Article

Can Digital Technology Enhance Social Connectedness Among Older Adults? A Feasibility Study

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Abstract

This study examined the feasibility of a novel communication technology to enhance social connectedness among older adults in residential care. Research suggests that technology can create opportunities for social connectedness, helping alleviate social isolation and loneliness. Studies on implementation and feasibility of such technological interventions, particularly among frail and institutionalized older adults, are scant. Data were gathered in a 3-month deployment with 12 older adults, including semistructured interviews with participants and relatives/friends, psychometric scales, field observations, and usability tests. Data were analyzed with qualitative profiling, thematic analysis, and Friedman tests. The technology was a feasible communication tool, although requiring an adaptation period. Use increased perceived social interaction with ties, but increased social connectedness (meaningful social

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interaction) was only reported by participants with geographically distant relatives. Sense of well-being and confidence with technology was enhanced, but negative effects were also observed. Findings are useful for researchers and practitioners interested in technological interventions.

Keywords
digital technology, social connectedness, technology acceptability, social isolation, loneliness

Introduction

Research shows that frail older adults living in retirement homes are particularly vulnerable to social isolation and loneliness (Keefe, Andrew, Fancey, & Hallet, 2006; Prieto-Flores et al., 2011; Victor, Scambler, & Bond, 2009). This vulnerability seems connected to decreased social networks, mobility, health status, and interaction with close ties (Keefe et al., 2006; Prieto-Flores et al., 2011; Victor et al., 2009). The literature indicates that 10% to 43% of older adults in North America experience social isolation, and 43% experience loneliness (Nicholson, 2012; Perissinotto, Stijacic Cenzer, & Covinsky, 2012). Social isolation and loneliness are interrelated yet different concepts. Social isolation refers to low/nonexistent levels of social support and participation and decreased quality/quantity of social ties (Cornwell & Waite, 2009), whereas loneliness refers to perceived feelings of lacking companionship and abandonment (Perissinotto et al., 2012). Older adults' experiences of social isolation and loneliness negatively affect their health and well-being (Cornwell & Waite, 2009; Perissinotto et al., 2012; Steptoe, Shankar, Demakakos, & Wardle, 2013).

Studies suggest that digital communication technologies, such as the Internet, can contribute to social connectedness—that is, meaningful social interaction—and help address both loneliness and social isolation in later life (Findlay, 2003; Khosravi, Rezvani, & Wiewiora, 2016; Masi, Chen, Hawkley, & Cacioppo, 2011). Social connectedness, which relates to quality rather than quantity of social interaction, seems to tackle feelings of loneliness and factors that contribute to social isolation (i.e., social support, frequency of interaction with close ties, etc.). Theoretically, social connectedness draws from social capital, wherein resources embedded in social ties (e.g., emotional or financial support) can be mobilized when necessary, showing that quality relationships matter for well-being and socioeconomic standing (Neves, 2013; Wong & Waite, 2016). Specifically, the role of social connectedness is explained by *main effects* and *stress-buffering effects* models: the first proposes that social connections influence positively health and well-being among older adults,

the second that social connections protect from stressors and their health consequences (Wong & Waite, 2016). Research has shown that, as with social capital, these two models are more nuanced as connections matter depending on their quality and type (Litwin & Shiovitz-Ezra, 2011).

The Internet shows potential for social connectedness due to its *social affordances*, that is, the convenience, connectivity, and social cues that create opportunities for diverse interaction (Wellman et al., 2003). These affordances offer synchronous and asynchronous communication opportunities with different ties—from family to communities of interest or practice—and the ability to manage interactions simultaneously (Delello & McWhorter, 2017; Wellman et al., 2003). Using the Internet can reduce feelings of loneliness among older adults (Choi, Kong, & Jung, 2012; Cotten, Anderson, & McCullough, 2012; Morris, Adair, Ozanne, & Said, 2014), but there is less conclusive evidence on social isolation (Cotten et al., 2012). This may relate to not using the Internet for communicating with family and friends; Sum, Mathews, Hughes, and Campbell (2008) reported that older adults felt less social connectedness after using the Internet to talk to strangers. Older adults seem to prefer maintaining current networks rather than building new ones, which might further add to issues of social isolation in old age (Neves, Franz, Munteanu, & Baecker, 2017; Hope, Schwaba, & Piper, 2014). In fact, increasing social connection with close ties, particularly with family members, is a main motivation for Internet use in later life (Cotten et al., 2012; Delello & McWhorter, 2017; Sayago, Sloan, & Blat, 2011; Tsai, Shillair, & Cotten, 2015; White et al., 2002). A functional approach to technology—exploring different types of use instead of general use—can help interpret the influence of the Internet and other digital technologies on social connectedness (Lifshitz, Nimrod, & Bachner, 2016).

Although various technological interventions (from social networking sites to robotics) have recently emerged to tackle social isolation, loneliness, and social connectedness needs, literature emphasizes the importance of accessible and targeted communication systems (Brown et al., 2017; Khosravi et al., 2016). Compared with other senior groups, frail older adults living in retirement homes have also received limited attention in the deployment and study of such technological interventions (Baecker, Sellen, Crosskey, Boscart, & Neves, 2014; Neves, Franz, Munteanu, Ngo, & Baecker, 2015). This is a group at risk of social isolation and loneliness that tends to struggle with standard digital technologies due to impairments, low digital literacy, or social settings (Lee & Coughlin, 2015). Furthermore, studies on the long-term implementation and feasibility of accessible digital interventions continue to be scant because of access, recruitment, and ethical challenges with this population (Neves et al., 2017; Hall, Longhurst, & Higginson, 2009). To

address this gap, we conducted a 3-month feasibility study of an accessible communication app (tablet application) to enhance social connectedness among frail older adults in a retirement home in North America. The design of this feasibility study draws on a feasibility pilot that we have conducted with five frail "oldest old" (aged 80+) in a long-term care facility (Neves et al., 2015; Neves et al., 2017). We employed a mixed-methods and conceptual approach focused on both psychosocial and contextual elements of adoption and outcomes of technology, an in-depth perspective missing in the literature (Khosravi et al., 2016). Using this perspective, this article discusses the app's feasibility, considering its acceptability (adoption and uses) and efficacy (outcomes).

Current Study: A Recursive Approach to Technology

We developed an accessible iPad-based communication app that supports older adults' asynchronous communication with family and friends. In addition to the literature emphasis on accessible and tailored communication technology to increase social connectedness (Khosravi et al., 2016), our participatory design approach, which included older adults in the process as codesigners, identified a tablet-based app as the most valuable tool (Baecker et al., 2014). Tablets have been shown to be useful as communication, inclusion, and well-being interventions (Delello & McWhorter, 2017; Tsai et al., 2015; Tyack, Camic, Heron, & Hulbert, 2017). Prototyping considered the social affordances perspective (Wellman et al., 2003), respecting the social features/actions defined by our codesigners. The app allowed users to send and receive photos, audio, video, and text messages (sent messages were predefined to increase simplicity; see Figure 1), whereas their contacts could respond using their own emails and devices. The interface offered large nontextual touch icons (no typing, only swiping/tapping) to accommodate users with visual and motor impairments, as informed by our field studies (Neves et al., 2017).

Once the app was ready to deploy, we asked,

> Is this a feasible app to enhance perceived social connectedness among frail older adults living in a retirement home?

To answer this question, we deployed the technology in a Canadian retirement home that offers different levels of care. To assess feasibility, we studied adoption and use through a *recursive approach to technology* that examined the app as used "in the wild," considering the interplay of users, technologies, and contexts (Greenhalgh & Stones, 2010). Existing adoption
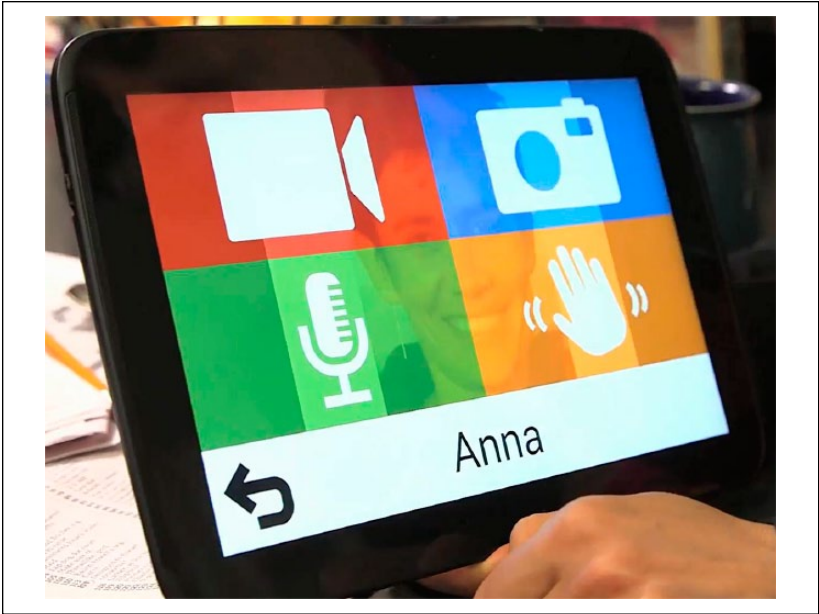
Figure 1. The message interface of our app with four options: wave (predefined), audio, picture, and video message (right to left).

models, such as the widely employed *Technology Acceptance Model* and extensions (Davis, 1989; Giger et al., 2015), tend to neglect the interaction of psychosocial and contextual factors. In addition, the literature lacks mixed-methods approaches that explore the lived experience of adoption and outcomes of new communication technology among older adults (Quan-Haase, Martin, & Schreurs, 2016).

Method

Design

A feasibility study was used because we were testing an unexamined intervention with a population for whom we lack in-depth knowledge, and prioritizing real-life settings and constraints over optimal conditions (Bowen, Kreuter, & Fernandez, 2009; Green & Glasgow, 2006). The study considered two feasibility components: *acceptability* and *efficacy* (Bowen et al., 2009). Acceptability refers to the adoption of and reactions to the app, whereas efficacy concerns the app's perceived outcomes for social connectedness. To

assess these components, we conducted a 3-month mixed-methods app deployment in 2015. Participants received an iPad restricted to our app ("Guided Access Mode"), which they kept after the study. Our University Ethics Committee approved this study (Ref. 31111) and participants signed an informed consent form.

Participants

With staff assistance, we recruited a convenience sample of residents at a Canadian retirement home. Residents were invited to participate after attending information sessions about the study. Staff also invited residents who seemed at risk of social isolation and loneliness. As we did not have access to residents' medical records, we relied on staff to exclude individuals with dementia or conditions rendering them unable to provide consent. Of 21 interested residents, we enrolled 13 participants including a married couple who shared one tablet and were counted as a single user. Health deterioration was the main reason for reducing the original participant pool. One participant withdrew in the first month due to lack of interest. Research suggests that a sample of 12 participants is reasonable, given our research objectives, design, study group, and intervention (Billingham, Whitehead, & Julious, 2013; Bowen et al., 2009; Guest, Bunce, & Johnson, 2006).

Staff considered our participants frail due to biomedical and psychosocial factors (Fried, Tangen, Walston, & McBurnie, 2001; Lally & Crome, 2007). Ten participants showed weakness (grip strength), slow walking speed, low physical activity, and self-reported exhaustion, and two evinced low physical activity and slowness. Depression and low resilience were also assessed as psychosocial factors (Freitag & Schmidt, 2016). Recruitment of frail and institutionalized older adults is challenging, mostly because of declining health, life expectancy compression, and corresponding ethical issues (Hall et al., 2009). These factors restricted our longitudinal design to 3 months. Nevertheless, the 3-month deployment and purposive sample were appropriate for our in-depth approach.

Our four male and eight female participants ranged from 74 to 95 years of age, with an average age of 82.5 (see Table 1). All spoke English. The sample included Canadians, British Canadians, American Canadians, Italian Canadians, Japanese Canadians, and Latin American Canadians. Our prior study (feasibility pilot) was conducted with five Chinese Canadians (Neves et al., 2015; Neves et al., 2017); thus for this feasibility study, we aimed to include more diverse ethnic backgrounds. The husband–wife duo completed interviews together, but the husband mostly answered questions as the wife reported not using the tool independently.

Table 1. Participant Sociodemographic Characteristics.

Pseudonym	Gender	Age	Marital status	Previous occupation	Children	Health limitations (visible or reported)
Gaby	F	84	Widow	Homemaker	Two daughters, one son	Mild vision problems, needed a cane, speech disorder, rheumatoid arthritis
Diana	F	85	Widow	Early childhood educator	Two daughters, two sons	Mild vision and auditory problems
Jen	F	80	Single	Librarian	0	Mild vision problems, used a walker, intense rheumatoid arthritis
James	M	86	Married	Minister and University Instructor	One daughter, one son	Mild vision problems
Kevin	M	95	Widow	Medical doctor	Four daughters	Vision problems (blind in one eye, wears glasses), memory problems
Ike	M	74	Married	Engineer	One son, one stepson, one stepdaughter	Vision problems, Parkinson's (motor problems including shaking)
Paul and Martha	M and F	80&77	Married	Accountant and Mathematics teacher	Two stepsons, one stepdaughter; two sons, one daughter	Mild vision problems, mobility problems
Pam	F	86	Widow	Homemaker	One son, one daughter	Vision and reading problems
Bree	F	79	Single	Teacher	0	Stroke-related health issues, memory problems, aphasia
Jane	F	87	Widow	Nurse	Two sons, two daughters	Macular degeneration, auditory problems (hearing aids in both ears)
Lily	F	83	Widow	Teacher	0	Mild vision and auditory problems (hearing aid)

Participants joined the study with a family member or friend (study partner), who agreed to support their use of the app and complete a pre- and postdeployment interview. As we were testing a communication tool, we needed at least one tie involved in the process; participants were free to select whomever they would like to have as a study partner. As expected (consistent with the literature on older adults and social networks), most participants selected strong ties, namely, family and close friends. Three participants' daughters and two sons joined (all in their 40s). Four friends or acquaintances (most more than 60, one in her 40s) also joined. One participant invited her sister (in her 70s), and another, her granddaughter (in her 20s).

At the start of the study, five participants reported communicating regularly with three or less ties (family and friends), five participants with four to six, and the remaining two with seven or more. Participants added between 4 and 10 contacts to the app, mostly relatives (M = 8.6, Median = 9, Mode = 9 and 10). At the onset, it may seem that participants were embedded in particularly strong networks due to the number of ties and frequency of communication (cf. McPherson, Smith-Lovin, & Brashears, 2006). However, not all ties would be characterized as confidants (e.g., people to discuss important matters with) and communication was often "lightweight", which means it included quick follow-ups and nonmeaningful/routinized conversations (Lindley, Harper, & Sellen, 2009). In addition, as noted by staff and confirmed throughout the 3-month deployment, there was considerable "social desirability" when reporting family involvement as well as an effort by older participants to avoid being seen as a "burden" to their relatives and friends. Nevertheless, none of our participants displayed substantial levels of loneliness or social isolation. Some were not socially isolated, but at risk of loneliness; others were vulnerable to both social isolation and loneliness because of increasing frailty and loss of meaningful communication with ties; others wanted to enhance their connectedness with relatives, especially grandchildren, family, and friends living close and afar.

Participants' skills and knowledge of using digital devices (digital literacy levels) varied. Using a simple categorization of digital literacy at predeployment, four had never used a digital device (no digital literacy); three had used a computer previously, but had a basic operational understanding (low level); and five had used computers, email, and/or smartphones, but struggled with some functions (medium level).

Procedure

The deployment study had a pre-, mid-, and poststage (see Table 2). Predeployment included an individual training session and the administration of a social support and loneliness scale with participants, and semistructured

Table 2. Data Collection at Pre-, Mid-, and Post-Deployment.

Data collection	Pre	Mid	Post
Semi-structured interviews with participants	✓	✓	✓
Semi-structured interviews with study partners	✓		✓
Duke Social Support Scale: I. Social interaction 1. Number of family members within 1 hr that you can depend on or feel close to. 2. Number of times past week spent with someone not living with you. 3. Number of times in past week talked with friends/ relatives on the telephone. 4. Number of times in the past week attended meetings of clubs, religious groups, or other groups that you belong to (other than work). II. Social satisfaction 1. Does it seem that your family and friends understand you?* 2. Do you feel useful to your family and friends?* 3. Can you talk about your deepest problems with at least some of your family and friends?* 4. Do you know what is going on with your family and friends?* 5. When you are talking with your family and friends, do you feel you are being listened?* 6. How satisfied are you with the kinds of relationships you have with your family and friends—very dissatisfied, somewhat dissatisfied, or satisfied? *Most of the time, some of the time, or hardly ever	✓	✓	✓
UCLA Loneliness Scale: 1. How often do you feel that you lack companionship?* 2. How often do you feel left out?* 3. How often do you feel isolated from others?* *Hardly ever, some of the time, often	✓	✓	✓
Usability and accessibility tests			✓
Field observations	✓	✓	✓

interviews with participants and their study partners. The training sessions showed participants how to use the tablet and app, having them send and receive different message-types. Authors then administered the scales. After the training sessions, participants received a printed manual and a tablet with

our app to use as they chose for 3 months. Six weeks after the training, in mid-deployment, we readministered the scales and conducted semistructured interviews with participants. During postdeployment, we repeated the scales, conducted semistructured interviews with participants and relatives, and carried out usability and accessibility tests. The study partner attended the training session and was interviewed pre- and postdeployment. Our prior study showed the need to interview study partners at predeployment, not just at postdeployment, and to interview participants at mid-deployment, not just at pre- and postdeployment (Neves et al., 2015; Neves et al., 2017). Participants were alone with researchers during scale administration, and interviews with participants and study partners were conducted separately. Throughout the deployment, we visited participants weekly to collect field observations and answer questions. The authors conducted interviews and usability and accessibility tests. The first and fourth author conducted a total of 230 hr of unstructured participant observation. Interviews were audio-recorded and usability and accessibility tests were video-recorded to see how participants interacted with the device.

The scales used were the *Abbreviated Duke Social Support Index*, comprising the social interaction and satisfaction subscales (Wardian, Robbins, Wolfersteig, Johnson, & Dustman, 2012) and the *Short Revised UCLA Loneliness Scale* (Hughes, Waite, Hawkley, & Cacioppo, 2004). The initial semi-structured interview included questions about social networks, frequency of contact with those networks, social participation, and experience with digital technology. The mid- and postdeployment interviews asked about app experience, use/nonuse, media, and communication with social ties. The usability and accessibility tests were based on tasks to perform with the app (e.g., participants were asked to send different types of messages) and open and rating questions regarding the app's interface and functionality. Interviews lasted around 40 min. Field observations were a mix of participant and nonparticipant unstructured formats, allowing note-taking when relevant (Pretzlik, 1994). Field notes documented the way participants used the app and interactions between participants, relatives, staff, and researchers. This information deepened our understanding of participant contexts and app adoption and captured the involvement of researchers, contributing to reflexivity regarding our position in the field (Patton, 1990).

Analysis

We analyzed fully transcribed interviews and tests with qualitative profiling and thematic analysis. Field notes were used for qualitative profiling and to complement interviews. The qualitative profiling crafted profiles and

contextualized participants (Seidman, 2006). Thematic analysis was employed to uncover themes within (individual) and across (collective) cases: These were identified from the data but we also looked for a priori categories, namely, technology-related codes (King & Horrocks, 2010). The first three authors coded independently, then together to test for convergence. A fourth researcher determined basic interrater reliability (Patton, 1990) of half of the data by manually counting discrepancies in assignment of codes and themes, reaching 97% for pre-, 93% for mid-, and 95% for postdeployment interviews. These procedures, multiple sources of data, and peer comparisons and checks aimed to enhance trustworthiness of the analysis (Patton, 1990). To examine differences over time, the scales were analyzed descriptively and with Friedman and Sign tests (nonparametric techniques suiting our sampling). Health practitioners use these scales to assess individual patients and gather baseline information. We adopted a similarly liberal criterion, as advanced statistical analysis was unfeasible due to the sample size.

Results

Acceptability of the App

Analysis of the interviews, tests, and observations showed that the acceptability of the tool was captured through different phases of app adoption and use.

Adoption. Of the 12 participants, one did not adopt the app—that is, her use of the app stopped before postdeployment. Martha, participating with her husband (duo), used the app in the first weeks, but stopped after mid-deployment. She explained her nonadoption by stating "I don't need to get in touch with them [family], because I'm the mother they call me." During the mid-deployment interview, she mentioned "using it very little now" as "I knit." Our field notes indicated that the husband presented himself as the user since predeployment, whereas Martha took a more passive role. This interpersonal dynamic could have affected her uptake of the tool. Although we offered Martha a tablet to use independently, she declined.

Patterns of use. At mid-deployment, four participants reported daily use, five weekly use (at least once a week), and two occasional use (once every 2 weeks). However, at postdeployment, nine reported weekly use and two occasional use. Two participants' use slightly increased from mid- to postdeployment, from once to twice per week. These self-reports were consistent with our notes and loggings. Messages were mainly sent to family members,

particularly children and grandchildren. Audio was the most used function, followed by picture messages, then video. For some, the audio option was easier to use than mobile phones, which are often "too small" and "hard to operate." Gaby, a participant, stated that there was "No comparison with anything else, like a phone . . . I can't use phones because buttons are too little and I have arthritis in my fingers." For others, picture and video messages were preferred:

> The other day at a birthday party, I was able to take lots of pictures and send it immediately, and then take one for myself, and I did quite a bit of that over the weekend [with the app]. A friend phoned the other day and she said, uh, you know: "How big is the place you're living in now?" And so I said, "Well, I'll send you a video." (James)

The least-used option was the "wave" (predefined messages). Diana, who had used a computer before, mentioned at mid-deployment "those messages [waves] are really too basic for me." Nevertheless, the wave was the most used function at the beginning of the study when participants were becoming familiar with the app, as described by Pam, "I used it at first a lot, but not anymore, doesn't feel personal now." Overall, our participants preferred sending audio or picture/video messages and receiving text messages, although relatives preferred to send and receive pictures or videos. Spatial context also seemed to affect functions: for three participants, living arrangements "didn't offer much" for taking picture/video.

Data from interviews with study partners largely matched that of participant interviews, while providing extra information. They confirmed that audio was the primary message type received, followed by picture and video messages, with wave messages being the least popular. Most responded with text-based messages. Diana's granddaughter, Ike's stepson, and Lily's friend often included pictures with text, whereas Gaby's daughter reported primarily sending pictures and videos. Only, Jane's daughter responded by calling "She can't read whatever I've sent back, so I think her hearing is better than her vision, so it's still best to communicate with her by the phone, where it's audio, and she's comfortable."

Patterns of use were also reflected in study partners' opinions regarding the tool's offerings. Diana's, Gaby's, and Lily's family members found the tool convenient, portable, and simple. Diana's daughter explained that "she can carry it with her, and she shows people photos, which she'd really like to be able to do, if she goes to the diner, she can open it up, and show them photos of her family." The benefits of simplicity were echoed by Jen's, Ike's, and Bree's family members, who felt that the easy-friendly nature of the tool

Table 3. Main Stages of Technology Acceptability.

Stage	Description
1. Introductory stage	Reliance on the manual and use of quick messages to practice different software functions.
2. Associative stage	Improved understanding of software functionality based on knowledge of other media.
3. Autonomous stage	Independent use of software, without use being integrated into daily routines.
4. Integrative stage	Understanding of the software's role within their own contexts and an integration of the software into existing communication practices.

determined its successful adoption. Some reported changes in participants' relationship with technology as a result of app use. Five family members reported participants' increased confidence, comfort, and interest in using the app over the study's duration. Three study partners, however, stated that they did not feel the tool offered anything new. Nearly all indicated some difficulty in getting their senior to fully use the app, particularly during pre and mid-deployment. This ranged from performing basic message-sending functions to issues with more advanced functions like adding contacts.

Main stages of acceptability. Combining adoption and use, we derived four main stages of acceptability: introductory, associative, autonomous, and integrative (see Table 3). In the *introductory stage*, participants relied on the manual, used the "wave" frequently, and required assistance from researchers/ties. In addition, they primarily used the app to practice by sending quick messages to contacts. Of the 12 participants, only one moved from the introductory phase in 3 weeks (James); remaining participants required an average of 4 weeks.

In the *associative stage*, participants displayed an intermediary level of understanding of the technology; they made sense of most functions, particularly through associations with other media. However, they still required assistance and not all functions were used independently (e.g., video messaging). Two participants remained in this stage until the study's end. Jen compared the app's functions with a system used when she was a librarian, reporting at mid-deployment: "From what I can observe and experience, it's a bit easier than the other kind of computer . . . but I am still not a very mechanical person." At postdeployment, she still felt she couldn't "master the machine." Martha reported knowing how to use the app, especially compared with other devices, but relied on her husband to use it.

The *autonomous stage* encompassed independent app use, while still requiring practice and not being embedded in daily routines. Three participants remained in this phase at postdeployment. Paul was proficient with the app, but only used it for short messages and to arrange meetings. At the study's conclusion, the app was not part of his routine as he relied mostly on his phone. Bree had a "steep learning curve" and struggled with the audio and video options due to her impairments, but mentioned it got easier as "you went along." She was then comfortable with the app, as it was the only way to communicate with an overseas relative; yet, she felt that practice was needed to not forget how to use it. Ike used the app more frequently at the beginning, and could use it independently by the end, yet felt his Parkinson's affected his usage: "I am [losing] cognitive abilities and is hard to create audio messages, I can't speak that clearly anymore." He continued to use it for taking pictures and receiving messages.

Finally, in the *integrative stage*, participants were able to "domesticate" the app, that is, fully use and make sense of the technology within their own contexts. This appropriation or domestication was illustrated by the ability to integrate the app into social routines and use it to complement other media. Seven participants were at this stage at postdeployment. Although their use was less frequent than at the beginning of the study (now weekly, not daily), it was curated to suit specific communication needs: It was not seen as a way of practicing use, but of employing diverse functions to reach social ties and convey different messages. In addition, at this stage, participants were more aware of the limitations of the tool (e.g., asynchronicity, no keyboard) and felt confident to combine the app with other media to overcome them. They even used other types of technology that were once seen as too complex, and asked researchers to disable the "Guided Access Mode" (tablet restricted to our app) when the study ended so they could learn other functions. Kevin, for example, used the app in "tandem with his laptop" because the app was simple to "start conversations. I am 95 and starting to forget words" and he could "carry it down the hallway." Gaby used the app to communicate with relatives abroad to avoid struggling with her "small" mobile phone and expensive calls, and to send brief daily messages to family living nearby: "I can just sit down and eat things in the morning or whenever and talk and send pictures to all." Diana planned to continue to use the app to communicate with a friend and her daughter because they shared pictures and daily updates, but she would be "phoning" others. James said, "love it for taking pictures and quickly sending it, it's easier than with the computer."

Sociotechnical factors of acceptability. Not all participants reached the integrative stage. This seemed associated to interrelated factors that included social support, attitudes, digital literacy, and usability. For instance, those with lower levels of social support—that is, who did not have families/friends
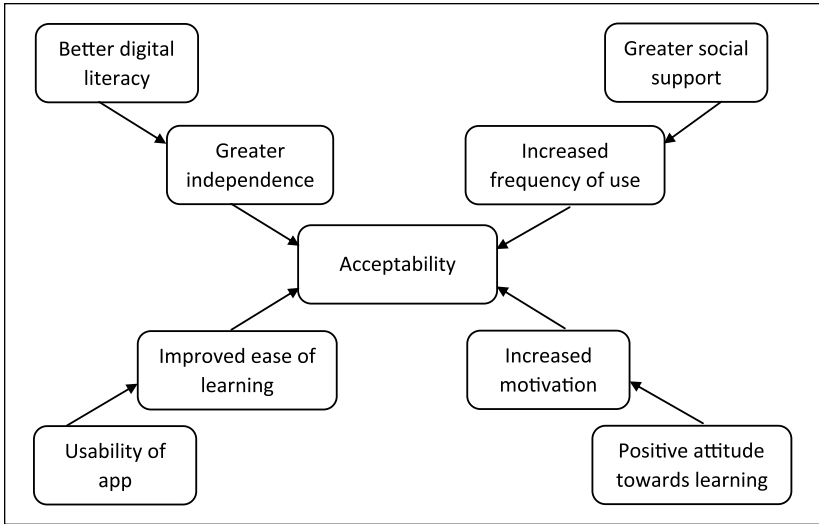
Figure 2. Sociotechnical factors of technology acceptability.

encouraging use of the tool—were less frequent users and less comfortable with the app. In contrast, having high family support seemed to compensate for prior lack of digital literacy. Most participants displayed positive attitudes toward learning to use the app, but those with previous digital literacy seemed more independent in their learning process. Contrary to what was planned, the initial training session was not enough, and even for those with prior digital experience; participants requested additional sessions. One usability factor that enhanced ease of use was the consistent layout of the interface. This enabled participants to use inference to determine the purpose of icons. Another important usability factor was the ability to choose an interface that responded to tapping only versus tapping and swiping. Most participants preferred to tap, stating it was easier than swiping. Digital literacy was interrelated with the usability factors: Participants with higher digital literacy successfully inferred meanings of the interface layout, and hence encountered fewer usability issues than other participants. In sum, acceptability (adoption and use) of the app seemed to rest on a complex interplay of social, attitudinal, digital, and usability factors, as illustrated in Figure 2.

Efficacy: Social Interaction Versus Social Connectedness

Although the app increased sense of social interaction (communication frequency and type) with family and friends for 10 participants, only four

reported high perceived social connectedness at postdeployment. The app allowed these four participants to reconnect, communicate more often, and deepen relationships with relatives living abroad or afar. For example, Gaby was limited in her communication with relatives, because most lived in different provinces or abroad—she "had no other way except to phone them" and was too unwell to travel. In her words, "we go years before we see each other," so using the app,

> It's been wonderful, being able to talk to my family so far away, and not need[ing] a special occasion to contact them, birthdays and Christmas, I can contact them now at any time . . . and talk and send pictures.

The technology affected Gaby's relationships with relatives because they could talk more often, have longer, deeper, and more informal conversations, and not worry about expensive calls.

For Pam, using the app allowed her to feel closer to her son ("living out West") and daughter-in-law. The different time zone was affecting her ability to communicate with them, and due to her impairments she could only write/call in the morning. The app's asynchronicity meant she could communicate when it suited her. Her son had a heart attack, and she was struggling with wanting to fulfill her mothering role while dealing with her health limitations. The technology gave her a way of overcoming those struggles: "I really feel much safer knowing that I can be in touch with him [son] . . . And, also, if he's in the hospital, or something like that, his wife, I can get in touch with her." Bree and Lily reported similar app usage and perceived impact. Both had family in Europe and "wouldn't be able to communicate with them if [they] didn't have this tool." Bree talked more frequently about her cousin, their reminiscences of the past, and how she was more involved in his life. She also communicated more often with her sister and new and old friends. Lily mentioned more "satisfying" relationships with family, old friends, and godchildren. At the start of the study, these four participants seemed to be the ones (in addition to Jen, which social connectedness did not change as reported below) displaying the least connectedness with their close and extended networks of our sample. Gaby and Pam had low contact with children and other relatives, mostly due to health impairments and different time zones; Bree and Lily were single, were childlessness, and had most relatives and friends living abroad.

For six participants, the app increased their perceived interaction (communication frequency and type) with social ties, but did not make those relationships more meaningful as it was mostly used for brief contact or follow-ups. Nevertheless, it allowed them to maintain their social interaction

and enhanced their engagement with different media. For example, Diana explained that the app added more multimedia options to her communication, as she talked to people on the telephone and then shared audio messages and pictures through the app. Her tablet was placed next to her telephone; when she could not reach people on the phone, she used the app. James also reported that through the app, he was able to communicate twice as often with relatives, especially his sisters, and had more spontaneous interactions.

The remaining participants, Jen and duo Paul–Martha, indicated no changes in social interaction or connectedness. Jen already had low social interaction with relatives and friends, and conditions did not change. Although she seemed connected with some church friends, most were not included as contacts in the tool because they did not use new technologies. Regarding family networks, she was the least socially connected participant of our sample. Paul felt limited by the asynchronicity and lack of keyboard. Martha mostly used the tool through Paul.

Study partners' reports supported these findings. The app was viewed as an additional communication medium, and Gaby's, Diana's, and Jane's relatives reported increased communication frequency due to the tool. For Diana's granddaughter, their conversations now contained more detail, and for Lily's friend, their conversations had new topics. Lily's friend and Gaby's daughter appreciated that the technology brought them closer to the participant. Lily's friend mentioned, "I send her a picture and then she looks at it and she likes it. I think it makes her feel more integrated."

Despite these positive elements, four participants reported some disappointment or tension with ties while using the app. Since predeployment, Jen described a problematic and distant relationship with close family due to religious differences. Nevertheless, she mentioned a nephew with whom she felt close and parishioners from her church. Not receiving replies from her nephew and some parishioners might have affected her use of the app, and even increased her perception of isolation and loneliness—although she did not express it, and staff were closely monitoring her. James, Kevin, and Jane indicated that some relatives would not reply to their messages. In some cases, this lack of engagement was because relatives did not know how to use email or open attachments; in others, they preferred alternative media. For instance, Kevin confided, "I'm somewhat disappointed in my kids, they preferred to use FaceTime." Jane also mentioned that she should have encouraged more replies from her grandchildren.

Our data, however, demonstrated that the app influenced perceived well-being of 7 of the 11 participants, who affirmed its impact on their positive mood, self-efficacy, and comfort with technology. For instance, Gaby indicated "living" more contentedly and capably. Pam emphasized feelings of

"safety" and how it "made me feel that I'm trying and that I can do a bit." Like Pam, Jane had never used "electronics before" and found the experience "informative and motivational." Both were hoping to learn how to "Google things" next. Lily felt more confident about technology, despite previous "computer anxiety." Diana felt "more relaxed and comfortable" when using the app in comparison with her computer and more patient with technology; Kevin reported similar experiences. We also captured increases in participants' levels of digital literacy: three had low digital literacy, six medium, and two high (compared with three with no digital literacy, three low, and five medium at the study's commencement).

The app had a negative impact on the perceived well-being of two users, making them more aware of their digital "inadequacy" or impairments. Jen felt "a little bit inadequate" at postdeployment, and Jane reported that the audio option made her more attuned to her "issues": "I'm nervous speaking . . . I figured my voice sounds kind of silly, but I've got to learn to speak up."

There were no significant changes in any of the scales used ($p > .05$), within and across participants. These were then used as baseline data, adding to qualitative profiling.

Discussion

We aimed to understand the feasibility of an accessible communication app to enhance perceived social connectedness among frail older adults living in a retirement home. For this, we focused on two main components of feasibility studies—acceptability and efficacy—and used a 3-month, mixed-methods deployment. Bringing together acceptability and efficacy, our findings revealed that an accessible app can be a feasible tool for social connectedness (as proposed in Findlay, 2003; Keefe et al., 2006; Khosravi et al., 2016; Masi et al., 2011) if five feasibility elements are considered. First, the *active involvement of one tie* was crucial for adoption of the app, learning dynamics, and type and continuity of use. Those who had relatives or friends deeply engaged in the process seemed more available to learn and use the app, even without digital literacy. As social capital theory and social connectedness perspectives have been showing, it is not quantity but quality and types of relationships that matter (Litwin & Shiovitz-Ezra, 2011; Wong & Waite, 2016). For instance, Jen, who did not have a very engaged study partner (a church friend), showed a tense relationship with relatives, and had a small close network (of which most members did not use new technologies), did not benefit from using the tool. Second, the app's *perceived usefulness and functionality* seemed related to levels of acceptability and efficacy. Usefulness seemed to increase adoption and use, as found in adoption studies (Davis, 1989; Giger et al., 2015). Yet,

data also highlighted that digital literacy levels did not seem to affect perceptions of usefulness and functionality. Family involvement was, however, critical to those perceptions. For example, although all participants reported enjoying the app's asynchronous aspect, relatives' preference for a synchronous tool meant most participants questioned their preference. Third, all participants, even those with higher levels of digital literacy, needed *adjustment periods* to learn to use the app. These periods included more training sessions, practice slots, and time to see what messages each contact preferred/would respond to. The latter is connected to a fourth feasibility element: *management of different intergenerational preferences, norms, and expectations.* These related to types of message (e.g., relatives preferred pictures/video whereas participants audio messages), asynchronous versus synchronous communication, and reply times. Although multimedia options were useful and praised by participants (as also suggested in Delello & McWhorter, 2017), digitally mediated intergenerational communication relies on different generational perceptions (Neves et al., 2015; Neves et al., 2017). Nonetheless, in their 3-year ethnographic study in an adult education center, Sayago et al. (2011) showed that feeling socially included motivates older adults to try to adapt to close ties' technology preferences—they suggest that acceptability and evolution of technology use seemed to rest on needs to be connected in meaningful ways. Finally, high social connectedness was only reported by participants who had relatives living abroad or in other provinces. Of our sample, these participants—Gaby, Pam, Bree, and Lily—seemed to have the least level of connectedness with ties at the start of the study (in addition to Jen), which seemed related to both health issues and having their main ties living in different regions/time zones or countries. As such, *having geographically distant relatives* can amplify the app's feasibility to enhance social connectedness. This finding supports the relevance of connectedness with close relatives, particularly those living overseas (Cotten et al., 2012; Sum et al., 2008; Tsai et al., 2015; White et al., 2002).

The social affordances perspective (Wellman et al., 2003) helps highlight the role of the app: its accessibility, convenience, and multioptions that created varied opportunities for interaction seemed fruitful for social connectedness. Furthermore, by using a recursive approach to technology evaluation that connected users, technology, and contexts (Greenhalgh & Stones, 2010), we were able to explore "adoption in the making", rely on a functional perspective that considered types of use rather than just use (Lifshitz et al., 2016), and flesh out the positive/negative interplay of family dynamics, digital literacy, attitudes, frailty, technology design and usability, residential settings, agency, and outcomes. Feasibility was the result of this interplay and not of isolated factors (cf. Davis, 1989; Giger et al., 2015). The acceptability stages emphasize the

complexity of adoption and use, even among a small sample. In addition, this comprehensive approach uncovered other outcomes: subjective well-being, feelings toward technology, and self-efficacy. Most outcomes were positive, but the app also seemed to augment feelings of inadequacy and awareness of frailty for at least two participants; tensions with relatives regarding different communication preferences and expectations were also found. These negative outcomes are not frequently addressed in research.

Overall, these findings on social connectedness match results from our previous study with five Chinese Canadians (aged 80+, low income, low literacy, high levels of frailty, and living in a long-term care facility). This suggests that low opportunities for social connectedness (in part related to frailty and institutionalization), geographical distance, and time barriers are issues faced by a group of the fragile older population, regardless of education, income, and institutional living setting (Neves et al., 2015). Furthermore, findings extend those of notable studies on the subject—however, former studies on social isolation and loneliness only examined general Internet use among older participants and were either quantitative or qualitative (Cotten et al., 2012; Sum et al., 2008; Tsai et al., 2015; White et al., 2002). By expanding this literature, we offer a fresh exploration of adoption, use, and outcomes of technology in later life from different angles, including family/friends. The 3-month mixed design contributed to this depth and lessened initial impression management efforts by participants, such as curated displays of social interaction and technology use—for example, overly positive narratives of family interaction and the app. The engagement of both older participants and relatives allowed us to capture different users, dimensions, and perceptions.

Implications

These findings can inform the design, implementation, and evaluation of similar communication tools or interventions. The feasibility elements will help refine and develop better and more sensitive digital tools. For instance, different intergenerational preferences, norms, and expectations must be taken into account to prevent tensions in the uptake of technology used to communicate with children and grandchildren. The negative unintended consequences must also be contemplated at the onset—through, for example, a set of pilot studies. The four acceptability stages will further assist in anticipating adoption(s) and use(s). The recursive and mixed approach proved critical to flesh out the interplay between users, technologies, and context, adding to a deeper analytical understanding of technology in later life. We argue that these approaches are needed to study this subject comprehensively from a dynamic perspective that recognizes different types of adoption, use, and outcomes.

Limitations

Despite these contributions, our results are limited by a nonrepresentative sample of frail older adults living in a retirement home. Participants had medium or high levels of education, lived in a relatively wealthy setting (although some participants were part of welfare programs for low-income older adults), and English was their first language or they were proficient in English. In addition, despite being vulnerable to social isolation and loneliness, no participant displayed high levels of social isolation. The tool might be less successful for those individuals, particularly as at least one tie (available and engaged) is needed for social interaction. Our study also had a restricted time frame due to institutional constraints. These limitations are usual in feasibility studies, which intend to set the stage for future research.

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