymmetries and support informal elderly caregiving. *This work is the focus of Chapter 8.*

1.8 Contributions

This dissertation contributes in advancing the fields of *computer-supported cooperative work in family settings*, *design and engineering of interactive computing systems for older adults*, and *social software engineering* by: (1) providing contextualized evidence on how to design computer-based technology to mediate family communication between older adults and their family members, simultaneously respecting the preferences and main expectations of the involved parties, and (2) articulating an empirical research process that inductively elicits user and software requirements considering the social and cultural nuances of the study domain, intertwining data analysis, theory formation, and continuous validation through an analysis framework inspired by the grounded theory approach. More specifically:

- We structure the literature on elderly caregiving by proposing a conceptual model representing the informal caregiving ecosystem, mapping the most relevant stakeholders,

their viewpoints, and their concerns. In addition, we formulate a family communication metamodel for promoting computer-mediated communication between older adults and their family networks, addressing their implicit and explicit communication asymmetries through synchronous and asynchronous channels. *This work is detailed in Chapter 3.*

- We define a set of roles describing the viewpoints and concerns of the main stakeholders in intergenerational family communication and in the informal elderly caregiving process, and we formulate a matrix as a way to analyze the current interaction scenario across the family network and inform the design of CSCW supporting systems in the studied scenario. *This work is described in Chapters 4 and 5.*
- We identify a set of design implications for social computing systems supporting intergenerational computer-mediated communication with older adults. These design implications, initially grounded in literature but later extended with empirical studies, *are reported in Chapters 1 to 5.*
- We contrast the design implications derived so far with those obtained from conducting an in-home deployment of a domestic system, mediating family communication with a sample of older adults and their family networks. *This work is detailed in Chapters 6 and 7.*
- Finally, we thematically cluster the identified design implications according to their main covered design concerns and involved stakeholders. Contrasting these aspects with empirical evidence allows us to propose a set of design guidelines to assist social computing designers and practitioners on conceiving computer-mediated mechanisms to support intergenerational family communication and informal elderly caregiving. We also describe how the proposed guidelines can be used as a way to assist software designers in taking architectural decisions when conceiving computer-supported solutions to mediate intergenerational communication and informal elderly caregiving in the studied socio-cultural context. In that respect, we structure the proposed guidelines around four architectural layers: user-system interaction, communication, coordination, and cooperation, which in turn suggest four mandatory quality attributes that need to be considered in design: usability, perceived value, understandability, and user-system confidence. *This work is presented in Chapter 8.*

Given the nature of the followed research method, these contributions are limited to the studied group. Therefore, future studies will be required to assess their generalizability to broader populations, particularly in other socio-cultural contexts.

1.9 Overview of Dissertation

The rest of this dissertation details the work summarized in this introductory chapter. Following on the simplified view of Grounded Theory—discussed in Section 1.6 and depicted in Figure 4—we show in Figure 6 an overview of its contents. In it, we explicitly address the dependencies between chapters and their relation to the inductive iterations of the research framework (i.e., action research cycles). Colors in each block map the stages to the solution, as they were presented in Figure 3.

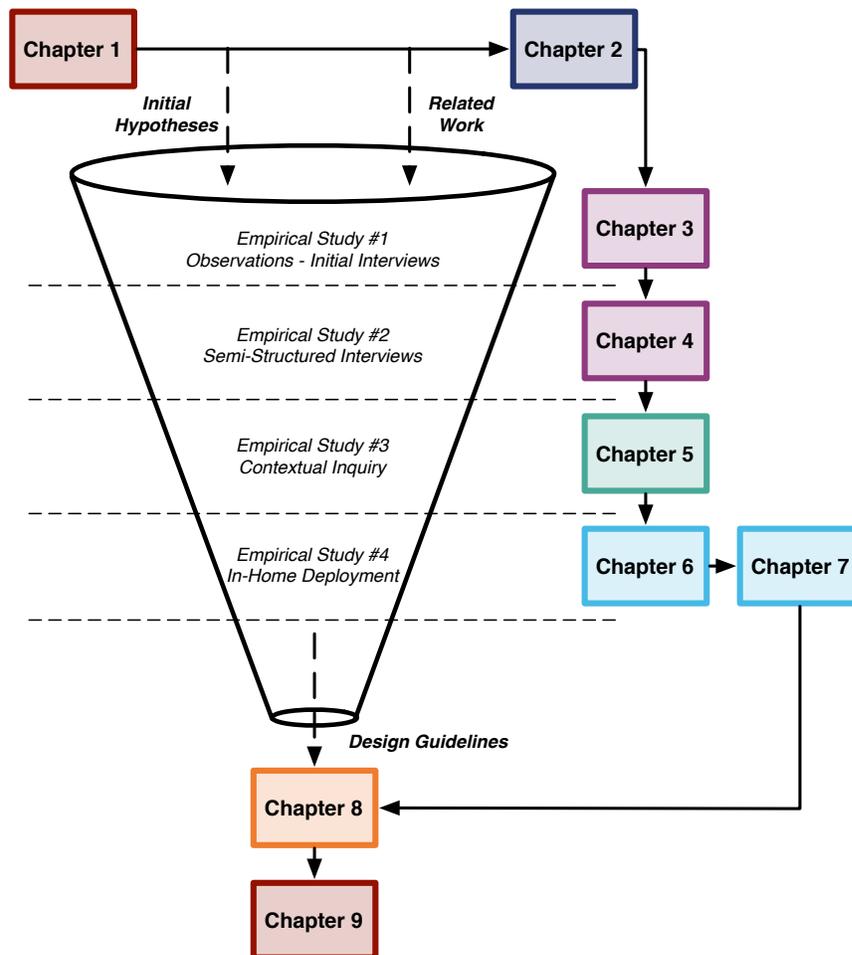


Figure 6: Overview of dissertation

Adhering to the action research approach, the conducted work in this dissertation follows several cycles of inductive chaining, where the findings of one study inform the method and specialize the research questions to address in the following. In particular, the dependencies between chapters are as follows: (1) Chapter 2 discusses related work, which is organized and structured under a CSCW lens in Chapter 3; (2) a preliminary research instrument for observing and understanding the nuances of intergenerational family communication and elderly caregiving is conceived in Chapter 3, which is then further improved in Chapter 4, and finally specialized in Chapter 5; (3) based on the findings of the studies conducted in Chapters 3 to 5, we report the design of the software platform presented in Chapter 6; (4) using the system described in Chapter 6, we conduct an in-the-wild study in Chapter 7 to corroborate the findings reported in previous chapters; (5) organizing the findings from the studies conducted in Chapters 3, 4, 5, and 7, we formalize a set of design guidelines in Chapter 8; and (6) Chapter 6 presents the conclusions and perspectives on future work.

The detailed content presented in each Chapter is as follows:

- **Chapter 2:** *Research background and related work.* This chapter presents and discusses the broad literature on intergenerational family communication and informal elderly caregiving, covering research grounded in gerontology, communication studies, anthropology, computer-

supported cooperative work, and human-computer interaction. It particularly contrasts the views between Western and Latin American families.

- **Chapter 3:** *Modeling communication asymmetries in family settings.* In this chapter, we structure the informal elderly caregiving ecosystem and we propose the formulation of a family communication metamodel, aimed to assist the design and development of interactive domestic software systems for addressing intergenerational communication asymmetries.
- **Chapter 4:** *Attitudes and expectations on the interaction with older adults.* Through a qualitative interview study, we characterize in this chapter the main viewpoints and concerns of Latin American older adults, regarding family communication and informal care provision. In particular, we model a vicious circle on technology adoption in this population, as well as describing a set of user personas to characterize the family ecosystem.
- **Chapter 5:** *On the cooperative nature of informal elderly caregiving.* In this chapter, we present the key findings of a multi-method qualitative study, aiming to understand the cooperative nature of the informal elderly caregiving work as perceived by a sample of families in Chile and Argentina. In addition, we systematize the acquired knowledge in form of a caregiving matrix, which can be used by social computing designers to get a broader view of the current assumption of duties in the care provision process, as well as identifying opportunities to intervene using computer-based technology.
- **Chapter 6:** *SocialConnector.* In this chapter we describe the main services of a system prototype to mediate social interaction in intergenerational family settings. In addition, we detail the features embedded in this system for conducting non-invasive research through monitoring and interactive logging.
- **Chapter 7:** *In-home deployment.* This chapter presents the empirical design and main findings of deploying the SocialConnector system in a sample of Chilean families, as a way to understand user interaction, acceptance, and perceived usefulness of the application in mediating intergenerational communication and supporting informal elderly caregiving.
- **Chapter 8:** *Design guidelines.* This chapter groups the design recommendations and formalizes structured design guidelines to support intergenerational family communication and informal elderly caregiving in the studied context.
- **Chapter 9:** *Conclusions and future work.* Finally, we summarize the work presented in this dissertation, validate the stated hypotheses, review the contributions, and outline future directions for this research.

2. RESEARCH BACKGROUND AND RELATED WORK

Considering older adults in the design of computing systems is complex, since multiple human and cultural factors must be addressed and related, that go beyond a mere characterization of their limitations caused by age or health conditions [Lind08, Östl05, Sun14]. Indeed, older adults might be able to learn and overcome media literacy issues [Harl09], thus effectively evading the negative effects derived from social isolation. We agree that the elderly can become active users of digital technologies (e.g., [Bell13, Corn13, Lind12, Wayc13]). However, the design of these tools should be integrated into their particular sociocultural context, aiming to facilitate their acceptance and appropriation. For instance, the use of common online spaces allows family members to share their values and attitudes, and strengthen the ties across generations [Siib13].

While most of the reviewed literature is focused on designing technology targeted to older adults, in this dissertation we aim to understand how to design mechanisms for coordinating and articulating the effort of family members—particularly that of informal elderly caregivers—for mediating social communication and informal caregiving work across the family network. Therefore, such interventions might impact not only the older adults, but also other family members.

The following sections present and discuss the most relevant work in intergenerational family communication and informal elderly caregiving. This extensive literature will be used in the upcoming chapters as an initial frame to analyze the collected data. Section 2.1 presents the main lines of discussion on intergenerational family communication under a social computing lens, while section 2.2 builds on this discussion to provide a socio-cultural description about intergenerational family communication in Chile and Argentina, as reported by sociology and cultural anthropology research. In section 2.3 we comparatively discuss how Latin American and Western families organize themselves to provide informal caregiving to their older adults, following an analysis grounded in classic computer-supported cooperative work theories. Section 2.4 reviews state-of-the-art on alternatives to design computer-supported technology to mediate intergenerational family communication. Finally, section 2.5 reviews deployed systems to mediate family communication, and we briefly contrast them with SocialConnector, i.e., the prototype application that serves as case study throughout this dissertation. We conclude this chapter by summarizing the main considerations of related literature, which will be the ground for deriving specialized and tailored design guidelines to mediate family communication and informal elderly caregiving in the upcoming chapters.

2.1 Intergenerational Family Communication

Recently, a lot of effort in HCI and CSCW literature has been devoted to exploring how family members interact using computer-mediated mechanisms. Particular topics of interest are: understanding the attitudes and needs of different generations around digital communication, and how to design ICT-based technology to support and integrate the elderly into the family rituals and routines.

According to Kennedy and Wellman [Kenn07], in developed countries, such as urban Canada, family members have found different means to live their own lives while staying more

connected. This way of living is partially attributed to the high penetration and adoption of ICTs. Conversely, in collectivistic societies (e.g., Asia and Latin America), where people are raised and continuously encouraged to support each other, the notion of family has a central role in society. For instance, adult children are usually prompted to support their older parents following a personal commitment that is grounded in affection [Herr07, Stui08].

This conceptual difference implies that intra-family communication, particularly with older adults, is perceived as different in individualistic and collectivistic cultures. For instance, while grandparents in individualistic cultures do not typically have as much contact with their grandchildren as they would like [Harw00] and may “view the exercise of familial obligation as an assault on their dignity and moral worth” [Lind08, p. 77], older adults in Chile, which is predominantly a collectivistic culture, still benefit from being considered by their family members as a fundamental pillar in the family structure. In this latter case, adults continuously aim to integrate their parents into the kin and provide them with care.

Concerning the motivation to adopt digital technology, related literature suggests that in developed Western countries this adoption is motivated by the interest of the elderly in staying in touch with other family members [Dick07, Lind08, Siib13], particularly with their younger relatives [Nef13, Wayc13] and grandchildren [Corn13, Forg14, Lind08]. Conversely, while Chilean older adults show the same need [Barr14], they do not perceive a benefit in adopting digital technology. The reason behind this attitude is that they manage their communication through mechanisms that are already assimilated by them. In fact, very few Chilean older adults describe themselves as active users of social media or demonstrate comfort in using smartphones [Nati12]. Likewise, while exceptions occur, in the United States and other Western countries, there is tremendous mobility and reduced family size, leading then to a reduced assumption of intergenerational social interaction commitment, when compared to what would be expected in a typical Latin American family.

In summary, although the findings obtained from studies in Western countries could help elucidate how family networks find their ways to interact with their older adults in a broad sense, they are not necessarily representative of the Latino culture. The main reason that explains this contrast is the underlying attitude of adult children on fulfilling caregiving tasks in favor of their parents, which is perceived as stronger in collectivistic societies. This particular difference implies that design guidelines tailored to Southern Cone families need to acknowledge the potential involvement of a broader scope of family members, than what is expected in other Western families.

2.2 Intergenerational Family Communication in Chile and Argentina

Most of the Chilean population (about 45%) lives in the metropolitan area of Santiago [Nati12], which opens the possibility for frequent face-to-face interaction. This approach to conducting intergenerational exchanges also holds in the rest of the country, given that filial obligations impose that at least one adult child has to live close to the older adults for taking care of them when needed [Fern14]. The case of Argentina is fairly similar, where a large part of its citizens resides in the metropolitan area of Great Buenos Aires, accounting for about 35% of the country population [Nati10]. In addition, family members in both countries usually have low geographical mobility [Nati10, Nati12]. Therefore, distance does not seem to represent an issue

for keeping frequent interactions among them. Although many older adults have access to computer-supported technology, their adoption of it is typically low [Fern14, Redo15].

2.2.1 Interaction Routines

While exceptions occur, Southern Cone families follow an interaction routine—grounded in tradition—that in most cases involves a weekly family reunion. These meetings take place in the home of a family member (usually the older adult or one of his/her adult children), uniting those who are available during the weekend. These family meetings, which also happen in other Latin American countries [Suar04], last for at least a couple of hours, and their main goal is to reinforce the affective links and agreements of mutual support among members that do not share the same household.

If these family meetings do not occur, or if their frequency is reduced, people miss them, particularly the elderly. By recognizing that this routine should be adjusted according to the intrinsic family evolution, most members value these opportunities to conduct face-to-face interactions [Fern14].

2.2.2 The Role of Older Adults

Typically, older adults live with their partner in the same household while they are still self-sufficient. During the first period after retirement, i.e., while they are still physically active, many of them (particularly women) take care of their grandchildren or collaborate in the parenting activities [Fern14, Redo15]. This is part of the protective parenting style of Southern Cone families, and it allows older adults to interact more frequently with their children and grandchildren. In this period, older adults usually consider themselves as being a sort of family leaders, whose position is also recognized by most family members.

The participation of older adults on parenting activities decreases with the advancement of their physical and cognitive limitations. This progressively reduces the frequency of face-to-face interactions with adult children and grandchildren [Fern14], and also their leadership. When the older adults are no longer self-sufficient, their adult children usually hire an external caregiver to help them, or they arrange for their parents to live with them [Fern14, Redo15].

2.2.3 The Role of Adult Children in Caring For their Older Adults

Southern Cone adults typically have a stressful lifestyle that involves quite long working shifts (9–10 hours a day, regulated by law). In particular, Mexico and Chile are among the Western countries belonging to the Organization for Economic Co-operation and Development (OECD) with the highest number of worked hours per year [Orga15].

Adults are also highly committed to their parenting activities, which are usually conducted after working hours. These duties are considered as a priority for them, and are performed even after their children have formed their own families of procreation [Barr14]. This protective parenting style considerably reduces the available time of the adults for taking care of their parents. Furthermore, the low technology adoption of the elderly conditions their adult children to use interaction means that are comfortable for the former (e.g., short visits and phone calls), hence restricting the available alternatives for the latter to deal with their filial obligation. This situation usually stresses and burdens those family members who are in charge of assuming and

coordinating within the family network informal caregiving duties targeted to improve the wellbeing of their older adults.

2.2.4 The Role of Grandchildren in Caring For their Older Adults

In general terms, the bond between grandparents and grandchildren is usually quite strong, second in emotional importance only to the bond between parents and children [Korn02]. However, at least in the case of Chilean and Argentinian families, the perception of strength of this relationship varies along their lives.

During their early years, grandchildren usually have a strong relationship with their grandparents. When the former grow up, their available time for socializing is reduced, and their priorities for building and maintaining social relations shift from within their families to their close peers, same-aged friends and couples [Akel04]. This is similar to what has been described in individualistic societies (e.g., [boyd14]), which is not surprising given that young people in Chile and Argentina are highly influenced by the American and European cultures. However, most grandchildren in these countries recognize having some kind of filial obligation toward their grandparents, but the literature is not clear about how this feeling of duty is materialized in practice. Later on, when the grandchildren get married and build their lives, their family of procreation (i.e., the nuclear family composed of the adult partners and their children) is of top priority, even over their own family of origin [Barr14, Mont04, Redo15]. Therefore, their available time and motivation for taking care of or interacting with their grandparents is being reduced to isolated instances, such as family reunions or when their elders suffer an illness.

2.3 Supporting Informal Elderly Caregiving

Contrary to most Western countries, in the Southern Cone of America—Chile, Argentina, and Uruguay—there is usually little or no participation of formal caregiving networks or government services to support the informal care provision for older adults [Mont04, Popu14]. Therefore, informal caregiving becomes more unpredictable in terms of response time, given that the assistance depends on the cooperative, voluntary, and articulated action of family members [Guti16]. These features configure an aging in place scenario that is different to that in most Western countries, where there is increasing governmental funding for home and community-based services [Redo15, West14], with an increasing demand for technology that can improve health and independence of older adults [Horg03, Proc14]. By understanding the dynamics of this scenario, we could enlarge our breadth of knowledge by formulating guidelines that would help software designers conceive, develop, and deploy domestic technology effectively.

Understanding the role of family members in informal elderly caregiving settings has become an important issue in rapidly aging societies. In fact, given that there are no clear signs of a reduction in disability among older adults, that family ties are loosening, and that there is a growing female labor-market participation [Colo11], there is an increasing need to care for chronically ill, disabled, and partially independent older adults.

According to Procter et al. [Proc14], an effective aging in place strategy should be based upon the social and collaborative contribution of all participants in the caregiving network. Therefore, the nature of informal elderly caregiving is sustained through cooperative work, which resonates with prior research by Consolvo et al. [Cons04], highlighting the distributed and articulated effort

required in coordinating the different activities within the family network as a way to sustain informal caregiving.

Schmidt [Schm91] states that cooperative work corresponds to a group of people engaging in a common task, in which they are mutually dependent and need to act together to get the work done. Therefore, this kind of work is sustained by interdependence, where each participant is rendered accountable for accomplishing his or her tasks [Schm92]. Studying the cooperative nature of the informal elderly caregiving process would then enable socio-technical researchers, designers, and practitioners to deepen their understanding of the attitudes, needs, and expectations of the involved stakeholders—older adults, caregivers, and extended family members—to ease the introduction of computer-mediated technology to facilitate the process.

Schorch et al. [Scho16] identified three aspects that characterize the informal care experience at home, highlighting the expertise of caregivers, feelings of social isolation, and burden. Although in a different socio-cultural scenario, informal caregivers in Latin America also feel burdened by having to deal with their duties, often struggling to maintain a sustainable work-life balance [Barr14, Guti16, Redo15]. Furthermore, Latin American caregivers currently do not have access to respite care alternatives [Redo15], which increases the workload and stress related to fulfilling their duties, particularly among the adult children assuming the role of primary caregiver [Barr14]. This situation highlights an opportunity for CSCW designers to conceive contextualized mediating technology to reduce the burden produced by assuming caregiving duties in Latin American families.

Friends and neighbors also help sustain the informal care provision to older adults [Hime00]. In a recent study conducted in Chile, Thumala et al. [Thum15] found that 6 out of 10 adults consider that the main source of informal caregiving for older adults has to be supported by the extended family network, including close friends. Therefore, deepening our understanding of the cooperative nature of informal elderly caregiving needs to go beyond the nuclear family structure, and involves extended family members as well as surrounding people who feel close to the older adult and are willing to provide assistance in case of need.

There are also differences attributed to the gender of caregivers regarding the fulfillment of caregiving duties. Related literature states that women provide more hours of care, are more prone to assume the emotional work [Carr08], and are more involved in tasks than men [Cala06]. For instance, daughters are more likely to assist their parents with their daily activities [Dwyer91], while sons are more proactive and deal with instrumental tasks [Conn96]. In Latin America, one of the adult daughters is usually the primary source of care for older adults [Barr14, Guti16b], whereas male children tend to rely more on their social capital to find assistance for sustaining their caregiving duties [Guti16b, Guti17].

Although in most cultures there are expectations for adult children to care for their older parents, the viewpoints on the importance of societal prospects to this matter usually do not converge [Stui11]. The strength of filial obligation toward caregiving duties is moderated by the influence of the family of procreation, i.e., consisting of the adult child, his/her partner, and their children. On the one hand, according to Gallagher and Gerstel [Gall01], having children is more positively associated with caregiving than is the absence of children. On the other hand, according to Barros et al. [Barr14], in Chilean families there are asymmetric views on the priority of fulfilling filial obligation duties: older adults expect that their adult children take care of them, while the latter prioritize their own families of procreation.

In the context of informal elderly caregiving, the collective effort for providing care to the older adults is sustained through the involvement of a considerable part of the family network. In that respect, literature reports further contradictory perceptions on the assumption of these tasks in Southern Cone families. For instance, younger family members tend to have asymmetric perceptions on aging and the need to provide informal support and assistance to older adults. While only one in four seniors are dependent—requiring external assistance to support their lives [Gonz10]—, young people usually generalize social stereotypes that do not agree with the present potential of older adults, thus encouraging resignation and fatalism [Arno08]. This viewpoint, complementing the ruling filial obligation [Barr14], causes informal elderly caregivers in Chile to feel burdened, struggling to find an acceptable work-life balance [Thum15].

Given the distributed and interdependent role of family members when fulfilling caregiving tasks, a major challenge that emerges is articulating the distributed collective effort within the network [Schm96]. This relates to the case of informal elderly caregiving, and understanding how to coordinate the actions of family members and allocate resources to improve the efficiency of the process. Indeed, following the discourse proposed by Star and Strauss on the ecology of visible and invisible work [Star99], there are confronting visions in Southern Cone family networks regarding the informal care provision to their older adults. While duties are mainly assumed by one of the adult children in the family, the work and consequent burden on these informal caregivers is not always assumed as such by society [Papa07].

Technology that supports the process of caring for older adults in Chile and Argentina can be an effective way of balancing the workload of caregivers. It also favors the social integration of older adults, simultaneously bridging the gap in the asymmetric views on aging among family members. However, the adoption of computer-supported home-care systems usually represents a challenge [Vine13]. In this sense, Huber et al. [Hube13] identified that one of the most important factors that limits the adoption of technology by older adults is the fear that these systems might replace human contact with their family caregivers. Similarly, Procter et al. [Proc14] add that informal caregivers and care recipients usually need to reschedule their daily routines around the caregiving tasks, whereas current assisted-living devices usually lack affordances that fit the mental model of older adults. Mynatt et al. [Myna04] also highlight a tension between assistance and autonomy, as well as privacy and independence concerns.

Therefore, one plausible alternative to assist older adults into embracing caregiving technology is to design meaningful experiences that do not limit physical exchanges. In addition, respecting the existing routines and expectations of the different involved stakeholders is required, not only for facilitating the technology adoption and promoting effective and meaningful exchanges, but also to try aligning the implicit and explicit asymmetries existing across generations. We can summarize this idea as follows:

Design Implication #3
Technology to provide coordination support is necessary to manage the information flow within the informal caregiving network. In terms of design, such technology should intelligently coordinate the effort required to sustain both intergenerational exchanges and informal caregiving activities, while simultaneously respecting the inherent routines, expectations, and human values of all involved stakeholders (e.g., older adults, family caregivers, and other family members in the supporting network).

2.4 Technologies to Facilitate Family Communication

With the proliferation of social media and ubiquitous technology for supporting communication with family and friends, it is likely that older adults face increasing challenges when interacting with their younger relatives, who typically use those kinds of supporting technology to socialize [Lind08]. When looking deeper into family communication practices, some forms of interaction do not necessarily involve an explicit sharing of messages between older adults and their close family members, but rather an ongoing awareness of the other party's communication state [Rich10]. In other words, people actually use both personal and environmental cues to help the other communication party understand what is happening. This observation provides design opportunities to mediate the social interaction space of family members through computer-supported technology.

Tee et al. [Tee09] studied communication practices and information sharing patterns between families in the United States. The authors found that, while most of the participants desired to enhance their communication with at least one relative, in practice it would be difficult to achieve it due to social or technological concerns. In addition, Karimi and Neustaedter [Kari12] studied communication practices of older adults, finding that these mainly depend on family ties and the openness of older adults toward technology. In that study, older adults were classified as: (1) low-tech communicators, who prefer traditional means to stay in touch, such as face-to-face interaction and the telephone; and (2) high-tech communicators, who can adapt their communication patterns and preferences to match those of their family members.

Regarding the communication between grandparents and grandchildren, Forghani and Neustaedter [Forg14] found that the elderly tend to be quite interested in being aware of the doings of their grandchildren. However, grandparents do not typically have as much contact with their grandchildren as they would like [Harw00]. In addition, Lindley [Lind12] found that older adults usually prefer prolonged synchronous interactions. However, asynchronous communication actually offers advantages to facilitate intergenerational exchanges. For instance, it allows accommodating competing schedules, providing control over the time and effort dedicated to each social interaction, and enabling the involved parties to reflect on their communication before sending it.

Following that line of reasoning, a study of Smith et al. [Smit03] indicates that young people typically had the largest social networks in a family, adults used the greatest variety of technology, while elders had the smallest networks consisting mainly of relatives and close friends. In today's society, when online communication has reached a massive dissemination, it is relevant to analyze how digital media facilitate family communication. Indeed, there are differences in how parents interact with their children, and the interaction frequency does not decrease with the geographic distance [Burk13].

Video-mediated communication has also brought the attention of the research community for facilitating family interaction. According to Kirk et al. [Kirk10], this kind of support helps family members feel closer to their counterpart in the communication. Videochat also helps teenagers socialize with their friends [Buhl13], while different generations in a same family may overcome existing cultural boundaries through an enhanced sense of connection provided by shared virtual spaces [Ames10]. Besides, video has substantially enabled synchronous communication with distant family members [Cao10]. For instance, Nawahdah and Inoue [Nawa13] propose the design of video-mediated technology for promoting tele-dining in time-shifted scenarios. The

particularity of this approach is the possibility to improve family connection and social engagement, by increasing the perceived presence of remote family members [Inou14].

The social inclusion of older adults through social networking services (SNS) can effectively assist the integration of the elderly to their families [Corn13]. In addition, it also empowers them with social engagement and self-expression tools [Wayc13]. There is also evidence that one of the main benefits of social media usage by older adults is the possibility to enhance their social linking with younger family members, which eventually tends to be appreciated by both parties [Nef13]. Indeed, Bell et al. [Bell13] found that older adults who actively use Facebook state that their main reason to use the platform is to stay connected with their families.

Digital content production in SNS empowers the elderly with social engagement and self-expression [Wayc13]. Conversely, SNS can assist the integration of older adults to their families, and contribute therefore to reduce the asymmetric relations with younger relatives [Corn13]. A continuous access to Internet technologies may assist family members in maintaining a sense of presence, despite physical distance among family members [Cao10, Pear13]. However, the lack of communication caused by a physical separation may weaken the emotional bond among family members, particularly in the grandparent-grandchildren relationship [Forg14].

According to Hope et al. [Hope14], while some older adults perform many social functions that could be supported by online technologies, only few seniors use these systems. Therefore, when designing software that support social interaction and social presence for family networks (particularly if they include older adults), there is an explicit need to consider face-to-face interactions, provide presence awareness mechanisms, assume heterogeneous preferences of social media, allow the mutual social interaction, and properly address usability and accessibility concerns [Mose11].

Several efforts have been done to bridge the cross-generational digital interaction gap. Baecker et al. [Baec14], Brush et al. [Brus08], Cornejo et al. [Corn13b], Garattini et al. [Gara12], Judge et al. [Judg13], Kaye et al. [Kaye10], Lindley [Lind12], Muñoz et al. [Muno15b], Raffle et al. [Raff11], Rodríguez et al. [Rodr09], and Visser et al. [Viss11] have adopted different approaches to deal with that challenge. They designed different domestic media spaces where remote family members, particularly older adults, can connect with each other using video-mediated communication and other kinds of messaging mechanisms. These proposals aim to integrate older adults into their families and prevent eventual negative effects of social isolation.

In summary, related literature indicates that communication asymmetries can jeopardize social interaction among family members. Since different generations have different preferences regarding what media they are able or willing to use under a particular social context, it is necessary to follow a personalized approach when mediating communication between two family members. This is particularly relevant when communication is mediated with older adults, since further restrictions limit the ways in which the mediation process can be conducted.

Design Implication #4

Computer-supported mediation strategies in family settings need to consider the broad and diverse expectations of the involved stakeholders. In particular, as suggested by the deployment of systems mediating intergenerational communication, related quality attributes such as usability, usefulness, perceived value, and accessibility must be considered in the design of services to help enhance the technology appropriation by older adults.
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In order to propose meaningful and potentially effective guidelines for designing supporting technology in this domain, software designers need to actively consider the requirements and concerns of older adults into the envisaged computer-supported strategies that mediate asymmetries in family communication.

2.5 Socio-Technical Systems for Mediating Social Interaction

In any socio-technical system, there are both symmetries and asymmetries present in the design of the technology and also in the ways that the technology is appropriated [Guer06, Pino98, Void08]. In particular, from a design point of view, family networks assisted with computer technology to mediate social interaction are a particular example of partially virtual communities, which correspond to a particular kind of online community “where its members can interact through both a virtual and physical space” [Guti15, p. 522]. In that respect, Gutierrez et al. [Guti15] proposed a layered architecture for assisting the design and evaluation of the software support for such kind of community: (1) providing the means to ensure user motivation and participation within the system; (2) ensuring smooth interaction among its members, particularly through awareness, coordination, and communication mechanisms; and (3) providing a meaningful sense of community to its members, through participation and motivation strategies, as well as contextualized governance structures.

When supporting intergenerational communication between older adults and their closer relatives, an asymmetrical pattern emerges. In fact, the grandparent-grandchild bond is an important emotional relationship in a human’s life and very close to the parent-child bond. A strong relationship between grandparents and grandchildren benefits both parties [Vutb10], but the lack of technological support makes this relationship more difficult to build and maintain [Ball09]. This asymmetry in the communication patterns is also expressed in terms of the media preference of both parties in the process. This preference can be explained by the technical abilities or merely comfort of the involved party involved in the communication [Forg14].

Related literature states that the nature of intergenerational family relationships is asymmetric [Lind08], and that this needs to be reflected in the design of computing solutions aiming to encourage family communication involving the elderly [Moff13]. For instance, Lindley et al. [Lind08] suggest that, regarding this design consideration, “older people are more likely to want to monitor and look in on their offspring, than vice versa” (p. 84). However, while we agree with the idea of considering asymmetries in design, the stated implication currently does not completely transfer to the Chilean scenario. For instance, it is assumed and expected by the Chilean society—including older adults—that adults and grandchildren should look after their elders, while the latter, in some cases, explicitly refrain themselves from excessively monitoring and taking the initiative in the social interaction process. This responds to the perception of the elderly that they could be disrupting the established routine of their children and grandchildren. We can summarize this particularity as follows:

Design Implication #5

The design of computer-supported communication mediators needs to find a balance between the expectations of older adults regarding care and affection from their families, and the current lack of means and opportunities for supporting family members to effectively provide the expected care and social interaction to their elders.
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In order to conceal the lack of time and means for communication, plausible alternatives to deal with this issue in Chile could be conceiving mediation strategies grounded on explicit personalized awareness or implicit persuasive notifications. However, while Romero et al. [Rome07] suggest that awareness messages should be small pieces of information, like short messages, in Chile the elderly explicitly demand a lot of attention [Barr14], and usually expect long communication with their family members. Next we review some deployed systems reported in the literature aimed to facilitate the social integration of older adults.

2.5.1 *Building Bridges*

Garattini et al. [Gara12] developed the Building Bridges system in Ireland, a communication prototype installed in the homes of older adults as a way to enhance communication among both friends and strangers, including other older adults. According to the authors, the system facilitates the interaction among socially isolated older adults. The device consists of a 12-inch touch screen computer, embedded in a custom-made stand (Figure 7). It also incorporates in its design a phone handset with cradle and speakers. VoIP is used to allow users to interact with their family members through four main features: (1) broadcast and chat, (2) calls, (3) messaging, and (4) tea room. Through the system, users can listen to regular broadcasts and, once they are finished, they can engage in group conversations with other listeners. Besides, users can make direct calls to one or more people, write them short messages (up to 160 characters long), and participate in a public chat room with other participants.



Figure 7: Building Bridges system [Gara12]

Among the offered services, participants preferred messaging and calls to the others. In other words, one-to-one interaction prevailed over stimulated opportunistic interaction as the preferred mechanism for socializing. Participants stated that they liked the system, as it provided them with opportunities to meet new people, and were satisfied with the tool as an alternative means to communicate with their families. Finally, the authors found that one of the major factors of engagement with technology is the perceived relevance of it, and there was a consensus among participants that the system would work best in conjunction with face-to-face meetings.

2.5.2 *Tlatoque*

Cornejo et al. [Corn13] developed Tlatoque, a situated display aimed to seamlessly integrate older adults into the social networking services used by their relatives. The system was evaluated

in Mexico where some elderly family members live abroad. According to the authors, the device provides the means to ease the integration of older adults to their social networks, enhancing the asymmetric relations with their younger family members.

Tlatoque is a lightweight Facebook client application running on an all-in-one PC with multi-touch screen capability (Figure 8). To start using the tool, a user acting as administrator sends an invite to the participating family members from a Facebook account created for the older adult. Using such information and the services provided by the Facebook API, the system retrieves the last ten uploaded photographs of the members in the social network of the elder. Over the time, complementary services aimed to provide ambient awareness to family members were considered, such as: comments on photos, context of the photo owner, weather, newspaper news, music, and Facebook likes.



Figure 8: Tlatoque system running in the home of an older adult [Corn13]

By using feedback mechanisms to provide bidirectional ambient awareness, older adults learned about the doings and whereabouts of their family members, and the latter gained increased awareness on the preferences of the former. In addition, this proved valuable to family members, as they can extend the possibilities for interaction due to limited time for having in-person encounters and face-to-face conversations. Weaker ties also could engage in interaction with older adults in a lightweight interaction paradigm using photos.

2.5.3 *InTouch*

Barbosa et al. [Barb15] developed InTouch, an accessible software application running on Android-based tablets (Figure 9), targeted to older adults aged 80 and more, under risk of social isolation and loneliness. The system was evaluated with five residents of a long-term care facility in Toronto, Canada. According to the authors, technology for older adults should not ignore the intrinsic challenges of technology acceptance and adoption, and particularly needs to address the limitations of theoretical models, such as TAM (Technology Acceptance Model) [Venk00].

The application has a non-language specific user interface based on icons, and it supports asynchronous communication. Given that accessibility concerns were extensively addressed during design, no typing is required for interacting with the system. One of its major features is “waves”, which consists in pre-set messages sent to family members and friends, as well as photo, voice, and video messages.



Figure 9: User interface of the InTouch system [Barb15]

While valuable, the reviewed systems do not completely address the requirements and particularities of the proposed work in this dissertation. For instance, both Building Bridges and InTouch have been conceived in a socio-cultural context different to the one existing in Chile, which could raise technology acceptance and appropriation issues if deployed in the study scenario, i.e., Latin American families. Similarly, our proposal extends the services provided by Tlatoque, by delivering feedback services aligned with sensing and monitoring services for informing family members and providing the basis of a sustainable care model for the older adults within the family.

2.6 Summary of Research Background and Related Work

Most related research about intra-family communication has been in the context of developed—mostly individualistic—countries, where older adults can live independently from their families and are likely to embrace technology. Contrarily, in Chile and other Latin American countries, most older adults live close to their families, are usually dependent of the latter, and rarely use digital means to communicate. Understanding the dynamics of intergenerational communication and informal elderly caregiving serves as the foundations on providing meaningful and potentially effective guidelines to design specialized and tailored domestic social technology to Southern Cone families.

Recent surveys show that Chilean older adults consider themselves as being well cared for by their family members, but mainly by their adult children, who assume the responsibilities imposed by a perceived ruling filial obligation. This situation, in some cases, affects the relationship within family members, particularly with the older adults. Therefore, digital technology can help augment and promote more sustainable interaction paradigms for all family members. In particular, computer-mediated systems can help reach such a goal, if they are grounded on the particular attitudes, agreements, and expectations of people within the target socio-cultural context.

Facilitating aging in place in Southern Cone families also requires addressing the cooperative nature of informal caregiving work. In these countries, family members usually assume implicit roles to address the main activities for providing care to their older adults. While literature suggests that this process burdens primary caregivers—usually one of the female adult children in

the family—it is still not evident how to design technology for improving the articulation of the caregiving work in this particular social context. Therefore, understanding these aspects would help socio-technical designers conceive new mechanisms for addressing this process.

To summarize, there is an opportunity to engage family members to take part in the supporting care network of their older adults. Sociological and anthropological research in Chile shows that grandparents implicitly assign filial obligations to their grandchildren, while the latter usually do not recognize those duties, but accept to take part in caring for their elders as a way to help their parents, or as a retribution for the affection they received from their grandparents during childhood. Similarly, adult children recognize and try to assume their filial obligation, but most of them have many other obligations and constraints, that leave their filial obligation in a second place. In order to address these design concerns, computer-supported mediation mechanisms can be designed to encourage family members to keep in touch with their older adults and thus perform simple yet achievable tasks in favor of sustaining the family network cohesion.

3. MODELING COMMUNICATION ASYMMETRIES IN FAMILY SETTINGS

In this chapter we present a set of models that help design computer-supported strategies to mediate intergenerational family communication and informal elderly caregiving. The proposed models were derived from the discussion of related literature—as presented in Chapter 2—and a qualitative empirical study conducted with a sample of twenty intergenerational triads belonging each to a same family branch (i.e., covering 60 people in total). In this study, we had a particular interest in understanding communication practices from and toward older adults, as well as identifying the perceived issues by the latter in a digital communication scenario. The analysis of these practices and the perceptions of family members allowed us to identify an initial set of variables that characterize communication asymmetries in family networks, and serve as foundation on formulating empirical guidelines to design complex domestic computing systems aimed to mediate intergenerational communication and informal elderly caregiving.

Our proposal suggests that the identified asymmetries can be covered by aligning preferences in different dimensions: *communication media*, *socializing capability*, *availability for socializing*, and *routine flexibility*. Besides, asymmetries in the social link between two people also shape how the mediation process needs to be modeled, especially in terms of who will be the initiator and how long the mediation will take. If the asymmetries between them turn to be too large to be resolved solely by both parties, the introduction of a third family member into the communication process, acting as a communication broker, would be necessary.

3.1 Method

Based on informal observation to family settings and autoethnographic analysis [Blan16], we framed an initial set of topics around intergenerational family communication that later turned into a semi-structured interview script. This script was then used to collect and analyze data about how middle-class Chilean family members manage their communication resources in intergenerational exchanges with their older adults. Finally, we iteratively contrasted the empirical data with related literature discussed in Chapter 2.

3.1.1 Participants

We conducted semi-structured interviews with the members of 20 cross-generational middle-class families living in urban settlements. For convenience reasons, we focused our study in the metropolitan area of Santiago, Chile and we followed a snowball sampling strategy to recruit the participants. Study participants were initially screened to be representative of the most common family structures, according to recent national socio-demographic data [Nati12].

3.1.2 Data Collection

In each family we interviewed three members covering three main generations: an older adult, an adult, and a teenager. Out of the 60 participants, 25 were men (42%) and 35 were women (58%). The interviews were held at the participants' homes, requiring the free, informed, and explicit consent of the three members of the triad in each family. As a pilot study, we

previously evaluated the research instrument with a sample of three families. Through this validation, we identified and resolved wording and ambiguous statements in the interview script.

The Institutional Review Board (IRB) Approval and endorsed informed consent forms of the conducted empirical studies presented in Chapters 3 to 6 can be found in Appendices A and B. Similarly, the followed interview script in this study is presented in Appendix C.

3.1.3 Data Analysis

In order to identify emerging themes on cross-generational asymmetries in family communication, we followed a grounded theory approach. This follows current recommendations and research trends in human-computer interaction [Adam08]. Each interview was tape-recorded with the explicit, free, and informed consent of each participant. The collected information was later transcribed and processed through open, axial and selective coding. By contrasting the emerging themes with existing literature, we built a model covering the main characteristics, issues, and social expectations of the involved stakeholders in a family network.

3.2 Structuring the Informal Elderly Caregiving Process

Based on the discussed literature in the previous chapter and the analyzed empirical data, we propose in Figure 10 a conceptual model that structures and characterizes the informal elderly caregiving ecosystem. This model identifies four interrelated factors—represented as quadrants—that affect the effectiveness of the family caregiving process: (1) the elderly caregiving needs, (2) the capability of informal caregivers to address these needs, (3) the actions taken to deal with the elderly needs, and (4) the impact that the conducted actions have in the wellbeing of the older adults. In Figure 10, ‘OA’ stands for older adult.

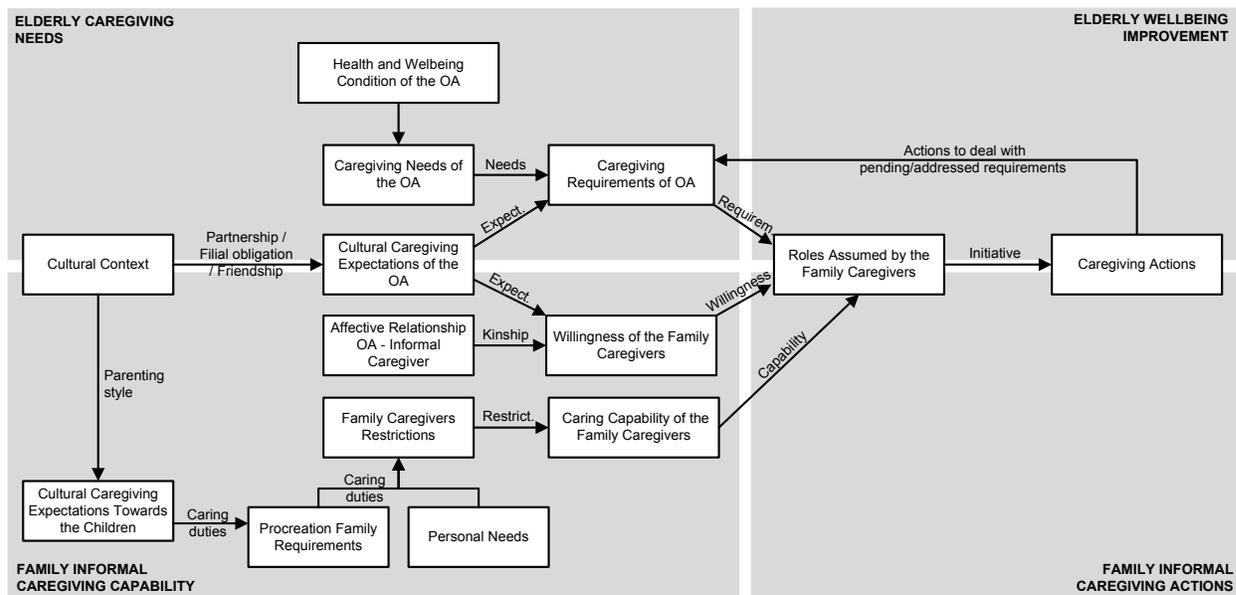


Figure 10: Informal elderly caregiving ecosystem in Latin American families

Each of these factors in our model (i.e., a quadrant) defines a particular concern to address in the design of social interaction supporting systems. Next we describe each quadrant.

3.2.1 *Elderly Caregiving Needs*

Although the user group of older adults is vastly heterogeneous and diverse [Vine15], there is a common trait in Latin American elderly, consisting on typically having a group of affectively close people that care for them [Thum15]. While these people typically are their partner and adult children, other relatives and friends also participate.

Some of the needs of older adults are due to a fluctuating or declining health and wellbeing status due to aging. Others are a result of the cultural aspects around the caregiving process, which create expectations not only in the older adults but also in the whole family community [Thum15]. This situation introduces a set of caregiving requirements, which according to the elderly, should be addressed by their family caregivers either due to partnership or as a result of their filial duties [Barr14, Rob14, Thum15]. In this respect, the filial obligation is understood as an implicit contract where mainly adult children take care of their parents as a repayment for the care they received during childhood [Barr14].

In order to sustain the wellbeing of older adults, the typical caring activities that informal elderly caregivers are faced to perform as a part of the filial obligation are the following:

- **Affective care.** By promoting affection, older adults feel themselves appreciated and loved by other family members. This also considers the provision of emotional support.
- **Social engagement.** This considers engaging older adults in the activities within their family; e.g., organizing reunions and organizing holiday trips together. It also includes promoting recreation activities.
- **Informal health care.** This considers the assistance to the elderly in addressing their health treatments and medical issues, as well as performing informal tracking of their health conditions.
- **Economic support.** It represents the provision of money, either directly or indirectly, to address needs of the elderly.
- **Financial support.** It considers helping manage—or explicitly managing—the economic resources of older adults. For instance, this includes: paying bills, taxes, and personal expenses.
- **Housekeeping.** It represents activities that allow managing the house of the older adult; e.g., cleaning, shopping, cooking, doing laundry, and providing safety and security.
- **Activities of daily living.** They are personal activities that people tend to do every day without needing assistance; such as eating, bathing, dressing, toileting, transferring (walking), and continence.
- **Sporadic supporting activities.** Represent actions to address unexpected non-critical needs, like repairing or installing electrical appliances. Sometimes family members assist in performing these activities, or by finding a provider to complete these actions.

The support for these caring activities has different relevance and frequency of required assistance, which is something clear for the older adults, but not always for the family caregivers. Typically, when the required support is highly frequent, such an activity is perceived by the

elderly as highly relevant and creates expectations on them. Frequently, the priority assigned by older adults to their needs does not match with that assigned by his/her informal caregivers. Therefore, both perceptions should be represented and contrasted to avoid misunderstandings.

3.2.2 Family Informal Caregiving Capability

Family caregivers usually take the responsibility to help older adults address their needs [Thum15]; however, some of them (particularly adult children) have their own commitments and duties, which take a considerable amount of their available free time. Culturally, in Latin American families, it is expected that parents focus on taking care of their family of procreation, which jointly with their personal needs, generate a set of restrictions that jeopardize a full-time commitment to address the elderly caregiving process [Barr14]. Furthermore, the cultural expectations on caring for older adults and the affective relationship between the elderly and the potential caregiver determine the willingness of family members to actively take part in this process. Considering these restrictions, family caregivers assume roles to sustain their activities, which potentially become a source of conflicts and tension among them.

3.2.3 Family Informal Caregiving Activities

Caregiving roles are informal, voluntarily assumed, and involve different levels of commitment in the caring process. It is expected that each role addresses specific activities to assist the elderly. Given the informality of these roles, it is rare that somebody monitors if the activities are actually performed, not even their frequency. Furthermore, family caregivers are reluctant to monitor these activities, as it is usually perceived as a source of conflict within the family network [Guti16, Guti17]. Consequently, there is little to no visibility about the caregivers' contributions, commitments, planned activities, and pending requirements, which also represents a source of conflict.

3.2.4 Elderly Wellbeing Improvement

One of the main goals of informal caregivers, when engaging in assisting their seniors, is to reduce the needs of the latter, as well as positively impacting their wellbeing. Given that older adults tend to have recurrent short-term needs, a good way to achieve a good positive impact on their wellbeing is to react promptly and actually address their concerns. As a result, older adults perceive the informal caregiving process as an increased interaction frequency with their families, and consequently better social integration.

3.3 Family Communication Metamodel

Complementing the filial obligation duties, sustaining intergenerational communication is also of high relevance to family members that assume caregiving duties in favor of their older adults. In that respect, communication in family networks can be represented as a metamodel, where each particular family is an instance of such abstract structure. This conception adheres to the model-driven engineering approach [Schm06], and it can be easily implemented using existing tools, such as Eclipse Process Framework [Ecli15]. Figure 11 shows the UML class diagram that represents the metamodel. This formulation provides ground on how computer-supported mediators could manage the social interaction space within a family network, as well

as how we can derive design guidelines to propose new mechanisms to specialize the interaction between its components.

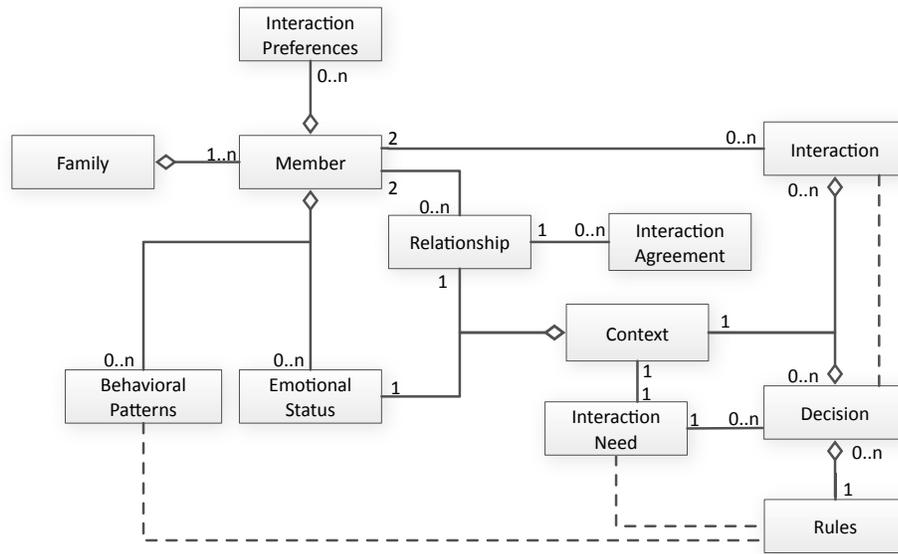


Figure 11: Family communication metamodel

We consider a *family* as a structure composed at least by a *member*. Each member possibly has *interaction preferences* (e.g., preferred tools to conduct synchronous and asynchronous communication), *emotional status* (set of emotions detected during a certain time window), and follows *behavioral patterns* that determine the way in which a person is going to behave under particular circumstances. Every pair of members in a family community has a *relationship*, which includes several variables that range from the affective attachment among them to their kinship relatedness. There could be an *interaction agreement* between these pairs, which establishes the interaction frequency and also the digital media involved in these interactions. Based on these agreements, and considering the emotional status of each member, it is possible to determine *interaction needs*, which represent people that are currently in need of emotional support.

Every interaction need has a *context* that determines who, how and when other family members could deal with such emotional support. Provided that various family members can potentially intervene in that situation, and trying to not overload all of them, one or more *decisions* should be made concerning who will be encouraged to provide support to the member in need. The decision process can be repeated until getting a successful result or using up all the available options.

Decisions are made using a set of rules that indicate how to intervene in a relationship considering the social needs of the involved family members and their behavioral patterns. The decision process also considers the historical record of interactions between these people. Each decision is translated into particular actions that are made by the system mediating the communication among family members; e.g., through an invitation message that can be received by a person for contacting other family member that is currently in need of external support. Such an action can be materialized in an interaction, or possibly fail. In the latter case, a new decision could be made.

3.4 Model Processing

This process involves four uncoupled stages: *data gathering*, *monitoring*, *decision-making*, and *intervention*. Figure 12 shows the proposed pipeline, where rectangles represent classes of the family model described in the previous section and rounded rectangles represent processes.

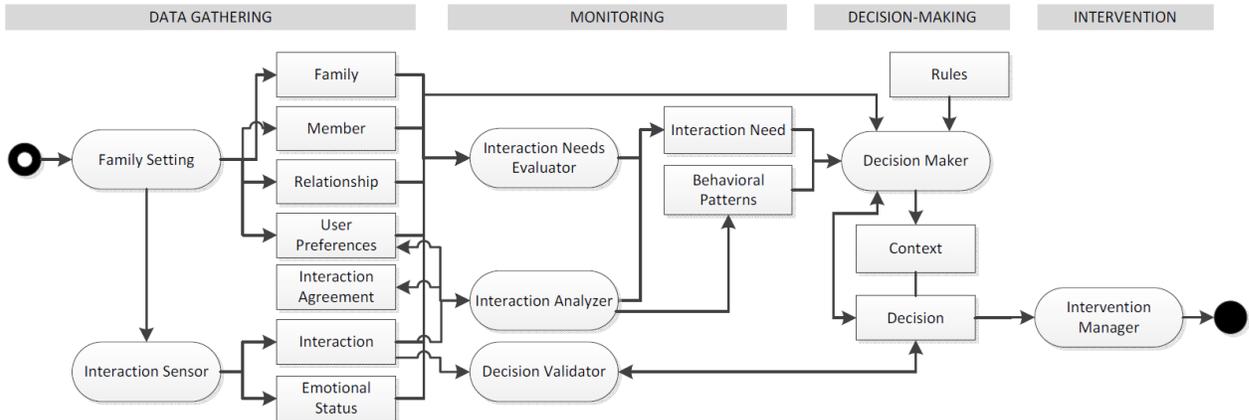


Figure 12: Pipeline for mediating family communication

- Data gathering.** This stage is in charge of obtaining the basic data of the system; e.g., family composition, user preferences and their interaction agreement. This information is provided through a *family setting* process, which is performed when the community is created. There is also information that is not provided by the end-users (i.e., family members), but that is automatically captured by the system and also used as input. Examples of this information are the current emotional status of a family member, or the interactions performed by the participants. Several family communication mediators—like SocialConnector [Muno15b]—can act as interaction sensors capturing and recording this information.
- Monitoring.** This stage adds meaning to the basic information captured in the previous stage. The system tries to determine if there are new interaction needs that should be addressed. Particularly, the *interaction needs evaluator* analyzes the basic information of family members as well as their emotional status to determine if there is a new need for social support. If it does, the process records such need in the system, and then other components are prompted to address it. Such a need can also be identified by comparing the interaction agreement between each pair of members and their effective interaction record. The analysis of interactions is also used to determine or adjust behavioral patterns of a user or his/her interaction preferences. The *interaction analyzer* is the process in charge of performing these activities. Finally, the *decision validator* process tries to determine if an effective interaction recorded by the system is the result of a stimulus triggered by the system to a user; i.e., a decision made by the system to promote the interaction between two people. If it does, the result is recorded and then used to inform future decisions.
- Decision-making.** This stage takes each interaction need recorded in the communication model, and based on the behavioral patterns and the basic information gathered in the first stage, determines a set of zero or more actions that could be taken to support the people in need. These actions can either be to trigger participation using persuasive strategies, or to raise an alarm and consequently provide awareness on the possible need to family members.

The *decision maker* is the process that determines which decision will be made in each situation. Such process uses a set of rules as support, and makes one or more decisions. Each decision represents a stimulus to a user. The information about these decisions and also about the context in which they were made, is properly recorded in the system.

- **Intervention.** In this stage, the *intervention manager* processes each decision and acts accordingly. A specific action is made by the system per each decision (e.g., send an email, or show an awareness component to the user). The actions can be successful or not. Regardless the results of an action, such an action and its result are properly recorded in the model, because they are then used to improve the decision-making process.

3.5 Limitations

Although the interviewed participants for inducing the presented models were screened as being representative of current family structures in Chile and Argentina, unfortunately we cannot ensure that the study results still hold for larger populations in other socio-cultural contexts. This is due to the diversity of family settings and the heterogeneity in aging people.

In the case of Southern Cone families, there is space for replicating this study with other groups in order to improve the soundness of the presented findings. In particular, this is the basis of the work presented in Chapters 4, 5, and 6.

3.6 Summary

Our interviews, backed with related literature, suggest that filial obligation burdens family members assuming caregiving duties, with little to no coordination or negotiation of the caring activities across the family network. By structuring the ways in which family members coordinate and articulate the caregiving work, we aim to provide ground on how computer-supported solutions can be designed and deployed to ease this process.

Design Implication #6

Understanding the structure of informal elderly caregiving in context provides ground on how computer-supported solutions can be designed and deployed to facilitate the process. Such systems should try mitigating the burden of the most involved family members in caregiving tasks, as well as preventing unnecessary interventions in the ecosystem of older adults.

In this context, asymmetries are inherent to family communication, particularly when they involve intergenerational members. While some people perceive their ability to adapt to other's preferences as natural in terms of communication media and flexibility, external mediation usually needs to be performed in order to increase the chances of effective communication.

We have identified asymmetry sources related to: media preference, socializing capability, the availability of both parties, and their flexibility for performing social interaction. The quality and strength of the affective tie between the involved parties is also relevant when studying family communication. In particular, if the asymmetries between two people appear to be quite strong, the inclusion of a third person acting as a broker in the mediation process is recommended, as it is already naturally considered in family settings.

Design Implication #7

By providing effective mechanisms to coordinate and mediate social communication among family members through digital means, older adults appear to be more prone to accept computer-mediated intergenerational communication media. Therefore, this suggests that these kinds of services facilitate not only the social inclusion of older adults to their families, but also enable technology acceptance and appropriation.

Although promoting social interaction among family members is a commendable objective, such interaction must not overwhelm people having little time for socializing. Therefore, effective mediation strategies should intelligently coordinate all the members in a family community, based on specific criteria, such as location, time of day, and the available communication media to support the interaction. This necessarily implies that such mediation process should be adapted to both, the individuals' interests and those shared among groups of his/her family network. Besides, a mediator system should not be too proactive, since people will eventually refuse to react when there is no urgency, and therefore would not respond in a really important situation. In this interaction scenario, understanding the social and technological context of the involved people is fundamental to ensure the success of the social mediation process.

3.7 Contributions of the Work Presented in this Chapter

The proposed formulations contextualize and provide an initial step in how we can propose design guidelines to address intergenerational communication and informal elderly caregiving issues through the use of technology support. A part of the results presented in this chapter has been published as a full paper [Guti15b] in the Proceedings of the 9th International Conference on Universal Access in Human-Computer Interaction (UAHCI'15), held as part of HCI International 2015. In particular, this chapter provides three main contributions:

- It organizes the literature on caregiving—discussed in Chapter 2—by providing a conceptual model from a CSCW perspective, aiming to structure the informal elderly caregiving ecosystem as well as understanding the caregiving workflow along with its involved stakeholders.
- It proposes a family communication metamodel that presents the main sources of potential asymmetries to be addressed when envisioning computer-supported technology to mediate social interaction in intergenerational family settings.
- Finally, this chapter also proposes an intergenerational family communication mediation pipeline, in the particular case of facilitating the interaction to/from older adults, by describing the underlying architecture of the model processing for the metamodel described above.

4. ATTITUDES AND EXPECTATIONS ON THE INTERACTION WITH OLDER ADULTS

In this chapter we extend the interviews described in Chapter 3, this time aiming to understand the key attitudes, expectations, and agreements on the usage of computer-mediated communication technology as expressed by older adults within their family networks. In particular, the study results indicate that the interviewed older adults consider themselves to be quite well cared by their family members, but mainly by one or more of their adult children, who assume the responsibilities imposed by the filial obligation. However, the approach used to deal with these duties *tends to evolve in a vicious circle that slows down the technology adoption among the older adults and stresses out their adult children*. This situation affects the relationship among family members with their older adults, so it seems imperative to find alternatives to break this vicious circle and generate a smooth evolution toward sustainable interaction paradigms for all family members. In this sense, design guidelines for conceiving domestic computer-supported technology can help reach such a goal respecting the socio-cultural background.

Although, for convenience reasons, the data reported in this chapter correspond to the perception of middle-class Chilean family members, we argue that it still serves as an interesting case study, because this cultural scenario shares several common traits with most Latin American countries, particularly urban families living in Argentina.

4.1 Method

The study presented in this chapter focuses on middle class Chilean canonical families living in urban settlements. By canonical, we mean the most common type of family structure according to the most recent national statistics on socio-demographical traits [Nati12]. In the case of Chile, a typical household currently comprises two generations: the adult children and their family of procreation. Middle class families are prevalent in the country, and most of them are composed of four or five members.

Grandparents enjoy from a close relationship with their grandchildren, while assuming caring duties and providing assistance to their own children [Thum15]. Adult children usually live with their parents until they reach a certain socioeconomic status that let them being independent—usually in their late twenties, after completing a professional degree and getting married [Mini12]. One of the most usual exceptions to this rule occurs when younger family members have to move to a different city for study or work reasons.

Similar to current trends in developed countries, technology adoption is high in children, teenagers, young adults and professional adults. However, it is still low among non-professional adults, and almost null in most older adults. Although Chile is the second highest Latin American country concerning Internet penetration [Lati15], only 25.6% of the population over 50 years old is able to search information online, 28.5% declares knowing how to send emails, and 70.5% states that they are not able to perform either of these tasks [Nati12]. Most of the digital illiterate people are older adults (aged over 65 years old).

4.1.1 *Participants*

We initially interviewed several older adults participating in senior community centers and religious groups of Santiago to determine if their families qualified as canonical. After selecting a group of candidates, we contacted their children and grandchildren belonging to the same family branch, in order to request for their participation in the study. While we did not explicitly consider gender in this selection process, we tried to balance the participation of the oldest and youngest people in each generation.

Following a snowball sampling strategy seeded upon the initially screened older adults, we reached 20 canonical families. While we focused mainly on the metropolitan area of Santiago for convenience reasons (7 million inhabitants), due to the used sampling strategy we reached participants from La Serena (400 km north of Santiago) and Concepción (450 km south of Santiago). These cities have around 250,000 inhabitants each. At least one older adult, one adult, and one young person belonging to the same family branch were interviewed.

Out of the 60 participants, 25 were men (42%) while 35 were women (58%). Young people (N=20; M=21.5; S.D.=4.2; range=15–29) ranged between high school and undergraduate students. Adults (N=20; M=45.1; S.D.=7.5; range=30–60) were dependent workers, independent workers, and homemakers. Regarding the older adults (N=20; M=70.6; S.D.=7.4; range=65–91), three of them were part-time workers, two ran their own business as small-scale shop owners, and the others were retired.

4.1.2 *Interview Method*

We conducted individual semi-structured interviews during February 2014, coinciding with summer holidays in Chile. The interviews were conducted in Spanish. They lasted between 46 to 72 minutes (M=61.2; S.D.=5.8) and were held at the participants' homes.

Each interview was structured as follows:

- **Introduction.** We explained the objectives of the study and what kind of data we were going to collect. We followed ethical considerations regarding personal data processing, and asked each participant for his/her free and informed consent to participate in the study (cf. Appendices A and B).
- **Family network.** Following the method proposed by Hogan et al. [Hoga07] on using sociograms for visualizing personal networks, we asked the participants to draw a visual map of their family structure, the kinship among its members, and how strong they perceive the affective link is between them. We also asked the participants to indicate how close they lived from other family members.
- **Communication media.** We asked the participants to inform us of what communication media they are capable of using, how often, and which ones they prefer to use with the other family members depicted in the visual map. We chose this approach, as according to Smith et al. [Smit03], it “allows people to remember who is in their network and to readily see the various relationships they have with the members of their social network” (p. 553).

- **Interaction practices.** We asked the participants to describe their interaction practices with other family members in several scenarios. For instance, how they would prefer to be contacted if they are at work and how they would react in case of interruption. In particular, we wanted to explore if the participants were aware of the different communication practices and media preference of their family members, and if they were aware of possible communication asymmetries with their relatives.
- **Affective care and interaction needs.** We finally asked the participants to describe how close they felt with the other members of their family network. We were interested in the affective perception of both parties in the case of informal communication, and if this social interaction is frequent enough. Using this information we identified the specific interaction needs among them, in particular, of older adults.

4.1.3 Data Collection and Analysis

A team of six psychology students and journalists conducted the interviews under the supervision of a trained clinical psychologist. Each interviewer followed a script with the topics to be discussed. This script—presented in Appendix D—was validated in a pilot study with three families, where wording problems and ambiguous statements were resolved. Before initiating the interviews, the authors held a meeting with the interviewing team to present the script and clarify doubts. This was to limit bias and avoid ambiguity.

Each interview was tape-recorded with the explicit consent of the participant, and they were later transcribed and analyzed by the authors. To analyze the data, we followed a grounded theory approach, performing open, axial, and selective coding to identify emerging themes.

4.2 Results and Interpretation

Next, we present the main study findings. Quotes were translated from Spanish and corrected, if necessary, to fit into Standard English grammar rules. They are also anonymized to comply with the informed consent form signed by the participants (cf. Appendix B). We use the following codes: ‘Y’ for *young person*, ‘A’ means *adult*, and ‘OA’ for *older adult*. The number identifies each family.

4.2.1 Needs of Older Adults Around Intra-family Communication

The study results indicate that most of the interviewed older adults need to interact with other family members to communicate their feelings, to assess if family links are still alive, and to receive affective care and support in activities that are challenging for them, many of which are related with health concerns.

The interviewed older adults also seem to be well cared by their adult children and do not suffer from social isolation. This situation is backed by the findings of a recent large-scale survey conducted by the Chilean government [Fern14], where a possible cause can be attributed to the structure and interaction dynamics of Chilean families. However, our interviews identify specific needs that are unsatisfied and can be addressed using digital technology. Unfortunately, older adults largely do not consider this possibility as evident.

Older adults always get support from the family. However, many times they have to demand it. This situation is mainly caused by differences in the caring priorities among adult children and older adults, and also in the available time for socializing. Concerning the caring priorities, older adults expect that the filial obligation becomes a priority for their children, but the latter prioritize their family of procreation.

“As you become older, you hope that your kids will take care of you. However, I know that at times my children have to take care of their own”. OA9, female, 73 years old.

Regarding the time periods for socializing, older adults recognize the difference of availability between them and the rest of the family. Therefore, they usually refrain from taking the initiative in the interaction, because they feel they will be disrupting the routine of their family members. This situation seems to shape the way in which family members reach each other implying that the design of effective proactive social mediators needs to consider the available times for socialization declared or inferred from the communication patterns and behavior of the involved parties.

“My son is always busy at work and I don’t want to bother him. I don’t want to affect my granddaughter’s routines either. I call them during the afternoon, once I know she’s finished her school work”. OA16, female, 66 years old.

In summary, although older adults expect more affective care than what they actually receive, they recognize the effort of their children to comply with their filial obligation. In that respect, the interviewed older adults show a strong desire to know the doings and whereabouts of their children and grandchildren. Indeed, when an older adult queries a family member for personal information, the former feels that s/he is enhancing the link with such a person. The same happens when the older adults use an intermediary person to know about other member; e.g., asking an adult child about a grandchild. Knowing about others make them feel part of the family, and give them background topics to interact with other members and participate in family conversations.

“I love to know how my daughter and my grandchildren are doing at all times. I love giving them advice on their problems, or just chat with them [...] It gives me the chance to get closer to them when they come visit me on Sundays”. OA1, female, 74 years old.

The interviewed older adults also expect more frequent interaction with their grandchildren. These interactions go usually well when the latter are kids, become less frequent when they are teenagers, and get reinforced when they become young adults. Although there are several reasons for such a reduction in the intra-family social interaction during adolescence, the interviews reveal a cultural aspect of the Chilean society: older adults, given their position in the family, feel that they have the right to make personal questions to grandchildren, which turns somewhat natural conversations into questionings.

“When I talk to grandma, she is constantly asking me annoying questions. [...] I sometimes don’t want to keep talking to her”. Y14, male, 17 years old.

Consequently, teenagers do not feel at ease with this situation and prefer to interact using asynchronous digital media, or simply opt to avoid communicating with their elders. This raises tensions in the relationship among grandparents and teenagers, as a result of unbalanced expectations in the social interaction process.

“It’s difficult to socialize with young people because they use their mobile phones all day. You need to constantly remind them that you exist; otherwise, you become someone that they are forced to invite to birthdays or other important family celebrations”. OA15, male, 65 years old.

This attitude allows teenagers to socialize whenever they are willing to, and they regulate the length of each interaction. They feel that this kind of control protects them from the interrogative attitude of other family members, particularly from the elderly. Therefore, although the interviewed teenagers indeed show traits from a cultural Latino background, they feel that they have the right to privacy, which is a distinctive feature of individualistic societies [Kim94]. Eventually, once the grandchildren become young adults, they tend to become less vulnerable to the questioning sessions and turn to be more conscious of the needs of their elders. Therefore, they are willing to be active in the caring process of their grandparents and other family members.

Summarizing, in terms of design, any domestic computing solution conceived to mediate the social interaction space of family members needs to respect the attitudes and expectations of the involved participants with regard to the usage and potential appropriation of the intended technological support. In particular, next subsections present the main viewpoints and concerns on the matter according to the different generations coexisting within a family network: older adults, adult children, and grandchildren.

4.2.2 How Older Adults Address their Intrafamily Communication Needs

The interviewed older adults stated they prefer to address their interaction needs using means that are already assimilated by them; particularly, face-to-face encounters and the telephone. One of the ways family members enable frequent and meaningful interpersonal exchanges is through periodic family meetings.

Most family members, but mainly older adults, consider that family reunions help them enhance their affective links, reduce tensions, and redefine agreements among them. These meetings allow family members to get updates about the family as a whole group. However, the existence of these reunions hides the potential benefits that the adoption of digital technology has for the elderly. As a rule of thumb, if this benefit is not evident, then the technology adoption does not represent a need for the older adults. Therefore, it does not become part of the filial duties, and consequently, the elderly do not receive this kind of support from fellow family members. This finding complements some recent studies conducted in Chile [Fern14, Nati12, Thum15] by identifying a cultural cause for the low technology adoption in older adults.

The interviews also reveal that the quality of the affective link diminishes with those family members that cannot regularly attend these meetings; e.g., because they moved to other city. Usually, this turns into both parties reformulating their social interaction agreements. However, the benefits of using digital media for supporting these interactions remain unclear for older adults, who in turn expect to interact with these people by phone.

“I haven’t seen my grandmother for a while. I haven’t made the time for travelling and visiting her. We therefore don’t communicate as much as I’d like. I think I might have lost all the bonds I had with her, so I doubt that she would even call me back”. Y19, female, 19 years old.

In this case, Y19’s grandmother also considers that the relationship between them has deteriorated. Although she still has affection for her granddaughter, the lack of initiative of the latter hinders their relationship.

“Of course I miss my little girl! I always ask her father how she’s doing to get some news about her. I know she’s studying in Santiago, but she could pick up the phone once in a while, don’t you think?”. OA19, female, 73 years old.

This situation highlights the value of the affective links for the elderly, particularly in the case where it is not possible to reunite with certain family members. However, this perception is also asymmetrical across generations. Indeed, the analysis of the kinship maps depicted by the study participants shows that most of the elderly perceive quite strongly their affective links with other family members, whereas adult children and young people consider their relationships to be stronger than those with their elders.

Although distance is a hurdle for family communication, particularly with older adults, this study has found that many adult children (and some grandchildren) have overcome this situation using synchronous communication routines, typically based on phone calls. In this case, calls are not only for monitoring the elderly, but also for socializing and keeping the affective links alive. When these interactions are not frequent, some older adults tend to be more active by taking the initiative. One reason that explains this behavior is that older adults feel that the affective link with their family members risks of deteriorating. This is aligned with the findings of Forghani and Neustaedter in intergenerational urban Canadian families [Forg14].

4.2.3 *How Adults Deal with the Duties in Favor of their Parents*

In 18 out of the 20 interviewed families, adults stated that they are expected to take care of their parents, not only as an integral part of their upbringing, but also as a contribution to the rest of the family. Therefore, even adults that do not have a good relationship with their parents find the way to contribute, reciprocating the affective links of belonging to the family. Adults indicate that they feel good when they manage to accomplish with their filial duties, and they feel guilty when they are not able to do so.

The study results also indicate that family members implicitly assume roles in the caring process, according to the affective link with the elderly and the feasibility of assuming particular commitments. This helps balance the caring efforts generated by the filial obligation. We identified a preliminary set of five roles that are implicitly and voluntarily assumed by Chilean family members. In Chapter 5 we build on this proposal by enlarging the sample of interviewed participants and consequently specializing the identified roles.

- **Caregiver:** External (formal) caregiver or family member cohabiting with the older adult, who continuously monitors the latter and is prompt to react when needed.

- **Monitor:** Family member who does not share the same household with the older adult, but monitors him/her, and is usually available for assistance. Typically, daughters play this role, and are willing to assume several others.
- **Helper:** Family member who is willing to assist the elderly when required. Helpers assume a particular responsibility in specific situations; e.g., buying medicine for the older adults. This role is usually assumed on-demand; i.e., somebody asks the helper to do something. Adult children living away are usually helpers, and they provide economic support to the elderly when required.
- **Broker:** Family member who provides information from the family network to the older adults, as a way to help them address their need for knowing the whereabouts and doings of their adult children and grandchildren. People living away also act as brokers and monitors in some way.
- **Meeting organizer:** Family member who organizes face-to-face reunions (typically, family meetings) to reinforce the family cohesion and the links with the elderly.

The assumption of family roles seems to be quite stable, but it also considers the temporal needs of the older adults and the willingness of people for contributing. In addition, a family member can assume simultaneously more than one role, although they can be expressed in different ways throughout families.

Family meetings serve as instances to play these roles and eventually to coordinate the caring efforts among them. However, apparently few family members appear to be willing to coordinate the caring activities of the others. Indeed, this process is perceived as time-consuming and exposes the person assuming such a role to conflicts with other family members. In order to keep some coordination in the caring process for the elderly, some families prefer to implement a separation of concerns.

“With my sister we decided to split the time we host our father at our place [...]. We understand that he (our father) would like to spend time with all my children and nephews at the same time, but it’s difficult to arrange a big lunch together every week”. A14, male, 46 years old.

Even though the literature reports the existence of a filial obligation across cultures (e.g., [Barr14, Dome09, Nati15, Stui08, Stui10]), the assumption of roles within the family to address with this concern has not been properly studied in depth, at least in the Chilean scenario. Given the current technology appropriation and habituation among adult children and younger generations, there is an open opportunity for designing alternative computer-supported mechanisms to ease the assumption of such filial duties, considering the constraints and expectations of the involved stakeholders.

Similar to current trends in Western countries, Chilean young people largely prefer communicating through social media, adults tend to prefer email, and older adults lean to face-to-face and phone communication [Corn13, Tee09]. The older adults do not perceive this asymmetry of media preference, as their position in the family imposes that their preferred communication media will be used instead of those chosen by other family members. Although

everybody accepts to interact with the elderly using these media, these interactions are time-consuming; therefore, some family members try to identify alternatives.

“I barely talk to my father through the mobile phone. We bought him one, but he doesn’t even know how to turn it on! I prefer to go and visit him, or to call mom and then talk to dad”. A3, female, 51 years old.

While the asymmetry of media preference is also present in several cultures (e.g., [Corn13, Dick07, Lind08]), the technology adoption that helps reduce it seems to follow a different trend in collectivistic cultures. Therefore, family members see themselves forced to use time-demanding mechanisms for interacting with their older adults.

Most adult children also recognize and assume the filial obligation as part of their family duties. However, their main concern is focused on maintaining and caring for their own families of procreation, which reduces the amount of time available for taking care of their elders.

“Sometimes I have to tell her: Mom, I know that you need my help, but I do have a family now! It’s my obligation to take care of them”. A9, male, 46 years old.

When an older adult demands a lot of attention and the adult children have little to no external help, achieving the filial obligation is likely to become an impossible mission. In these cases, adults tend to rely on their partner and own children to get external help to deal with the filial duties.

“I’m lucky that my mom and my wife like hanging out together. It’s good to rely on someone when you feel that you’re overloaded with work!”. A11, male, 48 years old.

Finally, the perception of filial obligation is not the same among all adults in the family. Therefore, some of them will tend to assume more responsibilities than others. In particular, women tend to be more engaged in this process than men, a situation that has also been identified in other cultures (e.g., [Nati15]).

4.2.4 How Grandchildren Care For their Grandparents

Many older adults think that their grandchildren should also assume part of the filial obligation in favor of them. However, this situation is not necessarily clear to the latter, who typically only assume roles—usually helper—if there is a strong affective relation with the older adult. The study results show that older adults, and sometimes adult children, usually remind young grandchildren their family duties, particularly during adolescence. However, grandchildren feel they are committed to reciprocate only the affective link they have built with their grandparents.

“Don’t get me wrong. I love grandma [...] but I don’t think I have to talk to her everyday. My mom already does so, and she tells me how granny is doing and gives her my regards”. Y8, male, 16 years old.

Most grandchildren seem to be ready to act as helpers, if somebody asks them. Apparently, they are not proactive because the needs of the elderly are not evident for them. In this sense,

young adults are more conscious of the elderly limitations and needs, and therefore they are more prone to collaborate in this process than teenagers. In that respect, some of the interviewed younger family members stated that they could assume the role of teaching their grandparents how to adopt digital media tools. However, this process requires the commitment of both parties.

“Adults and older adults need to be more updated with current technology trends. And we can teach them what’s required”. Y15, male, 17 years old.

Consequently, all of those older adults who have succeeded in this process appear to have had an important support of family members, mainly of their grandchildren.

“I’m lucky that my family taught me how to use my mobile phone. Now I can chat with my grandchildren, and I can use WhatsApp with my daughter. I’m quite happy that I’m part of my family!”. OA7, female, 68 years old.

This situation shows a possible way to facilitate the technology adoption by the elderly. Therefore, one of the challenges is identifying how to design mechanisms to engage grandchildren to actively take part in this process.

4.3 Discussion and Insights for Technology Design

The study results show that Chilean older adults do not see a need to adopt digital technology for interacting with their families, because they already use means that are assimilated by them. This interaction approach is time-consuming, and stresses out adult children, who are usually busy with their own duties toward their families of procreation. However, these people accept and do their best to address their filial obligation, and usually succeed, even maintaining regular interaction mechanisms. Therefore, most of the interviewed older adults continue without seeing a need to adopt digital technology to interact with other family members. Given the natural aging process of older adults, this approach tends to generate a vicious circle (Figure 13).

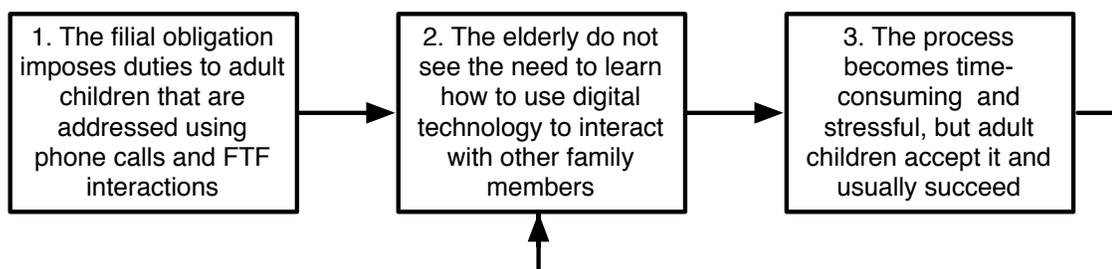


Figure 13: Vicious circle in the interaction with Chilean older adults

Adults assume that their own children will take care of them in the future. Therefore, we can expect that the filial obligation will continue to be present in Chilean families (situation 1). However, it is possible to introduce changes in the way in which it is addressed.

It is quite evident that several social computing solutions can be designed to help adults deal with their filial obligation (situation 3). They would help reduce the stress on the adult children, but keep the current status quo of the caring process. However, by facilitating the technology adoption by the elderly (situation 2), we can produce changes that shift the caring approach

toward a sustainable scenario, which respects the cultural aspects of Chilean families. We can summarize this idea as follows:

Design Implication #8

The attitude expressed by Chilean older adults toward the usage of digital technology in intergenerational communication scenarios obeys to cultural factors linked to collectivism. This situation induces a vicious circle that stresses their adult children assuming informal caregiving duties and limits the technology appropriation of older adults.

By understanding the implications of this vicious circle, social computing designers could be in position to conceive mechanisms that can be effective for mediating the social interaction space of Chilean family networks. In the following subsections we elaborate on this idea.

4.3.1 Helping Adult Children Deal with their Filial Obligation

This is the less interesting part of the problem. However, designing technology with this purpose can contribute to reduce the stress on the adult children, reduce tensions among family members, and eventually create some space that allows adult children to support the technology adoption of their parents.

Given that family members already assume roles for caring their older adults, follow interaction routines, and need to coordinate their activities, the design of mobile technology with these purposes can help address their duties in a less stressful way. For instance, persuasive systems can use positive computing [Calv14] (e.g., by promoting empathy, wellbeing, memories, and reinforcing affective links) to motivate people to do things in favor of older adults, according to the roles they have assumed. Similarly, design approaches based on positive principles may effectively promote wellbeing within the elderly [Blyt15].

Cooperative systems for helping address the filial obligation need to ensure some balance among the workload assumed by the family members and keep them engaged in this process. For instance, the use of gamification, i.e., game mechanisms in non-game scenarios, can help reach these goals and recognize people's contributions [McGo11]. This can also motivate the participation of younger family members, being recognized as contributors by the rest of the family.

All in all, while there exist several ways in which computational triggers can help mediate the caregiving and social interaction spaces of family networks, according to the results of the presented study they should be aligned with the current attitudes and expectations of the involved stakeholders. In other words:

Design Implication #9

Social computing solutions, for instance grounded on positive psychology principles or playful interaction, can be used to address particular activities of family members derived from the ruling filial obligation. In that respect, it is important to consider what kind of technology, with what purpose, when, and who should use it in order to address the specific needs of the involved parties while respecting the local culture.

4.3.2 *Helping Older Adults Embrace Digital Technology*

According to the study results, Chilean older adults do not intend to adopt digital technology because they do not see the need to do it. However, in several cases we can motivate the adoption of particular technology.

Design Implication #10
In all the successful cases of technology adoption observed throughout this chapter, we identify two common factors: (1) technology helped the elderly address an unsatisfied need that they recognize as important, and (2) there were family members engaged with the elderly in the adoption of that technological solution. Considering the current literature, we could assume that (3) the technology to be adopted should be understandable, usable, and valuable for older adults.

These three observations, which can be stated as design requirements, seem to be mandatory to facilitate the technology appropriation of the Chilean older adults. Therefore, they should be considered in the design of the product and in its adoption process.

Regarding the first requirement, the study identifies various unsatisfied needs that are important for Chilean older adults; e.g., to increase the interaction frequency with the grandchildren. Considering this need we can conceive, for instance, computer-supported cooperative games for kids, which require the participation of grandparents for achieving the goal of the game. By recognizing differences among the participants, the gameplay could promote the interaction among them (requirement 1) and provide awareness about the activities of the elderly. This will allow the kids to identify situations where their grandparents actually need external support (requirement 2). Thus, the supporting process to the older adults is embedded in the gameplay, where the kids are in charge of providing it. Moreover, the mechanics of these games are usually not complex and are based on simple user interfaces, which fit well for older adults that are learning how to use technology (requirement 3).

The presented study also shows various other unsatisfied needs that open interesting opportunities to motivate this technology adoption. Current literature reports novel approaches to design these solutions. For instance, augmenting habituated objects, as suggested by Brereton et al. [Brer15], could be useful to increase the interactions around common routines among older adults and the rest of the family. However, considering the participation of family members (as facilitators of technology adoption) in the product design represents a major concern for designers; particularly, because the technological solution should motivate the participation of both, older adults and the supporting family members. The willingness of the grandchildren to support this adoption process eases the accomplishment of the requirement 2. Similarly, as acknowledged by related literature [Dick07, Gara13], encouraging the participation of older adults within other close social networks—such as the one formed by their close friends and other older adults living similar conditions—empowers their social integration and complements the actual support provided by their family members.

Although the stated requirements for adopting technology could also be present in individualistic cultures, older adults in such societies can probably adopt technology only if requirements 1 and 3 are satisfied, due to the prevalence of autonomy and individual initiative [Kim94]. However, in the case of Chilean older adults, all of them seem to be mandatory. Moreover, it is not clear that the unsatisfied needs (requirement 1) considered as important in

individualistic cultures are the same than those in collectivistic societies. Therefore, design approaches need to comply with the cultural nuances in the way they intend to satisfy the stated requirements. In this sense, designing technology for Chilean older adults presents various challenges that seem to be not present in individualistic cultures.

4.4 Limitations

Given that the study presented in this chapter is particularly bound to a specific geographic and socio-cultural environment, we cannot ensure that the obtained results can be largely generalized to other populations or groups. However, we still consider our results to be useful when they are applied to designing cross-cultural mechanisms for family communication, by highlighting the media preferences, social practices, attitudes, agreements, and expectations of family members. In particular, and as we will see in Chapter 5, the reported results share common socio-cultural traits with those that can be inferred from studying middle-class Argentinian families. Therefore, the proposed models and implications in this chapter can be transferred to the broader context of Southern Cone families.

4.5 Summary

This chapter presents a cross-generational interview study that highlights the attitudes, agreements, and expectations around social interaction of Chilean family members, particularly when interacting with their older adults. The approach used by adult children for taking care of their parents generates a vicious circle that stresses out the former and limits the technology adoption of the latter. Therefore, a change in the interaction paradigm with the elderly seems to be required, and promoting the technology adoption by the elderly can contribute to perform such a change.

Although the analysis of the conducted interview provides opportunities to adopt technology that help adult children address the caring process in a more comfortable and sustainable way, changing the interaction paradigm requires that Chilean older adults embrace digital technology. In that respect, this chapter formulated three requirements that any kind of technological solution should consider, in order to have a chance of being adopted by Chilean older adults. This illustrates that technology adoption for intra-family communication in a collectivistic culture seems to be different from what can be observed in individualistic societies.

4.6 Contributions of the Work Presented in this Chapter

Understanding the main attitudes, agreements, and expectations of older adults with regard to the usage of digital technology as a way to support intergenerational communication helps us understand how to propose meaningful design guidelines for mediating the social interaction space of family members through computer-supported mechanisms. In particular, we describe the main attitudes, expectations, needs, viewpoints, and concerns of the involved stakeholders within an intergenerational family network as a way to identify a preliminary set of emerging roles to guide the design process of supporting domestic computer technology in this scenario.

A part of the results presented in this chapter has been published as a full paper [Guti16] in the Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW'16). In particular, this chapter provides four main contributions:

- It describes and characterizes the main needs, attitudes, expectations, viewpoints, and concerns of intergenerational family members regarding their social interaction and informal elderly caregiving.
- It introduces a vicious circle model that helps understand the underlying cultural factors on the interaction with older adults in Chilean families.
- It proposes an initial set of contextualized informal caregiving roles on the interaction with older adults within Chilean family networks as a way to guide the design process of domestic computing to mediate the social interaction space of family networks.
- It derives an initial set of design guidelines to support the informal care provision in favor of older adults in Chilean families.

5. ON THE COOPERATIVE NATURE OF INFORMAL ELDERLY CAREGIVING

Building on the results presented in Chapter 4, we conducted a third in-depth empirical study, this time extending to a new sample comprising Chilean and Argentinian families. The main line of analysis was to specialize the family roles inferred in the previous study—as presented in section 4.2.3—and better characterize the structure and dynamics of the informal elderly caregiving process and social communication practices across the family network in this specific socio-cultural scenario. In particular, this chapter presents the results of a contextualized and localized qualitative study that helps clarify the informal elderly caregiving process in the context of aging in place, as experienced by Chilean and Argentinian families. This way, we aim to understand how to design potentially effective domestic computing solutions to encourage active aging and face the negative effects of social isolation. The rationale behind these design considerations is acknowledging the inherent cooperative nature of the caregiving work and its underlying challenges.

Both Chile and Argentina share similar socio-cultural traits, such as religion, historical processes, and more recently a rapidly aging population along a decreasing number of people living under a same roof. Unlike most Western countries, in these two countries there are few formal caregiving networks and often no government services dedicated to support the informal care provision for older adults [Mont04, Popu14]. Therefore, informal caregiving becomes more unpredictable, mostly relying on the cooperative, voluntary, and articulated action of family members [Guti16]. This situation shapes an aging in place scenario that is different from that in most Western countries where there is increasing governmental funding for home and community-based services [Redo15, West14], with an increasing demand for technology that can improve health and independence of older adults [Horg03, Proc14].

While related literature in social gerontology and anthropology—as discussed in Chapter 2—describes cultural aspects around the informal care provision for older adults in Latin America [Arno08, Mont04, Osor13, Osor14, Redo15, Robl14, Souz12], it does not explore in depth the cooperative nature of the informal elderly caregiving process and does not characterize its structure and dynamics by identifying the involved actors and the relationships among them. In order to deepen the understanding of elderly caregiving in this context from a CSCW point of view, this chapter complements prior literature and provides ground for socio-technical designers and social computing practitioners to conceive technology-based caregiving services tailored to Latin American families.

The study presented in this chapter identifies the roles and caregiving activities assumed by family members, as well as their concerns related to the interaction, coordination, articulation, and negotiation necessary to accomplish an effective informal elderly caregiving process, thus favoring the aging in place paradigm. In particular, the study findings indicate that: (1) family members assume implicit roles and separation of concerns to participate in the informal elderly caregiving process; (2) the kinship relationship with the older adult and the gender of the caregiver are the main indicators of the willingness of a family member to address caregiving duties; and (3) the lack of visibility of the older adults' needs and caregiving activities, is the main source of inefficiency of the process, resulting in tension among family members and imbalance regarding caregiving tasks.

5.1 Method

We conducted a multi-method qualitative study [Blan16] confronting the viewpoints and concerns of adult children acting as informal caregivers with those proposed by the other members in the family network. By combining complementary methods for gathering contextualized data in the wild, we aim to build a richer picture on how family members co-construct their elderly caregiving experience. By doing so, we are in position to derive contextualized design guidelines of computer-supported technology conceived to mediate the social interaction space of Southern Cone family members.

5.1.1 Participants

Through online notices, email lists, and snowball sampling, we recruited four middle-class adult children acting as informal caregivers for their parents. We focused our recruitment process to match the most representative socio-demographic traits and generational structure of Southern Cone families, as reported in the literature [Barr14, Redo15, Thum15]. In the rest of this chapter, we refer to the recruited people as “*primary informal caregivers*”.

We centered our sampling strategy on the recruited primary caregivers, extending it then to their wider family networks. We approached the informal caregivers’ siblings, children, and nephews. In this latter case, candidates had to be over the age of 14 and explicitly express their intention of being part of the study in order to be considered as a participant. The final study sample was composed of 51 people across 4 family networks ($n = 16, 11, 13, 11$, respectively). Families are distributed across several households. Two of them were based in Santiago (Chile), while the other two in San Juan (Argentina). Table 1 details the socio-demographic data of participants.

Table 1: Locations, gender, and ages of participants (study 3)

Family	Households	Participants	
1 Chile	1A	2F (83, 61*)	2M (68, 28)
	1B	1F (36)	1M (37)
	1C	2F (55, 37)	2M (33, 29)
	1D	2F (41, 16)	2M (47, 22)
	1E	1F (32)	1M (31)
2 Chile	2A	1F (71)	1M (73)
	2B	2F (58, 29)	1M (31)
	2C	2F (49, 16)	2M (53, 18)
	2D	1F (48)	1M (43*)
3 Argentina	3A	1F (61)	1M (72)
	3B	1F (48)	2M (48, 24)
	3C	1F (28)	1M (25)
	3D	2F (44, 18)	1M (45)
	3E	2F (42*, 14)	1M (42)
4 Argentina	4A	1F (77)	1M (79)
	4B	1F (48)	2M (48, 24)
	4C	1F (40)	1M (42*)
	4D	3F (32, 16, 14)	1M (49)

The recruited primary caregivers, identified with a star (*) in Table 1 have daily eight-hour work shifts. None of the studied families had external assistance—except for housekeeping—to care for their older adults.

5.1.2 Data Collection

We gathered the data independently in each family, following a three stages process: (1) through contextualized interviews and observation with the four primary informal caregivers; (2) by observing the four settings during an informal family meeting; and (3) through interviewing the supporting family network of each primary informal caregiver. Next we describe each stage. The full data collection instrument is presented in Appendix E.

- **Contextual inquiry.** Aiming to gather insights on how primary informal elderly caregivers fulfill their duties, we conducted contextualized interviews intertwined with in-place observation. According to Beyer and Holtzblatt [Beye98], this method explores a group of users by observing and inquiring about what they actually do, why they do it in that way, what their latent needs are, and identifying their core values.

The authors met participants ($n = 4$, one from each studied family) and discussed their experiences and main concerns on being informal elderly caregivers. Some example interview questions were the following: *How do you feel when performing your caregiving tasks?* (to assess the personal expectations and engagement with the caregiving tasks); *How do you rely on other family members to fulfill your caregiving duties?* (to explore the involvement of the family network as well as how the primary caregiver positions him/herself within the group); and *What motivated you to assume this role?* (to understand the reasons that motivate the primary caregiver to achieve his/her duties). Interviews were audio recorded for later transcription and analysis, and later augmented with contextualized field notes. The process lasted for about three hours with each participant.

- **Participant observation.** To understand the internal dynamics of families and interaction regarding the care provision to older adults in a natural setting, we observed an informal meeting in each family ($n = 8, 8, 9, 6$ participants, respectively in each observed family). These meetings, deeply grounded in tradition and fairly common in Latin America [Suar04], are typically organized around lunchtime on weekends and gather together several family members.

While observing this setting, we took detailed handwritten field notes to understand the relation between the primary informal caregiver and the rest of the family network. We were also interested in the actual involvement of family members in terms of care provision for their older adults, as well as their informal interaction with each other. In particular, we observed how different family members related to the older adult receiving care, how these people coordinate the care provision and fulfillment of caregiving tasks, what sources of tension and conflict between participants emerge in the process, and the nature of informal exchanges (e.g., conversations and other ways of social interaction).

- **Semi-structured interviews.** Finally, with the goal of understanding the perception and experiences of the supporting family network in the care provision for the older adult receiving care, the authors conducted individual semi-structured interviews to the members in

each family. We interviewed a total of 41 participants (n = 14, 8, 10, 9, respectively in each family), covering each family network until reaching data saturation.

Interviews were conducted in Spanish, and lasted between 40 and 60 minutes each. We audio recorded them with the explicit consent of each participant for later transcription and analysis. The interview script was validated in a pilot study with three people, aiming to resolve wording problems and ambiguous statements.

The main topics covered in the interview were: *How do you participate in the care provision for the older adult in your family?* (to confront the vision of the primary informal caregiver with the rest of the family network); *How do you keep up to date of the doings and whereabouts of the older adult in your family?* (to explore the mechanisms used by the family network to sustain their interaction with their older adults); and *How would you situate yourself in the caring network of the older adult in your family?* (to understand the interaction within the family network and the individual concerns of family members regarding the care provision for their older adults).

5.1.3 Data Analysis

We generated our study dataset by transcribing the collected audio data, and extending it with our handwritten field notes. To analyze our dataset, we followed the thematic analysis approach [Brau06], which consists of generating initial codes from the data, searching for themes, contrasting the identified themes with the data, and iteratively refining the themes and narrative.

We framed our analysis around the idea that family members implicitly or explicitly tend to assume roles in informal caregiving. This is based on previous work by Miller et al. [Mill16] in hospital settings and on our initial proposal on caregiving and intergenerational family communication roles, as presented in Chapter 4.

Quotes, translated from Spanish by the authors, are provided to illustrate the main topics grouped under each theme. “AC” refers to the adult children in the family network, “AP” to the adult partners of family members belonging to the filial branch of the older adult receiving care, and “GC” represents grandchildren.

5.1.4 Ethical Considerations

Following the American Psychological Association (APA) ethical guidelines for fieldwork research [Amer10], all participants were compensated for their time and provided their free, explicit, and informed consent. The study design has been approved on ethical grounds by the Research Ethics Board of the Faculty of Physical and Mathematical Sciences of the University of Chile (cf. Appendix A).

Interviewees were informed about the goals of the research, the nature of the data intended to be collected, and our efforts to ensure confidentiality during data collection, treatment, and dissemination. Participants were also offered the right to withdraw from the study at any time. No participants declined to participate in the study nor dropped out (cf. Appendix B).

Regarding the observation of weekend family meetings, we contacted beforehand the participants who confirmed to participate in the study and provided consent. We presented the

scope of the study and explained the role that the assigned researcher would take as external observer during the meeting. Given the intimate nature of this setting, we only kept handwritten notes and opted to not use recordings.

Quotes and any kind of information exposed in this chapter containing personal or identifiable participant data were anonymized, and pseudonyms were used if necessary. Once the quotes were selected to sustain the narrative reported in this chapter, we returned to the involved participants and offered them the power to veto the publication of their quotes if they considered them a breach of confidentiality. No participants decided to edit or withdraw their quotes for publication.

5.2 Results and Interpretation

We identified three core aspects that shape the structure and dynamics of the informal elderly caregiving process: (1) the assumption of implicit roles; (2) the articulation of the work performed by family members for conducting the process; and (3) the sources of tension within the family network. We also identified gender as a transversal issue influencing the three core aspects stated above, which resonates with related literature in social sciences and nursing [Conn96, Cala06, Carr08, Dwy91, Papa07].

5.2.1 Roles in Informal Elderly Caregiving

Inspired by the work presented in Chapter 4 and by studying the cooperative aspects of the informal caregiving work, we specialize the proposed roles on caregiving and intergenerational communication, which are implicitly and voluntarily assumed by family members. In that respect, the main characteristic of cooperative informal caregiving in Latin America is that the involved stakeholders also share the trait of belonging to the same extended family network, rarely interacting with external service providers, such as professional caregivers or medical services [Redo15]. The derived roles characterize the concerns and viewpoints of informal caregivers. Although by no means the proposed roles intend to be exhaustive, we argue that it is possible to use this characterization for informing the design of social computing technology tailored to the expectations and scope of caregiving duties to be fulfilled by family members.

- **Assistant.** Family members assuming this role share the same roof with the older adult, continuously monitoring and providing care and assistance. In urgent cases, they are in a position to promptly address the situation. The significant other of the older adult receiving care, or an adult child usually assumes this role. For instance, one assistant explains how she ended up assuming this role:

“My parents lived together in a house close to ours. We visited them quite often, usually on weekends. Unfortunately, when my father passed away some years ago, mom started to feel very sad. She didn’t visit her friends like she used to, and started to get sick quite often. I decided to bring her back to my house, to help her with her needs. [...] It was difficult in the beginning, but I still think it was for the best. She seems happy now. She plays with my kids, she reads to them, and sometimes she goes for a walk and phones her friends”. AC1, family 1A, female, 61 years old.

Strictly speaking, the tasks associated with this role are similar to those that an external, formal caregiver performs; e.g., supporting the activities of daily living (ADLs), the instrumental activities of daily living (IADLs), and indirectly providing information and connecting family members with news about the older adult. Although literature reports design considerations for ambient information systems to assist older adults in accomplishing their ADLs (e.g., [Myna04, Rodr11, Staw14]), in the studied scenario family members typically assume this role, particularly adult children, and are aware of the implications of the unwritten social norm of filial obligation. These family caregivers therefore consider that fulfilling these duties is a moral repayment for the care received by their parents. For instance, another of our assistants, who is also the youngest son of the older adult in his family, states:

“I don’t see this [assuming caregiving duties] as an obligation, but rather as an honor!”. AC5, family 2D, male, 43 years old.

Following on the notion of articulation work proposed by Schmidt and Simone [Schm96], assistants are the family members who are in charge of articulating the distributed collective effort of sustaining the informal caregiving duties within the family network. This implicit leadership within the family is also an expression of invisible work [Star99], which is particularly stressed in Latin American families given the collectivistic nature of social links and the historic tradition of filial obligation [Barr14, Redo15]. In some cases, family members inadvertently overlook the invisible nature of this work, thus resulting in burdened assistants due to an unbalanced caregiving workload.

- **Monitor.** They are family members who do not share the same roof with the older adult, but are consistently aware of the doings and whereabouts of their older adults. Typically, monitors are in position to provide affective care, social engagement, informal health care, economic and financial support, and to a lesser extent, security and safety.

Most monitors are available to support care recipients when necessary (e.g., for running errands), and they coordinate their activities with the assistant (if any). Typically, one or more of the adult children assume this role.

“My sister and I coordinate with my father’s partner to address his needs, but mainly to support the health issues of our dad”. AC3, family 2B, female, 58 years old.

Given that monitors do not live with the older adult, they usually establish mechanisms to inform themselves about the older adult’s actions. In some cases, the monitors rely on their social capital within the family network and also involve neighbors to reach their older adults.

“I am always concerned about my parents. I tend to call them at least once a day, usually during my lunch break at work. However, when I can’t reach them, I worry because I don’t know if something bad has happened. In those cases, I usually call their neighbors or my brother who lives nearby to see if they have news about them”. AC10, family 4C, male, 42 years old.

Many recurrent tasks of monitors are related to sustaining the social capital within the family network. For instance, they mediate the interaction between two members who cannot

smoothly communicate with each other, as well as organize and run weekly reunions with the older adult.

“My children are not willing to interact with my mother because she is always bothering them with religious comments. Therefore, I keep my mom informed about my children’s activities. Sometimes, and with the consent of my children, I invite her to have lunch with us on weekends”. AC6, family 3B, female, 48 years old.

- **Helper.** They are less-committed family members, who typically contribute in instrumental duties that require low effort and do not represent a long-term commitment. They are usually the siblings of assistants and monitors, and grandchildren who are affectively close to the older adults. People assume this role on-demand, in response to a request typically raised by an assistant or monitor.

“My dad makes a significant effort to care for my grandfather, so I try to help him with these tasks. Sometimes he asks me for help, but other times I take the initiative”. GC18, family 4D, female, 16 years old.

Neighbors and close friends of the older adults act as helpers, which resonates with prior literature on the involvement of affectively close external members to the family, both in the United States [Hime00] and Chile [Thum15].

- **Outsider.** We identify as outsiders those family members who are not willing or available to assume caregiving duties. Among typical outsiders we include teenage grandchildren who do not feel affectively attached to their grandparents, and family members that do not live physically close to the kin.

These people justify their minor involvement indicating that they are not aware of the current needs of the older adult, and that there are others more capable who can conduct the caregiving tasks. However, in some cases, some outsiders are willing to participate if necessary. For instance, GC11 states:

“I would help grandma if she needs me, but I don’t know what to do! My parents and uncles already take care of her and keep telling me not to worry”. GC11, family 2C, female, 16 years old.

Although outsiders can initially be weak links when articulating the caregiving work, the collectivistic nature of social links in Latin America still sustains strong interpersonal ties, usually built upon affection. Therefore, based on our field observations during family meetings, we claim that these family members can be persuaded to participate in the process during short time periods, under specific conditions, and to perform particular tasks.

5.2.2 Assumption of Family Caregiving Roles

The set of activities performed by the family members in favor of their older adults is what determines their role in this process. Recognizing that people do not necessarily assume static roles, and that the informal caregiving work is articulated, the study results identify a set of factors that strongly influence the assumption of caregiving roles.

The gender and kinship relationship of caregivers with the older adult seem to transversally influence the assumption of roles, and affect the coordination and articulation effort of sustaining the informal caregiving work. Trying to not overgeneralize the structure of every family ecosystem, the study results indicate that there are noticeable differences in how people embrace their duties. In that respect, Table 2 shows the roles that, according to our observations, are usually assumed by family members.

Table 2: Assumption of roles in informal elderly caregiving

Relation	Female	Male
Partner	Assistant	Assistant
Adult child in the same house	Assistant Monitor	Monitor Helper
Adult child in another house	Assistant Monitor	Monitor Helper
Grandchild	Helper	Helper

The main difference in the assumption of roles according to gender is that female caregivers are usually more committed than male caregivers. As such, adult daughters tend to get involved in roles with more load and responsibility, such as assistants and monitors.

The affective link between the older adult and his/her family members also influences the role that will be implicitly assumed by the latter. We observed that it is not rare that the last adult child leaving the parental home tends to be the most committed in caring for his/her parents.

“I am the youngest one among my siblings, and we all assumed it was kind of ‘natural’ that I had to be more aware if dad and mom need something”. AC8, family 3E, female, 42 years old.

Similarly, as we observed during the family meetings, the number and quality of shared memories shapes the grandparent-grandchildren relationship, which in turn depends on the physical distance between these people. Therefore, those grandchildren who consider themselves to be affectively close to their grandparents, are more prone to assume more time and resource-consuming tasks in order to care for their older adults.

A third factor that influences the adoption of family caregiving roles is distance. This notion is usually considered in CSCW research as a hurdle to effectively mediate interaction between people [Brad02]. In the case of informal elderly caregiving in family settings, this still holds. When adult children move away, they typically reformulate their caregiving commitments with their parents. However, given the strength of socio-affective links within the family network, distance usually does not deteriorate the link between adult children and their parents, but negatively impacts the relationship between grandparents and grandchildren. This is aligned with our prior observations reported in section 4.2.2 when studying intergenerational communication in Chilean families.

“I switched jobs a couple of months ago and I had to relocate as well. [...] We [family members] can’t see my mother as often as we’d like to. In any case, I still try to call her quite often and I push my kids to do so as well. I also send her

some money every month to help her to buy medicines or cover other personal expenses”. AC2, family 1D, male, 47 years old.

In summary, adult children living away tend to proactively assume the role of helper and make an effort to engage their children into maintaining the contact with the older adults. However, the lack of frequent face-to-face interaction deteriorates the relationship between grandchildren and grandparents. This situation is recognized—and assumed—by younger family members, but not always by the older adults.

5.2.3 *Coordination and Articulation of the Informal Elderly Caregiving Work*

Ensuring the assumption of family caregiving roles requires articulating the collective distributed effort of family members. However, this can turn to be demanding due to the complex and dynamic arrangement of the family network with regard to this process. Indeed, in the studied families, promoting articulation work is more an expectation rather than an established practice. Through our field observations, we noted that improvisation and individualism often cause tension in the relationship among family members. However, the expression of collectivistic social links imposes a superior goal of avoiding conflicts inside the family, particularly when they involve the older adults. This latter situation helps maintain a balance among the people engaged in the caregiving process.

Monitors and helpers usually coordinate in a point-to-point way with the assistant. Otherwise, monitors act individually based on the separation of concerns implicitly assumed by family members, and eventually ask for the help of their partner and children. As AC10 stated, this attitude is usually assumed because coordinating the caregiving work is sometimes perceived as a source of conflict within the family.

“When dad passed away, we needed to decide who was going to take care of mom. My sister was initially reluctant, but she ended up helping her move to her place. Thank God she did it, so we don’t have to fight over it! Not only because she can keep an eye on mom, but also because she loves updating us on how mom’s doing or if she needs something”. AC10, family 4C, male, 42 years old.

Consequently, given that the articulation work tends to be centralized in the assistant, the caregiving activities conducted or mediated by a monitor are not visible to other monitors or helpers belonging to a different family branch. This limits the capability to coordinate and negotiate activities among those assuming caregiving roles, thus making the process inefficient. For instance, as we observed during family meeting #4, it was quite common to see actual needs of the older adult that ended up not being addressed, while others were over fulfilled.

Male caregivers tend to be more willing to ask for help and work cooperatively than female caregivers. Typically, the former convene people of their same filial branch. For instance, AC5 relies on his siblings when he is unavailable:

“I always try to support my parents. My siblings also take care of them, but to a lesser extent. [...] When you ask them to do something, they’re there. We’re very united and share responsibilities”. AC5, family 2D, male, 43 years old.

Contrarily, female caregivers in our interviews repeatedly claim to address the challenges due to caregiving by themselves. This leads to complaints about the lack of help, particularly toward family members of the same generation.

“Dad is already used to me being the one who drives him to the doctor. [...] I have to do it because I live closer (to him). [...] I would really like more involvement from my brothers. Although they are aware that they need to do more for our dad, they tend to overload me and avoid their responsibilities”. AC8, family 3E, female, 42 years old.

All in all, it turns that female caregivers expect more involvement from other family members, whereas male caregivers actually recognize that they benefit from more support, particularly that offered by members of their same generation. These observations resonate with related research on burdened family caregivers [Papa07].

Female and male adult children tend to look to different concerns when engaging in caregiving duties. On the one hand, women acting as monitors or assistants focus more on emotional expression and values; i.e., in supporting the human being that is cared for. Thus, they are more willing to provide affective and social care than male caregivers.

“Even if they [the older adults in the family] are not my parents, I love them. They are wise and deserve all our respect. I do everything that I can to support them, together with my husband and my children”. AP8, family 2D, female, 48 years old.

On the other hand, male monitors focus more on providing comfort, safety and peace to the older adults. They are more effective than female in this domain and usually do not feel burdened with the responsibilities that they assume. However, they are not always willing to engage in caregiving routines or accomplish the assumed duties.

“Although I love mom and dad, I also have to admit that my wife takes care of them more than I do (laughs)! I mean, we both work together: I am usually more present for assisting with particular tasks, doing shopping, fetching their medicine at the pharmacy, and so on. My wife is always there entertaining them, looking at old photos with our kids, watching TV, and spending quality time together”. AC5, family 2D, male, 43 years old.

Therefore, as suggested by caregivers in family 2D, the effort provided by both genders tends to complement each other in order to sustain an effective informal caregiving plan. This includes not only sharing duties and coordinating the allocation of resources, but also individually or jointly assuming responsibilities when providing care. In this family, both visions work coordinately in order to smoothly run the process, which indirectly engages other family members to actively participate in the caregiving process.

This implicit separation of concerns offers some kind of order and stability to the family ecosystem. When adult children are both of the same gender, one of them usually relies on the assistance of his/her partner for fulfilling the caregiving work.

“We are three brothers, and unfortunately there are caring aspects that are more naturally addressed by women, like emotional contention or just spending time listening to the older adult. When these issues arise, I ask my wife for help”. AC9, family 4B, male, 48 years old.

5.2.4 Sources of Tension among Informal Caregivers

The elderly caregiving process in the observed families is unstable and informal, where some participants periodically conduct independent efforts for stabilizing the situation. Through our interviews, we identified several sources of tension that for short-time periods jeopardize the relationship among family caregivers.

Typically, the caregiving process does not provide visibility of the activities conducted by family members in favor of their older adults. This induces an asymmetric perception of the assumed caregiving roles across the family due to an implicit assumption of separation of concerns in the fulfillment of caregiving tasks. In this case, most assistants and monitors feel themselves as those who are the most engaged with the care provision. Therefore, it is not unusual that they consider some family members as free riders, which increases tension in the family network.

“Don’t get me wrong. We all do our best to help mom, whenever we can. However, I regret that my brothers don’t take the initiative. I frequently need to keep reminding them to have lunch together on Sundays and to go pick mom’s medicines. It’s the least they can do! [...] However, you’re not in position to complain, because then the others [siblings] keep telling that it’s my role to keep the family together!”. AC1, family 1A, female, 61 years old.

“My sister thinks that she’s the only one supporting mom and doesn’t value the support that we provide her [mom]. This sometimes irritates me and we end up having an argument”. AC2, family 1D, male, 47 years old.

In addition, the separation of concerns within the elderly caregiving process imbalances the load assumed by the adult children, since the care activities of female caregivers are usually time consuming and performed more frequently than those assumed by male caregivers. Considering this situation, it is not surprising to observe that female adult children are more engaged in the caregiving process than male caregivers, which resonates with related literature [Barr14, Cala06, Carr08, Papa07]. Furthermore, given that monitors and most helpers are not broadly aware of the needs of the older adults, they usually fail to contribute to the extent expected by the primary caregiver, i.e., the assistant.

As a way to involve younger family members into caregiving duties and also address pending needs of their older adults, some adult children—usually assistants and monitors—try to impose filial obligation duties upon their own children in favor of the grandparents.

“I care a lot about grandma, but sometimes dad asks me a lot to do and I can’t manage keeping track of my stuff at the University and all the issues that we have at home. I have no problems with taking on certain tasks, but someone has to be there to help me if I can’t do it. I also have to take care of myself and nobody is going to help me there!”. GC12, family 2C, male, 18 years old.

However, as we observed throughout the study, grandchildren in many cases refuse the parental imposition on participating in the caregiving process. This strains the relationship with their parents, and in some cases, with their grandparents.

“I don’t know what’s wrong with mom and dad! It’s like they get mad if I don’t call grandma or I don’t go visit her. [...] Yes, they’re my grandparents but we already see each other once a week, so I don’t think I should do more for them. That’s what mom and dad are for!”. GC6, family 1D, female, 16 years old.

Following the formulation of Schmidt and Bannon on the nature of cooperative work [Schm92], younger family members typically do not feel accountable for taking part in the cooperative process of informal caregiving. This mismatch in the perception of following the filial obligation is a potential source of tension among family members, which according to our field observations, is higher when assistants feel burdened with their caregiving duties. This situation highlights the need to address the expectations of the various family members and conceive means to effectively support an appropriate articulation work within the caregiving network.

5.3 Discussion

There are no one-size-fits-all solutions for taking care of older adults, since such a process would have to address their particular needs, adapt to certain configurations of roles, and consider the commitments of family members. The study results presented in this chapter provide insights for informing the design of computer-mediated solutions for supporting elderly caregiving and mediating intergenerational communication.

Concerning the way the informal caregiving process is articulated, the results indicate that family members voluntarily assume implicit roles that determine their level of engagement and willingness to be aware of the caregiving process. In other words:

Design Implication #11

Socio-technical designers of informal caregiving technology should consider the potential influence of informal caregiving and intergenerational communication roles. Therefore, they should actively provide particular services for each role. For instance, the activities of assistants and monitors can be supported with technology for easily reporting the pending needs of the older adults, and thus establishing a platform for seeking help without being involved in the coordination of the caregiving effort.

The assumption of the proposed roles also implies the design of awareness, notification, and persuasion mechanisms for making the caregiving work visible, since participants expect to receive up-to-date information following their level of engagement. Similarly, the mediation of mechanisms for making the caregiving work visible should limit the imposition of caregiving duties that fall out of the range of responsibilities that family members could assume. This opens various challenges for social computing technology designers, such as providing the means to facilitate their identification within the family caregiving ecosystem, which would allow providing contextualized services to the involved participants. We can state this idea as follows:

Design Implication #12

Key design considerations to take into account when designing effective domestic computing technology for mediating the social interaction space of family members are: social awareness, activity awareness, persuasive strategies, and up-to-date feedback loop mechanisms.

Although the findings reported in this chapter indicate that gender and the kinship relationship of caregivers with the cared for older adult are the main drivers for mediating the assumption of caregiving roles, there are also other factors affecting the involvement of family members that are not easy to automatically identify, such as affection and physical distance. Moreover, the role assumed by a family member can change for several reasons.

Design Implication #13

Keeping track of the evolution of roles within a family network represents a design challenge that would also help conceive and deploy contextualized services. Similarly, such services should also support the technology adoption of older adults, for instance, by enabling and/or adapting services tailored to the current level of system appropriation. If a computer-supported mediator system intends to persuade people to engage in a more active role (e.g., outsiders becoming helpers), such a change should be detected as a way to increase the available resources for effectively intervening in the caregiving process.

The findings also indicate that, although it is required, there is little to no coordination among roles, given that this activity requires high availability from family members, is time consuming, and usually generates conflict within the caregiving network. This opens several opportunities for designing coordination services for family members.

According to Schmidt and Simone [Schm96], the articulation of the distributed activities that are part of a cooperative work requires appropriate mechanisms of communication and coordination among the involved participants. In that respect, the study results go a step forward by informing that such mechanisms should consider the roles assumed by family members and respect the loosely coupled nature of the caregiving work.

Design Implication #14

It seems to be more appropriate that helpers subscribe to particular requests raised by monitors and assistants, rather than the latter send these requests directly to the former. This would reduce the imposition of filial obligation among helpers, which constrains the dedication and involvement of these people.

Regarding the factors affecting the willingness of family members to engage in caring duties, the study results indicate that the gender of caregivers makes them prone to address particular types of caring activities. Moreover, the concerns of female and male caregivers are complementary.

Related literature in Western countries identifies the distinctive role of the female adult children in the caregiving process [Cala06, Carr08]. However, it does not clarify what key concerns are usually addressed by each gender in the studied socio-cultural context. In that respect, the study findings suggest that the design of specialized services need to consider not only the role assumed by caregivers, but also their gender. We can summarize this idea as follows:

Design Implication #15

Female monitors in Southern Cone families tend to prefer addressing the social and affective needs of the older adults, as well as keeping informed the latter on the whereabouts of the younger members of the family. Conversely, male monitors prefer to ensure instrumental security, safety and comfort issues by improving the living environment of older adults. These two attitudes toward the fulfillment of caregiving duties need to be aligned with the proposition of contextualized awareness mechanisms and computer-supported mediators.

Regarding the main sources of tension in the family caregiving process, the study results identify several causes. In that respect, the lack of visibility of both older adults' needs and actual fulfillment of caregiving activities, are the main sources of tension within the family network. Classical approaches of CSCW design suggest that using common information spaces, such as shared views or board systems [Schm91, Schm96] could contribute to make visible these aspects of the caregiving process. Therefore, in order to be effective for articulating the informal caregiving work in Southern Cone families, the study findings suggest that the design of mediating solutions should consider multiple views that display particular information according to the assumed roles and gender of family members.

Design Implication #16

Making the older adult needs visible can help identify the most demanding areas of the older adult receiving care and articulate the effort expected to be contributed by family caregivers. This also opens several opportunities for enabling and facilitating the participation of helpers, who could use notification services to be aware of particular caregiving requests in favor of the older adults.

For instance, helpers may decide what request to address depending on their availability and perceived affective link with the older adult. Therefore, such services help ease the coordination among caregivers, balance the workload on the most engaged people, and address the tension generated by the imposition of filial obligation matters to grandchildren.

Finally, concerning the visibility of the caregiving duties, and following the reasoning of Star and Strauss on the parallels of visible and invisible work in CSCW systems [Star99], the study findings show the need to make the roles and caregiving activities explicit, while visualizing the formal and informal duties of the family members as a way to recognize their contribution in the process and improve the balance of responsibilities among people assuming similar roles.

Making this information explicit also helps align the expectations of primary caregivers, the older adults receiving care, and the other members in the family network. However, the study results indicate that the interviewed family members tend to avoid conflict as much as possible regarding the articulation of caregiving work.

Design Implication #17

Visualizing the fulfillment of caregiving duties as a way to make people aware of the caregiving activities within the family network should encourage the participation of family members in a fruitful way, for instance following strategies based in positive psychology, rather than exposing them to the rest of the network.

5.4 Insights for Technology Design

Until quite recently, the socio-emotional nuances of the caregiving work have been overlooked by most HCI and CSCW literature [Chen13]. Resonating with the current breadth of literature, through this study we reaffirm that the work of informal elderly caregivers is typically invisible [Chen14, Star99] and lacks support [Scho16]. While several authors have reflected on ways to support the daily life of informal caregivers (e.g., Consolvo et al. [Cons04]; Schinkinger and Tellioglu [Schi14]; Zárate-Bravo, García-Vásquez, and Rodríguez [Zara15]), the presented study results show an evident lack of visibility about the pending requirements of older adults and also about the caregivers’ activities and assumed commitments. This situation represents a source of conflict and tension between family members and the older adults receiving care. Furthermore, it limits the capability to coordinate activities and identify opportunities to support this process.

5.4.1 Visualizing the Family Caregiving Ecosystem

Given that caregivers usually do not want to coordinate the caring activities within their family networks—due to the potential conflict that may arise with other family members—, Figure 14 represents a matrix we conceived for assisting social computing designers deal with these limitations.

Family Member	Daily	Weekly			Monthly			Sporadically
	Daily Activities	Social	Housekeeping	Affective	Financial Support	Economic Support	Informal Health Care	Repairing, Installing, Securing, etc.
Member 1								
...								
Member N								

Figure 14: Informal elderly caregiving matrix

In the representation above, each column represents the dimensions of the typical elderly caregiving needs, as discussed in section 3.2.1. In order to provide a more accurate representation of the requirements specific to a particular older adult, these dimensions are sorted by priority, and grouped by frequency; i.e., whether they are *daily*, *weekly*, *monthly*, or *sporadically*. Each need also has a particular level of required support: *high*, *medium*, and *low/not required*. These variables are visually mapped by color intensity in every column.

Each row represents a family member participating in the process. Therefore, every cell, i.e., the pair [family member – care dimension] represents how much a particular family member contributes (or is willing to contribute) to address a specific need of the older adult receiving care. This ranges from: *actual commitment in fulfilling the task* (represented as +), *willingness to engage in fulfilling the task* (represented as /), and *represents burden to the family member* (–).

The matrix can be implemented as a serious game in which the members declare an initial set of caregiving commitments. The study results can be used to infer the matrix information when it is not available for a particular person, hence acting as an initial seed for setting up the game. Then, the dynamics of the process updates and adjusts the initial definition of caregivers by providing a picture of the current process. This feature can be embedded in an intergenerational family communication mediator, such as SocialConnector. In this respect, game mechanics, and by extension gamification, provide a view on how to persuade people on keeping updated their caregiving actions, to encourage them to support particular activities, and to engage more people in the process. The temporal results could be displayed in a family dashboard (e.g., [Shi14]).

As an example, Figure 15 depicts an example of the family caregiving ecosystem for a male older adult (family #3 in the study presented in this chapter). ‘AC’ stands for adult child, ‘AP’ for adult partner, and ‘GC’ for grandchild.

Family Member	Daily	Weekly			Monthly			Sporadically
	Daily Activities	Social	Housekeeping	Affective	Financial Support	Economic Support	Informal Health Care	Repairing, Installing, Securing, etc.
AC6		++	//	++			++	
AC7		+		+		+	+	
AC8		++		++	+		++	
AP10		/		/	/			+
AP13		+		+				
GC13					/			
GC14				-				
GC15		+		//				
GC16		+		+				

Figure 15: Example of the informal elderly caregiving matrix for a male older adult

The matrix contrasts the elderly needs with the caring commitments and willingness of family members. Any action taken or untaken by them, related to a requirement of the elderly, updates the status of the matrix, thus reflecting the behavior of caregivers.

On the one hand, by analyzing the matrix information, we can identify caregivers that have no backup (e.g., AC7 for economic support, or AP10 for home instrumentation), family members acting as outsiders (GC13 and GC14), and helpers (AP10, GC15, GC16). This analysis also indicates that there is an over assistance in social and affective care, and an unnecessary support in informal health care, while there is little financial and economic support. These results can be

automatically obtained with simple algorithms that use a computable version of the proposed matrix as input.

The previous analysis can be then used to provide participation awareness, engage more people in the caregiving process, and persuade caregivers to address needs with insufficient support. The study findings represent a key input to identify candidate caregivers to be persuaded, by considering their gender, the relationship with the elderly, their commitments and willingness, the type of need to be addressed, and their caring activity recorded at a certain time.

On the other hand, making visible the matrix information can help family members reorganize, change their willingness towards supporting certain caring activities, and change their caring behavior. Moreover, this information could also allow them implicitly coordinate their activities without being exposed to potential conflicts with other members, to know when to intervene or ask for help to perform a certain caring activity.

5.4.2 *Assisting Family Members in the Caregiving Process*

Although the matrix allows identifying opportunities to improve the caregiving support (i.e., *what* to support), the study results indicate key aspects to be considered when designing solutions to address limitations of the caregiving process (i.e., *how* to support it). For instance, when assistants and monitors are all either male or female, it would be interesting to count on a system that persuades adult partners to help, given the positive influence of counting with the participation of both genders in effective informal caregiving schemes we identified in our study.

Considering the fact that the social and affective needs are usually important for Latin American older adults, serious games can be developed to engage them in these activities with their grandchildren, neighbors or friends. Thus, they address an elderly need and enhance their affective links. This can also be implemented around common routines between older adults and the rest of the family, as suggested by Brereton et al. [Brer15]. Similarly, given that the needs of older adults are usually visible only to assistants and monitors, mobile technology can be designed to keep the helpers aware of them. Some elderly needs are periodic, which allows supporting systems infer the demand for support. The study results can also be used to infer the suitability of systems designed to supporting older adults and caregivers in other cultural scenarios, for instance tele-dining systems [Inou14].

5.4.3 *Scenarios for Supporting Elderly Caregiving*

By aggregating the empirical data collected from the studies conducted in Chapters 4 and 5, we can identify the main configuration of intergenerational triads regarding the care provision to older adults and the commitment of the involved parties on engaging in informal social interaction. In an initial attempt to describe the communication and coordination practices of caregivers across different family structures, we grouped the interviewed triads under one of three family types as shown in Figure 16. We used circles to depict women and triangles for men. ‘OA’ stands for older adult, ‘AC’ for adult child, and ‘GC’ for grandchild. The quality of the affective link is represented with a line between the involved people. The thickness of this link maps the perceived strength of the relationship between each member within the triad. The color of the line indicates who evaluated the quality of each link.

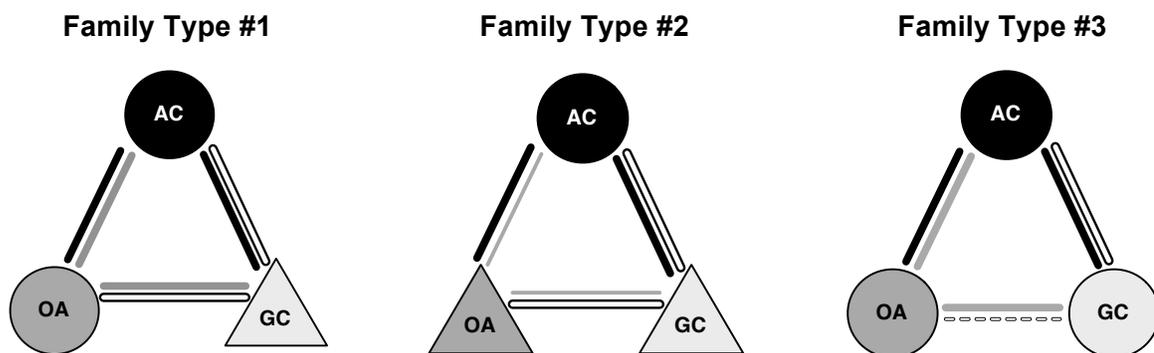


Figure 16: Representative intergenerational triads

Family Type #1 represents structures where one daughter usually acts as caregiver and the care recipient is a female older adult. This family type, which is the most frequent one in our sample, sometimes involves one or more grandchildren in the caregiving process. Family Type #2 involves male and female caregivers, where the care recipient is a male older adult. Finally, Family Type #3 represents triads where the adult children and grandchildren live far away from the older adult; e.g., in a different city. This involves male and female caregivers, and the care recipients are mainly female older adults. Naturally, given the complexity of family links, not all families fit under the identified groups, but most of the observed configurations (almost 80%) can be clustered under one of these family types.

Aggregating the results of the empirical studies conducted in Chapters 4 and 5, we identified four caregiving scenarios (Figure 17), which can be supported in different ways using computer-supported technology. Scenario #1 is the most frequent one, where a female family caregiver simultaneously takes care of her mother and own children. The size of the arrows indicates the willingness of a person to support the other party, and the type of line maps if the support is effective (solid lines) or potential (dashed lines). ‘OA’ stands for older adult, ‘FC’ for family caregiver, and ‘H’ for helper.

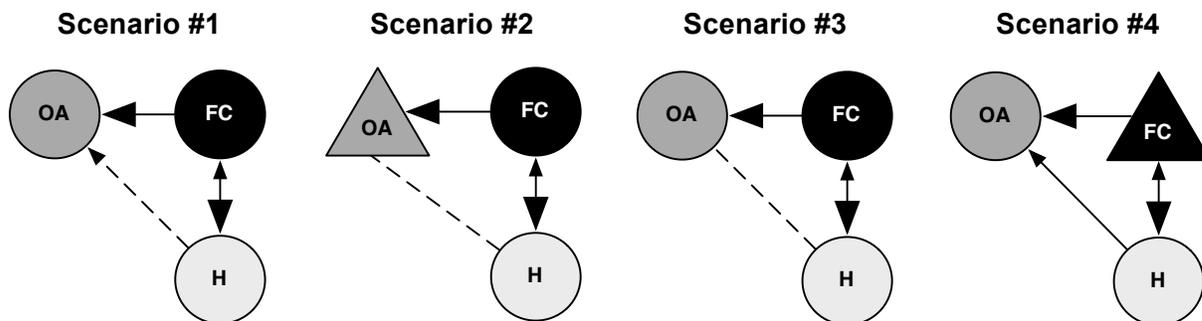


Figure 17: Scenarios of family caregiving support

Regarding scenario #1, we observe that grandchildren and some adult children are not available to be caregivers; however, they are willing to contribute as much as possible. Unfortunately, they do not frequently assume such a role since they have little to no understanding of the elderly short-term needs; e.g., buying medicine or groceries. Female older adults receiving help usually do not represent an obstacle for helpers. This opens several opportunities for designing technology to engage and support helpers, thus satisfying the needs of older adults and reducing the workload of caregivers. Nevertheless, designing this kind of

technology requires that female caregivers realize that other family members can contribute not only as caregivers, but also as helpers.

Design Implication #18

Designing technology that decentralizes (even partially) the control held by female caregivers represents a plausible design opportunity.

Scenario #2 is similar to the previous one, with the difference that the older adult is a man. In this case, there is not only a lack of visibility of the elderly short-term needs, but also a reluctance of older adults to receive external support. Therefore, effective technology to address the caregiving process should probably be aimed at persuading both helpers and older adults using positive computing solutions. For instance, highlighting shared memories can contribute to increasing the willingness of potential helpers to assist older adults, and to the latter for receiving external support. In that respect, there is also an opportunity to assist male older adults using their partner as mediator; i.e., the grandmother can make their shared needs explicit and thus getting external support that benefits both of them.

In scenario #3 the caregiver and her children live far away from the older adult. Typically, the older adults keep direct contact with their caregiver, but usually not as much with their grandchildren. Although there is technology specifically targeted at keeping alive and reinforcing the link between distance-separated grandparents and grandchildren, most of these solutions are focused on kids and do not necessarily consider teen or young adult grandchildren as potential actors in the caregiving process. This opens several opportunities to design technology for this scenario.

Finally, in scenario #4 the caregivers are male. Although they usually involve other family members as helpers, their coordination is centralized. Therefore, it depends on the active participation of caregivers. Coordinating activities in this scenario can benefit from technology that decentralizes or automates part of this process, given that male caregivers usually receive external support from other family members.

5.4.4 *Linking it All Together*

Considering the family caregiving model structured in section 3.2 (Figure 10), the specialized caregiving and family communication roles derived in section 5.2.1, and the matrix visualization on the elderly caregiving ecosystem proposed above (Figure 14), we can identify how these formalizations interact with each other as a way to identify opportunities for mediating the informal elderly caregiving process and engaging family members in intergenerational social exchanges. Figure 18 provides an overview of the structured model grounded in literature with design implications derived from the empirical studies so far.

On the one hand, the color of the matrix columns (Figure 15), representing the support required to address the elderly needs, matches with the caregiving requirements presented in the ecosystem conceptual model (Label 1 in Figure 18). Similarly, the willingness and commitment values of a caregiver in the matrix both correspond to the components labeled as 2 and 3 in Figure 18. The caregiving actions that update the status of the matrix correspond to the component labeled as 4. All these actions are performed following the current viewpoints and concerns of the roles that are assumed by the involved family members within the caregiving network.

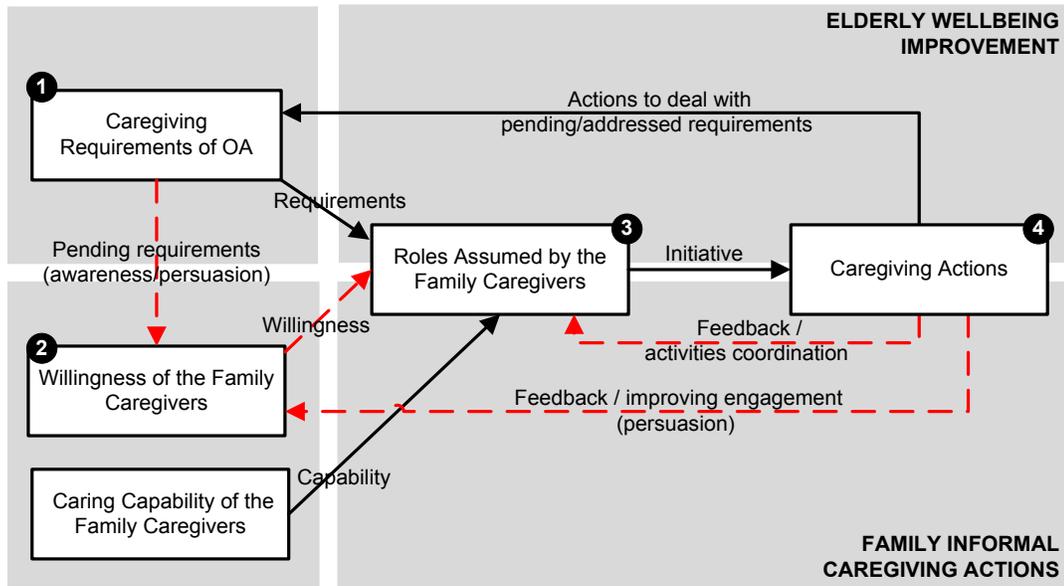


Figure 18: Opportunities for intervening the informal elderly caregiving process

Figure 18 also shows in red the main opportunities to make visible the elderly needs as well as the caregiving commitments (roles), willingness, and actions. Moreover, it indicates where social computing designers can take action to increase the participation, involvement, and engagement within the family network. These different concerns to address the asymmetries within the interaction space can be instantiated following one or more computer-supported technology strategies, such as personalized persuasion or awareness mechanisms.

5.5 Limitations

It is important to understand the context in which computing solutions might support older adults and their family members. In the particular case of the study presented in this chapter, we limit our analysis to the case of Chile and Argentina, where we did not find any noticeable cultural differences between the sampled families; i.e., the studied families are comparable in terms of how they articulate the informal care provision for their older adults.

However, given the diversity of family settings and the heterogeneity in aging people, we cannot ensure that the study results still hold for larger populations. Certainly, there is space to replicate this study in other groups, and thus identifying similarities and differences on how family networks structure themselves around the informal elderly caregiving process.

5.6 Summary

Facilitating aging in place in Southern Cone families requires addressing the cooperative nature of informal caregiving work. In these countries, family members usually assume implicit roles to address the main activities for providing care to their older adults. While literature suggests that this process burdens primary caregivers—usually one of the female adult children in the family—, it is not evident how to design technology for improving the articulation of the

caregiving work. Understanding these aspects would help social computing designers and practitioners conceive new mechanisms for addressing this situation.

In particular, as a way to bridge this gap, we identified a set of roles that characterize the concerns and viewpoints of the different family members regarding informal elderly caregiving, and therefore sustain the articulation of the process. We also drafted the main concerns of the involved stakeholders in the form of a caregiving matrix, which can be used for visualizing the current fulfillment of duties within the family network. Finally, based on the analyzed families in Chapters 4 and 5, we described a set of typical caregiving scenarios aimed to inform the design of contextualized strategies for mediating the social interaction space of intergenerational families through computer-supported technology.

In summary, given that most Latin American countries share a similar culture, social and economical development, and have seen similar historical processes over the years, it is quite possible that the presented findings help explain the cooperative nature of informal elderly caregiving in other countries of the region.

5.7 Contributions of the Work Presented in this Chapter

Understanding the dynamics of the cooperative nature of the informal elderly caregiving work drives us to formulate design guidelines of meaningful technology for older adults, particularly respecting the viewpoints, concerns, and expectations of informal caregivers and surrounding members in the family network. Similarly, understanding the informal caregiving work from a design point-of-view helps us specialize the formulation of guidelines for computer-supported technology to mediate family networks in contextualized scenarios.

A part of the results presented in this chapter has been published as a late-breaking work paper [Guti16b] in the Extended Abstracts of the 2016 ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'16), and as a full paper [Guti17] in the Proceedings of the 20th ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW'17). In particular, this chapter provides three main contributions:

- It specializes and provides a detailed description of elderly caregiving and intergenerational communication family roles, initially presented in Chapter 4.
- It frames a caregiving matrix, exposing the current availability of resources and engaged people within the family network, as a way to visualize the fulfillment of duties for supporting the articulation of the caregiving work.
- It characterizes a set of typical caregiving scenarios in Southern Cone families, which can be used as a way to inform the design of computer-supported technology to mediate the social interaction space of family networks, thus aiming to ease the coordination and articulation of the elderly caregiving work.

6. SOCIALCONNECTOR

Following the inductive research process formulated in Section 1.6, we now move one step forward and contextually study the effects of introducing computer-based technology to mediate the social interaction space of family members. In that respect, the work presented in the next two chapters is devoted to corroborate and specialize the findings obtained from the ethnographic work in Chapters 3 to 5 with empirical evidence grounded in a new cycle of action research structured around an in-home deployment study.

In this chapter we present the SocialConnector system, a computer-supported intergenerational family communication mediator that uses cloud services to allow older adults to interact with their family networks using touch-based and voice commands [Muno15, Muno15b]. We describe the main services provided by this system, how its software architecture adheres to the Family Communication Model—presented in Section 3.3—, and how we used the most recent version of SocialConnector in this cycle of action research.

Over the last years, a team of researchers at the University of Chile—including the author of this dissertation—has iteratively redesigned the services and user interfaces of SocialConnector. Acknowledging the partially virtual nature of family communities interacting with the mediation of computer-supported mechanisms, we adhere to the PVC software architectural model proposed by Gutierrez et al. [Guti15] to inform the design and evaluation of SocialConnector. Figure 19 shows the main user interface of the latest version of the system. A detailed description of the system can be found in Appendix F.

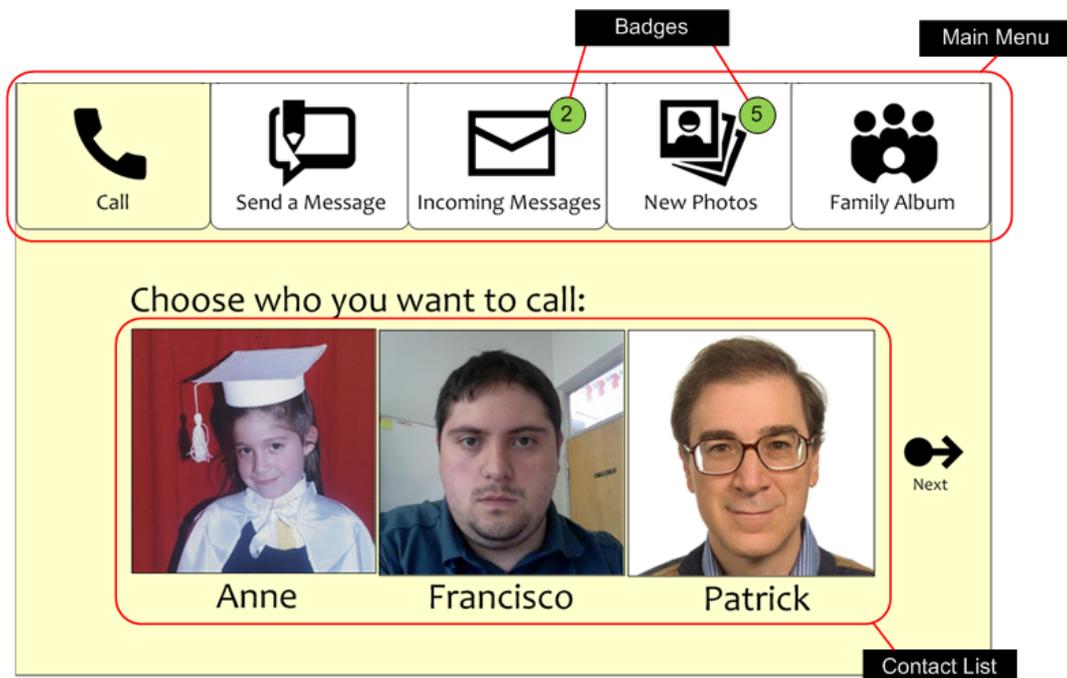


Figure 19: Prototype of the user interface of SocialConnector

The system mediates the communication between two parties, so that each participant could interact using their preferred media. The communication media currently supported are the following: synchronous and asynchronous voice messaging, synchronous video messaging, text messaging, and multimedia messaging. SocialConnector runs on a Tablet PC, physically installed

in the older adult's home in one of two possible arrangements: fixed to a wall (Figure 20–a) or over a piece of furniture (Figure 20–b).

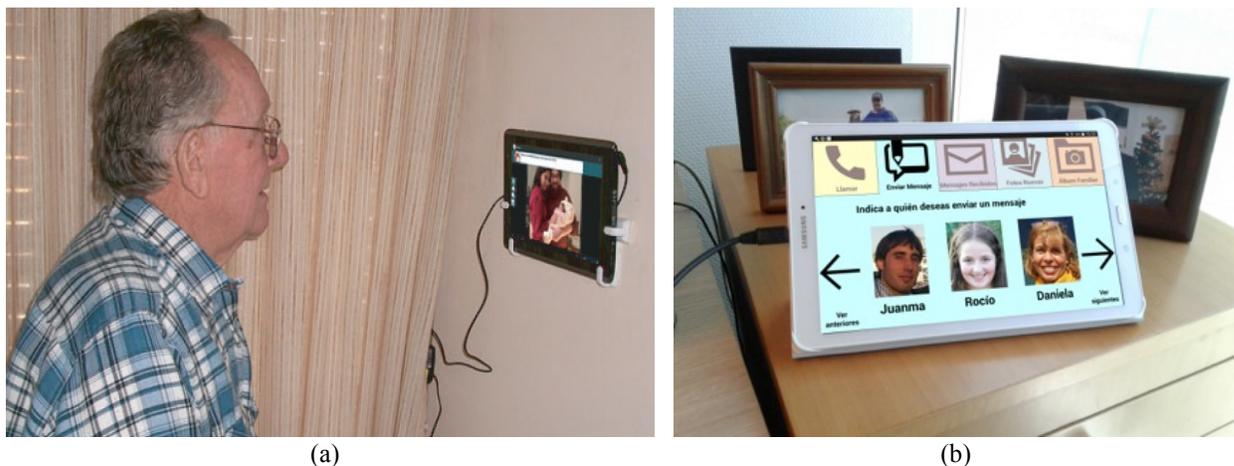


Figure 20: Home arrangements of SocialConnector

Older adults interact with the system using their voice and selecting very simple options by touching the screen. The design of the user interface of SocialConnector was initially informed by guidelines supported by the research community [Kurn05, W3C08], and later redefined with participatory iterative prototyping involving a sample of users in the target population. In terms of functionality, the application also monitors the interactions carried from and to older adults, and processes ambient data to infer details about the social health of older adults through embedded sensors in the Tablet PC, particularly the front camera.

6.1 System Description

SocialConnector has been designed as a Tablet application that mediates intergenerational communication, particularly with older adults who are not active users of social media. In that respect, this system was designed to facilitate the technology adoption and appropriation by older adults who are first-time computer users through seamless and simple user interfaces. The main interaction paradigm is providing bidirectional synchronous and asynchronous communication services, exposing social media services to older adults without the burden of having to manage user accounts and passwords, and allowing family members to interact with their older adults using the communication media they prefer. Therefore, SocialConnector internally acts as a communicator hub and as a mediator for enabling, facilitating, and rendering easier the social interaction process within a family network across multiple generations.

As a communication mediator, SocialConnector consumes and processes public social media data retrieved from the accounts of an older adult's family members, particularly email, Instagram photos, and Facebook posts. Then, it renders this content in an intuitive and accessible way for older adults, hiding behind a usable interface the inherent complexity of retrieving, processing, and transmitting social interaction data from the cloud [Muno15]. Therefore, this system helps address the asymmetry of media preference among family members. Although currently SocialConnector supports Skype, email services, and Instagram, its modular design allows that interacting with any other service provider—such as WhatsApp, Telegram, or even new social media applications—could be possible in the future. The main restriction in accessing

these services is that the owner provides access to them through standard Application Programming Interfaces (APIs), which are used for matching the dedicated connectors of SocialConnector with those provided by third-party social media services.

6.1.1 *Design Rationale*

Acknowledging that intergenerational communication is inherently asymmetrical (cf. Chapter 3), and therefore the preferences of each party might not be negotiable, it turns evident that one major feature of any mediator has to be providing the means to family members to interact through their preferred communication media. Otherwise, the interaction process may not be effectively completed, hence discouraging socialization with older adults [Muno15].

The design of SocialConnector followed an iterative user-centered approach [Harp08], involving multiple cycles of design, prototyping, evaluation, and refinement of the proposed services. Following an empirical approach, we worked directly with different samples of older adults who interacted with the system and tested it through successive stages of prototyping, until reaching a mature and robust product that could be evaluated in a real-life scenario. In particular, we followed the recommendations suggested by Barbosa Neves et al. [Barb15] on design considerations for facilitating the adoption of communication technology by older adults.

6.1.2 *System Architecture: Instantiating the Family Communication Model*

Recognizing the partially virtual nature of family networks interacting through a computer-mediated communication support, the design of SocialConnector adheres to the software architecture proposed by Gutierrez et al. for partially virtual communities [Guti15], which is also structured according to the 3C model of collaboration—initially proposed by Ellis et al. [Elli91] and later adapted by Fuks et al. [Fuks05] for media spaces. This representation covers the main issues that need to be addressed in the design of socio-technical systems: on the one hand, *communication* is the ground for any cooperative or collaborative process; on the other hand, *cooperation* is the instantiation of joint work in a shared space; and in between, *coordination* is the set of specific mechanisms to make possible the group work.

In the case of the studied domain, the cooperation layer represents the various proposed services to interact within the family network—and particularly to/from older adults—, the coordination layer comprises intervention and decision making mechanisms to support the interaction, and the communication layer is in charge to deal with the sensing and communication features of the system. Furthermore, the mediation process is guided through instantiating the family communication model presented in Sections 3.3 and 3.4. Figure 21 shows how SocialConnector actually instantiates such a communication model, adheres to the 3C model, and maps its architectural components to stages of the model processing.

SocialConnector, as most social mediators, allows family members to interact using communication mechanisms like videoconferences—through Skype—, emails and sharing contents (through Instagram). However, these tools do not identify when a person is in need of external support nor persuade other family members to help reduce or mitigate such situation. That role can be played by the proposed intervention model, which is complementary to the existing tools and can be added as an extension in future work.

As most modern software tools, we separated the design concerns of SocialConnector using layers. In this case, the software—and its future extension—involves four layers: data persistence, monitoring, decision-making and intervention. This matches with the stages of the process used to compute the model (cf. Section 3.4). The components and roles of each layer are also those mentioned for the model processing.

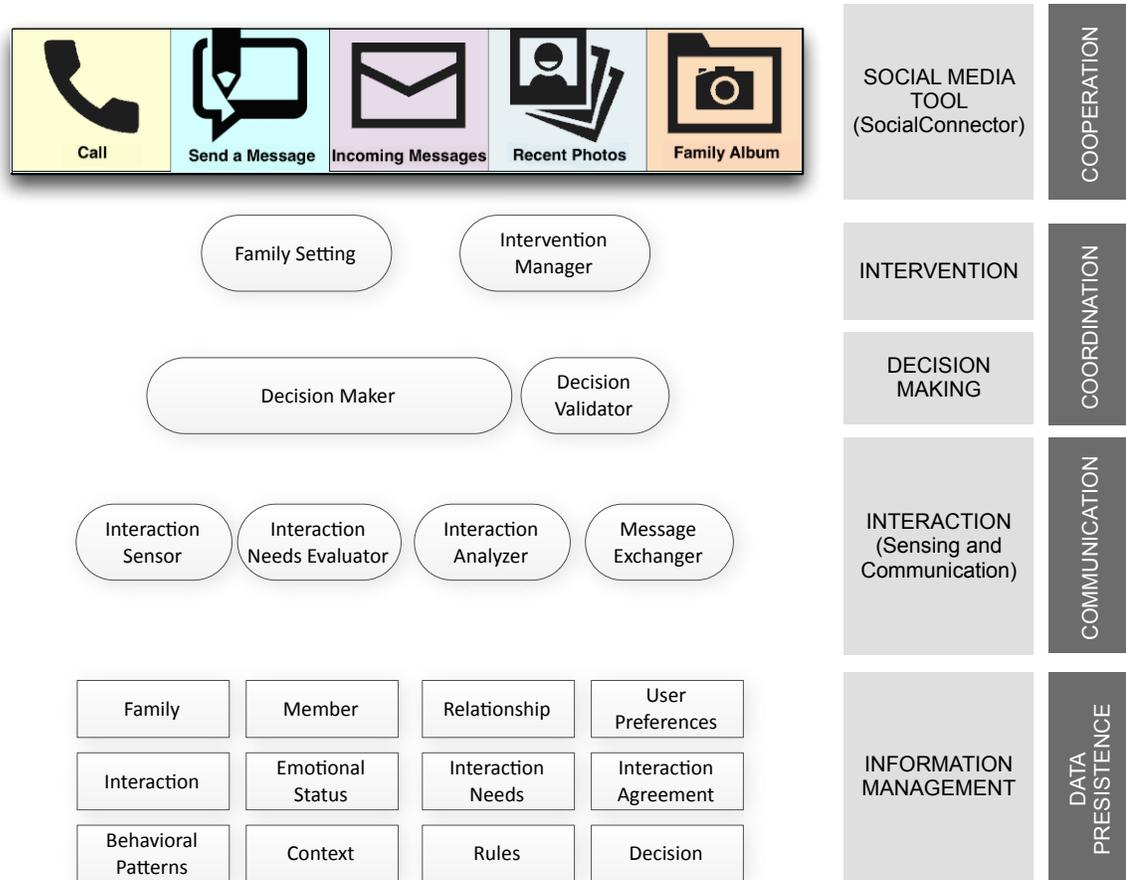


Figure 21: Architecture of SocialConnector, instantiating the Family Communication Model

In order to illustrate how SocialConnector instantiates the Family Communication Model (cf. Section 3.3), let us consider a working example of a family network composed by twelve members: two older adults (OA), four adults (Ad) and six young people (YP). Considering the relationship existing among them, in terms of social interaction, we can build an interaction graph similar to the one shown in Figure 22. The various types of links indicate how strong is the affective relationship between each pair of nodes, i.e., between two family members.

Let us suppose that the system detects that OA2 has been with a negative mood during the morning. The *interaction needs evaluator* performs such detection (Figures 11 and 12), which creates and records a new need in the persistence layer, i.e., it creates a new instance of the class *interaction need*. Then, the *decision maker* should determine, based on the available rules and context, how to support the person in need. By analyzing the graph, we can see that Ad-3 and OA-1 are the closest family members for OA-2. Probably, the first priority should be to try contacting Ad-3 because adults usually have better capabilities to deal with problems. However, Ad-3 would be the first option only if the *interaction agreement* between Ad-3 and OA-2, and also their *interaction preferences*, are aligned. Otherwise, other options must be analyzed.

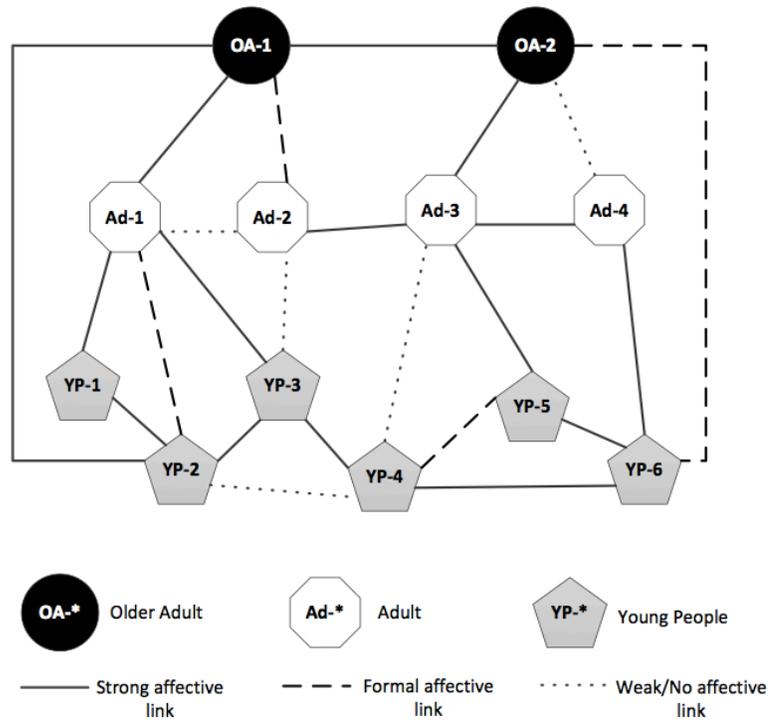


Figure 22: Example of a simplified family network interaction graph

Once the model determines the most suitable family member to assist in this situation, it should make one or more decisions. The *decisions* are stored in the corresponding class of the model. Each decision triggers an action that the system must perform in order to persuade the chosen member (e.g., Ad-3) to help the person in need. These actions could be either sending an email or instant message to Ad-3 informing such a situation. The *intervention manager* component is in charge of performing these actions. The result of each action should be verified or guessed (in the worst case) by the system, in order to determine if new decisions should be made because all of the stimuli to Ad-3 failed. Thus, the system uses the model to determine other options, and so on until it exhausts all the available intervention alternatives, or it eventually succeeds.

6.1.3 Interaction Services Provided to Older Adults

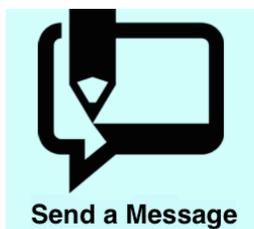
The interaction services provided by SocialConnector have been conceived and iteratively refined based on the definition of intergenerational communication and caregiving roles, as well as the attitudes, expectations, viewpoints, and concerns of family members regarding computer-supported communication mediators presented and discussed in Chapters 4 and 5. As a result, the current version of the system implements five communication channels through which older adults can interact with their family members using regular social media services (cf. Figure 9).



This service provides access to video calls mediated through Skype. While setting up the system, a Skype account is created for the older adult using SocialConnector, and the created handle is notified to his/her family members who already have a Skype account.

Once the older adult selects this option, SocialConnector displays a list of contacts presented as an interactive carousel where the names and profile

pictures of his/her family members are displayed. The older adult just needs to select the contact for initiating the call, without having to require a username or password. In fact, SocialConnector internally manages the user authentication process using the credentials stored in the system. Then, it gives the session token to Skype for making the call. Once both parties end up the videoconference session, SocialConnector regains the session token.



The older adult using SocialConnector can send private messages to a family member of his/her choice through email. In order to do so, while the system is being set up, an email account is created for the older adult. Then, the created handle is notified to all members within the family network.

In order to simplify the process of composing a new message, the older adult uses a speech-to-text service in which he/she dictates the message he desires to send to his family member, and SocialConnector internally manages the user authentication and sends the email.



Through this service, SocialConnector displays the ten most recent messages received in the social media accounts of the older adult. In particular, this component translates the message structure from the original source, and uniformizes it in a format that can be understood by the older adult interacting with the system.

In order to prevent misuse and spamming from external sources, this service filters the incoming messages to those belonging to the list of contacts—family members—that was defined during setup.



Similar to the previous service, in this module SocialConnector organizes the incoming photos and other multimedia content, rendering it in an accessible and uniform way to older adults.

Although this service was originally conceived as an output channel of content, i.e., not providing the means for a direct interaction between the family member publishing the contact and the older adult, through conducting pilot field studies of SocialConnector we realized that this service could be used as a mechanism to trigger interactions between the involved parties (e.g., through personalized persuasive messages or contextualized reminders and notifications).



This service consists in a collection of the most recent media content sent to the older adult by his/her contacts.

The photos displayed in this album are organized as an interactive carousel where the older adult can navigate through them. During the last stages of prototyping with end users, we learned that older adults found a hidden value in this service by augmenting the stored photos with short messages, hence acting as a sort of shared memory between the older adult and his/her contacts.

In addition to the presented services above, SocialConnector manages notification mechanisms. On the one hand, they serve to alert the older adult of new content within the system (cf. *badges* in Figure 19). On the other hand, they can act as social awareness triggers to alert

family members, such as in the case of new content created by the older adult, or as reminders for engaging them in social interaction. Finally, given that SocialConnector runs on a Tablet PC, it uses the embedded sensors in the hardware to assist in monitoring the activities of the older adult in a non-invasive way. Currently, the system supports two ways of monitoring: mood detection through voice processing [Rojal14] and presence detection through facial emotion recognition [Guer15]. These two services, developed within the research group, map the *emotional status* and *behavioral patterns* components of the Family Communication Model, as presented in Figure 21.

6.2 Using the System as a Research Instrument

A stable version of SocialConnector was used for conducting an in-home deployment study aiming to understand the effects of introducing this kind of technology into the homes of a sample of family networks in mediating their intergenerational communication, therefore corroborating the induced models and design implications discussed throughout Chapters 3 to 5. The empirical design of this study, its results, and derived implications to inform the design of similar computer-supported technology will be reported in Chapter 7.

In order to maintain a record of the mediated interactions within the family with the assistance of SocialConnector, the system keeps track of a group of measures on both sides of the communication. Every interaction with the system is registered in an automatically generated logfile, which then can be used for aggregated analysis.

In order to comply with the user consent provided by participants to be involved in the study (cf. Appendix A), data is stored anonymously and random identifiers are used to analyze the interaction links. In no way, we have accessed or processed the content of the interactions mediated with SocialConnector. For the conducted study, the collected data comprise:

- Frequency, time, and duration of Skype calls, initiated by the older adult.
- Frequency, time, and duration of Skype calls, initiated by a contact.
- Frequency, time, and length of incoming messages sent by the older adult.
- Frequency, time, and length of incoming messages received by the older adult.
- Number and time of received photos and other media from other family members.

6.3 Summary

In this chapter we presented SocialConnector, a computer-supported intergenerational communication mediator, addressing the asymmetry of media preferences and interaction times among family members. We particularly indicate how SocialConnector adheres to the Family Communication Model presented in Chapter 3, and how we can use this system to run in-home studies.

The current version of SocialConnector provides access to four communication channels: *video calls*—mediated through Skype—, *private one-to-one messages*—mediated through

email—, *incoming photos and media*, and a *family album*. The system also provides social awareness mechanisms, such as notifications and alerts. Finally, given that the system runs over a tablet, we use the equipped sensors in the device to provide mood detection through voice processing, and presence detection through face recognition.

6.4 Contributions of the Work Presented in this Chapter

The proposed system provides the technological support to corroborate in the field the induced models from empirical data presented so far. SocialConnector has been designed and co-iterated along the analysis of the ethnographic studies discussed throughout Chapters 3 to 5. As such, observing how this system is used—and appropriated—in the field, would deepen our understanding on how family networks co-construct their intergenerational communication and informal caregiving experiences.

A part of the content presented in this chapter has been published as a full paper [Guti15b] in the Proceedings of the 9th International Conference on Universal Access in Human-Computer Interaction (UAHCI'15), held as part of HCI International 2015. In particular, this chapter provides two main contributions:

- It presents the design and development of the SocialConnector system, an intergenerational family communication mediator targeted to older adults.
- It shows a concrete instantiation of the Family Communication Model, initially presented in Chapter 3.

7. IN-HOME DEPLOYMENT

Following on the action research cycle presented in Chapter 6, we aim corroborate the fit of the induced models and design implications identified from empirical data throughout Chapters 3 to 5. Furthermore, we envisage complementing the already identified design implications by studying in the field the effects of introducing computer-supported technology to mediate intergenerational communication at the home of a group of older adults. In that respect, this chapter reports the results of an in-home deployment study evaluating the SocialConnector system with a sample of 9 middle-class families living in Santiago, Chile over a period of nine weeks.

7.1 Study Design

We followed a mixed-methods study design evaluating the effect of introducing computer-supported technology at the home of a sample of older adults, and mediating their interaction with their family network using social awareness mechanisms. In particular, we gathered quantitative data regarding system usage by older adults and qualitative data regarding the perception of family members around the mediation of their social interaction space with computer-supported mechanisms.

7.1.1 Participants

Through online notices, email lists, and convenience and snowball sampling, we recruited 9 middle-class adults acting as informal caregivers for their parents. Following the characterization on intergenerational communication and elderly caregiving family roles proposed earlier in Section 5.2, these participants assumed at the time of the study either the role of *assistant* or *monitor* within their families.

We centered our sampling strategy on these recruited caregivers, extending then to their wider family network. In particular, we approached the informal caregivers' parents—who were the main targets of the proposed intervention—as well as their siblings, children, and nephews. In all cases, participants had to be over the age of 14 and explicitly express their intention of being part of the study. Furthermore, we restricted the study sample to cover at least one older adult, one assistant, one monitor, one helper, and one outsider in each participating family. The final study sample was composed of 64 people across 9 family networks ($n = 9, 7, 7, 6, 8, 7, 6, 6, 8$, respectively in each family). All families were based in Santiago, Chile, and were spread across several households within the urban area of the city.

We characterized older adults participating in the study following five factors: (1) gender, (2) whether they share their household with somebody or not, (3) prior experience with computer-based technology, and (4) social network size according to the Revised Lubben Social Network Scale (LSNS-R), a self-report measure of social engagement including family and friends [Lubb88]. These factors were later used for discriminant analysis as a way to further deepen our understanding of the studied social interaction scenario.

Table 3 summarizes the profiles of the older adults participating in the study. All older adult participants lived in their own homes in Santiago or surrounding urban suburbs. Of these, 5

(56%) were female, 5 (56%) did not share their household, 6 (67%) never used a computer before, and 5 (56%) were described as having low social engagement. The measure for overall social engagement was obtained by applying the Spanish version of the LSNS-R questionnaire. For reference, the English and Spanish versions of the scale are reproduced in Annexes A and B.

Table 3: Older adults participating in the study

Family	Age	Gender	Lives alone?	Used a computer before?	Low social engagement?
1	81	M	No	No	Yes
2	78	M	No	No	Yes
3	69	F	Yes	Yes	No
4	73	F	Yes	No	No
5	75	F	Yes	No	Yes
6	72	M	Yes	Yes	No
7	79	F	No	No	Yes
8	71	M	Yes	Yes	No
9	80	F	No	No	Yes

Regarding the participants in the supporting family networks—i.e., assistants, monitors, helpers, and outsiders combined—, 29 (53%) of them were female. In the cases of families 1, 2, 7, and 9, the older adult lives with one of his/her children assuming the role of informal caregiver (i.e., *assistant*). Table 4 summarizes the structure of the participant family networks. In each family network, gender and age of each participant are provided.

Table 4: Structure of participating family networks

Family	Older Adults	Assistants	Monitors	Helpers	Outsiders
1	1M (81)	1F (71) 0M	0F 2M (48, 39)	1F (36) 1M (19)	3F (21, 17, 14) 0M
2	1M (78)	1F (54) 0M	1F (49) 0M	1F (23) 1M (51)	0F 2M (18, 21)
3	1F (69)	0F 1M (31)	1F (33) 1M (38)	2F (39, 37) 0M	0F 1M (16)
4	1F (73)	1F (44) 1M (41)	1F (37) 0M	0F 1M (25)	1F (19) 0M
5	1F (75)	0F 1M (42)	0F 2M (49, 45)	2F (48, 41) 0M	0F 2M (25, 23)
6	1M (72)	1F (39) 0M	1F (44) 1M (42)	0F 1M (41)	2F (21, 19) 0M
7	1F (79)	1F (34) 1M (29)	1F (38) 0M	0F 1M (31)	0F 1M (29)
8	1M (71)	1F (68) 1M (69)	1F (66) 0M	0F 1M (34)	1F (38) 0M
9	1F (80)	1F (59) 1M (30)	1F (36) 1M (37)	1F (39) 0M	1F (16) 1M (15)

In summary, 13 (24%) of members in the supporting family networks were assistants, 14 (25%) monitors, 13 (24%) helpers, and 15 (27%) outsiders.

7.1.2 Materials

Each older adult participating in the study was provided with a tablet PC equipped with the latest version of the prototype system. Figure 23 shows a couple of older adults in a typical use scenario of SocialConnector.



Figure 23: An older adult being assisted on interacting through SocialConnector

The evaluated version of SocialConnector runs on a 9.6-inches Samsung Galaxy Tab E tablet under Android 4.4 as operative system. In order to control the effect of Internet bandwidth in the perceived user experience, we equipped each tablet with a SIM card providing mobile access to Internet over 3G. As described in Chapter 6, the participants in the supporting family networks interact with the older adult using their own terminals over Skype (for instant messaging) and email (for direct messages and photo albums).

7.1.3 Procedure

We structured the study design in five consecutive stages, spanning over a time period of nine weeks. Figure 24 shows the structure of the study.

SETUP	SYSTEM USAGE			CLOSURE
	PRE-INTERVENTION	INTERVENTION	POST-INTERVENTION	

Figure 24: Stages in the study design

- **Setup.** We recruited a sample of informal family caregivers, who acted as seeds for recruiting the family networks participating in the study and will assume the role of coordinator during the study. Being a family coordinator involves setting up the device by collecting and managing the social network data of family members within the system, and assisting the older adult on using the system in case of need.

After conducting a short interview with the candidate caregivers, we screened their family networks against the stated sample requirements. Once defined and confirmed the participant family networks, we asked all members for their explicit, free, and informed consent to participate in the study.

Afterwards, with the assistance of the informal caregiver in the family, we conducted an *entry semi-structured interview* with the older adult, aiming to assess his/her social engagement according to the Lubben scale, as well as informing a baseline measure of his/her frequency and perceived quality of social interaction within his/her family network. Such an interview, presented in Appendix G, was also conducted with the designated family members to participate in the study, mainly aiming to understand how they perceive their interaction relation with the older adult and the informal caregiver. The interview protocols and qualitative data collection instruments follow the recommendations suggested by Yarosh [Yaro15] for studying families in domestic settings.

Finally, and once the interviews were all conducted, we organized an informal meeting at the home of the participating older adult with the assistance of the coordinator, where we installed the system at a location chosen by the older adult, performed a demonstration on its usage, and asked the informal caregiver acting as coordinator to setup the initial data of the involved family members. All participants were aware that the system would track their interactions with the older adult and were left with information sheets on the proposed services and contact information of both the caregiver acting as coordinator and the research team.

- **System usage.** A daily log of the system usage by the older adult was automatically generated and reviewed by the research team every day. In such a log, we kept the following data: (1) incoming Skype calls, (2) outgoing Skype calls, (3) incoming email messages, (4) outgoing messages, and (5) incoming photos.

The system usage was tracked for a period of nine weeks. During the first three (i.e., *pre-intervention*), we did not integrate any method for mediating the interaction with other family members. During the following three weeks (i.e., *intervention*), we introduced a social awareness mechanism informing the family members on the effect of their interaction with the older adult (e.g., we send an informal message once the older adult has read an email sent by them), and we explicitly send periodic messages to family members to invite them to interact with the older adult. In order to contrast the effect of this intervention with the baseline measure obtained on the setup stage of the study and on the pre-intervention stage of system usage (i.e., *post-intervention*), we removed these awareness mechanisms during the last three weeks of the trial.

- **Closure.** After the nine weeks of the deployment, we organized a second informal meeting with each family at the home of the older adult. In this meeting, we applied a second time the Lubben social network questionnaire to the older adult, and we conducted individual semi-structured interviews with the participating family members around their experience on the mediating effect of the SocialConnector system and overall satisfaction on the provided services (*exit interview*).

Afterwards, we moderated a focus group contrasting the viewpoints of all participants regarding their perceptions on system usefulness, family connection, privacy issues,

motivation, reasons to use/not use the system, and articulation with the informal elderly caregiving process. By the end of the family meeting, we removed the device from the older adult's home.

7.1.4 Data Collection and Analysis

Throughout the study there were two main sources of data: (1) interaction traces to/from the older adult with his/her family members, and (2) qualitative perceptions on the mediating effect of SocialConnector in family communication and informal elderly caregiving. Each of these sources of data allows us to study a particular viewpoint of the considered computer-mediated social interaction spaces.

- **Measuring the effect of mediating the interaction space with computer-supported social awareness mechanisms.** By studying the generated log files reporting the interaction activity with the SocialConnector system, as well as contrasting the results of the entry and exit questionnaires applied to older adults, we aim to study the validity of the following hypotheses:

(H1) The system contributes to improve social engagement of older adults.

(H2) The system encourages a sustainable increase in the frequency of social interaction exchanges from/to the family older adults.

(H2a) The social awareness mediation increases the frequency of exchanges with older adults.

(H2b) After removing the mediation prompts, such frequency of exchanges does not decrease.

Regarding (H1), we compared the reported scores across each subscale following two-tailed dependent t-tests.

Concerning (H2), we studied the main effect of the intervention following a one-way repeated measures ANOVA. In those cases where the collected data violated the assumption of sphericity, we corrected accordingly the degrees of freedom for the effect following the Greenhouse-Geisser procedure.

In order to study the contrasts—defined as (H2a) and (H2b)—, we performed post-hoc tests whenever the main effect was deemed significant. In such a case, we adjusted accordingly the significance level following the Bonferroni correction for multiple comparisons.

Finally, we explored the relationship between system usage and discriminant factors, such as: gender, prior experience of older adults using computer-based technology, whether they share or not their household, and their social engagement. In this case, we analyzed aggregated data for all families using two-tailed independent samples t-tests, individually for each factor.

All statistical analyses were conducted using SPSS version 21. The calculation of Cohen's *d* effect size value was performed following the method proposed by Morris and DeShon [Morr02] for within-subjects studies, and that of Ray and Shadish [Ray96] for between-subjects data. Similarly, as significance cut-off, we considered $\alpha = 0.05$.

- **Understanding how family members perceive the mediation of their social interaction space with computer-supported mechanisms.** By generating a qualitative dataset collected from the transcription of the conducted semi-structured interviews and focus groups, we aimed to answer the following research questions:

(RQ1) What is the perceived role of the proposed computer-supported family communication mediation technology within the family network?

(RQ2) Do older adults perceive a disruption of their homes and daily routines with a computer-supported family communication mediator? If so, how?

(RQ3) How do informal elderly caregivers perceive SocialConnector as a tool for assisting their caregiving work?

(RQ4) How do family members perceive the disruption of their routines with incoming messages from a computer-supported mediator prompting them to interact with their older adults?

(RQ5) How does the current design of SocialConnector address the family members' attitudes, needs, and expectations around computer-supported family communication mediation?

We followed a thematic analysis approach for analyzing the collected data. We performed open, axial, and selective coding, and later grouped the emerging themes in affinity diagrams mapping the stated research questions.

7.1.5 Ethical Considerations

Following the American Psychological Association (APA) ethical guidelines for fieldwork research, all participants were compensated for their time and provided their free, explicit, and informed consent. The study design was approved on ethical grounds by the Research Ethics Board of the Faculty of Physical and Mathematical Sciences of the University of Chile (cf. Appendix A).

Interviewees were informed about the goals of the research, the nature of the data intended to be collected, and our efforts to ensure confidentiality during data collection, treatment, and dissemination (cf. Appendix B). All participants were able to contact the research team at anytime during the field study. Participants were also offered the right to withdraw from the study at any time. No participants declined to participate in the study nor dropped out.

Quotes and any kind of information exposed as results of this study containing personal or identifiable participant data were anonymized, and pseudonyms were used if necessary. Following the recommendations suggested by Brush et al. [Brus15] for in-home deployment studies, once the quotes were selected to sustain the reported narrative, we returned to the involved participants and offered them the power to veto the publication of their quotes if they considered them a breach of confidentiality. No participants decided to edit or withdraw their quotes for publication.

7.2 Results and Interpretation

In this study we intervened nine family networks, covering a total of 64 members. From a qualitative point of view, the insights derived from analyzing the collected empirical data (presented in full in Appendix H) allow us to, on the one hand, corroborate the inductive models and representations we have formulated throughout this dissertation. On the other hand, they also help us broaden our understanding on the effects of introducing computer-supported technology to mediate the social interaction space of older adults and that of their close family members fulfilling informal caregiving duties. However, from a quantitative point view, we acknowledge the limitations that a reduced sample size has in performing statistical inferences for generalizing to a broader population. Therefore, the presented statistics should only be interpreted from a descriptive way, representing just the study sample.

7.2.1 Aggregate Analysis

In order to have an overview of how the usage of the SocialConnector system impacted on mediating the communication between older adults and their family members, we initially compared the scores of the questionnaire and the main metrics of system usage, aggregating the collected data for all participants in the study sample.

- **Social engagement.** A paired-samples t-test was conducted to compare the total score reported by participants taking the LSNS-R questionnaire before and after the experiment (i.e., just before introducing the system and right after removing the system from their homes). A Shapiro-Wilk test was used to verify that the data were approximately normal.

There was a significant difference in the reported pre-condition ($M = 23.7$, $SD = 10.4$) and post-condition ($M = 27.9$, $SD = 11.4$) scores; $t(8) = -3.55$, $p = 0.007$, $95\% CI = [-6.96, -1.48]$, $d = -1.235$. These results suggest that older adults perceived a greater sense of inclusion within their social networks after using the system.

In order to look deeper in the source of the observed main effect, we ran paired-samples t-tests to compare the pre and post-condition scores of both subscales in the LSNS-R questionnaire, i.e., family and friendships.

For the family subscale, we observed a significant difference in the scores on pre ($M = 13.8$, $SD = 4.9$) and post ($M = 18.7$; $SD = 5.5$) condition; $t(8) = -3.192$, $p = 0.013$, $95\% CI = [-8.42, -1.35]$, $d = -1.069$. However, for the friendships subscale we did not observe a significant difference between the pre-condition ($M = 9.9$, $SD = 7.9$) and post-condition ($M = 9.2$, $SD = 6.2$) scores; $t(8) = 0.943$, $p = 0.373$, $95\% CI = [-0.96, 2.29]$, $d = 0.864$.

These results suggest that the main effect in the difference between pre and post condition LSNS-R scores was due to an increase in the family social engagement as perceived by the older adults participating in the study.

- **Incoming interaction.** In order to study the effect of mediating the interaction within the family network through contextualized social triggers, we ran a one-way repeated measures ANOVA to compare the volume of incoming calls, messages, and photos in three times: pre-intervention (weeks 1 to 3), during the intervention (weeks 4 to 6), and post-intervention (weeks 7 to 9). Figure 25 shows the volume of incoming interaction along the study.

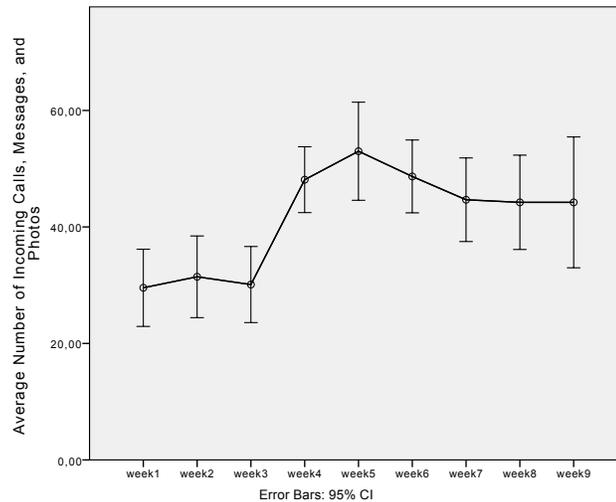


Figure 25: Volume of incoming interaction through SocialConnector

Mauchly’s test indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 0.031$, $p = 0.985$; therefore, degrees of freedom were not corrected. The results show that there was a significant effect of mediating the interaction with social awareness notifications: $F(2, 16) = 28.83$, $p < 0.001$, partial $\eta^2 = 0.783$.

Three paired-samples t-tests were used to make post hoc comparisons between conditions with p-values and significance levels adjusted following the Bonferroni correction. A first paired-samples t-test indicated that there was a significant difference in the scores for pre-intervention ($M = 91.1$, $SD = 19.1$) and intervention ($M = 149.8$, $SD = 25.3$) conditions; $t(8) = -7.223$, $p < 0.001$, 95% $CI = [-83.182, -34.172]$, $d = -2.466$. A second paired-samples t-test indicated that there was a significant difference in the scores for pre-intervention ($M = 91.1$, $SD = 19.1$) and post-intervention ($M = 133.1$, $SD = 31.1$) conditions; $t(8) = -5.458$, $p = 0.002$, 95% $CI = [-65.208, -18.792]$, $d = -2.063$. Finally, running a third paired-samples t-test indicated that there was not a significant difference in the scores for intervention ($M = 149.8$, $SD = 25.3$) and post-intervention ($M = 133.1$, $SD = 31.1$) conditions; $t(8) = 2.067$, $p = 0.218$, 95% $CI = [-7.647, 40.981]$, $d = 0.705$.

These results suggest that mediating the interaction of family members with notification triggers does have an effect on the volume of calls, messages, and photos sent to the older adults participating in the study. More specifically, our results suggest that during and after sending contextualized social awareness reminders to family members, they tend to increase their volume of interactions with their older adult. However, further research needs to be conducted in order to verify if the effect of intervening the social interaction space of the involved family members lasts longer than the observed period in the study.

- **Outgoing interaction.** Aiming to understand how older adults interacted with the system as a way to communicate with their fellow family members throughout the observed period, we ran a one-way repeated measures ANOVA to compare the volume of outgoing calls and messages following the three stages in which the experiment was divided: pre-intervention (weeks 1 to 3), during the intervention (weeks 4 to 6), and post-intervention (weeks 7 to 9). Figure 26 shows the volume of outgoing interaction—originated from older adults and mediated through the system—throughout the study.

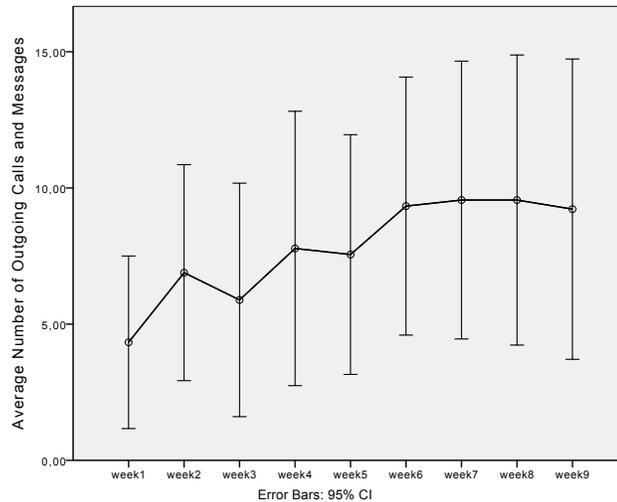


Figure 26: Volume of outgoing interaction through SocialConnector

Mauchly's test indicated that the assumption of sphericity was violated, $\chi^2(2) = 6.152, p = 0.046$; therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\epsilon = 0.631$). The results show that there was a significant effect of time on the volume of outgoing interactions generated from the older adults participating in the study: $F(1.26, 10.09) = 6.367, p = 0.025, \text{partial } \eta^2 = 0.443$.

Three paired-samples t-tests were used to make post hoc comparisons between conditions: pre-intervention ($M = 17.1, SD = 13.5$), intervention ($M = 24.7, SD = 16.4$), and post-intervention ($M = 28.3, SD = 19.9$). None of the pairwise comparisons were seen as significant, when adjusting the p-values and significance levels with the Bonferroni correction: pre-intervention vs. intervention: $t(8) = -2.630, p = 0.091, 95\% CI = [-16.219, 1.108], d = -0.928$; pre-intervention vs. post-intervention: $t(8) = -2.654, p = 0.087, 95\% CI = [-23.975, 1.531], d = -1.007$; intervention vs. post-intervention: $t(8) = -1.687, p = 0.390, 95\% CI = [-10.220, 2.887], d = -0.666$.

These results suggest that there is a slight tendency in time to increase the frequency of outgoing interactions, although not statistically significant between experimental conditions. Therefore, we cannot generalize that this situation will be sustained in time. We hypothesize that this tendency can be attributed to either: (1) a learning effect and/or (2) a positive moderation on the frequency of outgoing interaction due to the increasing volume of incoming interaction produced by family members (i.e., given that family members contact the older adult more frequently, s/he will contact them back more frequently).

In any case, further research needs to be conducted to better understand the observed phenomenon.

- **Incoming calls.** In order to have a closer look into how family members interacted with the older adult—as mediated through SocialConnector—we ran two one-way repeated measures ANOVAs to compare the volume and duration of incoming calls in pre-intervention (weeks 1 to 3), intervention (weeks 4 to 6), and post-intervention (weeks 7 to 9) conditions. Figure 27 shows the number of incoming calls for all participating older adults in the study (Fig. 26-a) and the duration of such calls (Fig. 26-b).

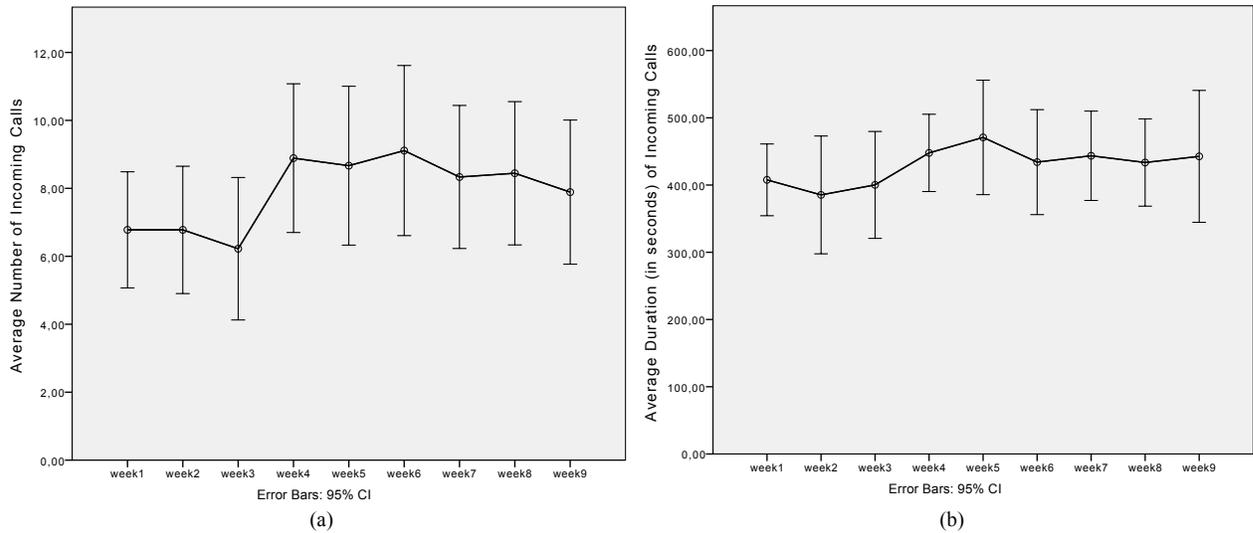


Figure 27: Volume and duration of incoming calls through SocialConnector

On the one hand, for the average number of incoming calls, Mauchly’s test indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 3.697$, $p = 0.157$; therefore, degrees of freedom were not corrected. The results show that there was a significant effect on the volume of incoming calls: $F(2, 16) = 10.439$, $p = 0.001$, partial $\eta^2 = 0.566$.

Given that the main effect was deemed significant, three paired-samples t-tests were used to make post hoc comparisons between conditions (p-values and significance levels were adjusted following the Bonferroni correction). A first paired-samples t-test indicated that there was a significant difference in the number of incoming calls for pre-intervention ($M = 19.8$, $SD = 7.0$) and intervention ($M = 26.7$, $SD = 8.8$) conditions; $t(8) = -3.488$, $p = 0.025$, 95% $CI = [-12.845, -0.932]$, $d = -1.211$. A second paired-samples t-test indicated that there was a significant difference in the number of incoming calls for pre-intervention ($M = 19.8$, $SD = 7.0$) and post-intervention ($M = 24.7$, $SD = 7.8$) conditions; $t(8) = -3.470$, $p = 0.025$, 95% $CI = [-9.137, -0.640]$, $d = -1.175$. Finally, running a third paired-samples t-test indicated that there was not a significant difference in the number of incoming calls for intervention ($M = 26.7$, $SD = 8.8$) and post-intervention ($M = 24.7$, $SD = 7.8$) conditions; $t(8) = 1.732$, $p = 0.365$, 95% $CI = [-5.482, 1.482]$, $d = 0.603$.

On the other hand, for the average duration (in seconds) of incoming calls, Mauchly’s test indicated that the assumption of sphericity had been met, $\chi^2(2) = 0.576$, $p = 0.750$; therefore, degrees of freedom were not corrected. The results show that there was no significant effect of time on the duration of incoming calls across conditions: $F(2, 16) = 2.545$, $p = 0.110$, partial $\eta^2 = 0.241$; pre-intervention: $M = 397.8$, $SD = 69.2$; intervention: $M = 450.9$, $SD = 49.6$; post-intervention: $M = 439.9$, $SD = 52.9$.

All in all, these results suggest that, while the effect of the intervention positively impacted on the volume of incoming interactions—which also lasted once the awareness notifications were lifted—the duration of such interactions did not vary over the observed period. Therefore, the effect of SocialConnector in the family networks participating in the study can be linked to modifying the behavior of family members in encouraging more frequent calls, but not in longer interactions.

- **Outgoing calls.** Similar to the case above, we studied how older adults used SocialConnector to reach their family members. In that respect, Figure 28 shows the number of outgoing calls mediated through SocialConnector that were generated from the older adults participating in the study (Fig. 27-a) and the duration of such calls (Fig. 27-b).

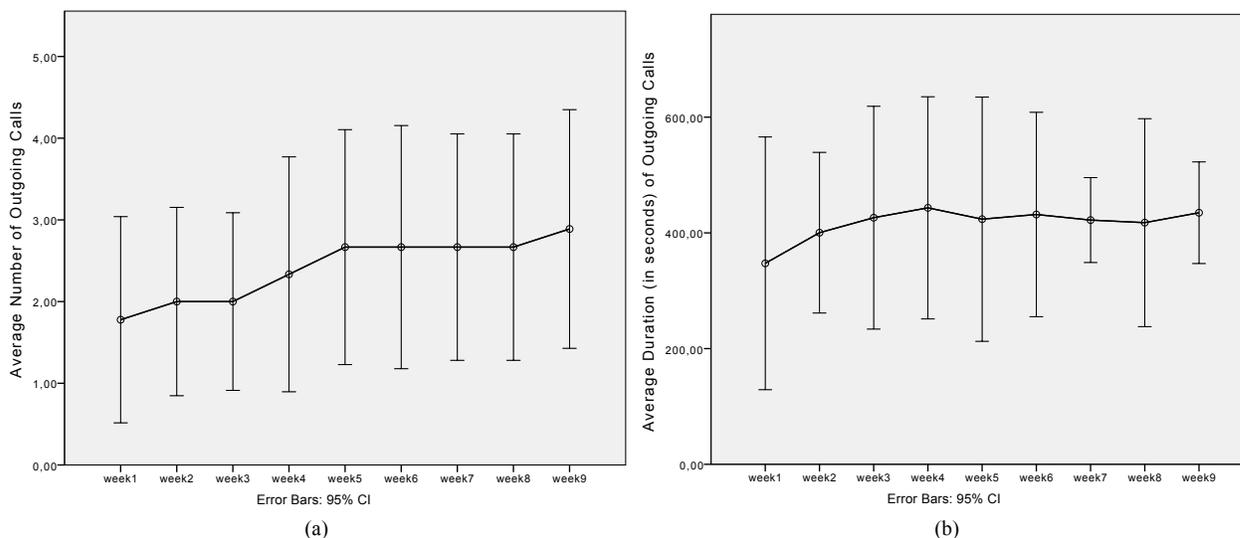


Figure 28: Volume and duration of outgoing calls through SocialConnector

We ran a one-way repeated measures ANOVA for studying the effect of the mediation of SocialConnector on the volume of outgoing calls performed by the older adults participating in the experiment. In this case, Mauchly’s test yielded that the assumption of sphericity had not been violated: $\chi^2(2) = 4.476, p = 0.107$. The overall effect was deemed as significant: $F(2, 16) = 5.019, p = 0.020$, partial $\eta^2 = 0.386$.

Running post hoc tests, adjusting the p-values and significance levels with the Bonferroni correction, we identified that no pairwise comparisons were statistically significant: pre-intervention ($M = 5.8, SD = 4.1$) vs. intervention ($M = 7.7, SD = 5.3$): $t(8) = -2.292, p = 0.153$, 95% $CI = [-4.374, 0.596]$, $d = -0.852$; between pre-intervention ($M = 5.8, SD = 4.1$) and post-intervention ($M = 8.2, SD = 5.2$) conditions: $t(8) = -2.408, p = 0.128$, 95% $CI = [-5.506, 0.618]$, $d = -0.854$; and between the intervention condition ($M = 7.7, SD = 5.3$) and post-intervention ($M = 8.2, SD = 5.2$) condition: $t(8) = -1.104, p = 0.905$, 95% $CI = [-2.073, 0.962]$, $d = -0.369$.

Regarding the average duration (in seconds) of outgoing calls, we also ran a repeated-measures ANOVA for studying the underlying effect of SocialConnector when mediating the interaction between older adults and their family members. Mauchly’s test indicated that the assumption of sphericity had been met: $\chi^2(2) = 4.383, p = 0.112$. The main effect of the intervention on the duration of outgoing calls was not statistically significant: $F(2, 16) = 0.473, p = 0.632$, partial $\eta^2 = 0.056$.

The results suggest that there is a slight increase in the number of calls performed by participating older adults to their family members through SocialConnector over the observed period. While this increase can be attributed to a learning effect, we are currently not in position to positively confirm this hypothesis, as the statistical power of the analysis is too

low. Therefore, replicating this study with a larger sample seems to be a plausible option for future work.

Similarly, there is no difference over time regarding the main effect of the intervention on the average duration of outgoing calls. However, we can note that there is a cold start effect in the interaction initiated by older adults that tends to slowly improve over time. In particular, both the volume and duration of outgoing calls appear to increase, but we cannot conclude yet if this effect would be stable in time. Future research needs to be conducted in order to verify this latter hypothesis.

- **Incoming messages.** Another relevant variable to include in the analysis is the flow of messages (emails) mediated through SocialConnector. We ran a one-way repeated measures ANOVA to study the effect of intervening the social interaction space of family members with social awareness notifications to provide contextual information about the interaction with the older adult. Figure 29 shows the number of incoming messages sent through SocialConnector to all participating older adults in the study.

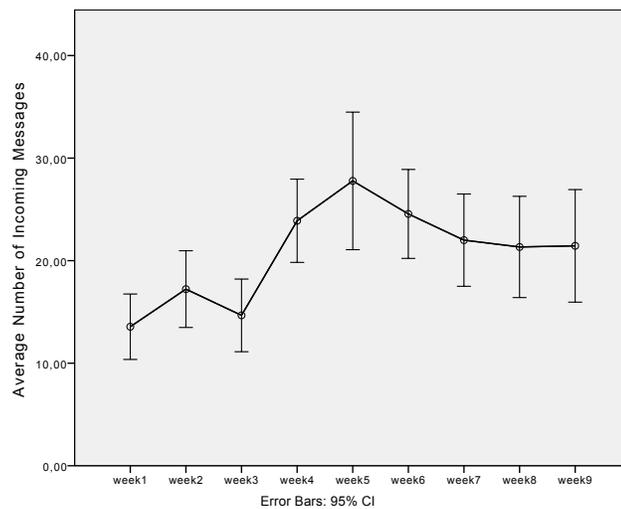


Figure 29: Volume of incoming messages through SocialConnector

Mauchly’s test indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 1.452$, $p = 0.484$; therefore, degrees of freedom were not corrected. The results show that there was a significant effect of mediating the interaction with social awareness notifications: $F(2, 16) = 13.756$, $p < 0.001$, partial $\eta^2 = 0.632$.

Three paired-samples t-tests were used to make post hoc comparisons between conditions with p-values and significance levels adjusted following the Bonferroni correction. A first paired-samples t-test indicated that there was a significant difference in the volume of incoming messages for pre-intervention ($M = 45.4$, $SD = 8.7$) and intervention ($M = 76.2$, $SD = 18.4$) conditions; $t(8) = -5.272$, $p = 0.002$, $95\% CI = [-48.382, -13.173]$, $d = -1.970$. A second paired-samples t-test indicated that there was a significant difference in the number of incoming messages for pre-intervention ($M = 45.4$, $SD = 8.7$) and post-intervention ($M = 64.8$, $SD = 16.7$) conditions; $t(8) = -4.068$, $p = 0.011$, $95\% CI = [-33.665, -5.002]$, $d = -1.553$. Finally, a third paired-samples t-test indicated that there was not a significant difference in the

volume of incoming messages for intervention ($M = 76.2, SD = 18.4$) and post-intervention ($M = 64.8, SD = 16.7$); $t(8) = 1.637, p = 0.421, 95\% CI = [-9.643, 32.531], d = 0.547$.

These results suggest that mediating the interaction of family members with notification triggers does have an effect on the volume of messages sent to the older adults participating in the study. More specifically, our results suggest that during and after sending contextualized social awareness reminders to family members, they tend to increase their volume of messages (emails) sent to the older adult in the family.

- **Outgoing messages.** Following on the results presented above, we now investigate whether there is a noticeable effect of time on the volume of messages sent from the participating older adults in the study to the members in their family networks. Figure 30 shows the volume of outgoing messages sent through SocialConnector from older adults.

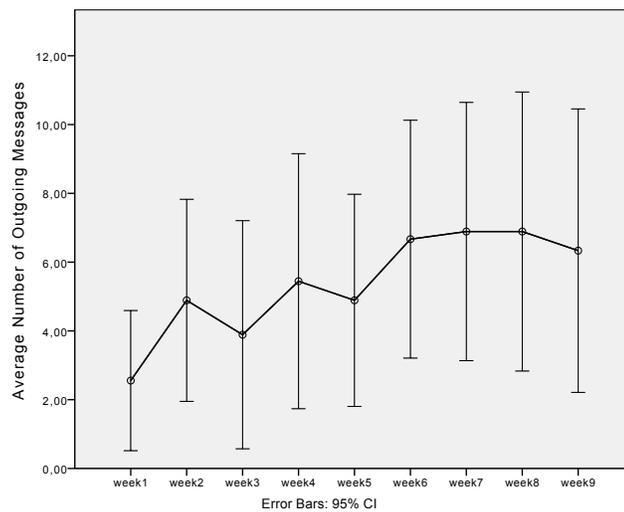


Figure 30: Volume of outgoing messages through SocialConnector

We ran a one-way repeated measures ANOVA to study the effect of time on the number of messages originated from older adults participating in the study. Mauchly's test of sphericity yielded that this assumption was not violated: $\chi^2(2) = 5.584, p = 0.061$. The results show that there was a significant main effect on the studied variable: $F(2, 16) = 6.234, p = 0.01$, partial $\eta^2 = 0.438$.

Given that we identified a statistically significant main effect, we ran post hoc tests with p-values and significance levels adjusted following the Bonferroni correction for pairwise comparisons. However, we did not find any significant difference when comparing the average number of outgoing messages mediated through SocialConnector across experimental conditions: pre-intervention ($M = 11.3, SD = 9.7$) and intervention ($M = 17.0, SD = 11.4$): $t(8) = -2.722, p = 0.078, 95\% CI = [-11.944, 0.611], d = -0.538$; between pre-intervention ($M = 11.3, SD = 9.7$) and post-intervention conditions ($M = 20.1, SD = 14.8$): $t(8) = -2.641, p = 0.089, 95\% CI = [-18.802, 1.247], d = -1.000$; and intervention ($M = 17.0, SD = 11.4$) vs. post-intervention conditions ($M = 20.1, SD = 14.8$): $t(8) = -1.622, p = 0.430, 95\% CI = [-8.896, 2.673], d = -0.655$.

Similar to the case of outgoing calls, these results suggest that there is a slight increase in the number of messages sent by older adults through SocialConnector. However, although this increase may be caused by a learning effect, we are not in position to claim this hypothesis, as the statistical power of the conducted analysis is too low. Therefore, replicating this study with a larger sample seems to be a plausible option to be followed in future work.

- **Incoming photos.** Finally, we studied whether there was an effect of the social awareness notifications sent to family members on the volume of photos sent to their older adults. We ran a one-way repeated measures ANOVA to quantify the magnitude of this effect. Figure 31 shows the number of photos retrieved by SocialConnector from those sent to the older adults participating in the study by their family members messages.

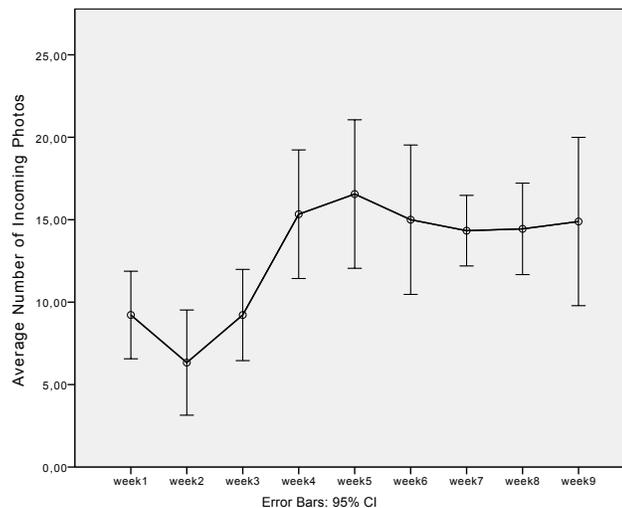


Figure 31: Volume of incoming photos through SocialConnector

Mauchly's test indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 4.500$, $p = 0.105$; therefore, degrees of freedom were not corrected. The results show that there was a significant effect of mediating the interaction with social awareness notifications: $F(2, 16) = 15.427$, $p < 0.001$, partial $\eta^2 = 0.659$.

Post hoc tests, adjusted with the Bonferroni correction, indicate that there was a significant effect between pre-intervention ($M = 24.8$, $SD = 9.0$) and intervention ($M = 46.9$, $SD = 15.6$): $t(8) = -6.784$, $p < 0.001$, 95% $CI = [-31.941, -12.282]$, $d = -2.947$. Similarly, there was a significant effect between pre-intervention ($M = 24.8$, $SD = 9.0$) and post-intervention ($M = 43.7$, $SD = 9.3$) conditions: $t(8) = -5.092$, $p = 0.003$, 95% $CI = [-30.077, -7.701]$, $d = -1.698$. However, the difference of the volume of incoming photos between intervention ($M = 46.9$, $SD = 15.6$) and post-intervention ($M = 43.7$, $SD = 9.3$) conditions was not significant: $t(8) = 0.578$, $p = 1.000$, 95% $CI = [-13.597, 20.042]$, $d = 0.201$.

These results suggest that social awareness notifications sent to family members positively increased the number of photos sent to their older adults. Furthermore, this effect lasted even after the triggers stopped, lasting at least for three weeks.

The main implication that we may derive from the analysis of the reported data is that social awareness notification messages are an effective way to mediate the social interaction between

family members and older adults. However, this effect has not been necessarily reciprocated by older adults, who did not show increasing levels on their participation due to this mediation. Nevertheless, although subtle, they did show increasing values on their engagement with the SocialConnector system, either by a learning effect or by an indirect positive feedback on their activity production (i.e., outgoing calls and messages) due to an increasing number of incoming calls, messages, and photos.

We also looked more in detail to the variables that added up to the total volume of incoming interaction mediated through SocialConnector. When comparing the effect size for the overall main effect (i.e., partial eta squared), we note that η^2 (calls) < η^2 (messages) < η^2 (photos). In other words, the main effect of photos was greater than that of incoming messages, which in turn is greater than that of incoming calls. These results suggest that social awareness notification messages were more effective in increasing the volume of photos, then of messages, and finally of calls.

Design Implication #19

When mediating intergenerational family communication, social awareness notification messages (i.e., reminders to encourage participation or short reports on the user activity performed by older adults) are effective in increasing the social exchanges between family members. In particular, they are more effective in increasing the frequency of family members on sending photos, then asynchronous messages, and then computer-mediated phone calls.

Similarly, this observation was also suggested by the results of outgoing interaction; however, we cannot attribute the mediation of social awareness messages as a cause to the slight increase on older adults' mediated calls and photos through SocialConnector, given that post hoc test results were not statistically significant. In that respect, we hypothesize that this variation could be due either to a learning effect or to an indirect feedback on the behavior of older adults triggered by a positive increase on incoming calls, messages, and photos sent by other members in the family network. In any case, replicating this study with a larger sample of older adults could possibly increase the statistical power of tests, and therefore provide more ground for validating or not the stated hypotheses.

7.2.2 Bivariate Analysis

Having already studied the overall effect of introducing the system for mediating the interaction within the observed family networks, we ran independent samples t-tests to explore if there are differences in the interaction behavior—mediated through SocialConnector—of participating older adults. Given the reduced sample size to compare in each case, we first ran Shapiro-Wilk tests for verifying that the collected data effectively held the assumption of *normality* and Levene's tests for verifying the assumption of *homoscedasticity*.

Following on the characterization of the study sample presented in Table 3, we analyzed the mediation effect of SocialConnector when grouping participants according to: (1) gender, (2) whether they share or not their household with other family members, (3) whether they used computer-based technology before or not, and (4) whether they showed a low level of social engagement before initiating the experiment.

- **Gender.** We first aimed to verify if there are noticeable differences on the interaction behavior of participating older adults due to gender. We run independent samples t-tests on the collected data (cf. Appendix H). Table 5 reports the main statistics for all studied outcome variables (M = mean, SD = standard deviation, d = Cohen’s measure of effect size).

Table 5: Mediation effect of SocialConnector according to gender

Variable	Male		Female		$t(7)$	p	d
	M	SD	M	SD			
Incoming interaction	350.8	57.6	392.6	70.3	-0.957	0.371	-0.642
Outgoing interaction	83.8	41.2	59.2	53.9	0.749	0.478	0.502
Number of incoming calls	70.3	21.4	71.8	25.5	-0.097	0.925	-0.065
Duration of incoming calls	420.2	43.8	436.9	37.4	-0.623	0.553	-0.418
Number of outgoing calls	27.5	14.1	17.0	13.8	1.127	0.297	0.756
Duration of outgoing calls	458.6	134.2	382.6	30.3	1.249	0.252	0.838
Incoming messages	173.8	20.9	196.6	40.5	-1.015	0.344	-0.681
Outgoing messages	56.3	27.7	42.2	40.3	0.591	0.573	0.396
Incoming photos	104.3	28.3	124.2	25.4	-1.114	0.302	-0.754

Concerning differences related to gender in the interaction behavior mediated by SocialConnector, we identified that, in the studied family networks, female older adults tend to be more contacted than male older adults. Conversely, male older adults participating in the study are those who tend to reach more frequently their family members in the network.

While these results suggest a tendency, we cannot positively conclude the existence of such effect because the observed p-values were not statistically significant. Furthermore, given the reduced statistical power—due to analyzing a small sample size—we cannot generalize this behavior to larger groups. Therefore, we propose to verify the validity of this hypothesis by replicating this study as future work.

In particular, accounting for this possible difference in user behavior attributed to gender, we propose that one line of future research could be designing personalized triggers to mediate the social interaction space of family members by encouraging female older adults to interact more frequently with the system, and by facilitating intergenerational encounters with family members involving male older adults.

- **Household status.** We also studied differences on the mediation effect of SocialConnector with older adults living alone or with older adults sharing their home with another family member. Table 6 reports the main statistics for all studied outcome variables.

Table 6: Mediation effect of SocialConnector according to household status

Variable	Lives with a family member		Lives alone		<i>t</i> (7)	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Incoming interaction	332.3	59.1	407.4	51.5	-2.040	0.081	-1.368
Outgoing interaction	32.5	18.7	100.2	41.3	-3.008	0.020	-2.018
Number of incoming calls	57.5	22.5	82.0	16.7	-1.881	0.102	-1.262
Duration of incoming calls	430.6	52.2	428.9	30.8	0.070	0.947	0.047
Number of outgoing calls	11.0	5.7	30.2	13.0	-2.717	0.030	-1.823
Duration of outgoing calls	454.4	136.1	385.9	34.0	1.100	0.308	0.738
Incoming messages	165.3	22.2	203.4	32.9	-1.975	0.089	-1.325
Outgoing messages	21.5	14.2	70.0	29.2	-3.023	0.019	-2.028
Incoming photos	107.0	33.0	122.0	22.9	-0.807	0.446	-0.541

Concerning differences on household status, the results suggest that older adults living alone interact more frequently with their family members through SocialConnector. In particular, the differences in overall volume of outgoing interaction, number of outgoing calls, and number of outgoing messages were deemed as statistically significant. Similarly, there are noticeable differences in the volume of incoming messages, number of incoming calls, but not in the number of incoming photos.

The obtained results can be used in terms of designing interactive systems to foster intergenerational exchanges with older adults, particularly on improving the usability and accessibility of the proposed services that enable the elderly take the initiative to engage in social interaction with their family networks. We can summarize this idea as follows:

Design Implication #20
Older adults living alone, as opposed to those who share their household with another family member, are more likely to take the initiative in using computer-mediated mechanisms to interact within their family networks.

- **Prior experience with ICT technology.** We also compared the mediation effect of SocialConnector between older adults having used ICTs before to those who have not. In that respect, Table 7 reports the main statistics for all studied outcome variables.

Table 7: Mediation effect of SocialConnector according to ICT experience

Variable	Has used ICTs before		Has never used ICTs before		<i>t</i> (7)	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Incoming interaction	400.0	46.1	361.0	72.6	0.834	0.432	0.590
Outgoing interaction	120.0	7.2	45.2	36.8	3.379	0.012	2.389
Number of incoming calls	83.0	22.6	65.2	21.5	1.155	0.286	0.817
Duration of incoming calls	430.2	35.1	429.2	43.6	0.034	0.974	0.024
Number of outgoing calls	36.7	5.13	14.2	10.3	3.485	0.010	2.464
Duration of outgoing calls	369.2	34.9	439.9	107.8	-1.077	0.317	-0.762
Incoming messages	200.7	41.4	179.3	30.6	0.885	0.405	0.605
Outgoing messages	83.3	8.6	31.0	26.9	3.196	0.015	2.260
Incoming photos	116.3	13.2	114.8	33.2	0.073	0.944	0.668

Concerning differences on prior experience using ICTs, the results suggest that older adults having used computer-supported technology before interact more frequently with their family members through SocialConnector. In particular, this effect is larger in the volume of outgoing calls than in the number of posted messages to other family members.

The obtained results can be used in terms of designing interactive systems to mediate intergenerational exchanges with older adults, particularly on improving the usability and accessibility of the proposed services that enable the elderly interacting using voice and text with their family networks. For instance, tutorials or other mechanisms to help users remind the main input commands to interact with the system can be useful to smoothen the learning curve on using SocialConnector—which, apparently, is still seen as steep by those users new to computer-supported systems. We can summarize this idea as follows:

Design Implication #21
Older adults having previously interacted with computer-supported systems are more eager to interact with their family members using mediated technology than those who have not.

- **Initial social engagement.** Finally, we explored whether there was a mediation effect of SocialConnector between those older adults who had low initial LSNS-R score (i.e., classified as *having low social engagement* at the beginning of the experiment, with scores lower than 30) and those with higher scores (i.e., with scores over 30). Table 8 reports the main statistics for all studied outcome variables.

Table 8: Mediation effect of SocialConnector according to initial LSNS-R score

Variable	Low social engagement		High social engagement		$t(7)$	p	d
	M	SD	M	SD			
Incoming interaction	360.4	81.1	391.0	41.7	-0.679	0.519	-0.455
Outgoing interaction	48.8	39.9	96.8	46.9	-1.661	0.141	-1.114
Number of incoming calls	63.4	23.6	80.8	18.9	-1.190	0.273	-0.798
Duration of incoming calls	424.6	47.1	435.6	30.6	-0.400	0.701	-0.268
Number of outgoing calls	15.4	11.0	29.5	14.9	-1.637	0.146	-1.098
Duration of outgoing calls	446.9	118.9	378.1	33.6	1.109	0.304	0.744
Incoming messages	177.8	33.9	197.2	34.5	-0.847	0.425	-0.568
Outgoing messages	33.4	29.3	67.3	32.9	-1.633	0.147	-1.095
Incoming photos	117.2	36.6	113.0	12.7	0.217	0.834	0.146

Regarding differences related to the initial LSNS-R score as a factor in the interaction behavior mediated by SocialConnector, we identified that, in the studied family networks, older adults with higher levels of social engagement tend to interact more frequently with SocialConnector than those with lower initial LSNS-R scores.

While these results suggest a tendency, we cannot positively conclude the existence of such effect because the observed p-values were not statistically significant. Furthermore, given the small sample size, we cannot generalize this behavior to larger groups. Therefore, we propose to verify the validity of this hypothesis by replicating this study as future work.

7.2.3 Qualitative Analysis

Having already explored the effect of mediating the social interaction space of intergenerational family members with computer-supported technology from a quantitative point

of view, we now extend the presented results with qualitative insights induced from the analysis of entry and exit interviews to family members. Supporting quotes in the narrative were translated from Spanish. Participants are identified as follows: ‘OA’ stands for older adult, ‘FC’ for (informal) family caregiver, and ‘FM’ for (other) family member. Number codes refer to the family identifier as presented in Table 4.

Entry interviews revealed that older adults considered themselves as being ‘well cared’ in most of the cases, with one or more close family members acting as their informal caregivers. This situation corroborates the broader findings described in the conducted ethnographic empirical studies, particularly those in Chapters 4 and 5. However, a common theme that emerged was a strong perception of independence among older adults, who feel themselves capable and willing to take care of themselves, yet still accepting the care and affection provided by their family members. Therefore, the main confronting vision on the accomplishment of caregiving work is that older adults consider that their younger family members somewhat limit them into their daily routines, although they appreciate the attention and dedication provided by their supporting caregiving network.

Conversely, younger generations argue that caring for their parents is an obligation, which is rooted in the supporting role that family members need to embrace together and collectively act as a group. This idea is vastly shared by those family members in the middle generation already assuming caregiving duties—i.e., adult children acting as assistants—who see their parents as subjects who require periodic attention.

“I’m quite old, so once I widowed my daughter brought me to live with her and the kids. I don’t want to be a burden so I do most of my affairs on my own. I go to the bank by myself every month, and I pick up my medicines at the drugstore. I even buy some groceries at the market to help with the expenses at home. [...] I appreciate what FC2 [anonymized] does for me, but sometimes she doesn’t get that I’m not handicapped and I can still stand up for myself”. OA2, male, 78 years old.

“We all care about dad at home. Even when I’m at work my sister comes to look after him. [...] We sometimes don’t agree with each other because he keeps saying that he can do everything on his own, but we both know it’s not true. Anyway, I care a lot for him and I give him his space, but I worry that something might happen if he stays at home alone for a long time. Fortunately, my little girls still live with us, so they can give me a hand when I need it”. FC2, female assistant, 54 years old.

This conflicting idea, referred to as *ageism* in social sciences literature, resonates with prior research in gerontology and cultural anthropology in Chile [Arno08, Thum15]. In terms of technology design, it provides a complementary view to the vicious circle on technology usage and appropriation among Chilean older adults, described as one of the abstractions derived from the empirical study on *attitudes, agreements, needs, viewpoints, and concerns on technology usage for intergenerational communication with older adults* presented in Chapter 4, and synthesized in Section 4.3. In that respect, studying the mediation effect of SocialConnector through an in-home deployment study (e.g., the one presented in this Chapter) allows us to contextually specialize the inferred design implications in Chapter 4.

Design Implication #22

Older adults consider themselves to be well cared by their family members. However, adult children assuming informal caregiving duties inadvertently assume that their older adults lack the means for taking care of themselves, thus reinforcing a vicious circle in which the views of aging are assumed as dependency, decline, and technology incapability.

Family members tended to value the system differently. For instance, while the participating older adults praise the system because they perceive it offers them a ‘new way’ for connecting within their families, their adult children acting as assistants and monitors value the opportunities for increased contact. However, helpers and outsiders—mainly grandchildren—have opposing views on the mediation strategies used for intervening the social interaction space within the family networks. For instance, one adult assuming the role of helper states:

“I liked the system a lot! However, I wasn’t so pleased to receive warning messages because they were kind of impersonal. They could’ve definitely been more engaging, or at least, feel more personal. [...] When I received them I didn’t know if it was actually grandma who sent the message or if I needed to call her immediately. It was weird, because I didn’t feel the affection to motivate me to call her back. Calling her was more kind of an obligation rather than a call for affection”. FM7, male helper, 31 years old.

In other words, while there is high perceived value on the system for mediating intergenerational communication, there are some concerns on how the mediation strategies are exposed to the family network. In that respect, while family members are usually willing to take the initiative on interacting with their older adults, the way in which social awareness notifications or persuasive triggers are displayed need to be personalized and adapt to the expectations of the involved parties, particularly in terms of affection and fit to the overall routine. One grandchild assuming the role of outsider reaffirms this concern:

“I must confess I was stumped when I received messages prompting me to call grandma. At times I was willing to do so, but couldn’t do it because I was quite busy. Then, when I turned free later that day, I didn’t know if it was worth to call grandma back or not! Other times I was at school, so I didn’t check my email until quite late in the evening. Then it was practically impossible to interact with her, because I risked bothering her with a message that she wouldn’t be able to read until the next day. Bummer!”. FM4, female outsider, 19 years old.

These two observations show that the design of personalized messages needs to map not only the preferred communication media of both parties in order to effective, but also has to align the current expectations and available times for interaction. In terms of technology design, communication mediators need to count with a set of rules, which have to be initially set up with the contextual variables that shape the social interaction spaces of family members, and then intelligently adapt to possible states that could maximize their effect.

Design Implication #23

The design of personalized computer-supported communication mediators needs to map not only the preferred media of both parties, but also has to align the expectations and available times for interaction.

The place at home in which SocialConnector was deployed was also identified as a factor for increasing social exchanges with family members. Given that we initially told participating older adults that they were free to place and move the system to wherever they liked, some of them indicated in the exit interviews that they were more eager to interact through SocialConnector in the living room or in the kitchen in the morning and in their bedrooms in the afternoon. This suggests that the physical place where computer-supported solutions to mediate personal communication does impact on the perceived value of the system—as a reflection of personal attachment to the technology—thus increasing the possibility of adopting and appropriating the system on the way that it was designed for. In that respect, complementary approaches to deploy the system, such as on larger displays (e.g., Smart TVs), could be explored as a way to enhance technology appropriation.

“I particularly appreciated that I could take the tablet [SocialConnector] wherever I go. For instance, while I was watching TV in the morning, I put it over the table in my living room. Later in the afternoon, I took it with me to my bedroom while I was taking a nap. That way, it was easier for me to see if somebody called me or sent me a photo”. OA6, male, 72 years old.

Similarly, family members praised the ‘flexibility’ offered by SocialConnector to conduct their intergenerational exchanges with older adults. In that respect, computer-based systems encouraging this kind of encounters should support the currently preferred—and used—media communication channels by family members in order to reduce their effort for taking the initiative on contacting their older adults.

“To me, the best feature of the system was its flexibility. I could use my own email account to send messages to my mother, and she could reply me back the same way. It was so easy!”. FC9, male assistant, 30 years old.

These two ways in which older adults and the members in the supporting caregiving network show how they adopt and integrate into their routines the evaluated system. Moreover, these findings suggest how implicit asymmetries, such as on technology usage, daily rhythms and available times for social interaction, and variety of social media for interacting with family members, can be addressed in design. In other words, we can summarize these ideas as follows:

Design Implication #24
In order to achieve an effective mediation of the social interaction space of family members, the supporting technology should adapt to the attitudes and expectations of the involved stakeholders. On the one hand, deployed services at home should be ideally situated in a way that could be easily reached by older adults for improving the chance of system interaction, and consequently, intergenerational exchanges. On the other hand, mediation strategies should map the technology already appropriated by family members as a way to ease their integration with the proposed computer-mediated communication services.

Older adults also showed concern on privacy matters regarding the disclosure of information across their family networks. For instance, some older adults stated that they were very cautious to expose themselves and their personal matters if they perceived they could worry the other party, as this situation ‘could force family members to feel obliged to respond or excessively intervene their space’.

“I usually had to think twice (or even more times) before sending a quite personal message to my family. [...] I worried that I could bother the other person, or making him/her feel uncomfortable for having to be forced to take care for me! I’m quite diplomatic in these situations, and I don’t want to make more problems for my children”. OA3, female, 69 years old.

In other words, while participating older adults felt they could engage in ‘open social interaction’ with fellow family members, there were specific topics in which they preferred to talk in person. As OA8 stated, the reason behind this concern is that he ‘does not trust that the message would be effectively conveyed through the system as it lacks emotion’:

“I enjoyed using the system because it was something new to me! However, I won’t use it for personal matters. Never. [...] I don’t think I could be that attached to a robot for clearly expressing my feelings or for asking for help when I need it. I don’t trust in machines, so I won’t be telling her my personal matters. [...] If I had to talk something personal to my family, I would do it the proper way. In person!”. OA8, male, 71 years old.

The expressed attitudes toward privacy and confidentiality complement prior research on HCI literature. For instance, while Caine et al. [Cain06] argue that privacy can be considered as a cost-benefit calculation that seems to have less weight when benefits are strong (e.g., in the case of older adults with mild impairments), the study findings provide evidence on supporting this claim by stating that older adults are actually aware of the possible implications of disclosing social information to their close family networks in case this situation could raise tension or limit the context of such mediated interactions.

Design Implication #25
Chilean older adults have some reserves to disclose social information to their families through computer-supported means. This situation is due to a perception of possibly burdening close family members, or a lack of communication cues that would restrict the social interaction between people.

SocialConnector was also highly praised by family members assuming caregiving duties, particularly for having an idea about how the family as a whole interacted with the older adult. As FC6 stated, mediating the interaction within the family network also helped her act as a communication broker between her grandfather and other family members when they did not have the time to interact frequently through the system, which in turn, makes it easier for her to fulfill informal caregiving tasks.

“I loved the system for keeping track of who in my family interacted with dad and who needed a little reminder to do so [laughs]. The system was also quite useful for my daughters, as they could either easily reach their grandfather through the system or I could give them news on how dad is doing”. FC6, female assistant, 39 years old.

This particular use case of SocialConnector shows how the proposed family roles for intergenerational communication and informal elderly caregiving—presented in Chapter 5—are mediated in practice. This also extends prior literature on home systems for assisting caregiving. For instance, this study corroborates and provides new ground on the claims proposed by Vines

et al. [Vine13] regarding the possible effects of monitoring technologies shifting “hidden care routines” into “care work”.

Finally, and controlling for a possible novelty effect in user perception of system usefulness and value, we queried study participants at the end of the exit interview about what features proposed by SocialConnector they deemed as useful, what features needed improvement, and what new services could be proposed in future iterations of development. In that respect, a large number of family members praised the possibility to engage in videocalls with their older adults, as well as easing the process of reaching them through asynchronous messages. Similarly, older adults liked that the system provided them with an interface that would allow them to interact with close family members, thus increasing their perceived connection within their family networks.

Design Implication #26

Providing computer-supported mechanisms to mediate intergenerational communication, mapping the mental model of older adults through simple yet usable interfaces, and fitting with the expectations of all involved family stakeholders, has the potential to bridge the digital divide gap within the family network, hence increasing the perceived sense of connectivity.

7.3 Discussion and Insights to Technology Design

In this chapter we report the usage and experience of older adults interacting with SocialConnector, and how their supporting family members are indirectly affected by the mediation of such a system. The obtained findings overall corroborate the proposed models inferred so far in this dissertation (e.g., family communication metamodel and roles for mediating intergenerational communication and informal elderly caregiving) and show the potential of using computer-supported technology to assist older adults in increasing their perceived family cohesion. In this study, we initially formulated two hypotheses and five research questions:

- **Hypothesis 1: mediation effect of SocialConnector for improving the social engagement of older adults.** Following on the study results, and particularly on the average differences on the pre and post LSNS-R scores for the study sample, we validate this hypothesis for the studied group, with a particular increase on perceived social engagement in the family subscale.
- **Hypothesis 2: mediation effect of social awareness strategies for increasing the frequency of exchanges between older adults and other family members.** Through analyzing the aggregated results for the measured variables through SocialConnector (i.e., incoming calls, messages, and photos, and outgoing calls and messages), we verified that there was a significant main effect on the difference on interaction mediated through SocialConnector before and after the introduction of social awareness messages (H2a). Furthermore, this effect was not affected after the messages were removed from the system (H2b), although we can only argue for the validity of this effect on the studied period.
- **Research question 1: perceived role of SocialConnector within the family network.** By analyzing and comparing the conducted entry and exit interviews with study participants, we identified that older adults praised the system because it offered them alternative means for

engaging in social interaction with fellow family members. Similarly, family members praised its flexibility for being able to manage different kinds of incoming media for easily interacting with their older adults. However, we also identified several concerns around privacy and unexpected effects of social awareness messages that can be reworked in a future iteration of the system.

- **Research question 2: perceived disruption of the homes and routines of older adults.** We identified that a major concern for older adults was related to privacy matters regarding information disclosure across the family network, particularly because they did not intend to worry or burden the family members caring for them, and because there is still a reticence on trusting an external agent—such as SocialConnector—for bridging personal matters.
- **Research question 3: informal caregivers' perception of SocialConnector as a tool for assisting their caregiving work.** The study results show that assistants perceived SocialConnector as an alternative way to make visible the caregiving work across the family, thus easing the articulation of tasks. In addition, the system showed potential on mediating the interaction across the family network, particularly among those family members who do not have the habit on interacting with the older adult by enabling the role of communication broker.
- **Research question 4: perceived disruption of the homes and routines of family members.** While perceived as valuable, family members also considered that the social awareness mediation messages did not completely fit in their routines, either due to the form of these messages or because they did not adapt to their daily life routines. In terms of design, this implies that computer-supported communication mediators need to match not only the expectations of older adults, but also with the tone and mental model of family members, particularly with those who do not usually take the initiative in contacting the older adult.
- **Research question 5: addressing the attitudes, needs, and expectations around family communication.** All in all, and while there is not a consensus across generations, family members still value SocialConnector as a way to facilitate their daily interaction with their older adults. Through this trial, we identified several lessons that can be applied in reformulating and improving the design of proposed services, particularly those related to user modeling, personalization, and adaptation tailored to family members in the supporting caregiving network.

As broader design concepts, we identified in this study that the design of computer-supported intergenerational communication mediators needs to account for the opposed views on ageism and technology design (vicious circle on technology adoption), particularly contrasting the perceived independence assumed by older adults, and the views on decline and technology reluctance raised by their family members—particularly that of the family members who are more closely involved in assuming caregiving tasks. Furthermore, while informal caregivers praised the possibilities to make visible the caregiving work as mediated by the system, this service could be improved by implementing the proposed informal elderly caregiving matrix (cf. Figure 14, in Section 5.4.1). We argue that by visualizing the assumption of tasks—and current fulfillment of duties across the network—family members would be in better position to engage in taking the initiative on caring for their older adults.

The perceived effects of mediating the social interaction space with SocialConnector are also in line with the claims of Grönvall and Verdezoto [Grön13], which state that supporting systems should move away from passive monitoring and surveillance, to solutions that assess and assist the individual enforcing active information seeking. In that respect, the design of SocialConnector as a mediator, while uses as input monitoring data retrieved from ambient sensors (cf. Chapter 6), the main intervention in the social interaction space is pushed toward family members in the supporting network. Therefore, design considerations, such as personalization and adaptation in persuasive and social awareness triggers, become relevant in future action research cycles in this project.

Finally, in terms of structural issues to tech design, we identified that, in terms of software support, the family communication metamodel (presented in Chapter 3) provides a modular architecture that respects the separation of concerns required by family members when interacting with the system. The proposed software also adheres to transversal software requirements for social computing systems supporting partially virtual communities (cf. Chapter 6), such as families interacting with a computer-based communication mediator, which encourages participation across the family network and provides loosely-coupled governance structures, respecting user identity and privacy.

7.4 Limitations

While valuable, the reported results are only applicable to the studied participants as the sample size is not big enough for yielding high statistical power, which would warrant generalization for a broader population. Regarding the qualitative analysis grounded on the the mediation effect of SocialConnector in the studied nine families, the implications of the study findings are applicable only to the particular socio-cultural scenario.

7.5 Summary

In this chapter we present the main findings of a mixed-methods in-home study, understanding the mediation effect of SocialConnector in a sample of intergenerational families. On the one hand, we measured how older adults and their family members interacted through the system (by quantifying incoming and outgoing interaction, aggregating calls, messages, and photos). On the other hand, we explored the implications of the mediation of SocialConnector across the studied family networks by interviewing the involved participants about their perception on using—and interacting with—the system, as well as how it fit within their daily routines and environments.

The obtained results suggest that older adults using SocialConnector did show increased social engagement, particularly with family members, when exposed to interacting with the system over a period of nine weeks. In particular, regarding the mediation with family members in the surrounding network, social awareness notification messages to encourage user participation are an effective way to mediate the social interaction space of the involved parties. However, the study results also suggest that these messages should be personalized to map the current routines and expectations of the involved people in order to maximize the potential effect of the intervention. Similarly, older adults were not necessarily affected by the mediation of these messages—initially sent only to family members in the surrounding caregiving network—as we

did not find statistical effect on the variation of system interaction between older adults and SocialConnector that can be linked to this intervention.

Although subtle, there was an increase in the produced outgoing interaction of older adults with their family members, which can be attributed either to a learning effect or an indirect positive feedback due to an increased volume of incoming messages, calls, and photos. In addition, detailed statistics on the variation of interaction variables showed that the effect of the mediation through notification messages impacted more on the photos sent from family members to their older adults, then on the volume of sent messages, and finally on the number of mediated calls through SocialConnector.

In terms of design, we also inferred implications that can be used to inform the development of further software applications or functionality to better impact the social interaction space of family members. In particular, the study results suggest that older adults liked interacting with SocialConnector, as it offered them an alternative way for engaging in social interaction with fellow family members. However, participating older adults also reflected on a major concern involving privacy matters and information disclosure across the family network. The reason behind this attitude can be attributed to an intention to not worry or burden the family members caring for them, and because there is still a reticence on trusting an external agent—such as SocialConnector—for mediating intergenerational communication about personal matters.

7.6 Contributions of the Work Presented in this Chapter

The study results reported in this chapter corroborate the findings of the previous empirical studies—presented throughout Chapters 3 to 5—and help understand further implications of mediating the social interaction space of family members regarding intergenerational family communication and informal elderly caregiving. This chapter provides three main contributions:

- It corroborates the previous findings derived from ethnographic studies, by conducting an in-home deployment study on the implications of mediating social interaction between older adults and their family members through SocialConnector system, an intergenerational family communication mediator targeted to older adults.
- It identifies further evidence for supporting the formulation of a vicious circle model that helps explain the concerns about technology adoption (initially presented in Chapter 4) among older adults in Chilean families.
- It shows how adult children assuming informal caregiving duties articulate in the field their work, by exposing their attitudes, expectations, viewpoints, and concerns on the matter. These results extend those initially inferred in Chapters 4 and 5.

8. DESIGN GUIDELINES

Having arrived to the bottom of the funnel model representing the inductive research process followed in this dissertation (cf. Section 1.6), in this chapter we consolidate the findings of the empirical studies conducted throughout this dissertation by formalizing a set of design guidelines for introducing computer-supported technology to mediate intergenerational family communication and informal elderly caregiving, tailored to the studied socio-cultural scenario. The pipeline for generating the proposed design guidelines is depicted in Figure 32.

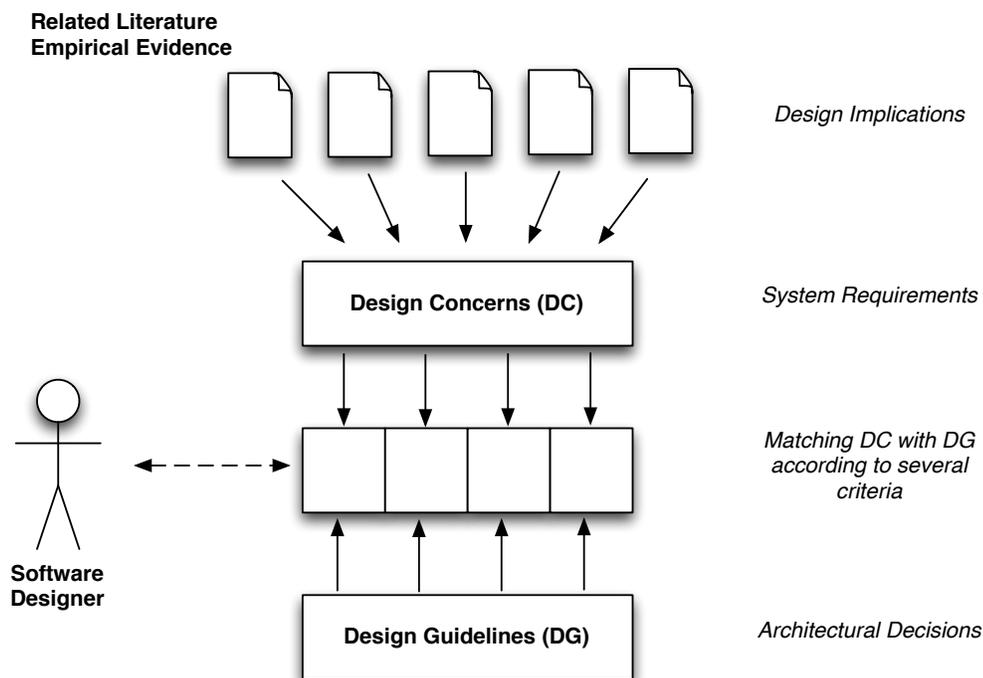


Figure 32: Pipeline for deriving the proposed design guidelines

In line with the findings deduced from the analysis of related literature and the conducted empirical studies, we formulated a set of 26 *design implications*. Each one of these implications comprises one or more *design concerns*, specific to the design of computer-supported technology for the studied scenario, covering the viewpoints and expectations of one or more stakeholders in intergenerational communication and informal elderly caregiving (i.e., older adults, family caregivers, and other family members in the supporting network). Then, we grouped the proposed design concerns into *core themes* referring to design dimensions of socio-technical systems particular to the study domain. Finally, the abstraction of such themes, mapping with the supporting evidence found in literature and that derived from the empirical work conducted in this dissertation, leads us to formulate *design guidelines*, which are concrete and reusable principles aimed to inform the conception, development, and deployment of computer-supported technology in the domain studied in this research.

By addressing the proposed design guidelines, software designers can take informed architectural decisions when conceiving the supporting system for mediating the social interaction space of family members. This can be achieved either by analyzing the concerns and guidelines related to a particular stakeholder (i.e., older adult, family caregiver, or family member) or to an architectural dimension (i.e., communication, coordination, cooperation, or

user-system interaction). In particular, this proposal extends the Web Content Accessibility Guidelines (WCAG) 2.0—formulated by the World Wide Web Consortium (W3C) [W3C08]—and those proposed by Kurniawan and Zaphiris [Kurn05], which were conceived to inform the design of Web-based user interfaces tailored to older adults.

8.1 Formalization of Design Concerns

Throughout this dissertation, we derived a total of 26 design implications that are structured as follows:

- Implications 1 and 2 were presented in the Introduction, based on background literature.
- Implications 3 to 5 were formulated in Chapter 2, grounded in related work.
- Implications 6 and 7 were specified in Chapter 3 from the results of Empirical Study #1.
- Implications 8 to 10 were presented in Chapter 4 from the results of Empirical Study #2.
- Implications 11 to 18 were shown in Chapter 5 from the results of Empirical Study #3.
- Implications 19 to 26 were inferred from analyzing the implications of the in-home deployment study reported in Chapter 7.

Acknowledging that this set of design implications covers multiple design concerns and stakeholders, a first step in abstracting reusable knowledge—in the form of guidelines—is to thematically group them. Section 8.1.1 maps design implications into more abstract design concerns, while Section 8.1.2 groups these concerns into core themes.

8.1.1 Summary of Design Implications

In order to provide contextual ground to the formalization of design guidelines, Table 9 summarizes the formulated design implications throughout this dissertation in the form of concerns related to the viewpoints of one of three stakeholders within the family ecosystem. OA stands for “Older Adults”, FC for “(Informal) Family Caregivers”, and FM for “(Other) Family Members”. Note that design concerns 1a and 1b are derived from the design implication #1 (presented earlier in Chapter 1). We use this same notation convention for referring to the derivative relation between design implications and design concerns.

Table 9: Summary of the identified design concerns grouped by stakeholder

ID	Design Concern	Stakeholders		
		OA	FC	FM
1a	Consider in an integral way the preferences and expectations of family members when designing computer-supported technology to mediate their social interaction space	X	X	X
1b	Respect the pre-existing home setting of older adults and minimally intervene their environment when envisioning deploying computer-supported technology	X		

2	Understand the complex and diverse living experiences of all family members: recognize and accept diversity in design, as well as its evolution	X	X	X
3a	Coordination support is necessary to manage the information flow within the caregiving network		X	X
3b	Coordinate the effort of family members in the surrounding caregiving network to provide informal care, which should be aligned to their inherent attitudes, values, and expectations toward the process		X	X
4a	Designing technology to support the appropriation by older adults needs to enhance usability, perceived value, understandability, and user-system confidence	X		
4b	Respect the diversity of attitudes, expectations, viewpoints, and concerns of family members regarding their implication with respect to computer-supported mediation strategies		X	X
5	Balance the expectations of older adults regarding care and affection from their families (<i>filial obligation</i>) and the current lack of means and opportunities for supporting family members to provide this expected care and social interaction	X	X	X
6a	Mitigate the burden of the most involved family members in caregiving tasks (i.e., assistants and monitors)		X	X
6b	Understand the structure of informal elderly caregiving in order to contextualize the computer-supported services provided to the involved stakeholders for facilitating the process	X	X	X
7a	Provide engaging means to coordinate and mediate social communication among family members as a way to promote the social integration of older adults	X	X	X
7b	When older adults become used to digital media, they recognize their benefits and can become active users of such systems	X		
8a	There is an initial reticence of older adults on using social media or other computer-supported mechanisms for communicating due to the collectivistic nature of social groups and the ruling filial obligation present in Latin American families	X		
8b	The inherent filial obligation produces a vicious circle that stresses adult children assuming informal caregiving duties and limits the technology appropriation of older adults	X	X	
9	Identify what kind of technology, with what purpose, when, and who should use it in order to address the specific needs of the involved stakeholders	X	X	X

10a	Family members should support their older adults in adopting the computer-based solutions developed to mediate intergenerational communication and informal elderly caregiving	X	X	X
10b	The intended technology to be deployed with older adults should be understandable, usable, and perceived as valuable by them	X		
11a	Intergenerational communication and informal caregiving can be modeled considering the scope and concerns defined as family roles	X	X	X
11b	Provide specific services tailored to the concerns and scope of each role: assistants, monitors, helpers, and outsiders (e.g., report pending needs of older adults and coordinate the effort of providing assistance in case of need)	X	X	X
12	Provide social awareness, activity awareness, persuasive strategies, and up-to-date feedback loop mechanisms	X	X	X
13	Include mechanisms to keep track of the evolution of roles within a family network, supporting the technology adoption and appropriation of older adults, family caregivers, and other family members	X	X	X
14	It is more appropriate that helpers subscribe to particular requests raised by monitors and assistants (bottom-up approach), rather than sending requests directly to the former (top-down line of command)		X	X
15a	Female monitors and assistants tend to prefer addressing the socio-affective needs of older adults as well as acting as communication brokers	X	X	
15b	Male monitors and assistants prefer to provide instrumental assistance to their older adults: security, safety, and comfort	X	X	
16	Make the older adult needs visible for identifying the most demanding areas requiring assistance and the required effort to address these needs	X	X	X
17	Visualize the fulfillment of caregiving duties as a way to provide positive personalized awareness to family members about the engagement in the process across the caregiving network		X	X
18	Decentralize the control held by female caregivers to reduce their burden		X	
19a	Social awareness messages sent to family members encourage the interaction with their older adults		X	X
19b	Asynchronous interactions (e.g., sharing photos or sending emails) are more affected by mediation strategies than synchronous interactions (e.g., calls)		X	X
20	Older adults living alone are more likely to take the initiative in using computer-mediated mechanisms to interact with other family members	X		

21	Older adults having previously used ICT-based systems are more eager to interact with other family members using digital social media	X		
22a	Family caregivers inadvertently assume that their older adults lack of means for taking care of themselves		X	
22b	Empower and provide to the older adults the opportunity to be an active participant in his/her caregiving process	X		
23	Computer-supported mediators needs to map not only the preferred media, but also align the expectations and available times for interaction	X	X	X
24a	Supporting technology deployed at the home of older adults should be located in a place that is easily recognizable and reachable by them	X		
24b	Computer-supported services to mediate intergenerational exchanges should respect the preferred ways for interacting of family members	X	X	X
25	Older adults have some reserves to disclose personal information to their families through computer-mediated means	X		
26	Computer-supported mechanisms to mediate intergenerational communication have the potential to bridge the digital divide across the family network, hence increasing the perceived sense of connectivity	X	X	X

From analyzing the whole spectrum of derived design implications, we note that the effort on effectively mediating intergenerational family communication and informal elderly caregiving needs to cover the viewpoints and concerns of all involved stakeholders. Therefore, potential solutions need to address several designs aspects, which range from the direct participation of older adults in the design process, to satisfying the main requirements raised by their informal caregivers, and to motivating and encouraging the participation of other members within the family network.

8.1.2 Thematic Clustering of Design Implications

As general framework for identifying core themes from the stated design concerns in Table 9, we follow the domains in the 3C model: communication, coordination, and cooperation [Elli91]. Two social computing designers with vast experience in conceiving software for mediating interpersonal communication were asked to group the proposed design concerns. They were instructed to follow the three layers proposed in the original formulation of the 3C model, and if they considered there was not a ‘natural fit’ for any design concern, they were free to group them in one or more separate groups. Once both designers independently came with a thematic grouping for all design concerns in Table 9, we facilitated a discussion meeting for exploring the covered areas and reaching consensus on the proposed solutions. As a result from the conducted discussion meeting, we extended the original 3C model in the studied domain with a fourth layer covering user-system issues covering issues regarding technology deployment, acceptance, and appropriation. Therefore, the scope for each identified *core theme* is as follows:

- **Communication:** Behavioral considerations for promoting an effective social interaction space mediation.
- **Coordination:** Coordination and articulation considerations for facilitating computer-supported caregiving work.
- **Cooperation:** Socio-technical considerations for involving the family network in the cooperative informal caregiving process.
- **User-system interaction:** Environmental and contextual considerations for developing and deploying domestic computer-supported technology involving older adults.

Figure 33 represents the relation between the proposed themes. The fourth one (*User-system interaction*) is transversal to the other three. Therefore, it should be considered when the services provided by the system have an explicit representation in its user interface. Moreover, and according to the 3C model, coordination services assume the availability of communication capabilities and cooperation assumes the availability of coordination services [Elli91, Fuks05].

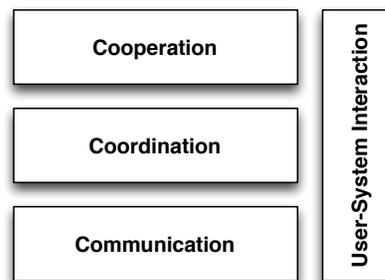


Figure 33: Structure of core themes in computer-mediated caregiving supporting systems

Based on the definition of the presented core themes, Table 10 matches the derived design concerns to core themes. Regarding stakeholders, ‘OA’ stands for older adult, ‘FC’ for (informal) family caregiver, and ‘FM’ for (other) family member.

Regarding their relative coverage, the most important design concerns to cover in social computing systems in this domain are the following:

- Understand the complex and diverse living experiences of all family members: recognize and accept diversity in design, as well as its evolution (design concern #2).
- Understand the structure of informal elderly caregiving in order to contextualize the computer-supported services provided to the involved stakeholders for facilitating the process (design concern #6b).
- Provide engaging means to coordinate and mediate social communication among family members as a way to promote the social integration of older adults (design concern #7a).
- Intergenerational communication and informal caregiving can be modeled considering the scope and concerns defined as family roles (design concern #11a).

Table 10: Core themes grouping the identified design concerns

Design Concern	Communication			Coordination			Cooperation			User-System Interaction			Coverage
	OA	FC	FM	OA	FC	FM	OA	FC	FM	OA	FC	FM	
1a	X	X	X							X	X	X	6
1b										X			1
2	X	X	X		X	X		X	X	X	X	X	10
3a					X	X							2
3b					X	X							2
4a										X			1
4b							X	X	X	X	X	X	6
5				X	X	X							3
6a					X	X		X	X				4
6b	X	X	X	X	X	X	X	X	X				9
7a	X	X	X	X	X	X				X	X	X	9
7b										X			1
8a	X									X			2
8b							X	X		X			3
9										X	X	X	3
10a										X	X	X	3
10b										X			1
11a	X	X	X	X	X	X	X	X	X				9
11b				X	X	X							3
12				X	X	X	X	X	X				6
13					X	X	X	X	X	X			6
14					X	X							2
15a					X								1
15b					X								1
16								X	X				2
17								X	X				2
18					X								1
19a		X	X					X	X				4
19b		X	X										2
20										X			1
21										X			1
22a					X			X					2
22b	X						X						2
23				X	X	X							3
24a										X			1
24b	X	X	X							X	X	X	6
25	X						X						2
26	X	X	X				X	X	X				6

In other words, these design concerns—which appear as *mandatory* for any kind of social domestic computing solution to deal with intergenerational communication and informal caregiving—deal with the main idea that design has to: (1) be personalized to the main expectations, viewpoints, and concerns of family members; (2) respect the cooperative nature of the process, understanding the main implications of cooperation, articulation, and invisible work; and (3) consider positive triggers to encourage interaction within the family network. A sorted list

of design concerns according to the relevance they have in the design process can be found in Appendix I.

In broader terms, the proposed guidelines encourage to support four quality attributes that appear as mandatory in the design of both components and connectors aligned with architectural decisions in this study domain:

- **Usability.** This concern refers to minimize the user-system interaction effort, by proposing explicit and meaningful affordances that fit with the mental model of end-users (i.e., older adults). Therefore, the goal of the designed services would be to ease the interaction, as well as supporting technology adoption and appropriation.
- **Perceived value.** The provided services by the conceived solution should be perceived as valuable by end-users. In other words, they should be deemed as necessary for enabling and facilitating the interaction with the system, as well as supporting both older adults and other family members in addressing their current requirements.
- **Understandability and accessibility.** The system should provide the means to understand the paradigm, the interaction context, and the ruling social norms linked to the functionality of the proposed services. For instance, point-to-point communication appears to be more ‘natural’ by older adults than group communication.
- **Trust and user-system confidence.** Users should feel they have the control over the system so they could be empowered to interact with the designed technology, and simultaneously trust on the offered services. For instance, the in-home deployment study results suggested that older adults were highly concerned on the implications of disclosing personal and sensitive information to their social networks. Therefore, the computer system should adapt its functionality to support this kind of behavior and encourage users to smooth their learning curve as an attempt to increase user-system appropriation.

Finally, by counting the number of design concerns grouped in each row, we can understand the relative importance of these themes with regard to their relevance on informing the design of other systems in the studied domain. In that respect, Table 11 summarizes the coverage of design concerns related to each core theme.

Table 11: Coverage of design concerns grouped in core themes

Core Theme	Coverage of Design Concerns
Communication	27
Coordination	37
Cooperation	32
User-System Interaction	32

It is not strange that, given the intrinsic cooperative nature of the informal elderly caregiving process—as discussed in Chapter 5—and the computer-mediated nature of intergenerational communication—as discussed in Chapter 4—, the most important core theme to address in the design of domestic social computing solutions in this domain is related to supporting coordination between the relevant stakeholders in the process. Similarly, both cooperation (i.e., socio-technical considerations for supporting both processes) and user-system interaction issues

also appear as highly relevant to address in order to achieve potentially effective solutions in the studied domain.

8.2 Formalization of Design Guidelines

Having grouped the identified design considerations throughout the conducted empirical work into core themes, we now organize and structure a set of design guidelines for all major stakeholders: older adults, family caregivers, and other family members. In that respect, we present in Table 12 a set of guidelines—reusable knowledge—to address the identified design concerns involving older adults.

Table 12: Design guidelines for mediating the interaction space of family members

Design Concerns	Design Guidelines	Supporting Evidence
COMMUNICATION		
COMM-1 Understand the complex and diverse living experiences of older adults and their family members in computer-mediated social interaction and informal caregiving (<i>based on design concerns #1, #2, and #24b</i>)	COMM-1.1 Balance the expectations of older adults with the current care provision that can be sustained by family members (i.e., assistants, monitors, and helpers)	[Barr14] [Lind08] Chapter 4 Chapter 5
	COMM-1.2 Design for a diversity of older adults regarding computer-supported communication media usage and levels of technology adoption	[Lind08] [Moff13] Chapter 7
	COMM-1.3 Structure a user context model regarding the individual preferences on communication media and available times for interaction	Chapter 3
	COMM-1.4 Structure a relationship context model considering the implicit agreements that shape the interaction between the older adult and other family members	Chapter 3
	COMM-1.5 The services to mediate the interaction between the older adult and other family members should be self-adaptive and explicitly respect the user preferences	[Lind08] [Lind09] [Muno15b] Chapter 3 Chapter 4
COMM-2 Provide contextual services to engage family members in a sustainable care provision for their older adults (<i>based on design concern #6b</i>)	COMM-2.1 Keep track of the older adults' interaction with the supporting system in an unobtrusive way (e.g., using ambient sensing for indirect activity and mood recognition)	[Guer15] [Roja14] Chapter 6 Chapter 7
	COMM-2.2 Structure a community context model covering the roles assumed by family members	Chapter 4 Chapter 5

	COMM-2.3 Keep track of the interaction and caregiving actions taken by every family member	Chapter 3 Chapter 4 Chapter 5
	COMM-2.4 Provide contextualized services to support family roles and current load in assuming caregiving tasks	Chapter 4 Chapter 5
	COMM-2.5 Map the performed caregiving tasks with the current requirements of older adults	Chapter 5
COMM-3 Encourage family interaction with older adults (<i>based on design concerns #7a, #19a, and #19b</i>)	COMM-3.1 Provide social and activity awareness to encourage family interaction	Chapter 4 Chapter 5
	COMM-3.2 Design personalized persuasive triggers to motivate the involvement of older adults on using the supporting system	Chapter 4 Chapter 5 Chapter 6
	COMM-3.3 Design positive computing mechanisms to engage family members and older adults in intergenerational exchanges	[Calv14] Chapter 4 Chapter 5
	COMM-3.4 Support gamification mechanisms to engage family members in intergenerational exchanges	Chapter 4 Chapter 5
	COMM-3.5 Use the history of interaction and caregiving actions taken by the family members to decide how to deliver awareness notification and personalized persuasive triggers to mediate intergenerational exchanges	Chapter 3 Chapter 4 Chapter 5
	COMM-3.6 Design social awareness messages sent to family members to increase their engagement on interacting with their older adults	Chapter 7
	COMM-3.7 Design social triggers to increase the frequency of asynchronous exchanges (e.g., sending photos or emails) and synchronous calls	Chapter 7
	COMM-3.8 Provide awareness on failed attempts to initiate intergenerational synchronous exchanges (e.g., missed calls)	Chapter 6 Chapter 7
COMM-4 Support users to overcome the implicit and explicit barriers for using computing systems by promoting technology acceptance and appropriation (<i>based on design concerns #8a and #25</i>)	COMM-4.1 Prioritize usability, perceived value, understandability, and user-system confidence in design	[Baec14] [Lind08] Chapter 6
	COMM-4.2 Encourage system usage: design tutorials and positive rewards that highlight the benefits of using technology for mediating intergenerational communication	Chapter 4
	COMM-4.3 Design mechanisms to allow older adults become active actors in their own caregiving experience	Chapter 3 Chapter 4 Chapter 5

	COMM-4.4 Be aware of and respect privacy preferences among older adults (e.g., regarding disclosure of personal matters within their social networks)	Chapter 7
COMM-5 Consider the structure of the family ecosystem (<i>based on design concern #11a</i>)	COMM-5.1 Structure a community context model covering the roles assumed by family members	Chapter 4 Chapter 5
COMM-6 Promote active aging (<i>based on design concern #22b</i>)	COMM-6.1 Design positive mechanisms to engage older adults in becoming active actors in their interaction with other family members	[Calv14] Chapter 4 Chapter 5
	COMM-6.2 Encourage active aging through personalized messages and persuasive triggers	Chapter 5
COMM-7 Increase the perceived connectivity within the family network (<i>based on design concern #26</i>)	COMM-7.1 Provide frequent interaction and community awareness mechanisms to understand the interaction flow within the family network	Chapter 5 Chapter 6 Chapter 7
	COMM-7.2 Design family visualizations to understand the interaction flow within the family network	[Shi14] Chapter 5
COORDINATION		
COORD-1 Recognize the diversity of living experiences for coordinating the available resources to sustain caregiving work (<i>based on design concerns #2, #3b, and #23</i>)	COORD-1.1 Value in design the main preferences, attitudes, expectations, viewpoints, and concerns regarding technology usage for intergenerational communication and informal elderly caregiving	Chapter 3 Chapter 4 Chapter 5
	COORD-1.2 Recognize and respect the concerns of user roles for articulating the caregiving process	Chapter 4 Chapter 5 Chapter 7
	COORD-1.3 Structure a user context model regarding the individual preferences on communication media and available times for managing the caregiving process	Chapter 3
	COORD-1.4 Structure a relationship context model considering the implicit agreements that shape the interaction between the older adult and other family members	Chapter 3
	COORD-1.5 The services to mediate the interaction between the older adult and other family members should be self-adaptive and explicitly respect the user preferences	[Lind08] [Lind09] [Muno15b] Chapter 3 Chapter 4
	COORD-1.6 Align the social interaction spaces of family members	Chapter 3 Chapter 6

	COORD-1.7 Provide a mechanism to ensure message mediation from multiple sources: allow the interaction through different media by properly transforming and dispatching content, requests, and notifications	[Corn13] [Muno15] Chapter 3 Chapter 6 Chapter 7
COORD-2 Articulate the caregiving work (<i>based on design concerns #3a, #5, #7a, #12, and #14</i>)	COORD-2.1 Computer-supported solutions must be able to identify when they should mediate the caregiving process by properly notifying the required intervention to the relevant stakeholders	Chapter 4 Chapter 5
	COORD-2.2 Provide situation awareness about family caregivers and monitors to articulate the process and balance the load and to keep updated older adults about the doings and whereabouts of their relatives	Chapter 5
	COORD-2.3 Use the history of interaction and caregiving actions taken by the family members to decide how to deliver awareness notification and personalized persuasive triggers to coordinate the caregiving process	Chapter 3 Chapter 4 Chapter 5
	COORD-2.4 Provide social and activity awareness to articulate the caregiving process within the family network	Chapter 4 Chapter 5
	COORD-2.5 Ensure that the feedback loop is complete as a way to inform relevant family members about the current level of care provision	Chapter 5
	COORD-2.6 Design positive computing mechanisms to coordinate family members in the caregiving process	[Calv14] Chapter 4 Chapter 5
	COORD-3 Balance the caregiving work across the family network (<i>based on design concerns #6a and #18</i>)	COORD-3.1 Make visible the caregiving work by empowering informal caregivers to delegate tasks and keep track of the interaction network with the older adult
COORD-3.2 Complete the feedback loop in information provision as a way to visualize the current caregiving provision to older adults		Chapter 5 Chapter 7
COORD-4 Provide contextualized services to coordinate the caregiving activities within the family network (<i>based on design concerns #6b and #11b</i>)	COORD-4.1 Structure a community context model covering the roles and commitments assumed by family members	Chapter 4 Chapter 5
	COORD-4.2 Conceive self-adaptive services that contextually intervene the process	Chapter 5
COORD-5 Ensure the assumption of family roles for articulating caregiving	COORD-5.1 Keep track of the interaction and caregiving actions taken by every family member	Chapter 3 Chapter 4 Chapter 5

work (<i>based on design concern #11a</i>)	COORD-5.2 Provide new functionality adapting to the current level of technology adoption of the older adult	Chapter 3 Chapter 4
COORD-6 Gender matters in coordinating the caregiving effort among assistants and monitors (<i>based on design concerns #15a, #15b, and #18</i>)	COORD-6.1 Provide the means to sustain the involvement of both female and male assistants and monitors by respecting their concerns and ensuring that they complement their approaches to deal with their duties	Chapter 5
COORD-7 Support users to overcome the perceived barriers for technology appropriation linked to the perception of family caregivers (<i>based on design concern #22a</i>)	COORD-7.1 Visualize the evolution in technology appropriation of older adults through family dashboards	[Shi14] Chapter 5
	COORD-7.2 Encourage active aging through personalized messages and persuasive triggers	Chapter 5
COOPERATION		
COOP-1 Recognize the diversity of living experiences for sustaining the cooperative nature of caregiving work (<i>based on design concerns #2 and #4b</i>)	COOP-1.1 Structure a user context model regarding the individual preferences on communication media and available times for managing the collaborative experience of caregiving work	Chapter 3
	COOP-1.2 Structure a relationship context model considering the implicit agreements that shape the interaction between the older adult and other family members	Chapter 3
	COOP-1.3 The services to sustain the collaborative experience of caregiving between the older adult and other family members should be self-adaptive and explicitly respect the user preferences	[Lind08] [Lind09] [Muno15b] Chapter 3 Chapter 4
	COOP-1.4 Mediate the social interaction space of family members, either by providing personalized awareness and/or persuasive triggers	[Muno15] Chapter 3 Chapter 6 Chapter 7
COOP-2 Mitigate the negative effects of caregiver burden (<i>based on design concerns #6a and #18</i>)	COOP-2.1 Conceive the means to reduce burden in informal caregiving	[Chen13] [Papa07] Chapter 4 Chapter 5 Chapter 7
	COOP-2.2 Sustain the involvement of both female and male caregivers by respecting their concerns and ensuring that they complement their approaches to deal with their duties	Chapter 5

	COOP-2.3 Reduce as much as possible the effort of family members for initiating intergenerational exchanges and assuming informal caregiving activities	[Corn13] [Muno15] Chapter 6 Chapter 7
COOP-3 Provide contextualized services to sustain the cooperative nature of informal elderly caregiving (<i>based on design concern #6b</i>)	COOP-3.1 Structure a community context model covering the roles and commitments assumed by family members in informal caregiving activities	Chapter 4 Chapter 5
	COOP-3.2 Design mechanisms to contextually sustain the cooperation across the family network	Chapter 5 Chapter 6 Chapter 7
COOP-4 Support users to overcome the perceived barriers for technology appropriation (<i>based on design concerns #8b and #22a</i>)	COOP-4.1 Design positive mechanisms to engage older adults in becoming active actors in their interaction with other family members	[Calv14] Chapter 4 Chapter 5
	COOP-4.2 Encourage active aging through personalized messages and persuasive triggers	Chapter 5
	COOP-4.3 Provide social and activity awareness mechanisms (e.g., visualizations or dashboards) about the current commitment of family members to balance the load among informal caregivers	[Shi14] Chapter 5
	COOP-4.4 Provide social and activity awareness mechanisms (e.g., visualizations and dashboards) to encourage the involvement of family members in intergenerational communication and collaborative informal caregiving duties	[Shi14] Chapter 5
COOP-5 Sustain contextualized collaborative roles for managing the caregiving process (<i>based on design concerns #11a and #13</i>)	COOP-5.1 Keep track of the interaction and caregiving actions taken by every family member, including both older adults and members in the supporting caregiving network	Chapter 3 Chapter 4 Chapter 5
	COOP-5.2 Provide new functionality adapting to the current level of technology adoption of the older adult	Chapter 3 Chapter 4
COOP-6 Promoting collaboration across the informal elderly caregiving experience (<i>based on design concerns #12, #16, #17, #19a, and #22b</i>)	COOP-6.1 Provide situation awareness about family caregivers and monitors to articulate the process and balance the load	Chapter 5
	COOP-6.2 Provide social and activity awareness to articulate the caregiving process	Chapter 4 Chapter 5
	COOP-6.3 Ensure that the feedback loop is complete	Chapter 5
	COOP-6.4 Design positive computing mechanisms to coordinate family members in the caregiving process	[Calv14] Chapter 4 Chapter 5
	COOP-6.5 Encourage active aging through personalized messages and persuasive triggers	Chapter 5

	COOP-6.6 Make visible the caregiving work activities, as a way to encourage helpers subscribe to particular requests of monitors and assistants	Chapter 5
	COOP-6.7 Encourage the participation of family members through social awareness messages, tailored to the current status of the older adult	Chapter 7
COOP-7 Increase the perceived connectivity within the family network (<i>based on design concern #26</i>)	COOP-7.1 Provide frequent interaction and community awareness mechanisms to understand the computer-mediated interaction flow within the family network	Chapter 5 Chapter 6 Chapter 7
	COOP-7.2 Design family visualizations to understand the interaction flow within the family network	[Shi14] Chapter 5
USER-SYSTEM INTERACTION		
USI-1 Recognize and respect diversity of family members around computer-supported technology to mediate their social interaction space (<i>based on design concerns #1a, #2, #4b, and #9</i>)	USI-1.1 Balance the expectations of older adults with the actual care provision that can be sustained by family members	[Barr14] [Lind08] Chapter 4 Chapter 5
	USI-1.2 Design for a diversity of older adults regarding media usage and levels of technology adoption	[Lind08] [Moff13] Chapter 7
	USI-1.3 Structure a user context model regarding the individual preferences on communication media and available times for initiating and mediating intergenerational exchanges within the family network, as a way to personalize the mediation services provided to family members	Chapter 3
	USI-1.4 Structure a relationship context model considering the implicit agreements that shape the interaction between the older adult and other family members, as a way to personalize the mediation services provided to family members	Chapter 3
	USI-1.5 The services to mediate the interaction between the older adult and other family members should be self-adaptive and explicitly respect the user preferences	[Lind08] [Lind09] [Muno15b] Chapter 3 Chapter 4
USI-2 Respect as much as possible the pre-existing environment of older adults when designing and deploying in-home technology (<i>based on design concern #1b</i>)	USI-2.1 Support interactions around common routines among older adults and the rest of the family (e.g., through augmenting habituated domestic objects located at home)	[Brer13] [Brer15] Chapter 6

	USI-2.2 Consider reducing the potential impact that the introduction of new technology would have in the home of older adults (e.g., adapt the services provided by the deployed system to the current daily routines of end-users)	[Muno15] Chapter 6 Chapter 7
USI-3 Support technology appropriation (<i>design concerns #4a, #7b, #10a, #10b, #20, and #21</i>)	USI-3.1 Provide bidirectional feedback to older adults on their interaction with the system (e.g., through badges or audible notifications)	[Corn13] Chapter 6 Chapter 7
	USI-3.2 Provide continuous assistance to the older adult through simple but meaningful alerts or other kinds of notifications	[Corn13] [Gara12] Chapter 6 Chapter 7
	USI-3.3 Allow family members to use their preferred communication media and digital mechanisms to engage in intergenerational exchanges from/to older adults	[Corn13] [Muno15] Chapter 6 Chapter 7
	USI-3.4 The visual metaphor of service icons should be supported with meaningful text labels	[Kurn05] [W3C08] Chapter 6 Chapter 7
	USI-3.5 Prioritize natural user interaction commands over artificial ones (e.g., speech-to-text mechanisms instead of virtual keyboards)	Chapter 6 Chapter 7
	USI-3.6 Reduce user anxiety by providing meaningful metaphors to hide possible long system processing times	[Kurn05] [W3C08] Chapter 6 Chapter 7
	USI-3.7 Provide interaction services that fit the mental model of older adults in terms of social media adoption and appropriation (e.g., visual services; point-to-point over group communication; audio-video calls rather than only audio)	Chapter 6 Chapter 7
USI-4 Encourage system interaction (<i>based on design concern #7a</i>)	USI-4.1 Provide meaningful and concrete metaphors that help the older adult easily recognize the main functionality proposed by the system	[Corn13] [Muno15] Chapter 6 Chapter 7
	USI-4.2 Provide contextual shortcuts and meaningful affordances fitting the mental model of older adults interacting with the system (e.g., accessible menus, understandable service icons, and representative metaphors) to help older adults be aware of the navigation schema of the deployed system	[Muno15] Chapter 6 Chapter 7

	USI-4.3 Shortcuts and menus improving the understanding of the navigation architecture of the designed system should be easily reachable and be available as much as possible	[Muno15] Chapter 6 Chapter 7
	USI-4.4 Provide automatic login services to reduce the need in older adults of unnecessary managing usernames and passwords	[Muno15] Chapter 6 Chapter 7
	USI-4.5 Allow family members to use their preferred communication media and digital mechanisms to engage in intergenerational exchanges and coordinate caregiving tasks in favor of their older adults	[Corn13] [Muno15] Chapter 6 Chapter 7
	USI-4.6 Reduce as much as possible the effort of family members for initiating intergenerational exchanges	[Corn13] [Muno15] Chapter 6 Chapter 7
	USI-4.7 Contextually support the form of delivering awareness notifications using different media capabilities (e.g., visual badges, sound alerts)	Chapter 5 Chapter 6 Chapter 7
USI-5 Support users to overcome the perceived barriers for technology appropriation (<i>based on design guidelines #8a, #8b, and #25</i>)	USI-5.1 Empower older adults to be the main actors in design, reflecting on their needs, attitudes, and current expectations toward technology deployment and inclusion	Chapter 3 Chapter 4 Chapter 5 Chapter 6
USI-6 Aligning asymmetries across the family network (<i>based on design guidelines #9 and #24b</i>)	USI-6.1 The services to sustain the collaborative experience of caregiving between the older adult and other family members should be self-adaptive and explicitly respect the user preferences	[Lind08] [Lind09] [Muno15b] Chapter 3 Chapter 4
	USI-6.2 Provide a mechanism to ensure message mediation from multiple sources: allow the interaction through different media by properly transforming and dispatching content, requests, and notifications	[Corn13] [Muno15] Chapter 3 Chapter 6 Chapter 7
USI-7 Accompany users along their learning curves by promoting technology adoption and appropriation by older adults (<i>based on design guideline #13</i>)	USI-7.1 Provide new functionality adapting to the current level of technology adoption of the older adult	Chapter 3 Chapter 4
	USI-7.2 Design mechanisms to allow older adults become active actors in their own caregiving experience	Chapter 3 Chapter 4 Chapter 5
	USI-7.3 Be aware of and respect privacy preferences among older adults	Chapter 7

	USI-7.4 Prioritize usability, perceived value, understandability, and user-system confidence in design	[Baec14] Chapter 6
	USI-7.5 Encourage system usage: design tutorials and positive rewards that highlight the benefits of using technology for mediating intergenerational communication	Chapter 4
USI-8 Facilitate the reachability of technology access (<i>based on design guideline #24</i>)	USI-8.1 Deploy technology at a place easily recognizable and reachable by older adults	Chapter 7

The current iteration of SocialConnector adheres to most of the proposed design guidelines presented above. For instance, its design was conceived around the idea of a digital photo frame, which highlights the metaphor of an interaction device supporting media content similar to a painting hanging on a wall. In that respect, using a Tablet PC as supporting hardware offers the convenience of either fixing the system to a wall or moving it around the home at convenience.

Older adults considered that the system is easy to use, as it was iteratively co-designed with the continuous feedback of a group of elderly users who participated in the design and prototyping stages of development. Regarding its functionality, SocialConnector provides visual awareness badges and sound alerts (*Capturer of the User Attention* [Mona14]) to give feedback and remind the older adult that new content is available on the system (e.g., new photos or messages). It also provides continuous feedback on the current status of the system on its navigation schema through visual affordances. Finally, SocialConnector automatically keeps track of the system usage by older adults without disrupting their daily routines or that of their family members also interacting through it.

SocialConnector also provides support to most of the design guidelines proposed for informal family caregivers. The most important feature in terms of supporting system interaction is that SocialConnector allows all members in the supporting network to use their preferred media, at their own available times, for initiating intergenerational exchanges with the older adult. This offers flexibility on media channels for bridging the communication between both parties by supporting synchronous and asynchronous mechanisms, as well as SocialConnector acting both as a communication hub and dispatcher.

Furthermore, besides interacting with the older adult, informal caregivers—assistants and monitors—used the system to manage the information flow within the network, e.g., by acting as brokers of other family members. This was achieved through periodic personalized social awareness reminding messages, informing about the overall activity within the interaction network. Based on the mapping of design guidelines with the current implementation of SocialConnector, one of the future iterations in the development of the system will consist in implementing the conceived visualizations for understanding the global interaction within the network, as a way to assist informal caregivers to coordinate and articulate the effort on conducting caregiving work.

Finally, SocialConnector also adheres to most of the proposed design guidelines targeted to family members in the surrounding caregiving and interaction network. Nevertheless, one of the future actions to take in the design of future iterations of the system will be to model the interaction of family members with the older adult as a way to instantiate personalized persuasive triggers to encourage their interaction following principles based on positive psychology. For instance, design components can be inspired by promoting empathy, reinforcing shared memories, and stressing on the benefits for wellbeing that can be achieved through social interaction.

8.3 Considerations on the Software Support for Computer-Mediated Caregiving

There are two structural aspects that must be considered by software designers during the conception and modeling of computer-mediated informal elderly caregiving solutions: (1) the software evolution and (2) its adaptability. The first aspect is required not only due to evolving maintenance reasons—extensions to the system—but also because of the continuous advances of scientific knowledge and evolving supporting technology, which give developers the opportunity to frequently improve the implementation of particular components (e.g., the deployed awareness mechanisms, the decision-making or monitoring processes, and the support for assuming family roles). In that sense, using a layered software architecture allows systems to group their functionality according to particular concerns, e.g., communication, coordination, and cooperation components.

Moreover, the functionality related to each concern (i.e., each layer of the software architecture) can be encapsulated in particular components (i.e., specialized modules that interact with others through a software interface). This reduces the coupling between components and increases the flexibility, maintainability, and evolution capability of the components and the supporting system. Therefore, this improves the evolution capability of these systems, which is the first structural aspect to be considered in the system design.

Concerning the system adaptability, several reasons justify the need to take into account this aspect: (1) there is a large diversity of caregiving ecosystems and needs of older adults that should be recognized; (2) there are several roles assumed by family members, which might evolve in time; and (3) while interacting with the system, both older adults and family members experience a learning effect. Therefore, the system should be context-aware, where its adaptability should be ensured automatically depending on the current parameters of the caregiving process. This means that a context representation is required, which must be automatically updated according to the system evolution and the services that need to be enabled or disabled depending on the values of the context variables that model the concerned ecosystem. In that respect, a decision-making mechanism should be embedded into the system to determine how to adapt its services according to the inferred context values.

Summarizing, in order to address the evolution and adaptability of the caregiving supporting system, it is recommended that the software architecture should be layered, modularized, and include context-aware services. These structural recommendations do not represent a contribution per se, since most of the literature in engineering interactive collaborative systems supports these proposals (e.g., [Antu12, Hers11, Neye08, Neye09, Schu07]). However, by assuming such a software structure, we are in position to conceive a process to use the proposed design guidelines.

8.4 Using the Design Concerns and Guidelines

First of all, it is important to note that it is usually unfeasible to conceive a supporting system able to address the wide variety of caregiving scenarios. Therefore, software designers should define a target scenario that will take into account several variations depending on the context variables considered to describe it. The first step in the conception of these systems is to determine the general scenario to be supported as well as its variability. Then, the designer should address the life cycle of the system according to the chosen development approach. In this section we show how the proposed design concerns and guidelines in this dissertation can be used to support a generic development process, without adhering to a particular methodology or approach (e.g., waterfall, incremental, or agile). In that respect, Figure 34 depicts the activities influenced by the stated design concerns and guidelines.

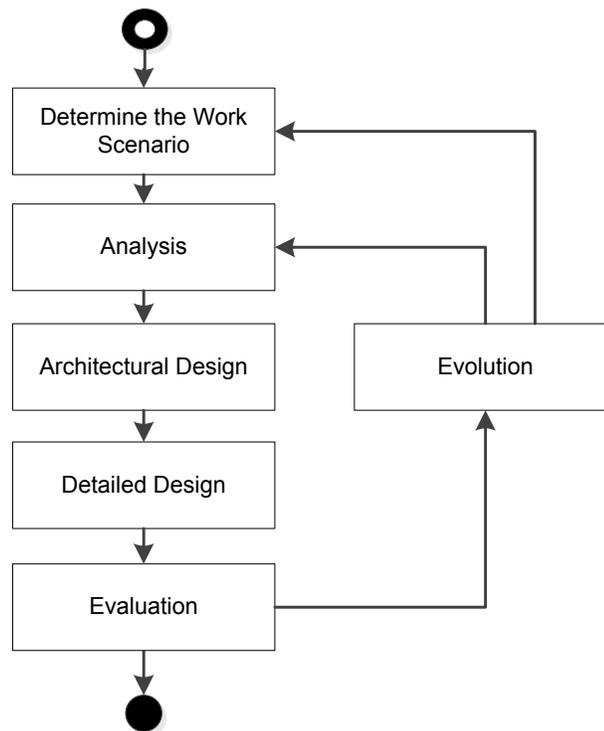


Figure 34: Major activities supported by the proposed design concerns and guidelines

8.4.1 *Determine the Work Scenario*

As mentioned before, social ecosystems are complex and diverse, and it is usually unfeasible to address such a diversity using a single solution. Therefore, software designers and developers should limit the scenarios to be intervened in order to provide suitable, effective, and contextualized services to users. The defined design concerns help developers get an overview of the whole process and identify target scenarios. For instance, the system could be focused on improving the coordination activities in the caregiving process by reducing thus the overload on the people playing the role of assistant (concerns #6a and #18).

In this case, the focus of the solution will be in providing the services required by assistants and monitors to be aware of the activities of other members, and the services required to address their commitment in a simple/fast way (concerns #3a, #7a, #11b, #16, and #17). Considering such

an application scenario, the developer should determine the variability (i.e., the particular work contexts) to be mediated by the solution under development. For instance, the system should be able to self-adapt whether there are only assistants, only monitors, or both of them. The same analysis can be done considering other context variables like gender or the type of need of older adults that requires attention. The output of this stage in the overall process is, therefore, the definition of the work scenario to be supported, including its variability. In that respect, the identified design concerns inform such a process.

8.4.2 Analysis

In this phase the developer establishes the rules, the involved actors, the services to be provided by the solution and its expected quality. In order to do that, and considering the initial definition performed in the previous stage, the developer should (approximately) follow these steps:

1. **Define the work context to be considered in the solution.** In this case, the context variables of the matrix presented in Section 5.4.1 should be defined and prioritized according to the frequency and relevance of the needs of the older adult that require support.
2. **Define the general process and its variability.** The specification of the particular caregiving process that is going to be affected—in this case, the family caregiving of older adults in the Southern Cone of America—should adhere to the general process defined in Section 3.2.
3. **Define actors and the relationship among them.** This activity determines the actors (i.e., roles) that are present in the work scenario and the relationship among them. The structure of such roles should match with the family communication metamodel shown in Figure 10. In that respect, Herskovic [Hers10] proposed a method and a visual language to represent this information in a collaborative scenario, based on the potential interactions among the participating roles. Such a proposal can be used to identify roles and represent the relationships among them.
4. **Define functional requirements (interaction and business-focused).** This activity determines the services that should be provided by the supporting application mainly to end-users. In that respect, the proposed design concerns represent a key input to identify these services. For instance, the design concern #3a indicates that a coordination service appears as required by the system in order to manage the information flow within the informal caregiving network.
5. **Define non-functional requirements (e.g., usability, security, privacy, and restrictions).** Similar to the previous activity, the design concerns also inform the non-functional requirements involved in the system. For instance, the design concern #3b indicates that the effort invested by family members in caregiving tasks should be coordinated and aligned to their inherent attitudes, values, and expectations toward the process. This establishes restrictions to the system behavior.

It is worth noting that the design concerns identified in this thesis work do not represent an exhaustive list of requirements to be considered in the development of a family caregiving supporting system. Instead, they represent a list of suggestions to be taken into account, given that they are considered as in the conception and design of this type of application. It is also

important to remark that the design concerns imply guidelines to identify functional and non-functional requirements not only during the analysis phase, but also in the whole software project.

8.4.3 *Architectural Design*

In this phase, the structure and main features of the system are defined. Considering the structure of the 3C model and the literature of the area (e.g., [Elli91, Fuks05, Guti15, Hers11]), it is recommended that the architectural design adheres to a layered infrastructure and its behavior be context-aware. In order to do that, the following activities should be performed:

1. **Define a macro-structure of the system.** This stage consists in determining the number of layers to be used, the responsibility of each layer, and the dependencies—interactions—among them. In this sense, the 3C model establishes three layers by default: communication, coordination, and cooperation. The design guidelines presented in this dissertation establish a fourth one: user-system interaction, tightly linked to context-awareness support. This matches with the architecture presented in Section 6.1.2 (cf. Figure 21).
2. **Define the context models.** This activity considers the definition of the context models that will support the system self-adaptation and the variability of the caregiving process. This includes the user context, the relationship context, and the caregiving context models. The design concerns inform the part of the structure supported by these context models. For instance, the design concern #4b indicates that context variables related to the attitudes, expectations, viewpoints, and concerns of family members should be represented, since they should be then used in the personalization of caregiving services provided by the system.

8.4.4 *Detailed Design*

In this stage the developer determines the details of system composition and behavior. This includes the following major activities:

1. **Structure the detailed process to be supported.** It includes the particular process—with its variability. This formalization should adhere to (or be informed by) the model proposed in Figure 10 (cf. Section 3.2).
2. **Define the supporting services and the quality attributes of the solution.** Tables 12, 13, and 14, which map design concerns to particular design guidelines for each relevant stakeholder in the studied domain, provide suggestions about how the functional and non-functional requirements can be addressed through the provision of particular services or infrastructure components. Similarly, Table 11 groups the design concerns in core themes (i.e., layers of the system architecture), which help determine the components of each tier. Furthermore, the design concerns determine minimum acceptable values for key quality attributes, such as usability and privacy.
3. **Support the service adaptability.** This activity determines how the behavior of the supporting services should be adapted considering the status of the context (individual and global). In this sense, the design concerns inform how such a self-adaptability process could be done.

8.4.5 Evaluation

This stage helps both measure and understand the impact of the system on the target process, including its usability and usefulness (i.e., the perceived value). Typically these systems are evaluated by the development team and then by a sample of real users. These activities are respectively known as *system* and *acceptance tests*.

1. **Conduct the system tests.** The system tests are performed by members of the development team who try to guess the behavior of real users. In this sense, the design concerns identified in this thesis work help infer a part of such behavior for the roles participating in the process. In other words, they inform some of the testing parameters, which will be used to validate the performance of the conceived system.
2. **Conduct the acceptance tests.** The acceptance tests are performed by real users who interact with both the system and other people according to the role they are assuming. This activity is the closest to a user experience evaluation, in which the system usability and usefulness are both measured in a real work scenario. The design concerns and their relationship with the guidelines help understand the results of these tests, which provide useful feedback to validate architectural decisions.

These evaluation activities, informed by the proposed design concerns, can also be used to determine the suitability of already implemented systems that are proposed to support a particular work scenario. For instance, the methods proposed by Antunes et al. [Antu12, Antu14] and Herskovic [Hers11] can be used to perform such an evaluation process.

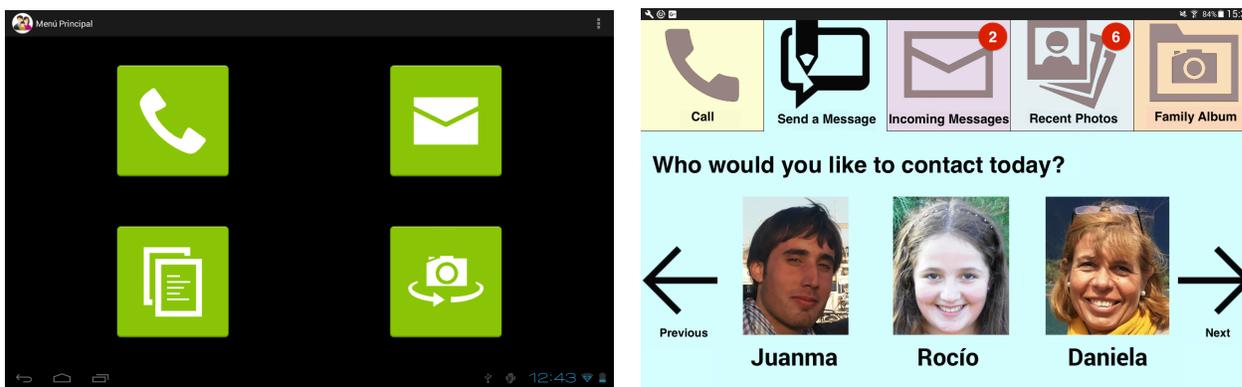
8.4.6 Evolution

Finally, this stage captures the natural evolution of the system due to several reasons, such as the learning effect of the users, technology advances, or change in the caregiving scenario. It consists on the redefinition and/or adjustments to the previous work scenario, process to be supported, or provided services by the solution. Therefore, it establishes a new scenario to be addressed. In this sense, having a layered and modularized architecture provides flexibility in the capability to evolve the solution in an incremental way, according to the particular needs and availability of the development team.

8.5 Putting the Design Guidelines into Practice

As a way to show how the proposed design guidelines can be used to refine the design of already developed systems, we briefly compare the result of two iterations of the development of the SocialConnector system: (1) the system design after concluding the initial ethnographic study reported in this dissertation, i.e., Chapter 3; and (2) its design after formalizing the guidelines through the analysis of the reported empirical work, i.e., Chapters 6 and 7. For reference, Figure 35 compares the main user interface of both versions of the system.

The version 1 of SocialConnector (cf. Figure 35–a) allows users to do a videoconference, exchange emails—private messages—, exchange public messages—through Facebook—, and display photos from family members that are automatically retrieved from the Facebook public accounts of these people.



(a) Version 1 – 2014

(b) Version 2 – 2016

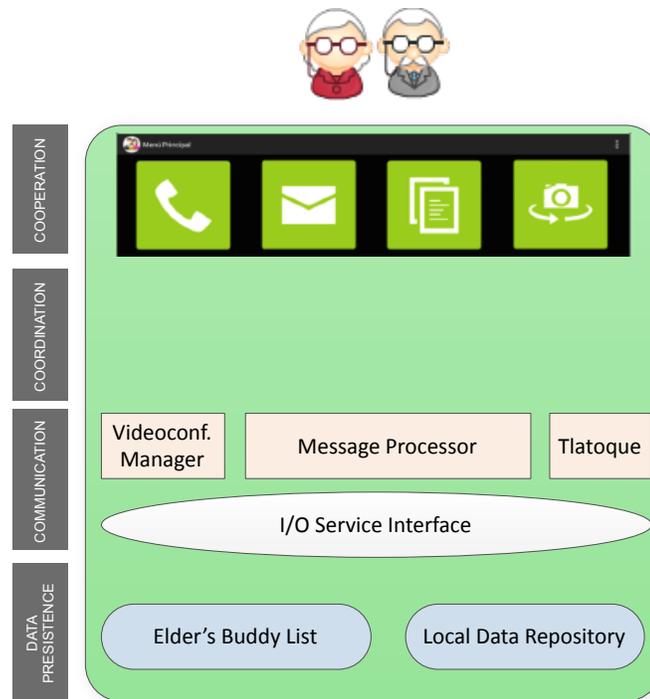
Figure 35: Comparative view of the user interface of two iterations of SocialConnector

Although the first version of SocialConnector already considers some of the proposed design guidelines (e.g., *COOP-2.3*, since it embeds the Tlatoque service [Corn13]), the user interface was considered as being partially usable and useful for the older adults. For instance, it does not address the design concerns *USI-3*, *USI-4*, and it partially adheres to *COMM-4*). Moreover, the service for exchanging public messages was perceived as not valuable by older adults, since this communication paradigm did not match with the mental model of the elderly (*design concern USI-3*). Therefore, such a service was removed in the next version of the system.

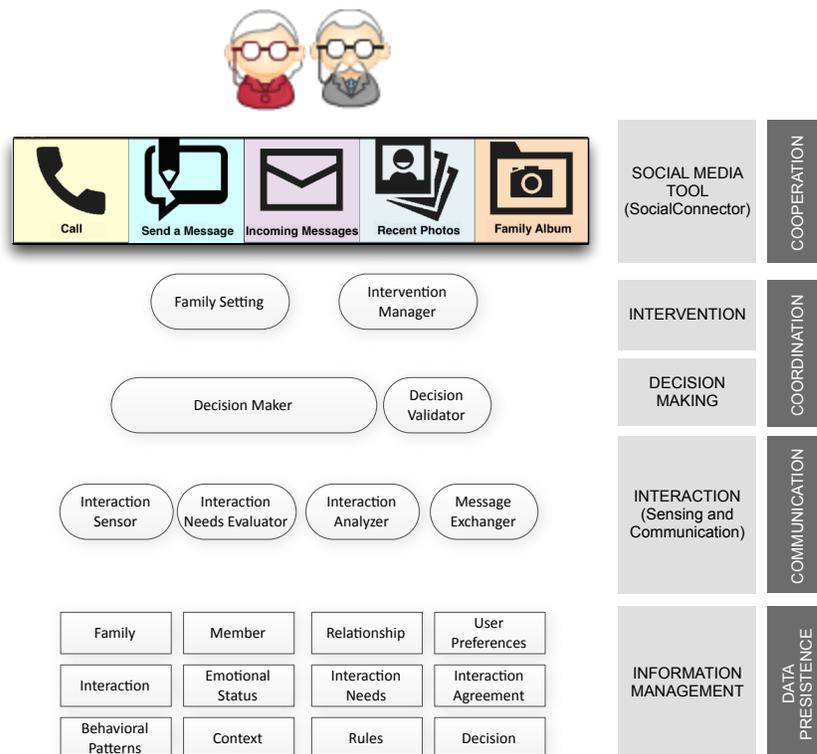
In the version 2 of the system, we included several features that tried to improve the usability, understandability, and usefulness of the system services. We also aimed to improve the user confidence in the system (*guidelines COMM-4.1* and *USI-7.4*). For instance, the visual metaphor of services was enhanced with text labels (*guideline USI-3.4*), the main menu is visible at all times (*guidelines USI-4.1* and *USI-4.3*), and the user interface automatically returns to the main menu when the user finishes using an interaction service (*guideline USI-4.2*). Furthermore, awareness about new information was supported through visual badges (*guidelines USI-3.1* and *USI-4.7*).

Concerning the system structure, Figure 35 comparatively shows the architecture of both versions of SocialConnector. Although version 1 was layered, it did not explicitly consider the separation of concerns according to the 3C model, and it was not context-aware as it did not address the design concerns *COMM-1*, *COMM-2*, *COMM-5*, *COORD-1*, *COORD-4*, *COOP-1*, *COOP-3*, *COOP-5*, *USI-1*, and *USI-4*. Therefore, the system was not able to deal with the asymmetries among family members nor respect their preferences (*design concerns COMM-1*, *COMM-4*, *COORD-1*, *COOP-1*, *USI-1*, *USI-6*, and *USI-7*).

The version 2 of SocialConnector is indeed context-aware and self-adaptable. Therefore, it allows dealing with most of the design concerns that were not addressed by the first version. Moreover, it implements an automatic login service to reduce the need of managing usernames and passwords (*guideline USI-4.4*), which older adults considered as problematic in earlier versions of the system. Besides, we integrated an automatic switch in the system that turns on and off the screen of SocialConnector when older adults are sleeping, thus reducing the potential impact that the introduction of new technology would have in the home of older adults (*guidelines USI-2.2*, *USI-4.1*, and *USI-7.3*).



(a) Version 1 – 2014



(b) Version 2 – 2016

Figure 36: Comparative view of the system architecture of two iterations of SocialConnector

The system also automatically retrieves messages and photos from the public social media accounts of the family members participating in the system, hence providing situational

awareness to older adults about the doings and whereabouts of their relatives (*guideline COORD-2.2*). In that respect, special attention was given to providing the means to family members for initiating intergenerational exchanges without burdening them with unnecessary system account creation (*guidelines USI-4.5* and *USI-4.6*). Therefore, the followed design decision was to enable SocialConnector to mediate the interaction within the family network through the preferred mechanisms of every family member, acting both as a hub and dispatcher respecting the incoming communication channel, if supported.

Concerning the perceived value of the system, through interacting with older adults during prototyping, we enhanced the value of visual information. In that respect, older adults particularly appreciated visual interaction with the system, such as photo albums, videoconferences, and birthday reminders (*guideline USI-3.7*). Therefore, if users perceive the value of having a digital device such as SocialConnector installed in their homes, and the deployed system does not unnecessarily disrupt them, then older adults progressively assume the technology as part of their lives (*guidelines USI-7.1* and *USI-8.1*). In our case, given that SocialConnector is also capable of sensing the mood of older adults—as part of an experimental broader health monitoring and sustainable care model—having the system actively being used by the participants is mandatory for achieving such goal. Similarly, by providing easy ways to family members for engaging with the system (such as wrapping the incoming communication inputs, automatically transforming them into content manageable by SocialConnector, and dispatching outgoing calls and/or messages through the preferred communication media of family members), then the system turns out valuable for mediating the process (*guidelines COMM-1.5, USI-4.5, and USI-4.6*).

This brief example illustrates how the design concerns defined in this thesis work can be used to identify opportunities for improving already implemented solutions. Similarly, it also shows how the proposed guidelines may inform the design the services and components that allow overcoming the previously identified limitations.

8.6 Limitations

We recognize that while valuable, the proposed design guidelines share limitations with the work reported in this dissertation. We focused, for convenience reasons, on a country—Chile—that is in transition to development, while simultaneously sharing cultural traits of America, Western Europe, and of course, Latin America.

There is an opportunity in complementing the presented findings with additional studies in other South American countries (e.g., focusing in diverse areas of Argentina and Uruguay). This suggests additional research in family communication, social computing, and computer-supported cooperative work aiming to enrich our knowledge in understanding the dynamic needs of the involved stakeholders in the informal caregiving process, with a larger representation of similar socio-cultural communities.

8.7 Summary

In this chapter we synthesized the induced design implications throughout the revision and discussion of related work, as well as the findings obtained from a collection of four empirical studies (three observational and one experimental). When grouping these design concerns

according to the relevant stakeholders affected by them, i.e., older adults, informal family caregivers, and other family members, we identified four major themes:

- Behavioral considerations for promoting an effective social interaction space mediation.
- Coordination and articulation considerations for facilitating computer-supported caregiving work.
- Socio-technical considerations for involving the family network in the collaborative informal caregiving process.
- Environmental and contextual considerations for developing and deploying computer-supported technology involving older adults.

We identified a set of design guidelines—grounded in empirical work—that would help social computing researchers, designers, and practitioners better understand the complexity of the studied scenario. One of the particular notes that can be inferred from the proposed design guidelines is that in this kind of social ecosystem, computer-supported solutions dealing with intergenerational exchanges should transversally consider the broad attitudes, interests, expectations, viewpoints, and concerns of all involved stakeholders due to the highly-coupled cooperative nature of the informal caregiving process. Similarly, key quality attributes—such as usability, perceived value, understandability, and user-system confidence—should be considered in the design of any computer-supported solution aiming to mediate the social interaction space of family members in the studied context.

Therefore, by following the proposed guidelines, it would be possible to identify plausible solutions that would improve user experience and the effectiveness of computer-supported mediation strategies in intergenerational communication and informal elderly caregiving. We also highlighted how these guidelines can be used as a reference framework for assisting social software designers into taking informed architectural decisions. Finally, as a working example, we showed how we improved the design of SocialConnector through iterative prototyping with older adults, guiding the process with the design concerns implied by the proposed guidelines.

8.8 Contributions of the Work Presented in this Chapter

The reported work in this chapter summarizes and structures the design implications inferred from the previous empirical studies presented throughout Chapters 3 to 7. In particular, this chapter provides four main contributions:

- It structures design implications according to common themes, involving several design concerns that need to be addressed in domestic computing solutions for mediating intergenerational communication and supporting informal elderly caregiving.
- It also structures the main concerns of the identified design implications according to the particular expectations, viewpoints, and concerns of the involved stakeholders in the process: older adults, adult children assuming the role of informal elderly caregivers, and other family

members potentially affected by computer-supported mediation strategies to bridge the social interaction scenario of older adults.

- It presents a set of design guidelines synthesizing the main findings of the empirical studies reported in this dissertation, reflecting the inductive nature of the followed research approach, and contrasting the ethnographic work with an in-home deployment study.
- It shows a structured process to use the proposed design concerns and guidelines in the conception of collaborative and social software systems, particularly assisting developers in taking informed architectural decisions and planning the software design, development, deployment, and evolution.

9. CONCLUSIONS AND FUTURE WORK

Most people today prefer to interact through social media and mobile-based applications, which, inadvertently, have increased the risk of social isolation among older adults. In particular, in collectivistic societies—such as Latin American families—there are particular socio-cultural traits that contrast with the broad discourse on promoting intergenerational communication and facilitating informal elderly caregiving currently reported in the HCI and CSCW literature.

The main issue when designing computer-supported solutions to mediate intergenerational communication and informal elderly caregiving is that they should account for the diverse caregiving experiences of the involved stakeholders. In that respect, this situation implies that software designers are faced to take architectural decisions that are highly dependent on the socio-cultural context of the family ecosystems in which the conceived solutions are going to be deployed.

Most of the related literature in intergenerational communication and informal elderly caregiving is grounded in social studies—mainly from gerontology, sociology, and anthropology. However, there is an increasing interest of the HCI and CSCW communities on further understanding the socio-technical nuances of dealing with older adults in the design, development, and deployment of services to increase family cohesion and reduce social isolation.

Given that much of this work has been recently conducted under a lens focused in the living experiences and cultural traits of Western countries—mainly Canada, the United Kingdom, and the United States—, current recommendations for design are not directly transferrable to Latin America, particularly in terms of usability, perceived value, technology adoption, and system appropriation. Therefore, we are currently faced to a lack of structured and empirically grounded design recommendations and guidelines to inform the design of such solutions. As a result, software designers and developers are mostly faced to conceive supporting systems without the assistance of a structured process, thus resulting in more uncertainty in the envisaged product.

By recognizing and understanding the implications of the similarities and differences between the Latin American socio-cultural scenario with that in other Western countries, we conduct several empirical studies in order to identify key design concerns for the presented domain of software applications. Based on these findings, we derive guidelines—and different classifications of them—that inform the design of computer-supported solutions tailored to the viewpoints, expectations, and concerns of Southern Cone families. Therefore, software designers can use the proposed design concerns, guidelines, and classifications to take informed—and better—architectural decisions for conceiving new solutions or evaluating existing ones, hence dealing with the previously stated challenges.

Next section summarizes the main business and technical findings of the presented work in this dissertation. On the one hand, *business findings* represent new reusable knowledge about the process to be supported. Such knowledge must be considered in the design of supporting solutions, as a way to increase their usefulness—perceived value—, simultaneously respecting the work scenario—context—and the particularities of that process. On the other hand, *technical findings* identify new reusable design knowledge about systems in the studied domain, which can later be directly used during the conception or modeling phases of software development.

9.1 Summary of Findings

By conducting four empirical studies following an inductive research approach, we identified several design considerations regarding the studied business process (i.e., family caregiving of older adults). First of all, we identified that the implicit duties imposed by filial obligation—deeply rooted in collectivistic societies—burdens those family members assuming caregiving duties, with little to no coordination or negotiation of the caring activities across the family network (*Business Finding #1*).

Moreover, the obtained results identified asymmetries in several interaction aspects among the involved family members. For instance, we identified asymmetries related to the preferred social media and time periods for socializing, as well as the current willingness to interact with other members across the family network (*Business Finding #2*). These asymmetries are inherent to intergenerational family communication and they must be considered as a key design concern to address. Given these asymmetries, external mediation was usually needed to increase the chances of performing effective communication between the involved people.

Trying to deepen our understanding on the sources and implications of communication asymmetries in family exchanges, we interviewed intergenerational triads about their attitudes, agreements, and expectations around social interaction with their older adults. We identified that the approach used by adult children for taking care of their parents generates a vicious circle that stresses out the former and limits the technology adoption of the latter (*Business Finding #3*). Therefore, a change in the interaction paradigm with older adults seems to be required, and promoting the technology adoption by these people can contribute to perform such a change.

Having understood the implications of such vicious circle, we were interested in better understanding how family members articulated themselves to sustain informal caregiving. In particular, we observed that family members usually assume implicit roles to address the main activities for providing care to their older adults (*Business Finding #4*). Therefore, we formulated a set of family roles that characterize the concerns and viewpoints of the different family members regarding informal elderly caregiving, and sustain the articulation of the process.

Families can be seen as living ecosystems that adapt themselves over time according to the current circumstances and family needs—including those of their older adults. Therefore, the design of supporting applications must consider this ecosystem in an integral way (i.e., covering the interests and concerns of all participants), even if the solution being developed will only be used by a small part of the family network, e.g., family caregivers (*Business Finding #5*).

While literature and our studies suggest that the caregiving process burdens primary caregivers—usually one of the female adult children in the family—, it is not evident how to design technology for improving the articulation of the caregiving work. In order to identify these situations, as well as opportunities for balancing the workload, we structured the main concerns of the involved stakeholders in the form of a caregiving matrix. This instrument can be used for visualizing the current fulfillment of duties within the family network and matching them with the current instrumental and non-instrumental requirements of older adults. The services embedded in the supporting system should be aligned with the information provided by the matrix; thus, the designer can be sure that the proposed services intend to address actual and current needs, and they do it considering the current work context, i.e., the status of the family ecosystem (*Technical Finding #1*).

Aiming to corroborate the inferred theoretical models grounded on ethnographic analysis, we conducted an in-home mixed-methods deployment study evaluating SocialConnector during nine weeks with a sample of the target population. The obtained results suggested that older adults using SocialConnector did show increased social engagement, particularly with family members, when exposed to interacting with the system over the study period. Similarly, social awareness notification messages to encourage user participation were an effective way to mediate the social interaction space of the involved parties. These results suggest that the social isolation suffered by older adults due to the massive penetration of social media systems can be successfully addressed using context-aware social technology (*Technical Finding #2*).

Regardless of the positive outcomes, the results also suggest that social awareness messages should be personalized to map the current routines and expectations of the involved people, as a way to maximize the potential effect of the intervention. Particularly, the study results indicate that the design of every service provided by the system should consider its usability, usefulness, understandability, and user-system confidence perceived by the older adult when interacting with the computer-supported application. Therefore, the study results indicate that the suitability of a service will be defined mainly by these four quality attributes (*Technical Finding #3*).

In terms of system design, we also inferred implications that can be used to inform the development of further software applications or functionality to better impact the social interaction space of family members. In particular, the study results suggest that older adults liked interacting with SocialConnector, as it offered them an alternative way for engaging in social interaction with fellow family members. However, participating older adults also reflected on a major concern involving privacy matters and information disclosure across the family network (*Technical Finding #4*). The reason behind this attitude can be attributed to an intention to not worry or burden the family members caring for them, and because there is still a reticence on trusting an external agent—such as SocialConnector—for mediating intergenerational communication about personal matters.

We concluded the empirical work by summarizing and synthesizing the design implications formulated throughout the dissertation, structuring them into four core themes: *communication*, *coordination*, *cooperation*, and *user-system interaction*. Therefore, for all of the studied stakeholders, we identified a set of design guidelines that would help social computing researchers, designers, and practitioners better understand the complexity of the studied scenario. In consequence, it would be possible to identify plausible solutions that would improve user experience and the effectiveness of computer-supported mediation strategies in intergenerational communication and informal elderly caregiving. As noted above, the proposed design guidelines cover four key quality attributes: usability, perceived value, understandability, and user-system confidence, which in turn appear as mandatory for taking informed architectural decisions in the conception of computer-supported systems to mediate the social interaction space of older adults and their family members. This is highly influenced by Technical Finding #3.

9.2 Validation of Dissertation Hypotheses

In this dissertation we stated three hypotheses involving the design and implications of computer-supported communication mediation strategies to intervene the social interaction space of older adults and that of their family members. The obtained results provide empirical evidence that sustains the validity of the stated hypotheses:

(H1) *Computer-supported software abstractions, developed to facilitate intergenerational communication, increase the perceived sense of connection of older adults within their families.*

In Chapter 6 we presented SocialConnector, which was formally evaluated through an in-home deployment study in Chapter 7. By applying the Lubben Revised Social Network Scale (LSNS-R) questionnaire to a sample of older adults before and after the intervention, we noted that there was a statistically significant increase in the overall score as a result of the mediation of the social interaction space caused by the studied system.

Furthermore, exit interviews with the participating older adults revealed that they overall accepted and showed a steadily increasing interaction with the system. Therefore, the obtained results show that computer-supported technology to mediate intergenerational exchanges with older adults does increase their perceived family cohesion and is technology that can be accepted and appropriated by these people. The study results also suggested design implications grounded on behavioral concerns of older adults regarding privacy matters and information disclosure across the family network.

(H2) *Computer-supported mechanisms, developed to seamlessly allow people to use their preferred media to communicate, reduce the perceived asymmetries between older adults and the rest of the family.*

The in-home deployment study also suggested a strong effect on mediating the frequency of interaction between family members and their older adults, particularly in terms of sending photos as triggers for initiating an interaction, asynchronous private messages, and video-mediated calls. As contrasted in the analysis of entry and exit interviews (cf. Section 7.2.3), all these mechanisms allow family members to use their preferred communication tools, thus reducing the perceived asymmetries on computer-mediated interaction by older adults.

(H3) *The usage of computer-supported software abstractions to mediate family communication by older adults, eases the informal elderly caregiving process.*

Similarly, the conducted in-the-wild study also revealed that family members—particularly those involved in informal caregiving duties—highly praised the system. Particular themes inferred from system usage and perceived value of the system are referred to making visible the caregiving work across the family network, thus easing the coordination and articulation of tasks.

In particular, the study results suggested that the design of computer-supported intergenerational communication mediators needs to account for the opposed views on ageism and technology design, particularly contrasting the perceived independence assumed by older adults and the views on decline and technology reluctance raised by their family members who are more closely involved in assuming caregiving tasks.

9.3 Thesis Contributions

The results obtained from the conducted empirical work directly impact the fields of *social computing* and *design and engineering of interactive computing systems*. The followed research approach, being inductive, allowed us to iteratively refine the partial conclusions and inferred

design implications by either confirming and/or specializing the work conducted in previous stages of the research. The main concrete and reusable contributions of this dissertation are the following:

- It reviews recent literature on intergenerational communication and informal elderly caregiving practices, contrasting the views of social sciences, gerontology, and technology design between Western countries (e.g., United Kingdom, Canada, and the United States) and Southern Cone countries (e.g., Chile and Argentina). The used thematic framing follows a lens grounded in Computer-Supported Cooperative Work theories and its lines of research. Therefore, the main interest on this literature analysis was to understand the caregiving process in the study scenario, and also identify the main design implications (from a holistic point of view) on the supporting systems, considering the main attitudes, expectations, viewpoints, and concerns of the involved stakeholders as a way to inform the design of computer-supported technology to mediate the intended scenario. In particular, this dissertation proposes in Chapter 3 a conceptual model representing the informal elderly caregiving ecosystem, mapping the most relevant stakeholders, their viewpoints, and their concerns.
- It reviews the main considerations regarding intergenerational computer-mediated communication in Chilean and Argentinian families through extensive empirical ethnographic research. This is a cultural scenario that has been poorly studied from an HCI and CSCW point of view, and consequently, there are almost no guidelines to support the design of caregiving applications for such a cultural context. Trying to advance the knowledge in this area, in Chapter 3 we formulated a family communication metamodel for promoting computer-mediated communication between older adults and their family networks, addressing their implicit and explicit communication asymmetries through synchronous and asynchronous channels. A concrete instantiation of such a model is presented in the design of the SocialConnector system shown in Chapter 6.
- Following on the factors that help explain the current expectations and attitudes of older adults toward technology usage and appropriation, we identified a vicious circle in the technology adoption of Latin American older adults. Such a vicious circle was specified, explained and justified in Chapter 4, and it was then used to inform a set of design requirements for CSCW technology intended to mediate intergenerational communication in Latin American families. Further evidence that specializes the formulation of the proposed vicious circle representation, collected from in-the-wild research, is presented in Chapter 7.
- Trying to understand the viewpoints and concerns of the family members in the supporting caregiving network of older adults, this dissertation presents in Chapter 4 a set of roles describing the viewpoints and concerns of the main stakeholders in intergenerational family communication and in the informal elderly caregiving process. We also formulated a matrix as a way to analyze the current interaction scenario across the family network and inform the design of CSCW supporting systems in the studied scenario. A specialization on the proposed roles—by covering more in depth the scope and interests of the stated roles—and illustrated through representative informal caregiving scenarios is presented in Chapter 5. Further implications on how the proposed roles and caregiving matrix can be deployed in the field, are derived from the insights obtained from analyzing the results of an in-home deployment study as presented in Chapter 7.

- Throughout Chapters 3 to 5 we identified a set of design implications for social computing systems supporting intergenerational computer-mediated communication with older adults, which were represented through design concerns and guidelines, and the relationships between them. In Chapter 7 we corroborated in the field the presented implications through studying in depth the mediation effect of SocialConnector with a sample of nine families over a period of nine weeks. Finally, in Chapter 8 we thematically cluster the identified design implications according to their main covered design concerns and involved stakeholders. Contrasting these aspects with backing literature and empirical evidence allows us to propose a set of design guidelines, which aim to assist social computing designers and practitioners on conceiving computer-mediated mechanisms to support intergenerational family communication and informal elderly caregiving. These guidelines cover the main interests and concerns of three kinds of stakeholders: older adults, family members acting as informal caregivers, and other family members in the surrounding intergenerational communication network. From a software engineering perspective, we also discuss the main implications of the derived design guidelines regarding how they can be used to evaluate architectural decisions of computing systems in the studied domain.

9.4 Generalizations and Abstractions

From a CSCW perspective, the identified asymmetries between media and availability in intergenerational exchanges with older adults can be explored in other family ties, such as those between parents and children. In particular, similar systems to mediate parent-child communication can be highly inspired from the software architecture of SocialConnector—as presented in Chapter 6—with minor adaptations to fit into the particular functional services required by the domain switch. Following the proposed design guidelines and the process presented in Section 8.4, software designers can identify where these adjustments should be performed. However, the major challenge would still be the design of effective mechanisms to convey and mediate interaction between these people, as the interests and attitudes toward technology usage are clearly not the same as those of older adults.

Similarly, the proposed design guidelines can be used to support the design of computer-mediated systems to support caregiving involving other relevant stakeholders, such as medical service providers, formal caregivers, and extended family members. In that respect, the empirical findings presented in this dissertation complement prior research in computer-supported caregiving (e.g., [Chen13, Cons04, Liu11, Mill16, Pipe16]), which emphasize the cooperative nature of the process.

The usage of SocialConnector and the proposed design guidelines can also be transferred to other domains, such as communities with people showing low levels of technology adoption (e.g., in rural or poor areas). Given that one of the main factors in design was to ease system adoption and sustain interaction through communication mediators, the proposed solution can provide insights into conceiving new or adapting existing services to facilitate social connection. Furthermore, from a social software engineering perspective, the followed inductive pipeline—based in Grounded Theory and Action Research (cf. Figure 6)—for eliciting requirements and contrasting viewpoints and concerns of different stakeholders across the software ecosystem, can be used in design, development, evaluation, and deployment of new or alternative computer-supported solutions.

Finally, the validity and suitability of the findings of this dissertation in other cultural contexts should be analyzed. Probably, more than one finding of this thesis work could be suitable (and therefore, reusable) to inform the design of family caregiving supporting systems in more than one cultural scenario.

9.5 Take-Aways

As final words, the analysis of the empirical findings and proposed models and formalizations can all be summarized in the following five key considerations:

1. Designing effective social mediation services to support intergenerational exchanges requires a comprehensive modeling of the family ecosystem that is going to be intervened by the conceived technology. Among the most relevant stakeholders that need to be considered in this task—which represent both direct and indirect users of the supporting technology to be designed—we can name: older adults, family members assuming caregiving tasks (i.e., assistants and monitors), and other family members involved in the supporting social network of the older adult (i.e., helpers and outsiders). Particular dimensions to capture in these models are referred to contextual information, such as their expectations, values, interests, attitudes, needs, viewpoints, and concerns regarding the caregiving process.
2. The diversity of social ecosystems—including media preference, availability, and willingness asymmetries—has to be recognized and considered in the architectural design of computer-mediated supporting systems for this kind of cooperative work. In order to complete this task, software designers need to conduct a specific definition of the following components:
 - a. A metamodel that structures the general view of the social ecosystem that is going to be intervened with technology.
 - b. A functional model that determines the global behavior of the ecosystem; i.e., abstract instances of the defined user models and the metamodel.
 - c. A contextual definition of the metamodel and user models, adapted to the particular configuration of the studied ecosystem, as a way to structure and understand the behavior of all its components. By accomplishing with this formalization, software designers will be in position to take informed architectural decisions to provide contextualized (i.e., ad-hoc) services to all of the involved stakeholders in the process.
3. Recognize the diversity of living experiences within the family network, addressing media, availability and willingness asymmetries with regard to system usage and computer-supported mediation. In that respect, envisaged solutions to deal with the problem need to be context-aware and context-sensitive.
4. Structure the design concerns around the proposed core themes (i.e., communication, coordination, cooperation, and user-system interaction). In other words, this maps the architectural decisions to inform the conception of contextualized solutions to deal with the problem need to cover components and connectors that support and mediate the interaction, communication, coordination, and cooperation layers of the studied ecosystem, in line with the suggested design guidelines.

5. The design of computer-supported mechanisms to address communication asymmetries—and by extension, mediate the social interaction space of family members—must deal with four mandatory quality requirement attributes: usability, perceived value, understandability, and user-system confidence.

9.6 Limitations

The proposed guidelines were obtained following an inductive way, therefore, it is expected to get successful results when these guidelines are embedded in a system that support a work scenario similar to the one used as source of information during the guidelines definition process. Therefore, in order to assess generalizability, it would be convenient to empirically study the usage of the proposed guidelines and software design process to inform the conception, development, and deployment of family social systems that follow a different purpose to informal elderly caregiving. This evaluation would help determine how generalizable are the findings of this research work.

Moreover, the same research and development team that built the proposed guidelines used them at a later stage to inform the design of the SocialConnector system. Therefore, it would be convenient to empirically study how other development teams use the proposed guidelines to inform their designs as a way to identify the level of usability and usefulness that they have for these people.

Finally, the method proposed for using the guidelines (cf. Section 8.4) was based on the experience of the author—and other members of the same research team—in the development of this type of application. Through replication, more analysis is required to determine if such a process can be improved.

9.7 Future Work

Understanding the main considerations regarding the design of interactive social computing systems to mediate family communication, as well as the underlying structure and cooperative nature of informal elderly caregiving in Latin American families, is just the first step in a more general problem that can be addressed following further iterations of the action research approach. In that respect, we aim in future steps of this research to design and study more complex computer-supported strategies to effectively mediate family communication, such as:

- Managing and combining seamlessly different preferred mediator tools to match the skills of older adults and family members.
- Managing the available time slots and workload balancing among family members.
- Ensuring awareness of the situation of the older adult, and of other family members' availability.
- Triggering social interaction through intelligent context modeling, social and activity awareness mechanisms, and persuasion.

Similarly, building upon the findings obtained in the in-home deployment study, we identify further design and evaluation opportunities that are relevant to address in the scope of the studied problem:

- Understanding the privacy concerns of older adults and their family members with regard to domestic information sharing and disclosure.
- Proposing new alternatives crossing research in persuasive technology, behavior change, and playful interaction practices.
- Defining metrics and evaluation processes that use the guidelines to determine the suitability of under-development and already-developed supporting systems; similar to those proposed by Antunes et al. [Antu12, Antu14] and Herskovic [Hers11].

Finally, a third line of further research is studying the effectiveness of the physical technological support to deploy the proposed mediation strategies. In that respect, we have conducted a preliminary study exploring the appropriation by older adults of the SocialConnector system embedded in a SmartTV using Google Chromecast as middleware [Tapi16]. As future work, we aim to conduct a 3-factor in-the-wild study comparing the perceived usefulness and value of mediating intergenerational family communication of SocialConnector by older adults using: gestures to control a native application running on AndroidTV, multi-touch commands on a tablet to control the system running on a SmartTV equipped with Google Chromecast, and multi-touch commands on a state-of-the-art Tablet PC. In particular, adhering to the TAM2 (Technology Acceptance Model)—proposed by Venkatesh and Davis [Venk00]—, diagnosing the technology acceptance of older adults requires measuring the perceived usefulness of the system and the perceived effort required to use it.

LIST OF THESIS-RELATED PUBLICATIONS

At the time of submission of this dissertation (May 2017), the work conducted in the context of this thesis has led to the following publications:

Refereed Journal Manuscripts

Francisco J. Gutierrez, Sergio F. Ochoa, Nelson Baloian, Gustavo Zurita, and Luis Loyola. 2015. An architecture to support the design and evaluation of software platforms for partially virtual communities. *Computing and Informatics* 34, 3, 521–558.

Diego Muñoz, Raymundo Cornejo, Francisco J. Gutierrez, Jesús Favela, Sergio F. Ochoa, and Monica Tentori. 2015. A social cloud-based tool to deal with time and media mismatch of intergenerational family communication. *Future Generation Computer Systems* 53, 140–151. <http://dx.doi.org/10.1016/j.future.2014.07.003>

Diego Muñoz, Francisco J. Gutierrez, Sergio F. Ochoa, and Nelson Baloian. 2015. SocialConnector: a ubiquitous system to ease the social interaction among family community members. *Computer Systems: Science & Engineering* 30, 1, 57–68.

Refereed Papers in Top-Tier Conference Proceedings

Francisco J. Gutierrez and Sergio F. Ochoa. 2017. It takes at least two to tango: understanding the cooperative nature of elderly caregiving in Latin America. In *Proceedings of the ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW'17)*, 1618–1630. <http://dx.doi.org/10.1145/2998181.2998314>

Francisco J. Gutierrez and Sergio F. Ochoa. 2016. Mom, I do have a family!: attitudes, agreements, and expectations on the interaction with Chilean older adults. In *Proceedings of the ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW'16)*, 1400–1409. <http://dx.doi.org/10.1145/2818048.2820000>

Peer-Reviewed Papers in Conference Proceedings

José M. Tapia, Francisco J. Gutierrez, and Sergio F. Ochoa. 2016. Using Smart TV applications for providing interactive ambient assisted living services to older adults. In *Proceedings of the International Conference on Ubiquitous Computing and Ambient Intelligence (UCAmI'16)*, 514–524. http://dx.doi.org/10.1007/978-3-319-48746-5_53

Francisco J. Gutierrez, Sergio F. Ochoa, and Julita Vassileva. 2015. Mediating asymmetries in family communication: supporting the eInclusion of older adults. In *Proceedings of the International Conference on Universal Access in Human-Computer Interaction (UAHCI'15)*, 438–448. http://dx.doi.org/10.1007/978-3-319-20678-3_42

Diego Muñoz, Francisco J. Gutierrez, and Sergio F. Ochoa. 2015. Introducing ambient assisted living technology at the home of the elderly: challenges and lessons learned. In *Proceedings of the International Work-Conference on Ambient Assisted Living (IWAAL'15)*, 125–136. http://dx.doi.org/10.1007/978-3-319-26410-3_12

Diego Muñoz, Raymundo Cornejo, Sergio F. Ochoa, Jesús Favela, Francisco J. Gutierrez, and Monica Tentori. 2013. Aligning intergenerational communication patterns and rhythms in the age of social media. In *Proceedings of the Chilean Conference on Human-Computer Interaction (ChileCHI'13)*, 66–71. <http://dx.doi.org/10.1145/2535597.2535607>

Diego Muñoz, Francisco J. Gutierrez, Sergio F. Ochoa, and Nelson Baloian. 2013. Enhancing social interaction between older adults and their families. In *Proceedings of the International Work-Conference on Ambient Assisted Living (IWAAL'13)*, 47–54. http://dx.doi.org/10.1007/978-3-319-03092-0_7

Peer-Reviewed Short Papers and Extended Abstracts

Francisco J. Gutierrez, Sergio F. Ochoa, and Julita Vassileva. 2016. Identifying opportunities to support family caregiving in Chile. In *Extended Abstracts of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'16)*, 2112–2118. <http://dx.doi.org/10.1145/2851581.2892386>

Francisco J. Gutierrez. 2015. Aligning the social interaction spaces of intergenerational family members. In *Extended Abstracts of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'15)*, 199–202. <http://dx.doi.org/10.1145/2702613.2702618>

Invited Articles

Francisco J. Gutierrez. 2016. Personalized computer-based mechanisms to increase family connection with older adults. *ACM SIGWEB Newsletter* (Autumn 2016), article 4. <http://dx.doi.org/10.1145/2996442.2996446>

Francisco J. Gutierrez. 2014. El “lado B” de las redes sociales [The flip side of social networks, in Spanish]. *Bits de Ciencia* 10, 64–69. <https://www.dcc.uchile.cl/Bitsdeciencia10.pdf>

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APPENDICES

A. Institutional Review Board Approval



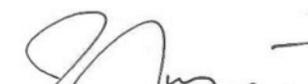
CERTIFICACIÓN N°007

CERTIFICACIÓN COMITÉ DE ÉTICA Y BIOSEGURIDAD PARA LA INVESTIGACIÓN FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS UNIVERSIDAD DE CHILE

El Comité de Ética y Bioseguridad para la Investigación de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile certifica haber analizado el Proyecto de investigación, FONDECYT REGULAR 1150252, titulado “**Reducing Social Isolation of Elderly People Using Social Media and Ambient Intelligence**”, presentado por Sergio Ochoa, profesor asociado del Departamento de Ciencias de la Computación.

El análisis del proyecto, así como los documentos de Consentimiento Informado para los sujetos de estudio, tanto para las entrevistas como para el uso de la herramienta computacional, permiten certificar que:

- i) El proyecto cumple con los estándares nacionales e internacionales de ética de la investigación, de acuerdo a la Declaración Universal de los Derechos Humanos, el Pacto de Derechos Civiles y Políticos, el Pacto de Derecho Económicos Sociales y Culturales, las leyes chilenas y el Documento oficial de ética para la investigación de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile.
- ii) El Comité de Ética considera que la investigación no vulnera la dignidad de los sujetos, no constituye una amenaza bajo ninguna circunstancia ni causa daño.
- iii) Dejamos constancia que el profesor Sergio Ochoa será el responsable por eventuales daños causado a las personas por errores que puedan cometerse durante la investigación.


Dr. Patricio Jorquera E.
Asesor Senior
IDIEM




Br. Claudio Pérez F.
Profesor Titular
Director Académico y de Investigación

MSc. Edgardo Krell
Gerente de Operaciones
NIC-Chile

Santiago, 08 de julio de 2015
CPF/PJ/rab

B. Endorsed Informed Consent Forms

FORMULARIO DE CONSENTIMIENTO INFORMADO (Evaluación del Software)

Solicitamos a usted, colaborar con el proyecto titulado "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental", patrocinado por Conicyt, proyecto Fondecyt Nro. 1150252.

La colaboración que solicitamos consiste en utilizar voluntariamente una herramienta tecnológica, por el lapso de diez semanas. La herramienta sirve para comunicarse con el resto de su familia utilizando un computador.

A continuación le proporcionamos información más detallada del proyecto, y de los términos concretos que involucra su participación en esta prueba. A esto lo hacemos con el fin de permitirle decidir, de manera informada, si desea o no colaborar con este proyecto.

Información sobre el proyecto

1. El proyecto "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental" tiene los siguientes objetivos: (i) crear un modelo social de las personas, el cual ayudará a entender su comportamiento social, (ii) crear mecanismos tecnológicos que le permita a los adultos mayores participar de manera más efectiva en sus comunidad familiares, (iii) crear mecanismos basados en tecnología, que permitan reconocer las emociones de las personas, y avisar a sus familiares en caso de necesidad, y (iv) crear una herramienta computacional que les ayude a los adultos mayores a mejorar su calidad de vida en términos de inclusión social.
2. Este proyecto proporcionará información de relevancia para el desarrollo de **soluciones computacionales**. En ningún caso el estudio implica ingerir líquido o sólido alguno, ni medicamentos, ni tratamientos médicos.
3. Este Proyecto está dirigido por el Prof. Sergio Fabián Ochoa, investigador del Departamento de Ciencias de la Computación de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile. Participan en el estudio, como asistentes, alumnos y profesionales de la misma universidad.
4. Los datos recopilados dentro del Proyecto serán administrados resguardando la estricta confidencialidad de la identidad de las personas participantes. Sólo tendrán acceso a ellos el director del proyecto y sus ayudantes directos. La persona responsable del resguardo de la información es el director del proyecto, ya mencionado: Prof. Sergio F. Ochoa.
5. Los datos recopilados dentro del Proyecto serán usados exclusivamente para ser publicados, en forma anónima, en revistas científicas del área de investigación, libros especializados y en congresos académicos en Chile y en el extranjero.

Información sobre su participación:

Su participación en este estudio es totalmente voluntaria, y consiste en utilizar una herramienta computacional para comunicarse con otros miembros de su familia. Por el lapso de 10 semanas usted usa la herramienta cuándo quiere y si quiere. Durante ese período de tiempo la herramienta estará monitoreando su estado de ánimo, y su presencia en el lugar donde estará instalado el dispositivo. El dispositivo eventualmente podrá pedir ayuda a través de un mensaje a algún familiar suyo, cuando dicho dispositivo estime que usted la necesita. Al final de este período le preguntaremos acerca de qué le ha parecido la experiencia y la herramienta que utilizó. Particularmente nos interesa saber si la herramienta le fue útil.

Si no acepta participar en este estudio, no hay ninguna consecuencia negativa para Ud. Si acepta participar, entonces usted puede dejar de participar en el estudio en cualquier momento que lo desee, sin que eso tenga



¿Qué debo hacer si quiero participar en el estudio?

Tiene que firmar tres copias de este documento, nosotros le entregaremos una copia del mismo, una va para el equipo investigador, y otra para Fondecyt.

Al firmar este documento está diciendo que:

- Está de acuerdo con participar en el estudio.
- Le hemos explicado la información que contiene este documento y hemos contestado todas sus preguntas.

En conocimiento del proyecto y de acuerdo a las condiciones antes descritas, indique con una cruz su decisión de participar:

- No acepto** colaborar con el proyecto "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental".
- Si acepto** colaborar con el proyecto "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental".

El Prof. Sergio Fabián Ochoa, investigador responsable del proyecto, suscribe el compromiso de respetar cabalmente las condiciones detalladas más arriba. Los datos de contacto de esta persona se detallan a continuación:

Prof. Sergio F. Ochoa, Profesor Asociado, Departamento de Ciencias de la Computación, FCFM, Universidad de Chile. Teléfono: 22978 4879, Correo electrónico: schoa@dcc.uchile.cl. Responsable general del proyecto

Nombre del participante: _____

Teléfono de contacto: _____

Correo electrónico: _____

Firma: _____

Fecha: _____

Nombre del asistente del participante: _____

Teléfono de contacto: _____

Correo electrónico: _____

(Se firman tres copias, quedando una en poder de cada firmante y una para FONDECYT)



UNIVERSIDAD DE CHILE
DIRECTOR ACADÉMICO Y DE INVESTIGACIONES
Facultad de Ciencias Físicas y Matemáticas
Sergio F. Ochoa

FORMULARIO DE CONSENTIMIENTO INFORMADO (Entrevistas)

Solicitamos a usted, colaborar con el proyecto titulado "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental", patrocinado por Conicyt, proyecto Fondecyt Nro 1150252.

La colaboración que solicitamos consiste en participar en una entrevista sobre el uso de tecnología para comunicarse con el resto de su familia. También se busca conocer las prácticas de comunicación familiar que tienen los participantes de este estudio.

A continuación le proporcionamos información más detallada del proyecto, y de los términos concretos que involucra su participación en esta entrevista. A esto lo hacemos con el fin de permitirle decidir, de manera informada, si desea o no colaborar con este proyecto.

Información sobre el proyecto

1. El proyecto "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental" tiene los siguientes objetivos: (i) crear un modelo social de las personas, el cual ayudará a entender su comportamiento social, (ii) crear mecanismos tecnológicos que le permita a los adultos mayores participar de manera más efectiva en sus comunidad familiares, (iii) crear mecanismos basados en tecnología, que permitan reconocer las emociones de las personas, y avisar a sus familiares en caso de necesidad, y (iv) crear una herramienta computacional que les ayude a los adultos mayores a mejorar su calidad de vida en términos de inclusión social.
2. Este proyecto proporcionará información de relevancia para el desarrollo de **soluciones computacionales**. En ningún caso el estudio implica ingerir líquido o sólido alguno, ni medicamentos, ni tratamientos médicos.
3. Este Proyecto está dirigido por el Prof. Sergio Fabián Ochoa, investigador del Departamento de Ciencias de la Computación de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile. Participan en el estudio, como entrevistadores, alumnos y profesionales de la misma universidad.
4. Los datos recopilados dentro del Proyecto serán administrados resguardando la estricta confidencialidad de la identidad de las personas participantes. Sólo tendrán acceso a ellos el director del proyecto y sus ayudantes directos. La persona responsable del resguardo de la información es el director del proyecto, ya mencionado: Prof. Sergio F. Ochoa.
5. Los datos recopilados dentro del Proyecto serán usados exclusivamente para ser publicados, en forma anónima, en revistas científicas del área de investigación, libros especializados y en congresos académicos en Chile y en el extranjero.

Información sobre su participación:

Para conocer y comprender la forma en que se realiza la entrevista, ésta se refiere al uso de medios de comunicación para interactuar con otros miembros de su familia, para lo que deberá responder varias preguntas del entrevistador sobre el tema. La entrevista durará alrededor de una hora.

Si se cuenta con su consentimiento, se grabará el audio de dichas entrevistas. La participación en la entrevista no contempla ningún tipo de remuneración económica ni retribución material de ningún tipo, por parte del equipo de investigadores, ni de Conicyt.

Su participación en el estudio es totalmente voluntaria. Si no acepta, no tiene ninguna consecuencia negativa para Ud. Si acepta, usted puede dejar de participar en el estudio en cualquier momento. Por favor, tómese todo el



Al firmar este documento está diciendo que:

- Está de acuerdo con participar en el estudio.
- Le hemos explicado la información que contiene este documento y hemos contestado todas sus preguntas.

En conocimiento del proyecto y de acuerdo a las condiciones antes descritas, indique con una cruz su decisión de participar:

- No acepto** colaborar con el proyecto "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental".
- Si acepto** colaborar con el proyecto "Reduciendo el aislamiento social de los adultos mayores, a través del uso de soluciones de sociales e inteligencia ambiental".

Grabaciones de audio:

- Si acepto**
- No acepto**

Entrevista:

- Si acepto**
- No acepto**

El Sr. Sergio Fabián Ochoa, investigador responsable del proyecto, suscribe el compromiso de respetar cabalmente las condiciones detalladas más arriba. Los datos de contacto de esta persona se detallan a continuación:

Prof. Sergio F. Ochoa, Profesor Asociado, Departamento de Ciencias de la Computación, FCFM, Universidad de Chile. Teléfono: 22978 4879, Correo electrónico: sochoa@dcc.uchile.cl. Responsable general del proyecto

Nombre del participante: _____
Teléfono de contacto: _____
Correo electrónico: _____
Firma: _____
Fecha: _____

Nombre del entrevistador: _____
Teléfono de contacto: _____
Correo electrónico: _____

(Se firman tres copias, quedando una en poder de cada firmante y una para FONDECYT)


Sergio


C. Interview Script: Empirical Study I (Chapter 3)

To older adults:

- What are your main needs?
- Do you need to frequently interact with other family members? If so, how do you manage this communication? How does your family manage this communication?
- Are you aware of the available times for communicating with your family members? How do you manage this process?
- Do you have any preferred communication channel for interacting with your family? If so, do you think it poses any problem to the other family member?

To other family members:

- What are the needs of your parents/grandparents?
- How are these needs managed by you and other family members?
- Do you think your parents/grandparents need to communicate regularly with you? If so, how do you communicate?
- How do you manage your available times for communication?
- Do you have any preferred communication channel for interacting with your family? In particular, how do you prefer to interact with your older adult?

7. ¿What communication media do you use for contacting other people?
E.g.: face-to-face conversation, telephone, etc. DO NOT indicate the options to the participant.

Face-to-face	_____
Landline phone	_____
Mobile phone	_____
Skype	_____
Chat	_____
SMS / MMS	_____
Whatsapp / Line	_____
Discussion boards / blogs	_____
Email	_____
Postal letters	_____
Facebook	_____
Twitter	_____
Other social media	_____

8. From the following list, please indicate what are the communication media that you use at a regular basis. Of those that you indicated, do you prefer any to the others?
Please give to the participant the attached "Communication media" sheet.

Communication channel	Preference
Face-to-face	
Landline phone	
Mobile phone	
Skype	
Chat	
SMS / MMS	
Whatsapp / Line / Telegram	
Discussion boards / blogs	
Email	
Postal letters	
Facebook	
Twitter	
Other social media	

9. ¿Do you use the following communication media?
Ask only for the media stated by the participant in the previous question. Remember to state each question accordingly to the actual names of the participant relatives.

Face-to-face	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Landline phone	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Mobile phone	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Skype	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Chat	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

SMS / MMS	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Whatsapp Line	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Discussion boards	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Email	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Postal letters	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Facebook	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Twitter	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

Other social media	YES <i>Indicate frequency</i>	NO <i>May I ask you why?</i>
Parents		
Siblings		
Children		
Grandparents		
Grandchildren		

C. PATTERNS AND TIMES OF COMMUNICATION

In the following questions, please ask the participant to refer to the communication media sheet provided. State each question with the names of the participant relatives. For instance: how do you usually communicate with Mrs. Sue at working hours?

10a. How do you usually communicate with... at working hours?

E.g.: how do you usually communicate with Mrs. Sue at working hours?

Children _____
Why? _____

Siblings _____
Why? _____

Parents _____
Why? _____

Grandparents _____
Why? _____

Grandchildren _____
Why? _____

10b. How do you usually communicate with... during your leisure time?

E.g.: how do you usually communicate with Mrs. Sue during your leisure time?

Children _____
Why? _____

Siblings _____
Why? _____

Parents _____
Why? _____

Grandparents _____
Why? _____

Grandchildren _____
Why? _____

11a. How do you prefer that ... communicate with you at working hours?

E.g.: how do you prefer that Mrs. Sue communicate with you at working hours?

Children _____
Siblings _____
Parents _____
Grandparents _____
Grandchildren _____

11b. How do you prefer that ... communicate with you during your leisure time?
E.g.: how do you prefer that Mrs. Sue communicate with you during your leisure time?

Children _____
Siblings _____
Parents _____
Grandparents _____
Grandchildren _____

12a. How does ... prefer you contact him/her at working hours?
E.g.: how does Mrs. Sue prefer you contact her at working hours?

Children _____
Siblings _____
Parents _____
Grandparents _____
Grandchildren _____

12b. How does ... prefer you contact him/her during his/her leisure time?
E.g.: how does Mrs. Sue prefer you contact her during her leisure time?

Children _____
Siblings _____
Parents _____
Grandparents _____
Grandchildren _____

13. If you would like to contact ..., what do you do?
E.g.: if you would like to contact Mrs. Sue, what do you do?

Children	___ Identify the best moment to contact	___ Try to directly contact
Why?	_____	
Siblings	___ Identify the best moment to contact	___ Try to directly contact
Why?	_____	
Parents	___ Identify the best moment to contact	___ Try to directly contact
Why?	_____	
Grandparents	___ Identify the best moment to contact	___ Try to directly contact
Why?	_____	
Grandchildren	___ Identify the best moment to contact	___ Try to directly contact
Why?	_____	

14. How much do you like to be contacted by ...?

E.g.: how much do you like to be contacted by Mrs. Sue?

Children	_____ A lot	_____ Somewhat	_____ A little
Siblings	_____ A lot	_____ Somewhat	_____ A little
Parents	_____ A lot	_____ Somewhat	_____ A little
Grandparents	_____ A lot	_____ Somewhat	_____ A little
Grandchildren	_____ A lot	_____ Somewhat	_____ A little

15. How often do you communicate with ... ?

E.g.: how often do you communicate with Mrs. Sue?

Children _____
Would you like to interact with this person more frequently? _____ Yes _____ No

Siblings _____
Would you like to interact with this person more frequently? _____ Yes _____ No

Parents _____
Would you like to interact with this person more frequently? _____ Yes _____ No

Grandparents _____
Would you like to interact with this person more frequently? _____ Yes _____ No

Grandchildren _____
Would you like to interact with this person more frequently? _____ Yes _____ No

16a. Imagine you receive a call from a close acquaintance telling you have won an important prize. Suppose you are at working hours. Would you like to communicate this to somebody?

Yes _____ No _____ (skip to 16.b)

When would you do it? _____

Who would you contact? _____

Why? _____

Using what channel? _____

And if you get contacted at night? _____

16b. Imagine you receive a call from a close acquaintance telling you have won an important prize. Suppose you are at your leisure time. Would you like to communicate this to somebody?

Yes _____ No _____ (skip to 16.b)

When would you do it? _____

Who would you contact? _____

Why? _____

Using what channel? _____

And if you get contacted at night? _____

Is there anything you would like to add regarding your preferences and points of view toward the usage of different communication media?

GENERAL OBSERVATIONS OF THE INTERVIEWER

E. Interview Scripts: Empirical Study III (Chapter 5)

Contextual Inquiry (with primary informal caregivers):

- Concerning your role as elderly caregiver, what is the main range of activities you have to perform regularly?
- How do you fit assuming this role within your daily routine?
- How do you feel when performing your caregiving tasks?
- How do you rely on other family members to fulfill your caregiving duties?
- How would you evaluate their involvement?
- What motivated you to assume this role?

Semi-structured Interviews (with the supporting family network):

- How do you participate in the care provision for the older adult in your family?
- Do you think some members in your family are 'forced' to assume informal caregiving tasks? If so, why?
- Would you like to be more involved in the caregiving process? If so, how?
- How do you keep up to date of the doings and whereabouts of the older adult in your family?
- Is there anything that you would like to do for getting more involved in caring for your parents/grandparents?
- How would you situate yourself in the caring network of the older adult in your family?
- Why do you assume such a position?

F. SocialConnector System Description (Chapter 6)

From the user point of view, SocialConnector is an application that allows exchanging public and private messages among community members, performing videoconferences using Skype and seeing family pictures. Its user interface is simple, to help older adults understand it and help themselves feel comfortable with it.

SocialConnector was designed to be used on a Tablet PC that is installed on a wall. The device is kept connected to the electrical network and Internet to avoid that elder people have to be aware of connection issues. Moreover, this contributes to have an easy and fast access when required.

Users interact with the system by choosing options on the screen using their fingers—like in an ATM—and also giving voice commands. Thus, the application helps reduce the elders' limitations to use this technological solution.

The photo display service provided by the system automatically captures pictures from the Facebook and Instagram accounts of the family members and deploys them on the screen when the SocialConnector is idle. Therefore, it works like a digital photo frame during those inactivity periods. The goal of deploying family pictures in the device intends to help reduce the reluctance that elders usually feel for these systems. Moreover, it motivates them to socialize with other. Both actions contribute to reduce the social isolation of older adults.

Once an older adult uses a service (e.g. the videoconference), the system automatically detects inactivity and presents by default the main user interface. This mechanism avoids that elders have to deal with the regular windows used in most software applications, and allows them to recognize the main user interface as the starting point to access other services. This also contributes to increase the system usability.

Software Architecture

After experimenting with several alternatives to structure the system, we decided to use an approach similar to a client-server architecture, as depicted in Figure F.1. The client application runs in a Tablet PC and it is self-contained; i.e. each device locally stores the software services required to support the social interactions, the setting information of the community that the local user belongs to, and the data shared with the community members. The servers are represented through the regular Skype, Facebook and Gmail servers, which support the videoconferences and the exchange of public and private messages among family community members. The digital photo display, implemented using Tlatoque [Corn13], works in a fully distributed way and it accesses the Facebook server only if it is available.

In other words, the servers act as intermediary between the regular social media tools used by the young and adult people, and the SocialConnector system used by the elders. This design decision was done after realizing that family members only feel comfortable if they can use their regular tools for socializing with others.

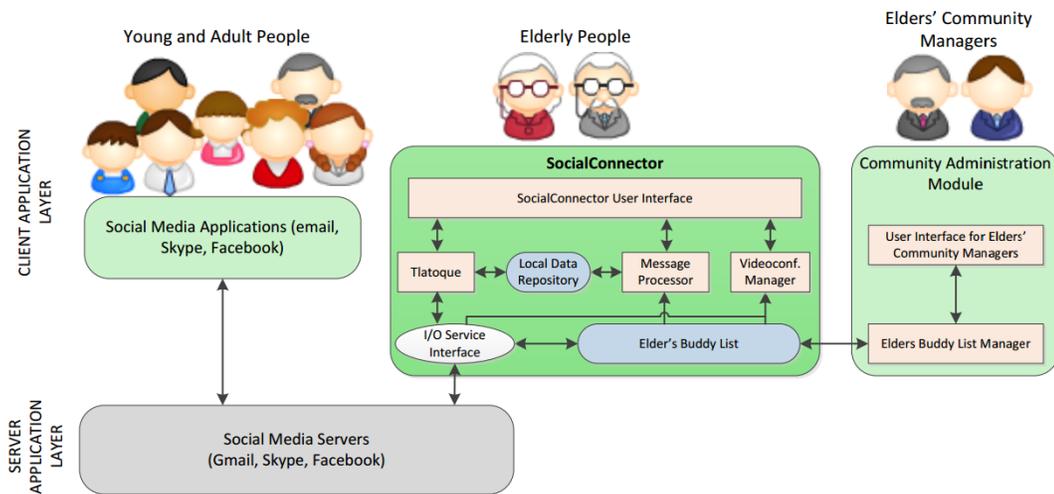


Figure F.1: Software architecture of SocialConnector

SocialConnector uses an *I/O Service Interface* to filter the incoming requests and messages from external users. When this component receives an external interaction request (e.g. a Skype call), it checks if the requester is a family member. The family members and the nicknames used by them in each supported communication channel (i.e. email, Skype and Facebook) are stored in the *Elder's buddy list*. Therefore, if the requester user is a family member, the *I/O Service Interface* accepts and delivers the call to the *Videoconference Manager*; in other case, the request is rejected. The event filtering process follows a similar dynamic when the older adult uses the SocialConnector to retrieve public or private messages from the community members; i.e. only messages from family members are shown and the others are discarded.

The *Message Processor* component is in charge of processing the messages from the family members, trying to align the communication channel preferred by the users. That activity is done translating the messages from one channel to other and vice versa. For instance, a grandchild can send a Facebook private message or an email to his/her grandmother, which will be shown as a private text message on the SocialConnector; no matter what tool was used to deliver the message. In that sense, the *Message Processor* component parses the message content and extracts the key information to be shown to the older adult. When the elder responds the message, the *Message Processor* identifies the media preference of the grandchild (e.g. Facebook), creates a Facebook private message and delivers it as if the elder has used such a tool. Thus, this component helps align the social media preference of several family members.

All information that is part of the social interactions, i.e., text messages and pictures, is kept stored in a *Local Data Repository*. This also includes the family pictures retrieved by the Tlatoque service, which follows a dynamic similar to the one previously described for the text messages retrieval process.

We also have developed a Web application named *Community Administration Module* that is complementary to the SocialConnector. This application allows community managers—typically, some family community members—to change the community settings of an older adult; e.g. to add or to remove members to the elder's buddy list. In order to do that, the Web application can remotely access and update that file in the elder's slate. The community manager must set the Skype, Gmail and Facebook accounts for the elder before the first usage of SocialConnector.

Representation of the Family Community

A family community, represented through the user buddy list, can be different for each older adult since it is specified in a local file stored in the elders' slate. Every buddy list includes the owner's information and a list of contacts (Figure F.2). There are two different possible roles for the contacts: *manager* of the buddy list and *regular contact*. The former is in charge of creating and managing one or more buddy lists using the *community administration module*. This module is a Web application that allows creating and managing buddy lists for older adults. The manager can add/remove contacts, change the roles to the buddy list members and change the attributes of the buddy list owner and the *regular contacts*.

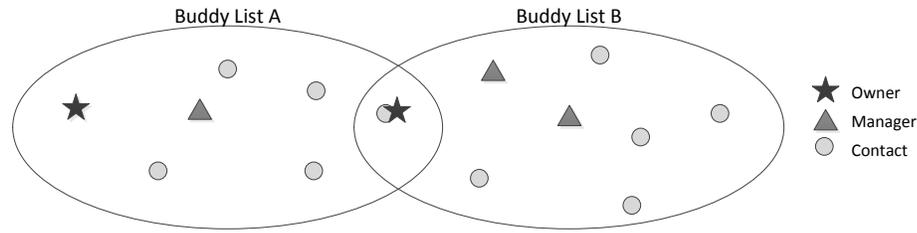


Figure F.2: Example of two overlapped buddy lists

The buddy lists can be overlapped, and a contact can play different roles in different buddy lists. For instance, the common contact in Figure F.2 can be the owner of the buddy list B, typically an older adult, and a regular member of the buddy list A, i.e., the family community of other older adult. This type of buddy list configuration allows people to include not only family members, but also neighbors or friends with whom they might want to communicate.

The Elder's Buddy List is represented as an XML file that stores detailed information of each contact, which allows the system to properly support the interactions. The contact record has the following information:

```
[contact ID, contact name, photo, gender, familiar relationship,  
email address, Skype username, Facebook username, preferred  
communication media]
```

Some context information like gender and familiar relationship (between the local user and the contact) are not particularly relevant for the system services, but they are useful to understand interactions performed among the community members. The preferred communication media of each contact helps the system select the most appropriate channel to interact with each user.

SocialConnector uses Facebook logins to authenticate the older adult. Therefore, the SocialConnector requires having the Facebook desktop application installed in the older adult's device, and that these people have a Facebook account. Only on the first use of the SocialConnector, the system will ask the local user for permissions to login and access the information of the Facebook account, which is needed for using the different features of SocialConnector. After this, the older adult does not longer need to use any credentials to log in. This eases the process to make available the SocialConnector system if the elders turn off the device.

In the same line of reasoning, the system automatically turns off the device screen during the night and turns it on at the morning. This avoids that elders feel that they have to really turn off the device during the night to reduce energy consumption. This issue was identified as a user requirement during a proof of concept performed with an initial prototype of the SocialConnector.

Videoconferences

The videoconference module was implemented using the Skype URI API; therefore the older adult's device must have installed the Skype client application, and the family members should be added as contacts. The *Videoconference Manager* reads the local buddy list and displays these contacts on the screen. Older adults can start a video call exclusively with people in such a list. This can be done by touching the displayed picture or the green icon that is below it.

The users that are not available to be contacted appear blurred. This awareness mechanism allows addressing, at least partially, a user requirement that indicates that people want to know when the person to be contacted is available for interaction.

Since the Skype URI API only allows controlling outgoing calls, incoming calls are managed by the Skype application. Therefore, it is recommended to set the *Videoconference Manager* to accept incoming calls only from Skype contacts. After each video call, the system automatically comes back to the main menu.

Private Messages Exchange Service

Private messages have been implemented as emails, which allow family members to use regular email systems to interact with their elders. Similar to the videoconference service, the older adults must have an email account (in this case, Gmail) and the access to it must be done through an authentication process (in this case, using the OAuth 2.0 protocol), which is automatically done by the SocialConnector. When the elders access the private messages, the system retrieves the local user email account and a saved authentication token; then, it uses such information to authenticate the user. Only after an authentication the user can send and retrieve these private messages (i.e. emails). The older adult can also select a contact of the buddy list and check the messages exchange with that person.

The reading of emails was implemented using the JavaMail API and the IMAP protocol. The system reads mails from the inbox and sent messages folders, and it creates an array of messages for each contact in the buddy list. The emails involving each contact are shown in sequence, as if it were a conversation.

The *Message Parser* selects the contents that will be displayed to the older adult. Figure F.3 shows a simplification of such a process. Most of the metadata of an email is discarded. Subject and attachments are not read, and only the text from the message body and the metadata identifying the sender and the message delivery are retrieved and displayed in the user interface.

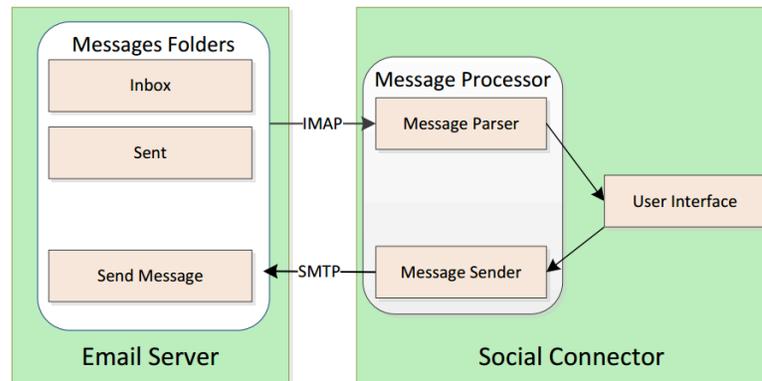


Figure F.3: Email processing

Older adults can respond to private messages using their voice or a touch keyboard. A speech-to-text translator implemented with the Android Speech library converts the voice message in text, and shows it on the screen. If the user agrees with the message content, it is sent as a regular email using the SMTP protocol. Otherwise, a new message response can be recorded, or the user can decide to not respond to the message. The design of the *Message Sender* component allows extending the current implementation of the *Message Processor* in order to support the delivery of private messages through other messaging tools, like Whatsapp or future applications.

Digital Frame Service

As mentioned before, SocialConnector integrates the Tlatoque service [Corn13] as a digital photo display that helps reduce the reluctance usually felt by elders when they have to use technology. The pictures shown through this service are those published in the Facebook accounts of the family community members (Figure F.4). Particularly, pictures from the last three months are downloaded by using the Facebook Query Language, and the results are added to a local list of pictures.



Figure F.4: User interface of the photo display

This service can be activated on-demand, when the older adult chooses the photo display option in the main menu of SocialConnector. In that case the local list of pictures becomes

available for the user, who can go forward and backward in that list, and also read comments or add a “like” to a picture.

The service is also activated when the system is idle. In that case, it acts as a screen saver that contributes to keep the emotional connection between the elders and the rest of their families. Every time that the service is activated, it goes to the server to retrieve and update the pictures list.

G. Interview Scripts: Empirical Study IV (Chapter 7)

Entry Interview – Older Adults:

- Considering the last month: Who visited you at your home? How often did these people visit you? How are you related to these people?
- Considering the last month: Who has frequently called you by phone? How often? How are you related to these people?
- Considering the last month: Whom have you frequently called by phone? How often? How are you related to these people?

Entry Interview – Supporting Network:

- How would you describe your relation, in terms of communication, with the older adult in your family?
- How would you describe the relation, in terms of communication, of other family members with the older adult in your family?
- Who in your family is aware of the needs of the older adult?
- How do you involve in caring for the older adult in your family?

Exit Interview – Coordinator (Caregiver):

- How would you describe the interaction between the older adult in your family and SocialConnector?
- Did you notice any change in the older adult over the last weeks? If so, could you please provide more detail?
- How would you describe the involvement of other family members on interacting through SocialConnector?
- Did you notice any change in the relation between your family members and the older adult in your family over the last weeks? If so, could you please provide more detail?

Exit Interview – Supporting Family Network (including the caregiver):

- How would you describe your current relation, in terms of communication, with the older adult in your family?
- How would you describe the actual relation, in terms of communication, between your family members and the older adult?
- Who in your family is currently aware of the needs of the older adult in your family?

- How do you currently involve in caring for the older adult in your family?

Exit Interview – All Participants (including the caregiver and the older adult):

- Based on your past experience, how useful is SocialConnector for you?
- How intrusive do you consider the system was in mediating the communication between you and the older adult in your family / you and other members in your family?
- Did you feel motivated on using SocialConnector? Why?
- Do you currently feel “closer” to your fellow family members? Why?
- Did you feel that SocialConnector invaded your privacy? If so, how? How did you feel about that?
- What reasons did motivate you (or not) to interact with the older adult in your family / other members in your family through SocialConnector?
- How satisfied do you feel about the system? Why?
- What did you like the most about SocialConnector? Why?
- What did you like the least about SocialConnector? Why?
- If you are given the opportunity in the future to use once again SocialConnector to interact with your family. Would you accept? Why?
- Do you have any additional comment or suggestion to improve the system?

H. Collected Data: Empirical Study IV (Chapter 7)

Table G.1: LSNS-R scores (pre and post intervention)

Older Adult	Pre-condition (before the experiment)			Post-condition (after the experiment)		
	Family subscale	Friendships subscale	Total score	Family subscale	Friendships subscale	Total score
1	6	3	9	13	4	17
2	9	4	13	11	4	15
3	18	16	34	25	15	40
4	21	10	31	23	12	35
5	12	5	17	19	5	24
6	16	16	32	21	13	34
7	19	4	23	17	4	21
8	12	26	38	26	21	47
9	11	5	16	13	5	18

The total score is calculated by computing the sum of all items across each subscale. Each item is graded from 0 to 5 (e.g., for item 1: 0 = none, 1 = one, 2 = two, 3 = three or four, 4 = five thru eight, and 5 = nine or more). For this instrument, the score ranges between 0 and 60 (30 along each subscale). A higher score indicating more social engagement, where 0 – 15 means *low social engagement*, and 16 – 30 means *high social engagement* in each subscale.

Table G.2: System usage (incoming calls, incoming messages, and photos)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	35	26	38	48	61	51	35	46	43
2	15	27	22	33	37	31	37	31	25
3	25	33	26	57	73	59	61	46	68
4	24	37	30	48	55	48	47	36	39
5	32	49	48	58	60	55	52	63	56
6	45	32	28	44	46	44	51	52	54
7	26	18	20	47	49	48	36	30	22
8	28	23	28	47	42	47	48	45	48
9	36	28	31	51	54	55	35	49	43

Table G.3: System usage (outgoing calls and outgoing messages)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	4	10	3	2	4	13	6	4	6
2	6	3	3	3	11	6	2	8	3
3	12	9	13	18	11	13	13	16	17
4	0	3	1	2	0	5	8	4	4
5	6	10	15	12	12	16	14	18	11
6	8	17	11	16	13	10	19	15	17
7	0	0	1	1	3	3	2	4	4
8	3	6	5	11	14	18	18	17	20
9	0	4	1	5	0	0	4	0	1

Table G.4: System usage (only incoming calls – number)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	7	6	7	9	11	13	10	11	8
2	5	6	4	6	5	6	5	6	5
3	8	7	9	14	13	14	13	11	9
4	6	8	5	9	11	10	9	8	8
5	9	11	10	10	9	9	9	10	10
6	11	9	9	12	10	11	10	11	11
7	4	3	2	5	4	4	4	3	2
8	5	4	4	7	6	8	7	7	9
9	6	7	6	8	9	7	8	9	9

Table G.5: System usage (only incoming calls – duration in seconds)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	2464	2010	1873	3986	5168	4981	4080	4143	2667
2	1813	2927	1441	3402	3077	2840	2631	2853	1164
3	2582	2408	3522	7711	5568	6382	5525	5749	4654
4	3215	2402	1864	3770	5973	4597	4747	4192	3525
5	4219	3274	2898	3532	5495	2070	4746	4958	3348
6	4892	3177	4850	5045	5004	5650	5060	4723	4721
7	1637	1749	1159	2067	1637	2232	1570	1246	1305
8	1714	1013	1474	3414	2329	2677	2852	2831	4812
9	2583	3599	2600	3451	2455	3489	2175	2322	4579

Table G.6: System usage (only outgoing calls – number)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	1	2	1	1	2	2	1	1	2
2	3	1	2	1	4	2	1	3	1
3	4	2	3	4	3	4	4	3	4
4	0	1	0	1	0	1	2	1	2
5	2	3	4	4	3	4	4	5	4
6	4	5	4	5	5	4	5	4	5
7	0	0	1	0	2	1	1	2	1
8	2	3	2	4	5	6	5	5	6
9	0	1	1	1	0	0	1	0	1

Table G.7: System usage (only outgoing calls – duration in seconds)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	671	745	728	702	1547	1354	477	870	951
2	1455	342	815	523	1982	1186	406	1382	570
3	1600	949	769	1601	1755	1349	1385	1105	1274
4	0	684	0	782	0	698	839	598	925
5	1348	1358	1319	1337	1324	1204	1694	2086	1534
6	1296	1951	1008	1287	1983	1689	1804	1144	1354
7	0	0	574	0	1444	591	330	809	563
8	1144	1194	973	1283	1997	1598	1945	1772	1946
9	0	489	792	670	0	0	647	0	545

Table G.8: System usage (only incoming messages)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	17	17	23	29	31	24	13	18	23
2	5	18	11	16	24	21	21	16	14
3	10	24	12	33	48	37	32	22	30
4	12	21	17	27	33	24	22	15	16
5	14	23	21	24	26	27	26	34	33
6	19	17	12	18	23	17	23	29	25
7	14	11	10	22	23	26	17	16	12
8	15	13	13	22	19	20	27	20	22
9	16	11	13	24	23	25	17	22	18

Table G.9: System usage (only outgoing messages)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	3	8	2	1	2	11	5	3	4
2	3	2	1	2	7	4	1	5	2
3	8	7	10	14	8	9	9	13	13
4	0	2	1	1	0	4	6	3	2
5	4	7	11	8	9	12	10	13	7
6	4	12	7	11	8	6	14	11	12
7	0	0	0	1	1	2	1	2	3
8	1	3	3	7	9	12	13	12	14
9	0	3	0	4	0	0	3	0	0

Table G.10: System usage (only incoming photos)

Family	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1	11	3	8	10	19	14	12	17	12
2	5	3	7	11	8	4	11	9	6
3	7	2	5	10	12	8	16	13	29
4	6	8	8	12	11	14	16	13	15
5	9	15	17	24	25	19	17	19	13
6	15	6	7	14	13	16	18	12	18
7	8	4	8	20	22	18	15	11	8
8	8	6	11	18	17	19	14	18	17
9	14	10	12	19	22	23	10	18	16

I. Sorted List of Design Concerns (Chapter 8)

The following list summarizes the relative importance—measured in coverage points—of the identified design concerns throughout the conducted empirical studies.

10 points	Design Concern #2
9 points	Design Concern #6b Design Concern #7a Design Concern #11a
6 points	Design Concern #1a Design Concern #4b Design Concern #12 Design Concern #13 Design Concern #24b Design Concern #26
4 points	Design Concern #6a Design Concern #19a
3 points	Design Concern #5 Design Concern #8b Design Concern #9 Design Concern #10a Design Concern #11b Design Concern #23
2 points	Design Concern #3a Design Concern #3b Design Concern #8a Design Concern #14 Design Concern #16 Design Concern #17 Design Concern #19b Design Concern #22a Design Concern #22b Design Concern #25
1 point	Design Concern #1b Design Concern #4a Design Concern #7b Design Concern #10b Design Concern #15a Design Concern #15b Design Concern #18 Design Concern #20 Design Concern #21 Design Concern #24a

ANNEXES

A. Lubben Social Network Revised Scale Questionnaire (original, in English)¹

FAMILY: *Considering the people to whom you are related by birth, marriage, adoption, etc...*

1. How many relatives do you see or hear from at least once a month?

none	one	two
three or four	five thru eight	nine or more

2. How often do you see or hear from the relative with whom you have the most contact?

less than monthly	monthly	few times a month
weekly	few times a week	daily

3. How many relatives do you feel at ease with that you can talk about private matters?

none	one	two
three or four	five thru eight	nine or more

4. How many relatives do you feel close to such that you could call on them for help?

none	one	two
three or four	five thru eight	nine or more

5. When one of your relatives has an important decision to make, how often do they talk to you about it?

never	seldom	sometimes
often	very often	always

6. How often is one of your relatives available for you to talk to when you have an important decision to make?

never	seldom	sometimes
often	very often	always

FRIENDSHIPS: *Considering all of your friends including those who live in your neighborhood...*

7. How many of your friends do you see or hear from at least once a month?

none	one	two
three or four	five thru eight	nine or more

8. How often do you see or hear from the friend with whom you have the most contact?

less than monthly	monthly	few times a month
weekly	few times a week	daily

9. How many friends do you feel at ease with that you can talk about private matters?

none	one	two
three or four	five thru eight	nine or more

¹ http://www.bc.edu/schools/gssw/lubben/downloads/_jcr_content/content/download/file.res/LSNSR.pdf

10. How many friends do you feel close to such that you could call on them for help?

	none		one		two
	three or four		five thru eight		nine or more

11. When one of your friends has an important decision to make, how often do they talk to you about it?

	never		seldom		sometimes
	often		very often		always

12. How often is one of your friends available for you to talk to when you have an important decision to make?

	never		seldom		sometimes
	often		very often		always

B. Lubben Social Network Revised Scale Questionnaire (translated, in Spanish)

A continuación se le presentan 12 preguntas referentes a su familia y amigos. Para cada una de ellas, por favor marque con una cruz (X) la opción que considere más pertinente de acuerdo a su situación personal actual.

RESPECTO A SU FAMILIA: *Teniendo en cuenta a las personas con las que usted está relacionado/a, ya sea por nacimiento, casamiento, adopción u otros.*

1. ¿Con cuántos parientes se junta o tiene noticias de ellos, por lo menos una vez por mes?

	ninguno		uno		dos
	tres o cuatro		de cinco a ocho		nueve o más

2. ¿Con qué frecuencia se encuentra o tiene noticias del pariente con el que tiene más contacto?

	menos de una vez por mes		mensualmente		algunas veces al mes
	semanalmente		algunas veces por semana		diariamente

3. ¿Con cuántos parientes se siente lo suficientemente cómodo/a como para conversar sobre sus asuntos personales?

	ninguno		uno		dos
	tres o cuatro		de cinco a ocho		nueve o más

4. ¿A cuántos parientes siente lo suficientemente cercanos como para llamarlos cuando necesita ayuda?

	ninguno		uno		dos
	tres o cuatro		de cinco a ocho		nueve o más

5. Cuando uno de sus parientes tiene que tomar una decisión importante, ¿con qué frecuencia se lo comenta a usted?

	nunca		rara vez		a veces
	con frecuencia		con mucha frecuencia		siempre

6. ¿Con qué frecuencia uno de sus parientes está disponible para hablar cuando usted tiene que tomar una decisión importante?

	nunca		rara vez		a veces
	con frecuencia		con mucha frecuencia		siempre

RESPECTO A SUS AMIGOS: *Teniendo en cuenta a todos sus amigos, inclusive a aquellos que viven en su vecindario.*

7. ¿Con cuántos amigos se junta o tiene noticias de ellos, por lo menos, una vez por mes?

	ninguno		uno		dos
	tres o cuatro		de cinco a ocho		nueve o más

Sigue al reverso de la hoja

8. ¿Con qué frecuencia se encuentra o tiene noticias del amigo o amiga con quien tiene más contacto?

	menos de una vez por mes		mensualmente		algunas veces al mes
	semanalmente		algunas veces por semana		diariamente

9. ¿Con cuántos amigos se siente lo suficientemente cómodo/a como para conversar sobre sus asuntos personales?

	ninguno		uno		dos
	tres o cuatro		de cinco a ocho		nueve o más

10. ¿A cuántos amigos siente lo suficientemente cercanos como para llamarlos cuando necesita ayuda?

	ninguno		uno		dos
	tres o cuatro		de cinco a ocho		nueve o más

11. Cuando uno de sus amigos tiene que tomar una decisión importante, ¿con qué frecuencia se lo comenta a usted?

	nunca		rara vez		a veces
	con frecuencia		con mucha frecuencia		siempre

12. ¿Con qué frecuencia uno de sus amigos está disponible para hablar cuando usted tiene que tomar una decisión importante?

	nunca		rara vez		a veces
	con frecuencia		con mucha frecuencia		siempre