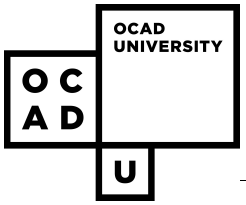

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Technology to reduce social isolation and loneliness

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Technology to Reduce Social Isolation and Loneliness

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ABSTRACT
Large numbers of individuals, many of them senior citizens, live in social isolation. This typically leads to loneliness, depression, and vulnerability, and subsequently to other negative health consequences. We report on research focused on understanding the communication needs of people in environments associated with social isolation and loneliness, and how technology facilitates social connection. Our work consists of successive iterations of field studies and technology prototype design, deployment, and analysis. Particular attention is paid to seniors in retirement communities and in long-term care settings (nursing homes). We present design implications for technology to enable seniors' social connections, the "InTouch" prototype that satisfies most of the implications, and a report on one older adult's experience of InTouch.

Categories and Subject Descriptors
H.5.2; K.4.2.

General Terms
Design; experimentation; human factors.

Keywords
Social isolation; loneliness; communications technology; chronic pain; long-term care; seniors; field studies; prototypes.

1. INTRODUCTION
Large numbers of adults live in relative degrees of social isolation. Many, but not all, are senior citizens, who we define as individuals 65 years of age and over. Some seniors live alone, some with a partner or others. Their limited social ties, often caused by geographic relocation or by the death of family and friends, can lead to isolation. Some seniors are lonely at home, or when hospitalized in rehabilitation facilities for weeks, months, or even years. They may suffer from chronic pain, and may have physical or cognitive challenges to mobility or communication. Many perceive themselves as being lonely. Being isolated often results in depression or significant vulnerability (6).

We became interested in this problem through a personal experience — observing two years of the increasing isolation of a close relative in a rehabilitation facility as she declined physically and cognitively. We imagined the hospital TV on her wall as a vehicle to bring in video updates from her children. This seemed especially salient as it became more and more difficult, both physically and emotionally, for family and friends to visit.

In 2009, we began field research and envisioning, prototyping, and testing novel technology to enable communications and support for socially isolated individuals. This paper reviews progress towards the development of the requirements for such technology, beginning with an elaboration of the problem's importance and a survey of relevant previous research. We then focus on the design process — what we have learned from potential users in a variety of relevant settings through observations, interviews, focus groups, and deployment of early prototypes. Then follows an enumeration of design implications synthesized from the studies, a description of the system we are testing in a field trial, and a report on the experiences of the first significant pilot user.

2. SIGNIFICANCE
We define isolation as a lack of quantity and quality of social contacts (4). In this paper, we speak primarily of *social* isolation, but acknowledge that social isolation can be caused *physically*, through distance or disability, or *emotionally*, through unsustainable friendships, social stigmas, or traumatic events. Isolation may lead to feelings of loneliness (7), which largely depends on whether isolation is freely chosen, since voluntary isolation may be associated with positive feelings (4).

A recent meta-analysis of the literature asserts that 10 to 43% of homebound older adults are isolated (30). Even more striking, Perissinotto et al. (31) report on a longitudinal cohort study of 1600 participants and find that 43% are lonely. Similarly, AARP (1) reports on a U.S.-wide representative sample of 3000 adults ages 45 or older and finds that 35% of older adults suffer from chronic loneliness.

There is clear and compelling evidence that social isolation is associated with negative health outcomes (13, 24). Isolation is closely linked to depression, each building on the other (3). In seniors, a limited social network is associated with poor health

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outcomes in measures such as daily activities, incontinence, vision impairment, and subjective health rating (24).

Social isolation is significantly associated with increased mortality (18, 39). Conversely, robust social networks are associated with reduced mortality among men living with cardiovascular disease (21). In the case of an emergency, any social contact is associated with increased survival rates (22).

Our research has engaged with different groups of individuals where isolation is often a factor in health outcomes. We have carried out an iterative set of mutually reinforcing field studies and prototype development. This work is significant because it has allowed us to make design choices based on an expanding qualitative understanding of social isolation, and the role of interactive systems in potentially alleviating that isolation.

3. RELATED WORK

Interest in technology for social connectedness was sparked early in this millennium, as illustrated by the seminal early papers by Mynatt et al. (28) on digital family portraits and by Hindus et al. (17) on social communication devices for the home. Our technology development is closest in spirit to the design of "communication appliances for intimate social networks" proposed by MacKay, Riche, and LaBrune (26), and typified by their work on "markerClocks" (33). Our field studies complement work on seniors and computers and communication (12), emailing (34), and computer-mediated communication (36).

The last decade has seen the continued expansion of this area of research, as documented in the recent edited volume entitled "Connecting Families" (29). Neustaedter, Harrison, and Sellen (29) stress that technology to support domestic communication differs profoundly from traditional media spaces (16) designed for the workplace. The former focuses on connection for its own sake, and not as a means towards an instrumental goal such as project coordination or document editing.

Although more recent work focuses on supporting video communications, Schatorje and Markopoulos (36) document the value of asynchronous audio messaging. Cao (9) asserts that families trying to bridge time zone differences value synchronous communication the most. Other investigators working in a number of domains, such as Inkpen (19), describe how various mixtures of synchronous and asynchronous communications are used in combination. Judge et al. (20) describe the use of always-on video linking between two or three sites, including a mixture of private and public media spaces. Blythe et al. (5) and Lindley (23) describe the use of technologies for cross-generational messaging.

Tsai and Tsai (41) show that only 3 months of 5 minutes per week of videoconferencing interaction with family alleviated depressive symptoms and loneliness for nursing home residents, as compared to a control group, over a period of a year. Seelye et al. (37) show that tele-operated robotic-controlled videoconferencing is perceived by independently living, cognitively healthy older adults as enhancing their well-being and physical health, social connectedness, and ability to live at home. Additionally, the concept of creating comfort and the role of communication in hospice care is explored in Ferguson et al. (14).

Our work differs from these studies in its focus on a large variety of groups of individuals in isolation, groups who differ in age, health conditions, and where they live; and in our exploration of asynchronous communications as the starting point for design.

4. FIRST STUDIES AND PROTOTYPE DEPLOYMENTS

Many, but not all, isolated individuals are senior citizens; we chose to work in successive studies with contrasting groups, including:

1) Home dwelling seniors suffering from chronic pain;
2) Older people in medium- or long-term hospitalization;
3) Seniors who live in long-term care residences;
4) Seniors who live in retirement residences, and
5) Seniors living at home and receiving health care services.

We began with individuals living at home with chronic pain. More ubiquitous than commonly perceived, chronic pain affects 10-20% of North American adults (15). Pain interferes with appointments, social outings, and regular communications, and often leads to social isolation.

We began our explorations into the design of systems to alleviate isolation by approaching the problem on two fronts. We wanted to build first prototypes that were robust so that these could be deployed in the field. We also wanted to better understand social isolation by speaking with potential users before, during, and after deployments. We took a grounded theory approach to the design and analysis of each successive deployment and engagement with users. We used a combination of observations, interviews, focus groups, and diary studies, depending on the size of the study. Researchers took written notes during the observations. In the case of interviews and focus groups, dialogue was audio recorded and fully transcribed and then analyzed using thematic analysis informed by a grounded theory approach (40).

All studies presented in this paper were carried out with appropriate ethics approvals. This paper presents each study briefly (details of study design and results can be found elsewhere) and then follows with a discussion of our findings and implications for design.

4.1 Interview Study of Individuals at Home Struggling with Chronic Pain

This first interview study aimed at exploring the use of media to prevent isolation by seniors with chronic pain. During 2010, we interviewed 27 seniors who had experienced chronic pain for three months of more. Semi-structured interviews included questions related to background and demographics; social network structure and media use; interaction challenges; use of mass communication modalities; and the roles of loved ones and caregivers.

Three themes emerged from this data: setting the stage for interaction, managing others' expectations, and revealing and concealing pain (3). Participants indicated that participating in social activities required tactics to avoid or minimize possible disruptions that could be caused by their chronic pain. If such disruptions did occur, as was often the case, they sought to mitigate negative impressions that could result. To do so, there were times that they revealed and other times that they tried to conceal the pain. Because it seemed risky and threatening for such individuals to repeatedly arrange times for real-time chat, this study supports an asynchronous communications approach.

4.2 Families in Touch Prototype

Our first prototype was called Families in Touch (FIT), based in part on unpublished undergraduate thesis research (23). During 2009, the student observed three seniors with differing degrees of isolation and loneliness. During conversations with the

participants she noticed their tendency to touch pictures of their relatives. She believed that it was a way to reconnect with their family members and treasured memories.

Figure 1. FIT using photo of family and tactile interaction

Her design solution (Figure 1) consisted of a wooden picture frame incorporating a touch screen display surrounded by LEDs as new message indicators, and asynchronous messaging capability leveraging tactile interaction. When the senior touches the frame, a family member may receive an email to indicate that their relative was thinking of them, and access a web site to respond with a video message. The video was then transmitted to the frame, and the LEDs' glow invited the senior to touch the frame, their touch commencing the video playback. The design focused on creating an asynchronous, unobtrusive communication tool with a simple interface and tactile user experience.

In 2010, we deployed FIT for 2 weeks with three participants from the interview study, one of whom lived alone, the other two being a caregiving daughter and her mother. Participants appreciated the asynchronous communications, and developed their own patterns of viewing. Participants and family members really liked FIT and had no difficulty using it, but wanted to be able to send messages, possibly even video recordings, to family members, and not just the "I'm thinking of you" message conveyed by touching the screen.

4.3 Diary Study and Next Prototype — Ringo

To further inform our next design, we then in 2011 carried out a 2-week diary study of daily communication patterns and needs of 11 older adults with chronic pain (11). Participants were asked to record situations where they had social contact (224 situations in total), and situations where they desired social contact (a total of 106). Roughly 60% of the contacts were made by phone, 20% face-to-face, and 20% using a computer. Communication was initiated to catch up, to obtain practical information, to give or receive support about health issues, and for social and holiday purposes. Social contact was initiated for both functional and emotional reasons.

Based on insights derived thus far, we next designed a system (called Ringo) using a 7" Samsung Galaxy Tab (Android) tablet in place of both the picture frame and the enclosed picture. The system supported message sending and easy media uploading to a web site, asynchronously through a touch interface. Messages could be chosen from a set of standard messages: "Missing you", "Not feeling well today", "Change of plans", and "Need information". Media could be text, photos, or videos.

Ringo was deployed with three seniors and their families for 2 weeks each. Each person had been part of the diary study. Results were mixed. In one case, photos and videos were sent most days by family members and viewed and appreciated by the senior. A way to send back different sets of messages, such as "Got it!" was desired. The second senior already used frequent email exchange with family and friends, and did not adopt Ringo. The third senior made use of Ringo, but was limited by technical issues encountered by family members. Another de-motivating factor was that this project was a 2-week test and the technology would then be removed.

4.4 Interview Study with Individuals in a Complex Continuing Care (CCC) Hospital

The objective of the next study (2012-13) was to take what had been learnt previously and engage with a diverse set of potential users who might have a greater variety of issues resulting in social isolation. We designed a study on communication patterns and preferences of older adults residing in a complex care facility. Due to their age and the nature of their medical conditions, many seniors reside in these facilities for a considerable amount of time (years), and are often socially isolated and lonely.

Semi-structured interviews were conducted with 11 seniors who had resided in the facility between three months and 13 years. Diagnoses often included more than one condition including: paraplegia, multiple sclerosis, cerebral palsy, diabetes, hypertension, and chronic obstructive pulmonary disease.

We documented how various participants used face-to-face interaction, Skype, email, Facebook, the telephone, letters, cards, and gifts to maintain intimate relationships (6). We discovered barriers to accessing communication technologies, especially the lack of infrastructure, and the absence of support for learning and use of communication technology.

We can see that a nuanced account of communication needs and the role of technology must consider the diversity of the population of seniors and the settings in which they reside. Hence we turned our attention to seniors living in a variety of settings.

4.5 Interview and Observational Studies of Seniors' Retirement, Long-term Care, and Home Health Care

The objective of the next and last "needs analysis" study was to understand communication patterns with seniors in a range of settings, including long-term care, retirement residences, and the home setting where nursing care was being received on a regular basis. Many older adults in these settings receive care and reside in these settings for a considerable amount of time, again raising concerns about the potential for social isolation and loneliness. Included in these settings were seniors with a broad range of impairments to hearing, vision, mobility, and speech. We also included seniors who were based in rural settings as well as urban centers.

Semi-structured interviews were conducted during 2013-14 with 16 older adults residing in long-term care, retirement, and home care settings. Interview topics were developed based in part on our previous studies; making use of a review of the current HCI research on technology, social connections, and families (29); and adding a few topics from the social science and medicine literature (8, 32) that are relevant to retirement and long-term care.

Eight female and eight male participants ranged between 65 and 90 years of age, with lengths of stay, or receipt of home care, between three months and thirteen years. Diagnoses often included more than one condition including diabetes, hypertension, and heart disease.

We documented how various participants use technology to maintain and control communication specifically in acute situations or when reflecting or tired. We also looked at patterns of communication and interpersonal engagement independent of technology. Themes emerging from a qualitative analysis of the interviews and described in full elsewhere (38) show a range of technology use and communication patterns.

We spoke to some who actively manage contact and communication with family, friends, and providers, such as taxi services, clothing stores, and banks, through technology ("tech-savvy"). Technology is perceived as a tool to manage and adapt to changing circumstances and loss of capabilities.

We also spoke to some who displayed active "social" communication styles and activity patterns. This included sharing memories through pictures, postcards, and conversation, as well as heavy use of the cellphone, mainly through incoming calls from family, at specific designated times. Alternative media formats including video and voice recordings were also described as being desirable and valuable, although tools to create and share such media were not evident.

At the other extreme were those passive in their interpersonal communications and in their use and non-use of technology. This "resigned" style appears often in more acute settings such as long-term care, where loss of capabilities makes use of a cellphone difficult (in particular remembering numbers or using small keypads), and where family are perceived as "busy, unreachable, and not to be disturbed". What we found expressed by participants was a fear of further loss of contact with family that could result from new attempts to connect (i.e., with a new device), and little interest and motivation in learning to use something new. This confirmed findings from our previous studies regarding the need for extra supports for learning and use of technology in institutional settings.

A number of other themes emerged from the data that support the need for communication technologies for story telling and remembering, connecting between generations, and checking-in and maintaining lightweight forms of social interaction. While many participants described using a phone kept close to the body as their main communication device for routine, social, and acute communication needs, there was also recognition that with further loss of capability (hearing, dexterity etc.), this technology would no longer support their needs.

We also observed that photos, letters, and other highly valued tangible objects were referenced by participants in telling stories about people who were meaningful to them, but that considerable work was necessary to protect these objects from deterioration, and maintain orderly proximity to these objects. Different strategies for keeping these objects close and available were used, for instance, taping pictures to specific walls, balancing letters and photos on walking devices, and using notebooks to house letters and photos. Access and manipulation of these objects, however, was challenging for those with limitations to dexterity and mobility such as result from stroke, arthritis, and tremor.

Additional findings point to the prevalence of the phone as the currently preferred communication tool. There is a critical role of family in introducing and maintaining technology beyond the phone for seniors, especially those in institutional settings or with mobility restrictions. These findings were common across all three settings.

5. IMPLICATIONS FOR DESIGN

Themes and connections between themes were used to uncover design implications. Some implications confirmed observations from our previous studies, but there were also new insights.

Particularly important is the difference in style and attitudes towards technology and communication with family and friends. Tech-savvy groups are likely only to use something new if it enables independence and activity beyond the tools they have discovered for themselves, as they may already be well served by existing technology. Resigned individuals are difficult to reach; their adoption of any technology for communication would need to be facilitated by family and/or staff. Many of these individuals are also fearful of or not interested in computers, or feel that they cannot master high-tech. For example, we found numerous cases of regular mobile devices having been discarded in trash bins. Hence our first three design implications:

Design Implication 1: Avoid traditional computing aesthetics (screens, keyboards, grey, black, and office plastic) and conventions. Design appliances, not computer interfaces. Support compelling concepts and metaphors from real life, such as a "wave."

Design Implication 2: Support expressions of personhood through alternate interaction techniques and tangible interfaces based on real-world objects and practices. Specifically, natural objects may be a good source of design inspiration, given that seniors relate well to animals and plants, and use tangible objects on their persons as emotional supports — letters, pictures, cards, small stuffed animals.

Design Implication 3: Leverage pictures of family to engage seniors. We have seen this idea in many of the studies and locations summarized above.

For the resigned group in particular, light forms of short social engagement, akin to a wave or a smile across the street, may be beneficial as a first step to relieving a sense of resignation and a possible state of social isolation.

For all groups, the family and caregivers play an important role in the adoption of technology. Additionally, it is important to respect existing patterns of communication, e.g., telephones, cell phones, and social media. These insights support the next two design implications:

Design Implication 4: Do not disrupt social ties with existing family or new friends; leverage emergent social activity in place e.g. sharing stories between seniors as well as remote connections with family and friends.

Design Implication 5: Respect existing uses of devices such as smartphones and patterns of family communication, e.g., email and social media.

Our studies support the appropriateness of asynchronous communication in particular to allow seniors and families to manage interaction patterns, to deal with seniors' concerns, and to respect the unpredictability of availability for conversation. Yet, we respect work such as Cao (9), which asserts that families trying to bridge time zone differences value synchronous communication the most, and manage to achieve this by adopting routines for ensuring availability.

Design Implication 6: Support and emphasize asynchronous but also provide opportunities for synchronous communication.

Our various studies also suggest other attributes of ideal communication appliances.

Design Implication 7: Provide multiple possibilities for communication including video, photos, and audio, but do not require seniors to type.

Design Implication 8: Use tactile interaction that accounts for such issues as arthritis or tremor.

Perhaps because our studies were done in Toronto, but we suspect more generally applicable, we encountered many language challenges due to a diverse urban population.

Design Implication 9: Be non-language specific. Make use of icons as much as possible.

Finally, we saw in several settings the need to design systems and infrastructure as well as appliances, and to realize that appliances in seniors' residences and care centers may need to be shared.

***Design Implication 10*:** Design with a realistic understanding of the availability of technology infrastructure, maintenance, and assistance, which is likely to be low in nursing homes.

Design Implication 11: Support an institutional context with sufficient administration and privacy settings. Especially where rooms are shared or use of a device/appliance needs to be facilitated by the staff.

6. INTOUCH SYSTEM DESIGN

We used the design implications from the research described above in the design of our next iteration, InTouch (working name) — an application designed for seniors to connect with family and friends. In particular, we support the ability to send a 'wave' (a pre-set message), the interface is non-language specific, it supports asynchronous capabilities, and it integrates with existing common forms of communication, such as email and use of a smartphone by family members.

InTouch is currently built for use on an Android device, providing users with the option to use a 10" tablet or a 7" tablet. Support of a mobile phone would not be difficult, although screen size does pose a challenge. Users are encouraged to think of the tablet as a communicating digital picture frame. Family members can communicate with the senior via email from laptops or mobile phones as long as they have an email account.

Figure 2. InTouch application key functions.
Going clockwise from the lower right, there is a wave, an audio message, a video message, and a photo message.

InTouch can send and receive photos, videos, audio messages, and waves (see Figures 2 and 3). A wave is a standard message sent to a family member to let them know that the senior is thinking of them (checking-in), and can be responded to by the family members through their email client by sending text, a photo, a voice message, or a video message.

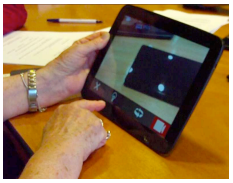

Figure 3. A senior preparing to shoot a video with InTouch.
Icons at the bottom, from left to right: are exit; use the flash; switch from front to back camera, or vice versa; and start the camera rolling.

InTouch also supports reviewing of past messages for memory, storytelling, and sharing with others within the environment (see Figure 4). Choice of a specific communication from a particular family member is done by touch and gestures on the tablet; no file system or naming method is required.

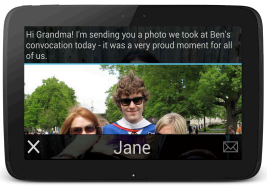

Figure 4. InTouch review of text and photo messages

InTouch has implemented several security features, for example, a senior can only receive messages from contacts that are pre-set.

To accommodate for seniors in care facilities, who may not have their own device, the senior can log into their account just by tapping on the device with an NFC tag (designed but not yet implemented). The tag could be embedded into an identity wristband, keychain charm or necklace.

Depending on the senior's (dis)abilities and preferences, certain functionalities can be disabled (designed, not yet implemented). For example, a person who experiences tremors may have difficulty hitting the targets, so targets could be adjustable.

The current implementation satisfies all design implications but #2 and #6. It needs to be improved in terms of #8. We are working with care staff to implement design implications #s 9 and 10.

7. PILOT DEPLOYMENT

We now report on the pilot deployment to understand how InTouch is being used to evaluate its impact on the perceived quality of life of potentially socially isolated and lonely seniors. The pilot study was conducted with Ms. J, a lady in her late 70s who resides at a retirement residence with her husband, and Ms. J's daughter who lives nearby. While Ms. J has strong family ties, she often feels left out and frustrated because many of her family members are geographically dispersed and she is not included in the family online communication. Ms. J connects with her family via a landline telephone and in-person, but her family primarily communicates online; sharing personal news and photos on social media platforms and discussing news articles and plans for family gatherings via email. Despite having never used a computing device, Ms. J's 'social' disposition and the support of her daughter made exploring InTouch as a communication tool an exciting opportunity.

The pilot study was conducted over a seven-week period, between Ms. J and ten of her family members, her daughter being the primary contact. The study involved three phases: pre-deployment (introduction to InTouch), deployment (use of InTouch, interaction analysis, usability and accessibility testing), and post-deployment (interviews with senior and family member). Data collection included interviews, observations, and data logging and was analyzed using thematic analysis.

The analysis of the pilot study data revealed that the use of InTouch had reduced Ms. J's frustration and feelings of being left out and improved her overall confidence and quality of life. She was able to keep up to date on family news and remarked that using InTouch felt like, "the whole world is coming into my room" and "It [InTouch] is special. They [family] haven't forgotten me." She was relieved at how easy InTouch was to learn and use. The main communication screen (Figure 2) was particularly appealing to Ms. J, "It's right in front of you, large and comfortable; easy to use." The design to create a minimalistic

interface was effective in keeping the interaction clear and simple as Ms. J noted, "There are so few things to push you can't go that far wrong. It's not that complex."

In terms of the messaging functionality, Ms. J began learning InTouch by exploring the 'wave' and audio messages. She found the wave "for beginners is excellent," a technology icebreaker that was "gratifying because it is instant." The audio messaging was also appealing because sending a verbal message takes less time than writing, and it is not as intrusive or disruptive as calling someone on the phone because it is sent asynchronously. Ms. J added that her hand and ear get tired using the telephone, whereas InTouch is quick to send and receive messages and can be used with a stand for support. The video and photo messages were introduced to Ms. J in the initial meeting, but she was not using them even after seven weeks and a second demo. She said she wanted to become proficient with the 'wave' and audio messages first. She regarded this as a positive aspect, "I'll never get tired of it [InTouch] because I can learn new things and they are within reach."

While Ms. J had an overall positive experience using InTouch, the pilot study revealed four key areas that require further consideration: (1) the physical form factor of the InTouch device, (2) the refinement of the interaction and software design, (3) improvement on the participating family member's experiences, and (4) the importance of considering intergenerational differences.

The most challenging part of using InTouch for Ms. J was an accessibility barrier presented by the device form factor: a seven-inch Android tablet. The smooth, flush, 'invisible' external buttons were not only difficult to locate, but they were difficult to depress. To make the location of the power button more prominent a piece of tape was added, however Ms. J still found it difficult to depress the button and determine if the device was on or "asleep." Learning the appropriate duration and pressure required to turn the device and off and to put it to sleep and to wake it up was not intuitive or easy to quantify. There were at least two times during the pilot where the tablet was not used because Ms. J was unable to turn it on.

Charging the device with a micro-USB also proved difficult, but manageable, which was attributed to the small size of the connector and the specific orientation required. The device itself was difficult to hold due to the limited physical abilities of Ms. J who has arthritis in her hands. Replacing or augmenting the external buttons with more prominent, customized ones and designing a stand to hold and automatically charge the device are possible solutions that we are exploring.

The second major consideration is the refinement of the interaction and software design. The tactile nature of the device, while novel and fun, was especially difficult for Ms. J to use with her arthritic hands, which had little to no sensation in her fingertips. She had to touch the screen multiple times before it registered her touch. Haptic feedback and sensitizing her fingers to the necessary amount of pressure and contact were insufficient her situation. Swiping through the contacts and scrolling through messages were also hard to execute, so tapping the screen was preferred even though it was not always successful. Consideration of multi-modal inputs, such as speech, gesture, tangible objects, or eye tracking should be considered to increase accessibility.

Several refinements to the software design were suggested: (a) Supporting the ability to delete old or read messages. Having a lot of messages to scroll through is physically difficult and overwhelming. The challenge is doing this in a way that does not add needless complexity. (b) Touching the 'x' to exit a window was too abstract and difficult to learn. When Ms. J wanted to exit the message screen (Figure 2) she would send a wave instead of tapping the 'x' in the lower left corner because the 'x' symbol did not resonate with her mental model. She said that using an arrow to indicate moving back to the previous screen would have been more intuitive. (c) The digital video recorder icon was not recognizable at first – a reel of film would have been more intuitive.

A third, and critical, consideration is the need to improve the experience of InTouch message recipients. Ms. J's daughter explained that the wave "by the forth or fifth time gets annoying more than anything else" and "there's nothing to respond to." She suggested being able to personalize the 'wave' message with a simple line of text to be more engaging. The daughter expressed that the audio messages were "superficial . . . You don't get into a deep meaningful conversation. There's no actual discourse. Writing gives you pause to think about what you want to say." The daughter also noted the disadvantage of not being able to quickly scan an audio message to reference the original message when writing a response email. These observations raise real design challenges, because we will never require our senior users to type, but speech recognition technologies may enable an answer.

While InTouch offered lightweight communication for Ms. J, it was heavyweight for her daughter, who has become a "Facebook interpreter." This involves relaying messages and photos from Facebook, which requires tedious copying, pasting, and sending. For the daughter, the communication with her mother via InTouch became less personal; however, she added that this did not replace the frequency of their more personal phone conversations. We are of course considering how InTouch should interact with social media such as Facebook.

The fourth and final point is the importance of addressing intergenerational differences. Discussing communication expectations and styles, etiquette for online communication, and technical jargon is critical to ensuring the sustainability of this deployment. Ms. J checked the device only once every couple days and would sit down for an hour or so and reply to messages as if she "was replying to a letter," whereas her family was constantly checking their smart devices and responding to messages within 24 hours. From Ms. J's perspective her family was very responsive and sent frequent messages, but the perceived delay in her responses eventually resulted in family reaching out less frequently or not at all. The etiquette and expectation that one will respond to a digital message within a 24-48 hour time frame is one that should be discussed before the deployment to prevent misunderstandings. Likewise, the differences and preferences in communication styles should be expressed and respected.

Another intergenerational gap identified was the use of technical jargon when talking about the device. Reducing technical jargon and providing a glossary for terms like "swiping" and putting the tablet in "sleep mode" can empower the senior to be on the same level and support their transition in integrating new technology into their personal life.

The pilot study with Ms. J and her daughter demonstrated that InTouch increases the senior's feelings of connectedness and confidence, and that the device is relatively easy to learn and use. Further consideration needs to be given to the overall form factor of the device, the interaction and software design, the experience of message recipients, and the expectations of all stakeholders.

8. DISCUSSION

We have conducted several sets of observations, interviews, focus groups, and deployment studies to understand the communication patterns and needs of older individuals in a number of settings. Despite this variety of population and study contexts, some insights emerge that are useful in guiding current and future designs in the form of the design implications and new understandings that we believe to be useful.

The research described in this paper started with one metaphor as a design strategy: the picture frame, as in (10) and (28). This metaphor seemed to be a good choice given that our research pinpoints tangible forms of communication as being compelling for seniors.

The application's current design relies heavily, but not exclusively, on an understanding of common mobile device form factors (the cell phone or tablet), building on the everyday concept of a picture frame with its own specific meaning and use. We are now also designing and developing a version of InTouch to provide multi-modal input/output with an alternative display option — a flat screen TV controlled by a cell phone masquerading as an augmented TV remote control. Our research suggests that other metaphors may also be useful, for example, devices such as smart watches and display media such as photo albums.

The results of the qualitative studies undertaken with residents in several institutional settings provide new insights into the use of existing communication technology, communication patterns, and social connection. One outcome of our research is the identification of three distinctive styles — Tech-savvy, Social, and Resigned. These styles imply quite different needs and behaviors. There are several opportunities for further research and exploration to develop a richer understanding of each of these groups, and particularly the 'resigned' style that implies greater potential for social isolation.

Our work confirms the importance of mechanisms by which seniors can 'check-in' with family and friends, this serving both a social and practical purpose. As we mention earlier, some recent HCI work on social connection (36) stresses the value of asynchronous audio messaging. Our research highlights the different styles among the seniors we interviewed in terms of the messaging modalities they most appreciate. Some styles prefer synchronous video and perceive this as special, and others view audio communication by phone as useful for managing communication or being 'just enough.' As in (9), we too heard seniors mention routinized communication patterns and mechanisms for coordinating connections, but the issue of physical distance was not present in participants' responses. Instead, participants mentioned that having a busy family was a major factor in connecting, indicating that further research might be needed on the concept of distance (both far and medium), as well as incorporating existing understandings of social distance (27) from the sociology literature.

9. SUMMARY, CONCLUSIONS, FUTURE WORK

Social isolation typically leads to loneliness, depression and vulnerability, and often causes negative health consequences. It is significantly prevalent in subpopulations of senior citizens. We have reported on the evolution and outcomes to date of an iterative research project that elicits the communication needs and patterns of people in environments often associated with social isolation, and the role that technology plays in facilitating social connection. The work has included successive iterations of field studies and technology prototyping, deployment, and evaluation, with significant emphasis on seniors in retirement communities and in long-term health care (nursing homes). We have developed an understanding of the context and diversity of needs of isolated seniors, a number of design implications for technology that can facilitate social connection for isolated seniors, and a prototype that satisfies most of these.

We deployed InTouch this summer in a six-week field trial in a long-term care facility with 5 participants. Preliminary results suggest that the standard usability and accessibility designs and implementations have to be adjusted to better serve the needs of frail older adults. In January, we will be starting a two-month field trial with 12-24 seniors in a retirement residence that provides graceful movement as one gets older from independent living to assisted living to long-term care.

In terms of technology, there remain many opportunities and challenges including supporting synchronous communication gracefully, providing an always-on video and audio connection (20, 33), integrating with social media; enabling new varieties of display media such as large-screen TVs, family albums, smart watches, and wall displays; exploring multi-modal input, including voice; and imagining and prototyping tangible interaction modalities.

Our most recent work also suggests other design research directions including understanding the role of social distance, and the distinction between light and heavyweight communication for seniors (e.g., wave versus video message).

10. LIMITATIONS

The voice of family members has not been fully researched and incorporated yet, nor have we looked carefully at how best to engage staff without increasing their care burden. We plan to address these limitations.

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