

# Design Guidelines for Socio-Domestic Systems Supporting Informal Elderly Caregiving

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## Abstract

Current communication practices broadly rely on social media services and instant messaging. However, in the context of intergenerational interaction, this paradigm has not been deeply studied from a holistic perspective, i.e., considering the attitudes, expectations, viewpoints, and concerns of all involved stakeholders. Therefore, 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 this paper, we aim 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 for supporting the design of novel computer-supported mechanisms to mediate these processes. More precisely, this implies identifying key design aspects, considering the perspective raised by older adults and how other family members articulate themselves in this context. By addressing the proposed design guidelines, social computing researchers, designers, and practitioners would be able to better understand the complexity of informal elderly caregiving, and identify plausible solutions that would improve user experience and the effectiveness of computer-supported mediation strategies.

**Keywords:** Older adults, Social media, Intergenerational communication, Informal caregiving, Design, Social computing, Empirical study.

## 1 Introduction

As a person gets older, the size of his/her social networks, sense of social connection, and interaction frequency all tend to decrease [1, 2], focusing more on close family members—mainly children and grandchildren. This perceived reduction in the number of 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 [3], which end up reducing the space for interacting with others. In this paper we address informal elderly caregiving practices and intergenerational communication in Latin America; more specifically, countries located in the so called *Southern Cone* region (i.e., Chile and Argentina).

As in any culture, the health, physical, and economic state of Latin American older adults determine many of their needs. However, several others of these needs are shaped by cultural expectations in favor of older adults. 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 [4]. 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 [5] in which family members are prompted to promote social engagement and provide affective care to their older adults [5]. 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 and particularly in Southern Cone families, 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 this population. As a result, a large number of Latin American older adults still prefer to stick to this interaction paradigm [6]. This shapes the way in which family exchanges should be supported, reinforced, or mediated.

One of the most important duties that informal elderly caregivers are expected to fulfill is ensuring that older adults reach a suitable status of social health, i.e., favoring the social inclusion within their 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 make possible 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 [6].

Given that older adults, in general, tend to prefer to live independently in their own homes for as long as possible [7], computing technology, and particularly systems aimed to be deployed in-home (also known as *domestic technology*) are valuable assets to support this user group. 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 [8], these solutions are not fully transferable to the case of middle-class Latin American families, and particularly, those based in the Southern Cone region.

In summary, we are faced to a problem that is shaped by human and social factors rooted in 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 the design of both human-human and human-computer interaction experiences. These considerations include selecting the appropriate technology support and interaction mechanisms to be supported through the mediation system. Therefore, conceiving a solution to mediate intergenerational family communication in Southern Cone families 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, Instagram) and other social networking services. Consequently, we are faced to an opportunity of identifying design guidelines, grounded in an understanding of the design space and underlying challenges that characterize the dynamics of informal elderly caregiving—both from an organizational and collaborative viewpoint—encouraging active aging as well as facilitating the involvement of the family network.

## 2 Related Work

Recent efforts in the Human-Centered Computing research community have 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 [9], in developed countries, such as Canada, urban 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 [10].

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 [11] and may “view the exercise of familial obligation as an assault on their dignity and moral worth” [12] (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 [5]. In this latter case, adults continuously aim to integrate their parents into the kin and provide them with care [6].

Therefore, 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.

Contrary to most Western countries, in the Southern Cone of America there is usually little or no participation of formal caregiving networks or government services to support the informal care provision for older adults. 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 [6]. 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, with an increasing demand for technology that can improve health and independence of older adults [13, 7]. 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 [14], there is an increasing need to care for chronically ill, disabled, and partially independent older adults.

Recent literature in HCI (Human-Computer Interaction) and CSCW (Computer-Supported Cooperative Work) provides some directions on the design problem of understanding the cooperative and collective effort of family caregiving and intergenerational communication involving older adults. For instance, according to Procter et al. [7], 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. [15], highlighting the distributed and articulated effort required in coordinating the different activities within the family network as a way to sustain informal caregiving.

Likewise, following a more traditional approach, Schmidt [16] 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 [17]. 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.

More recently, Schorch et al. [18] 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 [5, 6]. Furthermore, Latin American caregivers currently do not have access to respite care alternatives, which increases the workload and stress related to fulfilling their duties, particularly among the adult children assuming the role of primary caregiver [5]. 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.

Therefore, 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—, young people usually generalize social stereotypes that do not agree with the present potential of older adults, thus encouraging resignation and fatalism [19]. This viewpoint, complementing the ruling filial obligation [5], causes informal elderly caregivers in Chile to feel burdened, struggling to find an acceptable work-life balance.

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 [20]. 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 [21], 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 [22].

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 [23]. In this sense, Huber et al. [24] 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. [7] 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. [25] 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.

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 Latino families 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 Understanding the Socio-Cultural Nuances of Caregiving Work

In order to achieve a first detailed view on how families articulate the distributed effort of conducting informal elderly caregiving, in this section we describe three qualitative—ethnographic—studies characterizing the cooperative nature of this kind of work. We also reflect on how these insights can be derived into design implications which could be applied in this particular application domain.

These studies follow an inductive and incremental approach based from the Action Research framework and the Grounded Theory approach to data analysis. The first study, conducted with an exploratory sample of families in Chile, aims to provide an initial set of insights which will be used as input for strengthening the complexity of the narrative and building a more thorough and detailed theory on intergenerational communication and informal caregiving in Southern Cone families. Following such a line of reasoning, the second study enlarges the study sample to comprise a more general sample of middle-class families living in urban settings, as a way to explore internal dynamics of communication and caregiving practices in this scenario. Finally, the third study scales even more the study sample, comprising now families in Chile and Argentina and more complex units of analysis, namely cooperative practices of caregiving work as well as expectations and nuances with regard to intergenerational communication.

#### 3.1 Understanding the caregiving ecosystem and modeling communication asymmetries

In this first study [26], 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.

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. 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.

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.

### 3.1.1 Method

Based on informal observation to family settings and autoethnographic analysis [27], 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.

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.

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.

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 [28]. 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.

### 3.1.2 Findings

Based on the analysis of the conducted interviews, Figure 1 shows 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 the figure, 'OA' stands for older adult.

Although the user group of older adults is vastly heterogeneous and diverse [29], there is a common trait in Latin American elderly, consisting on typically having a group of affectively close people that care for them [4, 5, 19]. While these people typically are their partner and adult children, other relatives and friends also participate.

Some of the needs of older adults are caused by 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 network. 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 [5]. 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 [5].

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.* Family members through promoting affection, trigger feelings of appreciation, caring, and love among older adults within the family. This also considers the provision of emotional support.
- *Social engagement.* This considers engaging older adults in family activities as well as promoting recreation activities (e.g., family reunions and holiday trips together).
- *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.

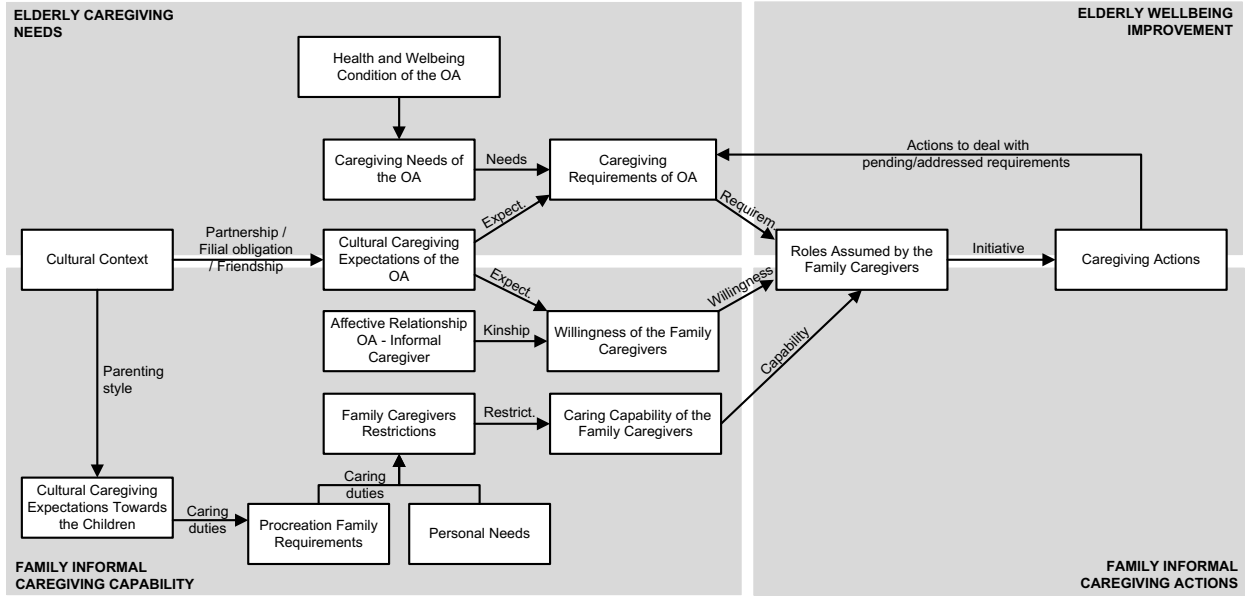


Figure 1: Informal elderly caregiving ecosystem

- *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.

### 3.1.3 Implications to design

Our interviews, backed with related literature [4, 5, 6, 19], 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.

In this context, asymmetries are inherent to family communication, particularly when they involve inter-generational 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.

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.

### 3.2 Attitudes and agreements on intergenerational communication

This second study [6] extends the interviews described in the Section 3.1, 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 for 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.

#### 3.2.1 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.

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.

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.
- *Family network.* Following the method proposed by Hogan et al. [30] 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. [31], 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.

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.

### 3.2.2 Findings

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 to health concerns.

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.

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 out to 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.

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 another 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.

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.

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.

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 [32]. 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, intergenerational communication is structured around asymmetric viewpoints and expectations around the frequency, duration, times, and mediating channels used in the process. While older adults usually expect—and prefer—long synchronous interactions, younger generations tend to align with



shorter and asynchronous communication. 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.

### 3.2.3 Implications to 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, which is depicted in Figure 2.

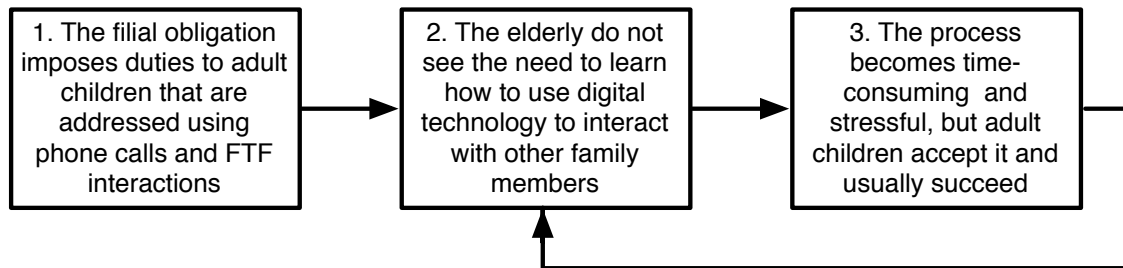


Figure 2: Vicious circle in the interaction with Chilean older adults. The acronym FTF stands for “Face-to-Face”. Number codes refer to stages in the vicious circle model.

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, i.e., the block to the left in Fig. 2). 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, i.e., the block to the right in Fig. 2). 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, i.e., the block in the center of Fig. 2), we can produce changes that shift the caring approach toward a sustainable scenario, which respects the cultural aspects of Chilean families.

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.

## 3.3 Nuances of cooperative work in informal elderly caregiving

Finally, in this third study [4] we extend to a new sample comprising Chilean and Argentinian families. The main line of analysis was to *identify a set of family caregiving roles 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, we present 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. In 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.

### 3.3.1 Method

We conducted a multi-method qualitative study [27] 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. In that respect, the findings derived from this study will help formulate contextualized design implications, which could be used to support the

conception and development of computer-supported technology to mediate the social interaction space of Southern Cone family members.

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.

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). The participating families were distributed across several households. Two of them were based in Santiago (Chile), while the other two in San Juan (Argentina).

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.

- *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 [33], 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, 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, the author conducted individual semi-structured interviews with members of 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.

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 [34], 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.

### 3.3.2 Findings

By studying the cooperative aspects of the informal caregiving work, we propose a set of 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. 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.
- *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.
- *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.
- *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.

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.

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.

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 [35]. 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.

### 3.3.3 Implications to design

Considering the family caregiving model structured in Section 3.1 (Figure 1), the vicious circle model depicted in Figure 2, and the caregiving and family communication roles derived in Section 3.3.2, 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 3

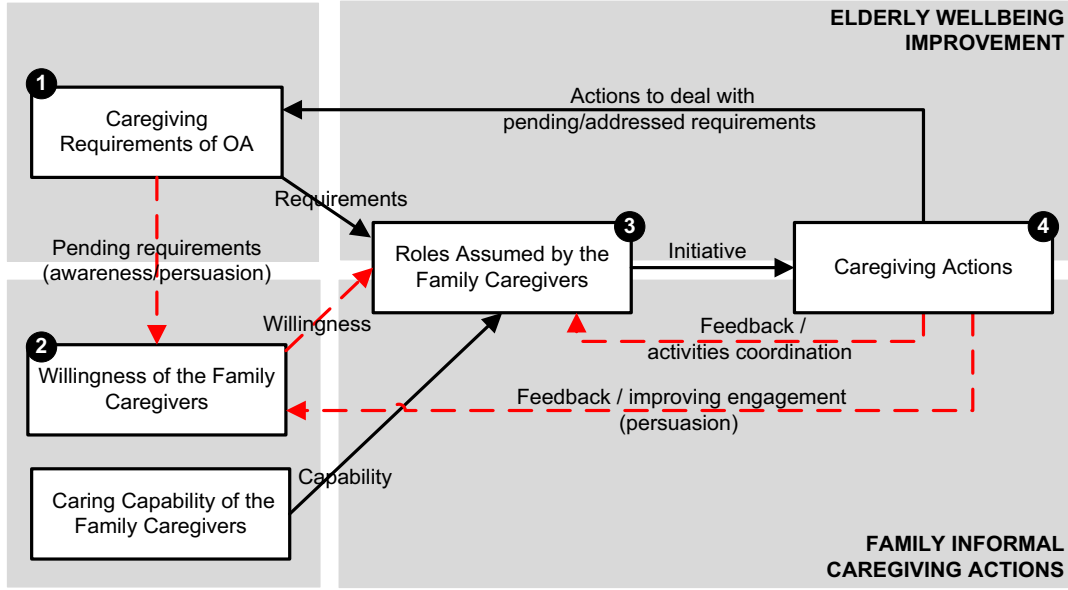


Figure 3: Opportunities for intervening the informal elderly caregiving process

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 support required to address the elderly needs, matches with the caregiving requirements presented in the ecosystem conceptual model (Label 1 in Figure 3). Similarly, the willingness and commitment values of a caregiver both correspond to the components labeled as 2 and 3 in Figure 3. 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 3 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.

All in all, 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.

## 4 In-Home Deployment Study

In this section 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, we report 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. This section extends the findings already reported in a preliminary work [36].

### 4.1 SocialConnector

SocialConnector is 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 [37]. 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: syn-

chronous 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: (a) fixed to a wall or (b) over a piece of furniture.

Older adults interact with the system using their voice and selecting very simple options by touching the screen (as depicted in Figure 4). The design of the user interface of SocialConnector was initially informed by guidelines supported by the research community [38], 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.

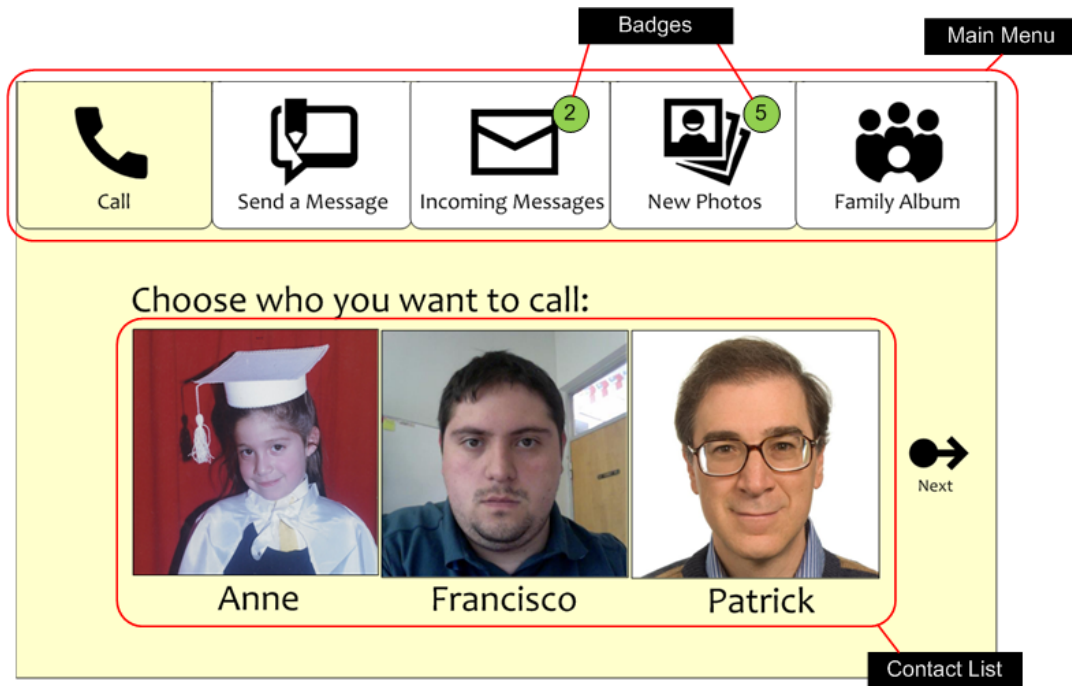


Figure 4: Prototype of the user interface of SocialConnector

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 [37]. 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.

Acknowledging that intergenerational communication is inherently asymmetrical, 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 [37].

The design of SocialConnector followed an iterative user-centered approach, 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. [39] on design considerations for facilitating the adoption of communication technology by 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. 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. We now briefly describe each one of these services. A more thorough discussion on the technical aspects of their implementation, as well as the embedded ambient intelligence and sensing capabilities in the system, can be found in [37].

#### *4.1.1 Calls*

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 requiring 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.

#### *4.1.2 Send a message*

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/she desires to send to his/her family member, and SocialConnector internally manages the user authentication and sends the email.

#### *4.1.3 Incoming messages*

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.

#### *4.1.4 New photos*

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 content 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).

#### *4.1.5 Family album*

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.

#### 4.1.6 Background services

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. 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.

## 4.2 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.

### 4.2.1 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 3.3.2, 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 (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 [40]. These factors were later used for discriminant analysis as a way to further deepen our understanding of the studied social interaction scenario.

Table 1 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.

Table 1: 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*).

#### 4.2.2 Materials

Each older adult participating in the study was provided with a tablet PC equipped with the latest version of the prototype system.

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 4G. As described in Section 4.1, 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).

#### 4.2.3 Procedure

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

- *Setup.* We recruited a sample of informal family caregivers, who acted as seeds for recruiting the family networks designated to participate 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 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 [41] 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 that respect, the base message used in the intervention was: “*Hey! It’s been XX days since you last called/sent a photo/sent a message to your grandfather/grandmother. Why don’t you do it now?*”. This message was adapted according to gender of the older adult and preferred mechanism of interaction.

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.

#### 4.2.4 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, which can be further specified as: (H2a) The social awareness mediation increases the frequency of exchanges with older adults; and (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 [42] for within-subjects studies, and that of Ray and Shadish [43] 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.

#### 4.2.5 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.

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. 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. [44] 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.

### 4.3 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 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 of 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.

#### 4.3.1 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 5 shows the volume of incoming interaction along the study.

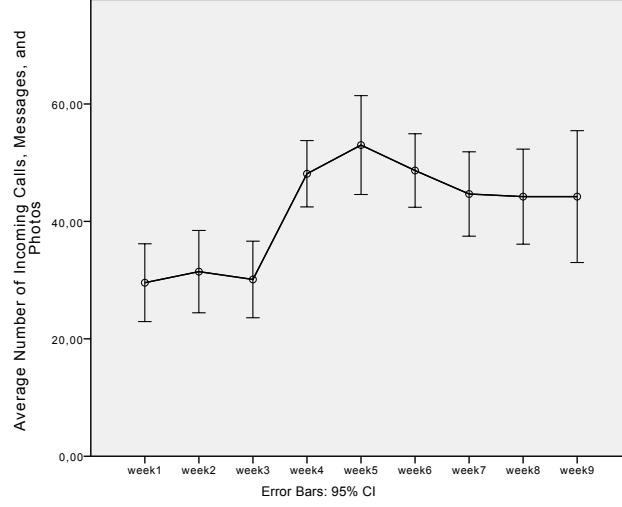


Figure 5: Volume of incoming interaction through SocialConnector

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 6 shows the volume of outgoing interaction—originated from older adults and mediated through the system—throughout the study.

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:  $F(1.26, 10.09) = 6.367, p = 0.025$ , partial  $\eta^2 = 0.443$ .

Three paired-samples t-tests were used to make post hoc comparisons between: pre-intervention ( $M = 17.1, SD = 13.5$ ), intervention ( $M = 24.7, SD = 16.4$ ), and post-intervention ( $M = 28.3, SD =$

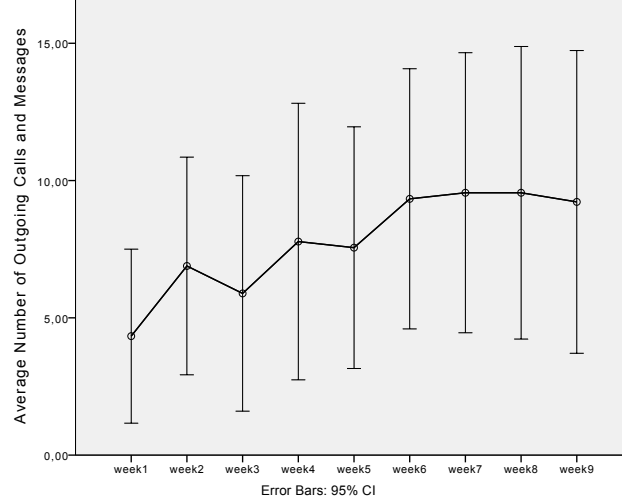


Figure 6: Volume of outgoing interaction through SocialConnector

19.9) conditions. 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 too).

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 7 shows the number of incoming calls for all participating older adults in the study (left) and the duration of such calls (right).

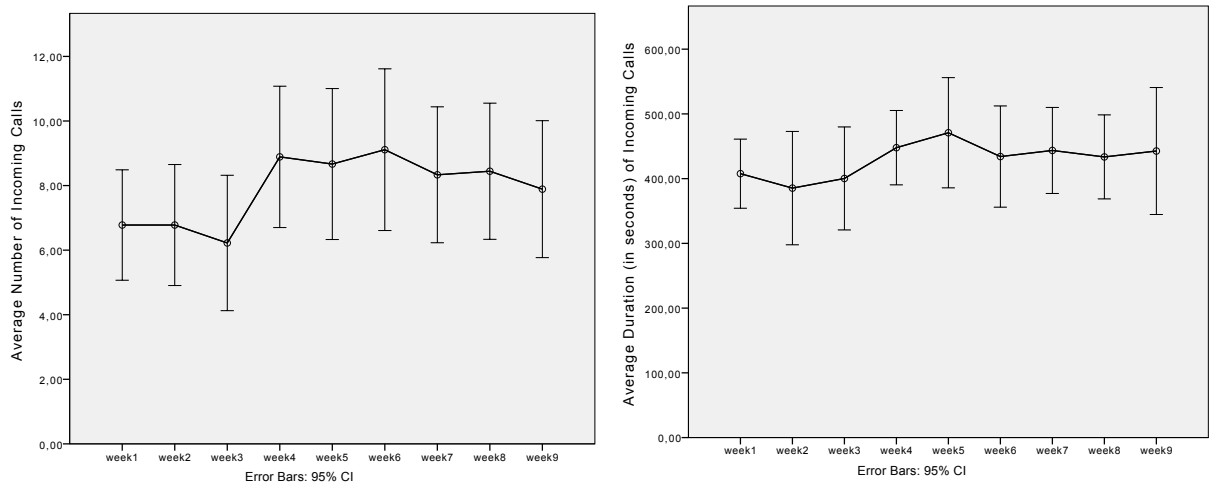


Figure 7: Volume and duration of incoming calls through SocialConnector

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 8 shows the number of outgoing calls mediated through SocialConnector that were generated from the older adults participating in the study (left) and the duration of such calls (right).

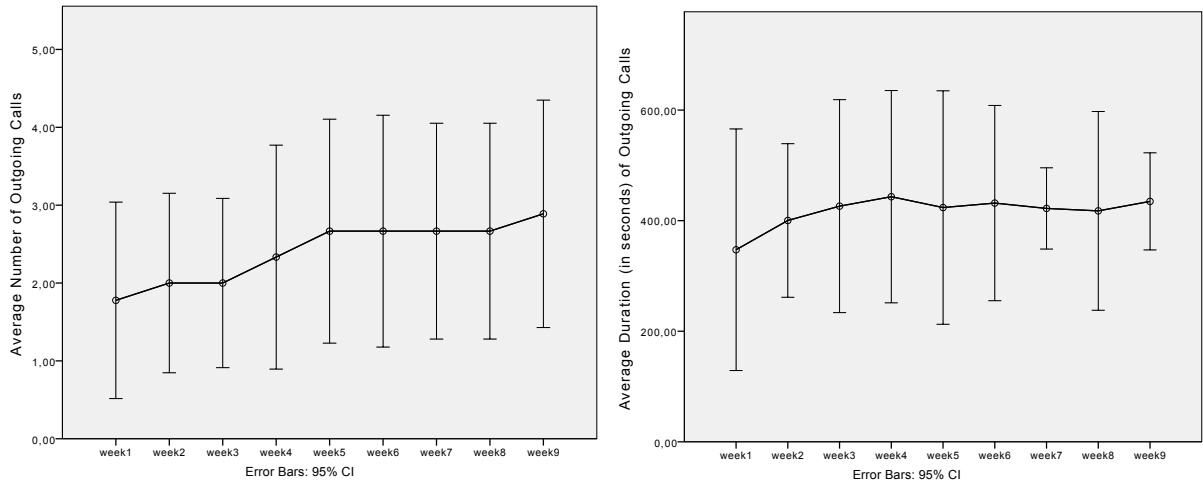


Figure 8: Volume and duration of outgoing calls through SocialConnector

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 in-

tervention 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 9 shows the number of incoming messages sent through SocialConnector to all participating older adults in the study.

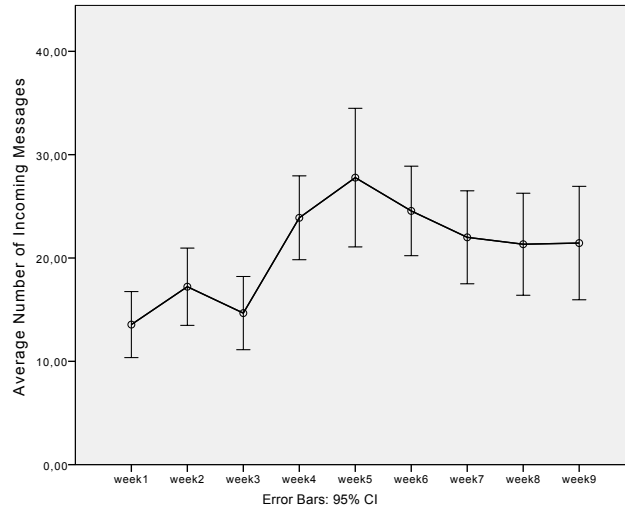


Figure 9: Volume of incoming messages through SocialConnector

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 (e.g., SMS, instant messages through social media, or emails) 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 10 shows the volume of outgoing messages sent through SocialConnector from older adults.

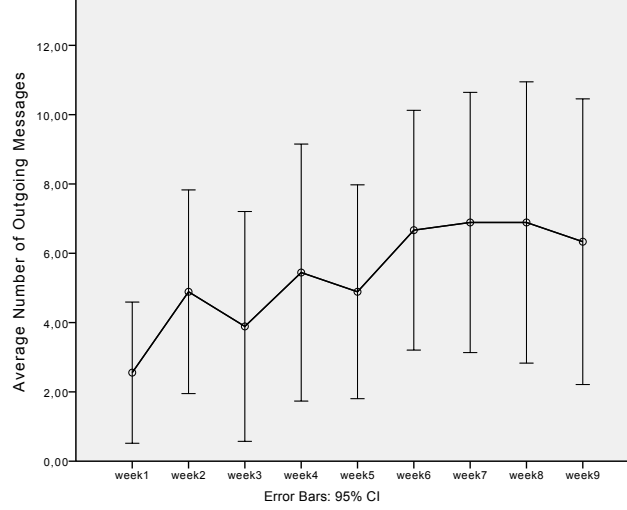


Figure 10: Volume of outgoing messages through SocialConnector

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 a 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 11 shows the number of photos retrieved by SocialConnector from those sent to the older adults participating in the study by their family members messages.

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 ( $M = 46.9, SD = 15.6$ ):  $t(8) =$

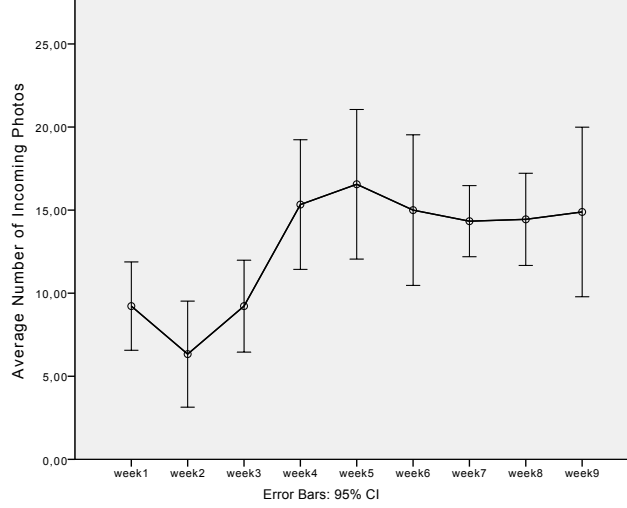


Figure 11: Volume of incoming photos through SocialConnector

$-6.784, p < 0.001, 95\%CI = [-31.941, -12.282], d = -2.947$ . 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  $\eta^2(calls) < \eta^2(messages) < \eta^2(photos)$ . 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*.

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.

#### 4.3.2 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 1, 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 ran independent samples t-tests on the collected data. Table 2 reports the main statistics for all studied outcome variables ( $M$  = mean,  $SD$  = standard deviation,  $d$  = Cohen's measure of effect size).

Table 2: 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 out to their family members more frequently*.

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 3 reports the main statistics for all studied outcome variables.

Table 3: Mediation effect of SocialConnector according to household status

Variable	Lives with family		Lives alone		$t(7)$	$p$	$d$
	$M$	$SD$	$M$	$SD$			
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 all statistically significant. Similarly, there are noticeable differences, although not statistically

significant, in the volume of incoming messages, number of incoming calls, but not in the number of incoming photos for older adults living alone when compared to older adults sharing home with at least another family member.

The obtained results can be used to inform design decisions for interactive systems fostering intergenerational exchanges with older adults. More particularly, by *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. For instance, this could be achieved through certain communication channels, as preferred by family members within the caregiving network, and prioritizing exchanges with the older adult depending on household status.

- *Prior experience with ICT technology.* We also compared the mediation effect of SocialConnector between older adults having used ICTs before and those who have not. In that respect, Table 4 reports the main statistics for all studied outcome variables.

Table 4: Mediation effect of SocialConnector according to ICT experience

Variable	Has used ICTs before		Has never used ICTs		$t(7)$	$p$	$d$
	$M$	$SD$	$M$	$SD$			
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, according to informal observations, is still seen as steep by those users new to computer-supported systems.

- *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 5 reports the main statistics for all studied outcome variables.

Table 5: Mediation effect of SocialConnector according to initial LSNS-R score

Variable	Low engagement		High 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.

#### 4.3.3 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 1.

Entry interviews revealed that older adults considered themselves as being well cared for in most of the cases, with one or more close family members acting as their informal caregivers. 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.*

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.

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 routines, and available times for social interaction, and variety of social media for interacting with family members, can be addressed in design.

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 of 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. [45] 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.

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 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. [23] 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.

#### 4.4 Discussion

The obtained findings overall corroborate the proposed models inferred so far 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 strategies (H2a). Furthermore, this effect was not affected after the prompting 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.
- *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. Privacy concerns and unexpected effects of social awareness messages will be reworked in a future iteration of the system.
- *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 the caregiving work visible 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 of 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. 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 [46], 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.* Section 4.1.6 – Background Services of SocialConnector), 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.

## 5 Conclusions and Future Work

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.

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. 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. 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. 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.

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 with their 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 [1, 6, 8, 13, 26, 37] can be successfully addressed using context-aware social technology.

Regardless of the positive outcomes, the results also suggest that social awareness strategies 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.

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. 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.

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 Southern Cone families, is just the first step in a more general problem that can be addressed following further iterations of the action research approach.

As part of the results of the in-home deployment study, we identified a set of awareness strategies that could be used as a way to promote intergenerational communication and ease informal caregiving within a sample of middle-class Southern Cone families settled in urban settings. In that respect, the mediation effect of SocialConnector in terms of frequency and duration of calls, number of incoming and outgoing messages, and number of incoming photos, all serve to promote this kind of interaction. However, due to the limited sample size addressed in this trial, future work will be devoted to replicate this study in larger and increasingly more general family settings (e.g., covering broader geographical diversity and family composition).

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: (1) Managing and combining seamlessly different preferred mediator tools to match the skills of older adults and family members; (2) Managing the available time slots and workload balancing among family members; (3) Ensuring awareness of the situation of the older adult, and of other family members' availability; and (4) 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: (1) Understanding the privacy concerns of older adults and their family members with regard to domestic information sharing and disclosure; as well as (2) Proposing new alternatives crossing research in persuasive technology, behavior change, and playful interaction practices.

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